59TH ANNUAL MEETING | September 10-14, 2024

BARCELONA Spain

FINAL PROGRAM

www.srs.org/am24

SRS
Scoliosis Research Society

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We are pleased to acknowledge and thank those companies that provided financial support to SRS in 2024. Support levels are based on total contributions throughout the year and include the Annual Meeting, IMAST, Global Outreach Scholarships, Edgar Dawson Memorial Scholarships, SRS Traveling Fellowships, and the Research Education (REO) Fund.

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TABLE OF CONTENTS

MEETING INFORMATION

MEETING AGENDA

ABSTRACTS

INDUSTRY WORKSHOPS & NETWORKING SESSIONS

RELEVANT FINANCIAL RELATIONSHIP DISCLOSURES

AUTHOR INDEX

ABOUT SRS

ANNUAL MEETING VENUE

Centre de Convencions Internacional de Barcelona (CCIB)
Plaça de Willy Brandt 11-14
08019 Barcelona, Spain

All information as of September 2, 2024

Scoliosis Research Society

SRS Executive Office
555 East Wells Street, Suite 1100 Milwaukee, WI 53202
P: 414.289.9107 F: 414.276.3349 *info@srs.org* *www.srs.org*

MEMBER'S BUSINESS MEETING AND LUNCH

Friday, September 13 | 13:15-14:30
Room 211-212 | Level P2

A hot lunch will be provided.

All SRS members are invited to the 2024 Member Business Meeting. This meeting is an opportunity to hear a summary of the many activities of the Society over the last year.

The agenda will include:

- Reports from the various SRS committees presented by each Council
  - Communication
  - Education
  - Governance
  - Research
- Updates on SRS activities, programs, and financial state
- Reports from the 2024 Traveling Fellows
- Voting for the Slate of Officers and the 2024-2025 Nominating Committee

Attendance at the Member's Business Meeting is an opportunity to not only hear updates, but actively participate in shaping the future of our Society. We encourage ALL MEMBERS to attend.

Scoliosis Research Society

MEETING INFORMATION

The Scoliosis Research Society gratefully acknowledges ATEC Spine for their grant support of the Annual Meeting Directional Signage.

PRESIDENT'S MESSAGE

On behalf of the Scoliosis Research Society, it is my great pleasure to welcome you to the 59th SRS Annual Meeting in beautiful Barcelona.

The program was chosen from the best submissions of more than 1,300 abstracts. Co-Chairs **Ivan Cheng, MD**, and **Mitsuru Yagi, MD, PhD**, along with the Annual Meeting Scientific Program Committee have done outstanding work in putting together a truly great program that features an international and forward-thinking focus.

As always, an SRS Annual Meeting kicks off with the prestigious Hibbs Society meeting on Tuesday with sessions covering topics in pediatric and adult spine treatments and 'New Technologies in OR Daily Life'.

One of our "must attend" sessions is the Pre-Meeting Course on Wednesday on the theme of **Long-Term Outcomes of Spine Deformity Surgery, Update on Current Knowledge and Future Directions**, planned by Brian Hsu, MD and Javier Pizones, MD, PhD, Annual Meeting Education Committee Co-Chairs. After presenting some truly valuable long-term outcome data that can help guide shared decision making with our patients, the precourse then looks towards the future – how can we learn and do better – with presentations on burning issues such as the role of sarcopenia and osteoporosis on adverse events; the impact of radiomics and machine learning on surgical planning; the behavioral patterns of mechanical complications; the role of knee pathology on compensatory mechanisms and updates on the effectiveness of T4-L1 hip axis correction.

The Opening Ceremonies on Wednesday evening includes a welcome by our local host Dr. Ferran Pellisé and this year's Howard Steel Lecturer, **Bruno Dubois**. I encourage everyone to attend the ceremonies because it's great fun and it allows us to highlight award and research winners, thank our donors and corporate partners, and present the Walter P. Blount Humanitarian Award to this year's deserving recipient, **Richard M. Hodes, MD**.

Thursday morning commences with sessions from the scientific program, followed by the Harrington Lecture featuring **Steven Glassman, MD**, Professor of Orthopaedic Surgery at the University of Louisville, past President of the Scoliosis Research Society, former Chair of the Professional Society Coalition Task Force on Lumbar Fusion and one-time Program Chair for the North American Spine Society.

We will also present two Lifetime Achievement Awards this year to members who exemplify distinguished service to SRS and to spinal deformity research, **Charlie E. Johnston, MD** and **Nana Prof. Oheneba Boachie-Adjei Woahene II**.

Industry Workshops, highlighting topics and technologies selected by the supporting companies take place on Thursday during lunch. Delegates are encouraged to attend one of the concurrent workshops.

Friday will be a full day of scientific sessions beginning with the Hibbs Award-Nominated Papers for Best Basic/Translational and Clinical Research. The Member's Business Meeting will be held during lunch and will cover all the updates from our committees, budget, progress reports and outlook for the coming year.

We close the Meeting with a half-day of scientific sessions on Saturday, including the Transfer of the Presidency to **Laurel C. Blakemore, MD**.

It has been an honor to serve as the President of the Scoliosis Research Society over the past year. It was a goal of my term, together with the Board and countless volunteer members, to guide our society in the post-pandemic world, to identify our strategic themes for the next years, whilst also setting the SRS on a path of fiscal success for the next 60 years. Our global perspective is unique in the spine arena and provides a deep well of knowledge, experience and expertise that sets us apart for charting the course of future research.

Best wishes for a great meeting!

Marinus de Kleuver, MD, PhD

ANNUAL MEETING COMMITTEES

SRS PRESIDENT

Marinus de Kleuver, MD, PhD

LOCAL HOST

Ferran Pellisé, MD

SRS EDUCATION COUNCIL CHAIR

Munish C. Gupta, MD

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Cristina Sacramento Dominguez, MD, PhD
John S. Vorhies, MD

PROGRAM ABSTRACT REVIEWERS

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John S. Vorhies, MD

GENERAL INFORMATION

MEETING DESCRIPTION

The Scoliosis Research Society (SRS) Annual Meeting is a forum for the realization of the Society's mission and goals: the improvement of patient care for those with spinal deformities. Five faculty-led instructional course lectures, 178 abstract papers, and 80 E-Point Presentations will be presented on an array of topics, including adolescent idiopathic scoliosis, neuromuscular scoliosis, growing spine, kyphosis, adult deformity, minimally invasive surgery, and machine learning.

LEARNING OBJECTIVES

Upon completion of the Annual Meeting, participants should be able to:

1. Increase level of knowledge about the mid- and long-term outcomes of patients who have undergone surgery for scoliosis across three life stages (EOS, AIS, ASD).
2. Review current concepts and analysis of sagittal plane pathology, preoperative patients' optimization, and how to prolong surgeons' longevity.
3. Recognize new technology that helps in the treatment of spinal deformity.
4. Focus on patient-reported outcome measures (PROMs) in spinal deformity care to enhance patient satisfaction and quality of life post-surgery and discuss strategies for integrating PROMs into clinical practice.
5. Share insights and experiences from various global regions on the challenges and solutions in scoliosis treatment, with a focus on overcoming barriers to care in underrepresented populations.

TARGET AUDIENCE

Spine surgeons (orthopaedic and neurological surgeons), residents, fellows, nurses, nurse practitioners, physician assistants, engineers, and company personnel.

ABSTRACT VOLUME

All abstracts accepted for presentation at the 59th Annual Meeting are published in the Final Program. Abstracts are also available online on the Program page of the SRS Annual Meeting website (https://www.srs.org/Meetings-Conferences/Annual-Meeting/AM24#program) and in the Annual Meeting mobile app.

ATTIRE

Business (suits) or business casual attire (polo or dress shirt, sport coat) are appropriate for all Annual Meeting sessions; ties are not required. Cocktail attire is appropriate for the Farewell Reception.

CELL PHONE PROTOCOL

Please ensure that cell phone ringers, pagers, and electronic devices are silenced during all sessions.

CME INFORMATION

Accreditation Statement

The Scoliosis Research Society (SRS) is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians.

Credit Designation

SRS designates this live activity, 59th SRS Annual Meeting, for a maximum of 28 *AMA PRA Category 1 Credits*™. Physicians should claim only the credit commensurate with the extent of their participation in each activity.

The 59th Annual Meeting , Barcelona, Spain 10/09/2024 - 14/09/2024, has been accredited by the European Accreditation Council for Continuing Medical Education (EACCME®) with 28.0 European CME credits (ECMEC®s). Each medical specialist should claim only those hours of credit that he/she actually spent in the educational activity.

DISCLOSURE OF CONFLICT OF INTEREST

It is the policy of SRS to ensure balance, independence, objectivity, and scientific rigor in all educational activities. In accordance with this policy, SRS identifies all financial relationships held with an ineligible company* by individuals in a position to influence or control the content of a CME activity. Relevant financial relationships are mitigated by SRS to ensure that all scientific research referred to, reported, or used in a CME activity conforms to the generally accepted standards of experimental design, data collection, and analysis. Complete faculty disclosures can be found on page 229.

**An ineligible company is one whose primary business is producing, marketing, selling, re-selling, or distributing healthcare products used by or on patients.*

EMERGENCY & FIRST AID

The CCIB is fully prepared to handle emergency requests and first aid. Contact an SRS staff person for support. Remember to note all emergency exits within the venue.

E-POINT PRESENTATIONS

There are 80 E-Point Presentations available for your review on the virtual meeting platform in the E-Point module.

EVALUATIONS

Please take time to complete the evaluations for each session you attend. Session evaluations and the overall meeting evaluation are available online on the AM24 Meeting App. Your input and comments are essential in planning future Annual Meetings.

GENERAL INFORMATION

FDA STATEMENT (UNITED STATES)

Some drugs and medical devices demonstrated during this course have limited FDA labeling and marketing clearance. It is the responsibility of the physician to be aware of drug or device FDA labeling and marketing status.

INSURANCE/LIABILITIES AND DISCLAIMER

SRS will not be held liable for personal injuries or for loss or damage to property incurred by participants or guests at the Annual Meeting including those participating in tours, social events or virtually. Participants and guests are encouraged to take out insurance to cover losses incurred in the event of cancellation, medical expenses, or damage to or loss of personal effects when traveling outside of their own countries.

SRS cannot be held liable for any hindrance or disruption of the Annual Meeting proceedings arising from natural, political, social, or economic events, or other unforeseen incidents beyond its control. Registration of a participant or guest implies acceptance of this condition.

The materials presented at this Continuing Medical Education activity are made available for educational purposes only. The material is not intended to represent the only, nor necessarily best, methods or procedures appropriate for the medical situations discussed, but rather is intended to pre-
sent an approach, view, statement, or opinion of the faculty that may be helpful to others who face similar situations.

SRS disclaims all liability for injury or other damages resulting to any individual attending a scientific meeting and for all claims that may arise out of the use of techniques demonstrated therein by such individuals, whether these claims shall be asserted by a physician or any other person.

LANGUAGE

Presentations and meeting materials will be provided in English.

LOST & FOUND

Please feel free to stop by the SRS Registration Desk if you have lost or found an item during the Meeting.

NAME BADGES

Official name badges are required for admission to all Annual Meeting sessions, breaks, and lunches. Meeting attendees will receive a name badge with their registration materials. Name badges are required to be worn while inside the meeting venue, as badges will be used to control access to sessions and activities. Attendees are cautioned against wearing their name badges while away from the venue, as badges draw unwanted attention to your status as visitors to the city.

NO SMOKING POLICY

Smoking is not permitted during any Annual Meeting activity or event.

PHOTOGRAPHY POLICY

SRS will be taking photographs throughout the Annual Meeting. SRS will use these photos in publications and to produce related literature and products for public release. Individuals photographed will not receive compensation for the use and release of these photos and will be deemed to have consented to the use and release of photos in which they appear. If you are opposed to being photographed, please immediately notify the photographer or a SRS staff member if your picture is taken. Thank you for your cooperation.

REGISTRATION DESK HOURS

Location: Ground Level, Entrance Hall C

Tuesday, September 10	12:00-17:00
Wednesday, September 11	08:00-19:30
Thursday, September 12	08:00-17:00
Friday, September 13	08:00-18:00
Saturday, September 14	08:30-11:30

SESSION RECORDING ACCESS

Online Platform:
https://spinelearning.brightspace.com/d2l/home

All SRS members and registered meeting delegates will be granted access to the recorded sessions 3-4 weeks following the Annual Meeting. To access the virtual content, go to https://spinelearning.brightspace.com/d2l/home select "I have an account on the SRS website", enter your SRS username and password, click "Continue", and select 59th Annual Meeting listed under "My Courses".

SPEAKER READY ROOM

Location: Level P1 | Room 114

Presenters may upload their presentations onsite in the Speaker Ready Room. Presentations should be uploaded no later than 24 hours before the session is scheduled to begin.

Tuesday, September 10	12:00-17:00
Wednesday, September 11	08:00-19:30
Thursday, September 12	08:00-17:00
Friday, September 13	08:00-18:00
Saturday, September 14	08:30-12:30

SPECIAL NEEDS

If you have any health issues for which you may require special accommodation or assistance, please notify an SRS staff member. SRS will make every effort to accommodate any special needs.

GENERAL INFORMATION

SRS DEI TABLE

Location: Level P1 | Foyer 1

Learn more about the SRS Diversity, Equity and Inclusion Task Force's efforts and connect with similarly minded individuals at the new DEI table. Content will include summaries of past and on-going SRS DEI efforts, DEI related surgical organizations, and an opportunity for non-members to make their voices heard, and information from our supporting partners about their DEI efforts. Gathering at the DEI table during breaks is encouraged.

The SRS DEI Table is supported, in part, by Medtronic and Stryker.

SRS HISTORICAL DISPLAY

Location: Level P1 | Foyer 1

Explore the unique spine history of Spain at the local host Historical Display. The SRS Historical Committee, in conjunction with Ferran Pellisé, MD, PhD, Joan Bagó, MD, PhD, Enrique Izquierdo, PhD, Francisco Javier Sánchez Pérez-Grueso, MD and Carlos Villanueva, MD, PhD, have created a timeline of noteworthy Spanish contributions to spine and spine deformity surgery.

Informational videos that focus on important contributors to the study of spinal deformity will be featured and available to view near registration.

SRS MEMBERSHIP DESK

Location: Level P1 | Foyer 1

Stop by the SRS Membership Desk for more information about becoming an SRS member, application status, upcoming meetings, and more.

VIDEO RECORDING PROHIBITED

SRS does not allow personal video recording of presentations of any kind. SRS holds the right to confiscate all recordings taken of any of the presentations. All session rooms will be recorded and will be available to delegates after the meeting on the Annual Meeting virtual platform.

WIRELESS INTERNET

Wireless Internet access is available throughout the meeting space.

Network: SRS Meeting
Password: SRSAM2024

JOIN THE CONVERSATION

Join the conversation surrounding the SRS Annual Meeting by using **#SRSAM24** in your social media posts.

@srs_org

@ScoliosisResearchSociety

@ScoliosisResearchSociety

@srs_org

@srs_org

SESSION AND EVENT INFORMATION

HIBBS SOCIETY MEETING - $50

Tuesday, September 10 | 13:00-17:00
Available to meeting delegates for an additional fee of $50

Over the years, the Russell A. Hibbs Society, formed in 1947 as an international travel club for continuing medical education and furthering orthopaedic knowledge, has held an educational meeting at the SRS Annual Meeting. These meetings address difficult and complex issues that do not lend themselves to the usual kind of scientific presentations. The meeting encourages interaction among international participants and highlights new ideas, new concepts, and reports on personal experience. The Hibbs Society Meeting is planned by the SRS Traveling Fellows and will feature updates on deformity treatments, with some exchanges about hot topics such as EOS, sagittal alignment objectives, pelvic fixation, and new technologies.

OPENING CEREMONIES AND WELCOME RECEPTION

Wednesday, September 11
Opening Ceremonies | 18:20-19:40
Welcome Reception | 19:40-22:00
Available at no charge to meeting delegates, $50 per guest

The Annual Meeting will officially begin with the Opening Ceremonies and this year's Howard Steel Lecturer, Bruno Dubois. The Opening Ceremonies are the kickoff to another wonderful meeting, giving the Society the opportunity to highlight award and research winners, thank our donors and corporate partners, and will include the presentation of the Walter P. Blount Humanitarian Award.

A hosted reception featuring hors d'oeuvres, cocktails, and reunions with colleagues and friends will follow the Opening Ceremonies.

If you would like to purchase guest ticket(s), you may do so at the SRS Registration Desk.

INDUSTRY WORKSHOPS

Thursday, September 12 | 13:30-15:00

Delegates are encouraged to attend the industry workshops. Each workshop is programmed by a single-supporting company and features presentations on topics and technologies selected by the company. Lunch will be available during the workshops. CME credits are not available for workshops.

Industry workshops will be hosted by: ATEC Spine, Globus Medical, Highridge Medical, Johnson & Johnson MedTech, and Medtronic. Please see page 223 for program information.

NETWORKING SESSIONS

Thursday, September 12 | 17:00-18:30

Delegates are encouraged to attend hosted Networking Sessions immediately following the last session of the day. Networking Sessions will be hosted by: ATEC Spine, Highridge Medical, Medtronic, and Stryker. Please see page 225 for more information.

MEMBER'S BUSINESS MEETING

Friday, September 13 | 13:15-14:30

All SRS members are invited to the Member Business Meeting. The agenda will include reports from the various SRS committees, updates on SRS activities and programs, and voting. Attendance at the Member's Business Meeting is an opportunity to not only hear updates, but actively participate in shaping the future of our Society. We encourage *ALL MEMBERS* to attend. A hot lunch will be provided.

NON-MEMBER LUNCH

Friday, September 13 | 13:15-13:45

While SRS members participate in the Business Meeting, all non-member delegates are encouraged to attend the Non-Member Lunch to connect with colleagues and learn more about SRS.

FAREWELL RECEPTION - $50

Friday, September 13 | 20:00-22:00
Location: La Llotja de Mar
Available to meeting delegates for an additional fee of $50, $150 per guest

Open to all registered attendees and guests of registered attendees. Registration is required and tickets must be purchased in advance. A limited number of tickets may be available onsite, please stop at the registration desk for information and ticket availability. Tickets are $50 for registered attendees and $150 for registered guests.

Attire is business or cocktail.

ANNUAL MEETING APP

A mobile app delivering content, networking, engagement, and navigation all in one convenient location is available to all delegates during the meeting.

DOWNLOADING THE APP

1. Go to your device's app store and search for *SRS AM 2024*.
2. Select the meeting app and install.

PUSH NOTIFICATIONS

Apple and Android device users who have downloaded the meeting app can receive push notifications including reminders and schedule changes. Upon downloading the app, you must provide permission to receive these notifications on your device. You can update these permissions at any time within the Settings area of your device if necessary.

USING THE APP

1. Open the downloaded app and enter your email address to sign up or log in.
2. If you already have an account, you will be asked to enter your password. If you do not already have an account, you will be prompted to create a password and add profile information (optional).
3. The app can also be accessed by entering the URL, www.eventmobi.com/am24 on any current internet browser.
4. Once you are logged in, all event information will be readily available.

USER DASHBOARD

Click the icon in the top-right corner to access the User Dashboard. Here, you can find your personal schedule, notes you have taken, companies you have added to your favorites, documents you have added to your collection, and your chat inbox.

GAMIFICATION

Gamification within the SRS Annual Meeting app is a unique way to interact with your peers and engage with the presenters by collecting codes to earn points. To get you started, enter program for free points.

The app includes the details on points available and other ways to earn them. Delegates with the most points will win prizes.

The app also includes a leader board so you can see who is earning the highest points throughout the week. Stop by the SRS Registration Desk to learn more about gamification and the Annual Meeting app.

EVENT MENU

Access the event menu by clicking the Menu icon in the top-left corner. Here, you will find a list of sections that contain all of the event content, from speakers and sessions to meeting information and social media links. Select the section you are interested in and navigate through to find the information.

ASK A QUESTION IN THE APP

If you see a Q&A tab at the top of a session page, you can submit pertinent questions and comments to the moderator during that session. You can submit as many questions as you would like and view questions submitted by other attendees.

1. From the Agenda, click on the session you are in and click Q&A to see the question list.
2. From here, type your question in the text box provided and click Submit. Your question will appear within the question list.
3. To upvote someone else's question, click the upvote button to the right of the question in the list.

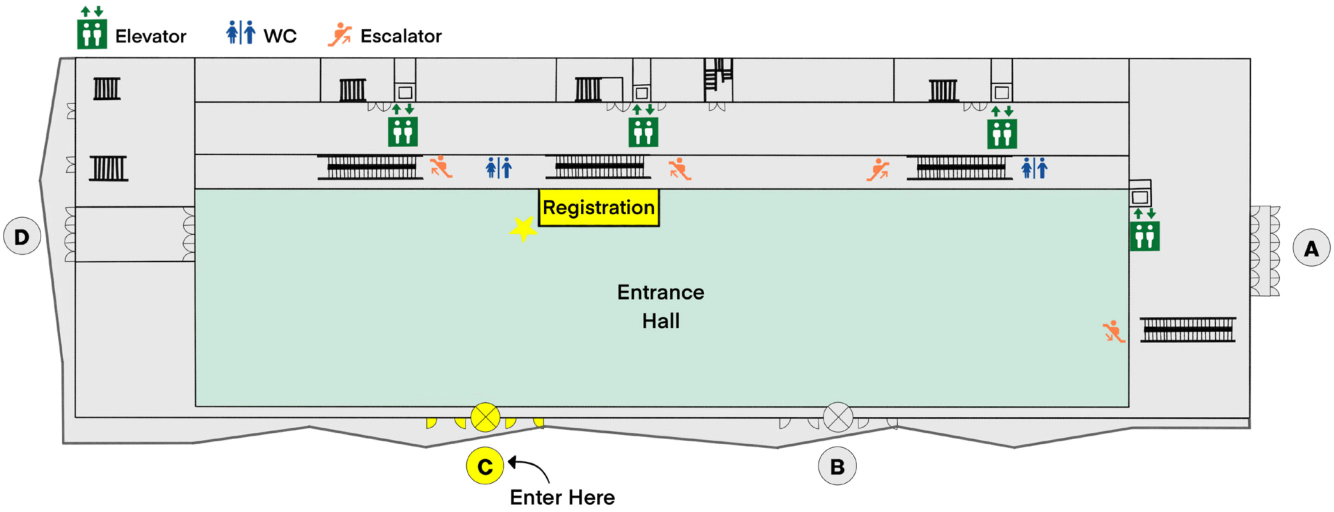
LIVE SESSION POLLS

Session polls can be found at the top of session pages. If prompted by the moderator or speaker, click Polls at the top of the page. Once you have started a session poll, you can move from question to question by selecting your answers and clicking Submit or by clicking on the navigation arrows to the left and right of the Submit button. Moderators can display the poll results live on screen for the entire audience to view.

MEETING SPACE FLOORPLANS

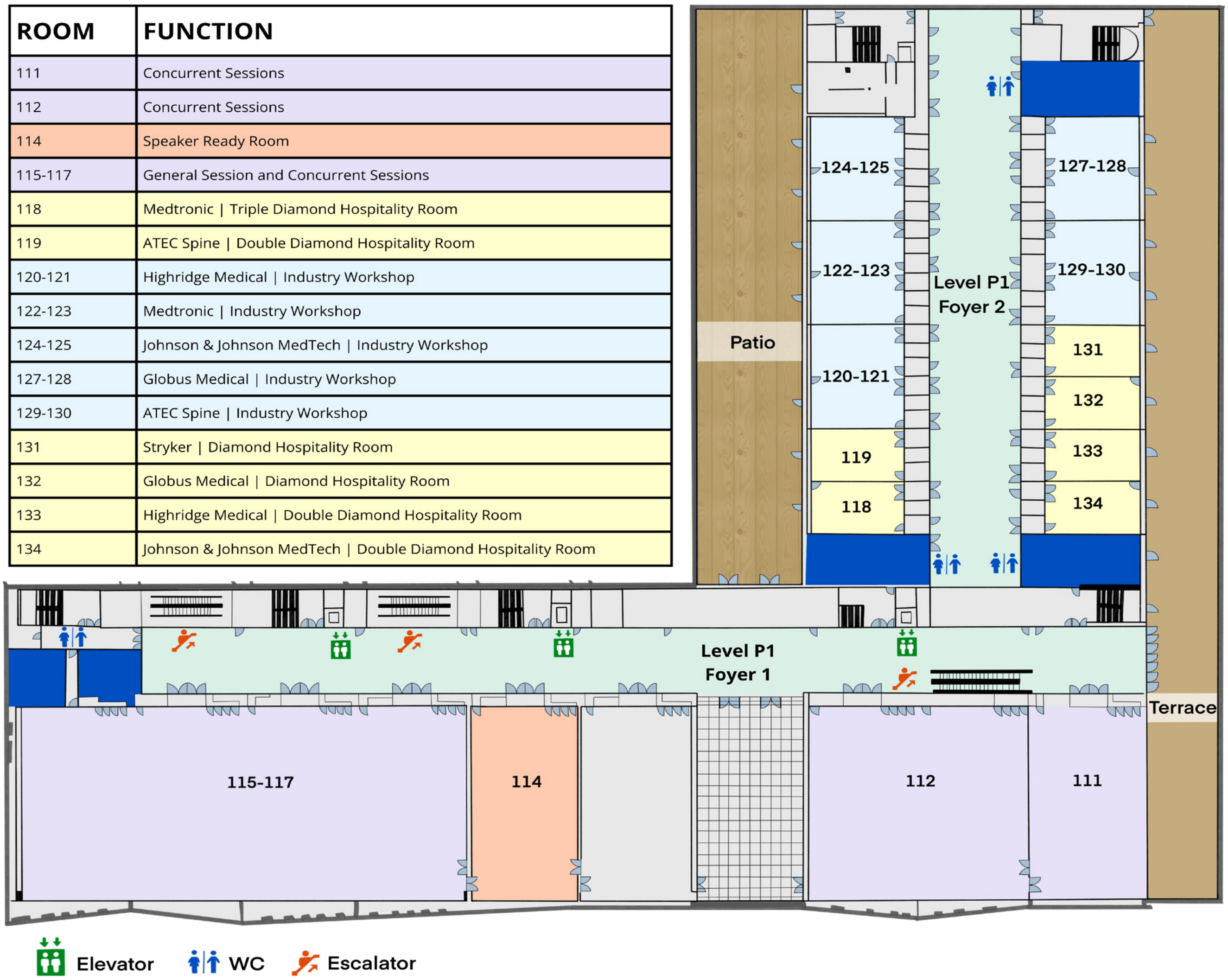
CENTRE DE CONVENCIONS INTERNACIONAL DE BARCELONA (CCIB)

GROUND LEVEL – Entrance Hall C



LEVEL P1

ROOM	FUNCTION
111	Concurrent Sessions
112	Concurrent Sessions
114	Speaker Ready Room
115-117	General Session and Concurrent Sessions
118	Medtronic | Triple Diamond Hospitality Room
119	ATEC Spine | Double Diamond Hospitality Room
120-121	Highridge Medical | Industry Workshop
122-123	Medtronic | Industry Workshop
124-125	Johnson & Johnson MedTech | Industry Workshop
127-128	Globus Medical | Industry Workshop
129-130	ATEC Spine | Industry Workshop
131	Stryker | Diamond Hospitality Room
132	Globus Medical | Diamond Hospitality Room
133	Highridge Medical | Double Diamond Hospitality Room
134	Johnson & Johnson MedTech | Double Diamond Hospitality Room



MEETING OUTLINE

MONDAY, SEPTEMBER 9, 2024			
09:00 - 17:00	SRS Board of Directors Meeting*	M211-M212	Level M2
TUESDAY, SEPTEMBER 10, 2024			
07:00 - 08:00	Committee Chair Breakfast*	Room 127-128	Level P1
08:00 - 16:30	Committee and Council Meetings*	Rooms 118-134	Level P1
12:00 - 17:00	Registration Open	Entrance Hall C	Ground Level
12:00 - 17:00	Speaker Ready Room Open	Room 114	Level P1
13:00 - 17:00	Hibbs Society Meeting	Room 112	Level P1
18:30 - 21:30	SRS Leadership Dinner* (by invitation only)	Offsite	
WEDNESDAY, SEPTEMBER 11, 2024			
08:00 - 19:30	Registration Open	Entrance Hall C	Ground Level
08:00 - 19:30	Speaker Ready Room Open	Room 114	Level P1
09:00 - 13:00	Pre-Meeting Course (PMC)	Room 115-117	Level P1
The Pre-Meeting Course is supported, in part, by Medtronic			
13:00 - 13:15	Lunch Pick-Up	Foyer 1	Level P1
13:15 - 14:15	Lunchtime Symposia (3 Concurrent Sessions)	Room 111 Room 112 Room 115-117	Level P1
Lunchtime Symposia are supported, in part, by ATEC Spine			
14:15 - 14:30	Break		
14:30 - 16:00	Abstract Session 1 | Adolescent Idiopathic Scoliosis	Room 115-117	Level P1
16:00 - 16:20	Refreshment Break	Foyer 1	Level P1
16:20 - 18:05	Abstract Session 2 | Adult Spinal Deformity	Room 115-117	Level P1
18:05 - 18:20	Break		
18:20 - 19:40	Opening Ceremonies*	Room 115-117	Level P1
19:40 - 22:00	Welcome Reception*	Banquet Hall	Level P2
THURSDAY, SEPTEMBER 12, 2024			
08:00 - 17:00	Registration Open	Entrance Hall C	Ground Level
08:00 - 17:00	Speaker Ready Room Open	Room 114	Level P1
07:30 – 08:30	L.E.A.D. SRS Cohort Breakfast & Panel* (by invitation only)	Room 111	Level P1
09:00 - 10:50	Abstract Session 3 | Quality/Safety/Value/ Complications	Room 115-117	Level P1
10:50 - 11:10	Refreshment Break	Foyer 1	Level P1
11:10 - 13:15	Abstract Session 4 | Quality/Safety/Value/ Complications II, Harrington Lecture and Lifetime Achievement Awards	Room 115-117	Level P1
13:15 - 13:30	Lunch Pick-Up	Foyer 2	Level P1
13:30 - 15:00	Industry Workshops* (5 Concurrent Sessions)	Rooms 120-130	Level P1
15:00 - 15:10	Break		
15:00 - 17:00	L.E.A.D. SRS Cohort Session* (by invitation only)	Room 111	Level P1
15:10 - 16:55	Abstract Session 5A | Adult Spinal Deformity II Abstract Session 5B | Adolescent Idiopathic Scoliosis II	Room 115-117 Room 112	Level P1
17:00 - 18:30	Industry Networking Sessions*	Varied	Level P1

*Denotes non-CME Session/Activity

MEETING OUTLINE

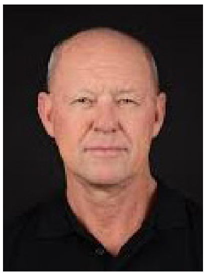
FRIDAY, SEPTEMBER 13, 2024			
08:00 - 18:00	Registration Open	Entrance Hall C	Ground Level
08:00 - 18:00	Speaker Ready Room Open	Room 114	Level P1
07:30 - 08:30	Past Presidents' Breakfast* (by invitation only)	Room 120-121	Level P1
09:00 - 10:50	Abstract Session 6 | Hibbs Award-Nominated Papers	Room 115-117	Level P1
10:50 - 11:10	Refreshment Break	Foyer 1	Level P1
11:10 - 13:00	Abstract Session 7 | Adult Spinal Deformity III and Presidential Address	Room 115-117	Level P1
13:15 - 14:30	Member Business Meeting (lunch pick-up at 13:00)	Room 211-212	Level P2
13:15 - 13:45	Non-Member Information Session (lunch pick-up at 13:00)	Room 112	Level P1
14:30 - 14:45	Break		
14:45 - 16:30	Abstract Session 8A | Cervical Deformity and Early Onset Scoliosis Abstract Session 8B | Kyphosis and Basic Science	Room 115-117 Room 112	Level P1
16:30 - 16:50	Refreshment Break	Foyer 1	Level P1
16:50 - 18:35	Abstract Session 9 | Adolescent Idiopathic Scoliosis III and Non-Operative Treatment Methods	Room 115-117	Level P1
19:30 - 20:30	President's Reception* (by invitation only)	Offsite	
20:00 - 22:00	Farewell Reception* (tickets required)	Offsite	
SATURDAY, SEPTEMBER 14, 2024			
07:30 - 08:30	SRS Board of Directors Meeting*	Room 122-123	Level P1
08:30 - 11:30	Registration Open	Entrance Hall C	Ground Level
08:30 - 12:30	Speaker Ready Room Open	Room 114	Level P1
09:00 - 11:10	Abstract Session 10 | Adult Spinal Deformity IV, Miscellaneous, Hibbs Award Presentation & Transfer of Presidency	Room 115-117	Level P1
11:10 - 11:30	Refreshment Break	Foyer 1	Level P1
11:30 - 13:15	Abstract Session 11 | Neuromuscular and Miscellaneous	Room 115-117	Level P1
13:15	SRS 59th Annual Meeting Concludes		

**Denotes non-CME Session/Activity*

GUEST LECTURES

WEDNESDAY, SEPTEMBER 11

Howard Steel Lecture



Bruno Dubois

Bruno Dubois (BEL/CAN) understands the challenges of managing high performance sports teams in one of the most dangerous sporting environments -- around the world, high-speed yacht racing.

A former sailmaker and professional sailor with more than 250,000 miles of sailing, Bruno has established himself as one of the leading names in the sport, called upon to lead teams at the highest level.

After 40 years in business, combining top-level racing with sales across Europe and North America, he became more aware of his strengths, and weaknesses. He loved the buzz of starting new projects, the discovery process, and getting everything set-up and in place, but the quickly realized if he would delegate work to those who are more qualified, he was far more successful in bringing these projects to fruition.

Using this experience, he established three rules when approaching a new project. First, choose people with better skills than your own to be part of the team. Second, create a structure as flat as possible, but with visionary leadership. And third, bring rigid flexibility. Make sure there is clarity in exact roles and responsibilities but invite interest from everyone across all departments.

Early in his professional sailing career, he learned about *disruption or constant change.* This helped him understand the importance of constantly adapting, and how to bring disruption to everyday life.

This was very apparent when he was as Sailing Team Manager of China's Dongfeng Racing Team's Volvo Ocean Race. Their win in 2018 surprised many, and reflected Bruno's ability to recruit, manage, and motivate an international team of women and men, helping them to bond, compete, and exceed all expectations.

Over the past few years, the business of sport has been growing and developing, with leagues, sponsors, and teams looking to achieve more than just success on the water – very similar to how many businesses are also looking for their point of difference. His involvement in this sport encouraged him to pursue a postgraduate degree in performance coaching to better understand what sets apart a good athlete from a winning athlete.

Bruno's work with the technologically advanced, global SailGP circuit, and experience leading the French entry in the world's oldest sporting trophy -- the America's Cup – brought the understanding that we should be driving ourselves to deliver day after day; physically, emotionally, and technologically, but we also must ask ourselves what is our *why*? Why are we doing this? What is our purpose, and how can we combine sporting excellence with impactful change.

When sharing his journey and experiences, he regals audiences with stories from the depths of the Southern Ocean to the high-tech computer simulators to showcase why disruption matters, why delegation brings experience, and how to define the small difference between first and second.

THURSDAY, SEPTEMBER 12

Harrington Lecture

Steven D. Glassman, MD

Dr. Glassman did his undergraduate training at Princeton University (Princeton, NJ). He attended Medical School and completed his Orthopedic Surgery residency training at The Columbia University College of Physicians and Surgeons (New York, NY). He did Spine Fellowship training at the Norton Leatherman Spine Center (Louisville, KY). He has been staff surgeon at Leatherman since 1991, and has trained over 125 US and OUS spine fellows.

Dr. Glassman is widely recognized both nationally and internationally as a leader in spinal surgery. Dr. Glassman is Professor of Orthopaedic Surgery at the University of Louisville. He is past President of the Scoliosis Research Society, past Chair of the Professional Society Coalition Task Force on Lumbar Fusion and past Program Chair for the North American Spine Society. He is currently co-Chair of the American Spine Registry (ASR) and a member of the AAOS Registry Oversight Committee. Dr. Glassman has been visiting Guest Professor throughout the United States and in over 20 countries.

Dr. Glassman has won numerous honors and awards. He was the first orthopaedic surgeon to receive the Meritorious Service Award from the AANS/CNS Joint Section on Spinal Disorders. He has been a multiple time winner of the Hibbs award from the Scoliosis Research Society (SRS) and has won multiple Outstanding Paper Awards at North American Spine Society (NASS), and the International Meeting for Advanced Spine Techniques (IMAST).

Dr. Glassman has published over 350 peer reviewed papers. His work on sagittal alignment is among the most highly cited in the spinal deformity literature and his work on MCID/SCB thresholds for patient reported outcomes (PROs) is among the most highly cited in the degenerative spine literature.

2024 SRS AWARDS

2024 WALTER P. BLOUNT HUMANITARIAN AWARD

Presented for outstanding service to those with spinal deformity and for generosity to the profession and Society. The 2024 Blount award will be presented on Wednesday, September 11.

Richard M. Hodes, MD

Rick Hodes is an American physician who has lived and worked in Ethiopia for over 35 years. Raised in Long Island, he is the medical director of the American Jewish Joint Distribution Committee (JDC) in Ethiopia, a 110-year old NGO which sponsors his spine work. He has also been in charge of the health of over 70,000 Ethiopians immigrating to Israel. He has worked with refugees in Rwanda, Zaire, Tanzania, Somalia, and Albania.

Rick is an internist who never did an orthopedics or neurosurgery rotation and had no interest in spine. In 1999, he met 2 abandoned orphans with severe Pott's Disease at Mother Teresa's Mission in Addis Ababa. He adopted them and brought them to Texas for surgery. He started a spine practice in 2006, partnering with Dr. Oheneba Boachie-Adjei and FOCOS. That year he got 20 new deformity patients, with 11 operated at FOCOS in Ghana. Since then they have done over 1600 surgeries, including 50 surgeries in May-June, 2024 in Ethiopia with SRS partners from Dallas, Stanford, Phoenix, and Lithuania.

He practices in the basement of a crowded Addis Ababa hospital, concentrating on spinal deformities. All care is free. Last year he got over 500 new deformity patients from Ethiopia and neighboring countries. Patients cross the border from Eritrea and travel by bus for 3 days to reach his spine clinic. A patient who could not afford busfare walked for 8 days from NW Ethiopia. Daily he sees the natural history of untreated spine deformities. Neurofibromatosis, diastomatomyelia, complex congenital and TB deformities are common. He collaborates with FOCOS Hospital in Ghana and Ganga Hospital in India. He also consults at Mother Teresa's mission in Addis Ababa.

Rick is a graduate of Middlebury College and University of Rochester Medical School, and trained in internal medicine at Johns Hopkins Bayview. He worked in the Ethiopian famine, and returned in 1985 on a Fulbright Fellowship to teach internal medicine at Addis Ababa University.

He has been a CNN Hero, and holds 5 honorary doctorates. The American College of Physicians has awarded him "Mastership" and the Rosenthal Award for creative practice of medicine.

He is the subject of the HBO documentary "Making the Crooked Straight," as well as the book "This is a Soul: The Mission of Rick Hodes" by Marilyn Berger (a journalist who adopted one of Rick's TB spine patients she found begging on the street). The documentary film Zemene highlights the life of a young spine patient and her journey from rural Gondar to Addis Ababa to Ghana and New York. Rick lives with his family in Addis Ababa. His goal is to establish a national spine center in Ethiopia. Please consider volunteering!

Listen to upcoming episodes of Scoliosis Dialogues: An SRS Podcast for exclusive interviews with the Lifetime Achievement Award winners and the Walter P. Blount Award winner. Scoliosis Dialogues can be found wherever you listen to podcasts or at www.srs.org/podcast.

2024 SRS AWARDS

2024 LIFETIME ACHIEVEMENT AWARDS

Presented to a member who has exhibited long and distinguished service to SRS and to spinal deformity research and care. The 2024 Lifetime Achievement awards will be presented on Thursday, September 12.

Oheneba Boachie-Adjei, MD, DSc

Nana Prof. Oheneba Boachie-Adjei Woahene II is the President and Founder of the Foundation of Orthopedics and Complex Spine (FOCOS). Nana Prof immigrated to the United States in 1972 and completed undergraduate studies at Brooklyn College of the City University of New York where he received a Bachelor of Science (summa cum laude-Chemistry). He received his Doctor of Medicine Degree from Columbia University's College of Physicians and Surgeons in 1980 and completed an Orthopaedic surgery residency at the Hospital for Special Surgery in New York.

Nana Prof. is an Emeritus Professor of Orthopaedic Surgery at Weill Cornell Medical College, the Hospital for Special Surgery, New York-Presbyterian Hospital.

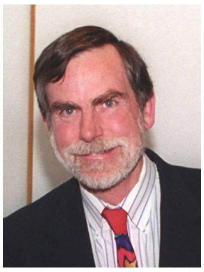
The coveted Russell Hibbs and Louis Goldstein Awards for Best Clinical Research and posters were awarded to him in 1989, 1999, 2002 & 2013 by the Scoliosis Research Society (SRS)

He was presented with the Philip D. Wilson Award for Outstanding Teacher in 1998 by Hospital for Special Surgery, the Distinguished Alumnus Award in 2003 by Brooklyn College, the Humanitarian Award in 2004 by the American Academy of Orthopaedic Surgeons (AAOS), the Albert Schweitzer Science & Peace Gold Medal in 2005 and the Walter P. Blount Service Award in 2006 by the SRS and was featured in the Discovery channel documentary entitled, "Surgery Saved My Life." He was elected President of the Scoliosis Research Society for the year 2008-2009 and in June 2013; Prof. Boachie-Adjei received the Lifetime Achievement Award from Hospital for Special Surgery. In 2015, He was featured on CNN's African Voices documentary as the Ghanaian Doctor transforming Spine Surgery in 2016; the University of Toledo, Ohio inducted him into their Global Medical Mission Hall of Fame. In 2016, he was awarded by the Philanthropy Forum Ghana; the individual philanthropist of the year (Special Needs). Since 2017 he won twelve more national and international humanitarian and philanthropic awards.

Prof. Boachie-Adjei has published and lectured extensively on spine surgery, with special emphasis on surgery to correct complex spine deformity. He is also an inventor who holds several patents for devices used in spine surgery.

Nana Prof was enstooled as Otumfuo Hiahene on the 19th November 2020 at the Manhyia palace Kumasi, Ghana. He is the current board chairman of the Otumfuo Osei-Tutu II foundation. He is married to Hilda Boachie-Adjei and they have three boys Kwadwo, Yaw and Kwame.

Charles E. Johnston, MD



Charles E. Johnston, MD ("Charlie") is assistant chief of staff emeritus at Texas Scottish Rite Hospital for Children, where he has practiced continuously since 1985. A native Southern Californian with strong family ties to south Texas, he graduated from Yale University and Columbia University College of Physicians and Surgeons, then did a surgical internship in San Antonio, eventually completing orthopedic surgery residency at the UVa Medical Center Charlottesville. He returned to Texas as a Harrington Fellow in Pediatric Orthopaedics and Scoliosis at Texas Scottish Rite Hospital for Children in Dallas 1981-2 (fellowship had no relationship to Dr. Paul R. Harrington).

Dr. Johnston is currently Professor in the Department of Orthopaedic Surgery at the University of Texas Southwestern Medical Center at Dallas. He is a reviewer for The Journal of Bone and Joint Surgery and the Journal of Children's Orthopaedics. He is a fellow in the American Academy of Orthpaedic Surgeons and serves on the executive committee of the Pediatric Spine Study Group and Foundation. An active member of the SRS since 1987, and has served on and chaired several committees, most recently the Education and Growing Spine committees. He is also a member of the Pediatric Orthopedic Society of North America, receiving its Humanitarian Award in 2020; the European Pediatric Orthopaedic Society; and the Texas Orthopedic Association.

Dr. Johnston has published over 150 papers in peer-reviewed journals and approximately 30 books chapters. Most important, Charlie and Ellen have been married for 45 years; have two daughters and five grandchildren.

SRS ANNUAL MEETING AWARDS

The 2024 Annual Meeting awards for the best basic/translational science and clinical research papers (Russell A. Hibbs Awards) and the best basic/translational science and clinical research E-Point Presentation (John H. Moe and Louis A. Goldstein Awards) at the 59th Annual Meeting will be presented on Saturday, September 14.

58TH ANNUAL MEETING RUSSELL A. HIBBS AWARDS

Presented to the best basic science and clinical research papers at the 58th Annual Meeting.

2023 Hibbs Award for Best Basic Science/Translational Research Paper

Hierarchical Evaluation of Mechanically Induced Growth Modulation of the Spine in a Growing Pig Model

Madeline Boyes, DVM; Axel C. Moore, PhD; Julie Engiles, VMD, DACVP; Benjamin Sinder, PhD; Rachel Hilliard; Jason B. Anari, MD; Sriram Balasubramanian, PhD; Edward Vresilovic, MD, PhD; Thomas P. Schaer, VMD; Dawn M. Elliott, PhD; Brian D. Snyder, MD, PhD; Patrick J. Cahill, MD

2023 Hibbs Awards for Best Clinical Research Paper

The Reunion with my Patients. Their Journey and Experience 30 Years after Their Intervention for Adolescent Idiopathic Scoliosis (AIS) via CD Instrumentation

Francisco Javier Perez-Grueso, MD; Lucía Moreno-Manzanaro, BS; Javier Pizones, MD, PhD

58TH ANNUAL MEETING JOHN H. MOE AND LOUIS A. GOLDSTEIN AWARDS

Presented to the best basic science and clinical research E-Point Presentation at the 58th Annual Meeting.

2023 John H. Moe Award for Best Basic Science/Translational Research E-Point Presentation

Soft-tissue Insufficiency as a Predictor for Proximal Junctional Kyphosis and Failure in Patients with Adult Spinal Deformity

Bahar Shahidi, PhD; Eli O'Brien, BS; Brianna Kuhse, BS; Courtney Moltzen, BS; Christopher B. Colwell, BS; Camille Nosewicz, BS; Tina L. Iannacone, BSN; Robert K. Eastlack, MD; Gregory M. Mundis, MD

2023 Louis A. Goldstein Award for Best Clinical Research E-Point Presentation

Influence of Smoking on Patient-reported Outcome Measures (PROMs) in Patients Undergoing Surgery for Adult Spinal Deformity. A Propensity Score-matched Analysis Excluding Known Tobacco-related Complications

Alejandro Gomez-Rice, MD, PhD; Maria Capdevila Bayo, MS; Susana Nunez Pereira, MD; Sleiman Haddad, MD, PhD, FRCS; Francisco Javier S. Perez-Grueso, MD; Frank S. Kleinstueck, MD; Ibrahim Obeid, MD; Ahmet Alanay, MD; Ferran Pellise, MD, PhD; Javier Pizones, MD, PhD; European Spine Study Group

MEETING AGENDA

The Scoliosis Research Society gratefully acknowledges Medtronic for their support of the Pre-Meeting Course.

Program (topics, timing, and faculty) is subject to change.

13:00 - 17:00 Room 112

Hibbs Society Meeting: Deformity from 7 to 77

Co-Chairs: Emmanuelle Ferrero, MD, PhD, Seung-Jae Hyun, MD, PhD, Kenny Y. Kwan, MD & Qianyu Zhuang, MD

13:00 - 14:13 Room 112

Hibbs Society 1: Pediatric

Moderators: Kenny Y. Kwan, MD & Qianyu Zhuang, MD

13:00 - 13:05	**Introduction** *David S. Marks, MBBS, FRCS, FRCS(Orth)*
13:05 - 13:12	**Techniques and Pitfalls of Casting in Early Onset Scoliosis** *James O. Sanders, MD*
13:12 - 13:19	**Apical Control Growing Rod Technique in the Treatment of Congenital EOS** *Terry Jianguo Zhang, MD*
13:19 - 13:26	**Posterior Hemivertebra Resection with Short Fusion for Congenital Scoliokyphosis-More than 10 Years Follow-Up** *Qianyu Zhuang, MD*
13:26 - 13:33	**Is There Still a Role for Magnetically Controlled Growing Rods?** *Kenny Y. Kwan, MD*
13:33 - 13:40	**Tethering in Tweeners** *A. Noelle Larson, MD*
13:40 - 13:47	**When Do I Fuse when Do I Tether in Lumbar Curve?** *Amer F. Samdani, MD*
13:47 - 13:54	**Management of Syndromic Scoliosis** *David S. Marks, MBBS, FRCS, FRCS(Orth)*
13:54 - 14:04	**Case Discussion** *Kenny Y. Kwan, MD*
14:04 - 14:13	**Discussion**

14:13 - 15:30 Room 112

Hibbs Society 2: Adult

Moderators: Emmanuelle Ferrero, MD, PhD & Seung-Jae Hyun, MD, PhD

14:13 - 14:21	**Surgical Challenges in Old AIS** *Emmanuelle Ferrero, MD, PhD*
14:21 - 14:26	**Specificity of Sagittal Profile** *Renaud Lafage, MS*
14:26 - 14:32	**PJK: Why and How to Prevent** *Virginie Lafage, PhD*
14:32 - 14:38	**Young vs Old AIS: Clinical and Surgical Outcomes** *Sebastien Pesenti, MD, PhD*
14:38 - 14:44	**Clinical Case Live Voting: LIV in Old Lenke** *Virginie Lafage, PhD*
14:44 - 14:52	**Discussion**
14:52 - 14:58	**Promising Parameter L1 PA** *Michael P. Kelly, MD*
14:58 - 15:04	**Take a Look at Head/Hip: Impact of Head-Hip Offset on Mechanical Failure** *Seung-Jae Hyun, MD, PhD*
15:04 - 15:10	**Preoperative Surgical Planning in Real World** *Javier Pizones, MD, PhD*

MEETING AGENDA

TUESDAY, SEPTEMBER 10, 2024

Program (topics, timing, and faculty) is subject to change.

15:10 - 15:16 **How I Do It Intraoperatively for Optimal Sagittal Correction**
Rajiv K. Sethi, MD

15:16 - 15:22 **How I Use AI or Machine Learning for ASD**
Samuel K. Cho, MD

15:22 - 15:30 **Discussion**

15:30 - 15:50 Foyer 1

Refreshment Break

15:50 - 17:00 Room 112

Hibbs Society 3: New Technologies in OR Daily Life

Moderator: David S. Marks, MBBS, FRCS, FRCS(Orth)

15:50 - 16:00 **3D Printing in Huge Deformity**
Brice Ilharreborde, MD, PhD

16:00 - 16:10 **AI: Patient Specific Rods**
Gregory M. Mundis Jr., MD

16:10 - 16:20 **Pelvic Fixation**
David W. Polly, MD

16:20 - 16:30 **Different Navigation Options**
James O. Sanders, MD

16:30 - 16:40 **How to Help the Surgeon: Motor and Robot**
David L. Skaggs, MD, MMM

16:40 - 16:50 **End of the Day Clinical Case**
Kariman Abelin Genevois, MD

16:50 - 17:00 **Discussion**

18:30 - 21:30

SRS Leadership Dinner* (by invitation only)

**denotes a non-CME session/event*

Program (topics, timing, and faculty) is subject to change.

09:00 - 13:00 Room 115-117

Pre-Meeting Course: Long-Term Outcomes of Spine Deformity Surgery, Update on Current Knowledge and Future Directions

Co-Chairs: Javier Pizones, MD, PhD & Brian Hsu, MD

09:00 – 11:18 Room 115-117

Part 1: Long-Term Results (10-yr FU) of EOS Patients

Moderators: Amy L. McIntosh, MD & David L. Skaggs, MD, MMM

09:00 - 09:06	**Long-Term Pulmonary and Physical Function in EOS Graduates** *Charles E. Johnston, MD*
09:06 - 09:12	**Long-Term Mental Health in EOS Graduates** *Muharrem Yazici, MD*
09:12 - 09:18	**Long-Term Hazards After EOS Treatment** *Ying Li, MD*
09:18 - 09:30	**Discussion**
09:30 - 09:36	**Long-Term Experience Comparing TGR vs MCGR** *Firoz Miyanji, MD*
09:36 - 09:42	**Update in Knowledge: Observation vs Final Fusion for EOS Graduates** *Paul D. Sponseller, MD, MBA*
09:42 - 09:48	**Future Directions for EOS Management** *René M. Castelein, MD, PhD*
09:48 - 10:00	**Discussion**

Invited Lecture

10:00 - 10:10	**A New Clinical Phenotype to Understand Pain and Anxiety: The Clue of Joint Hypermobility** *Antonio Bulbena, MD, PhD, MSC (Cantab)*
10:10 - 10:18	**Discussion**

Part 2: Long-Term Results (25-year FU) of AIS patients

Moderators: Laurel C. Blakemore, MD & Suken A. Shah, MD

10:18 - 10:24	**Update in Knowledge: Natural History of Non-Operated AIS Patients** *Martin Gehrchen, MD, PhD*
10:24 - 10:30	**Long-Term Clinical Outcomes of Operated AIS Patients** *Francisco Javier S. Perez-Grueso, MD*
10:30 - 10:36	**Long-Term Distal Degeneration Radiographic and MRI Results** *Meric Enercan, MD*
10:36 - 10:48	**Discussion**
10:48 - 10:54	**Sagittal Plane in the Long Run, Transition from the Pediatric World** *Nicholas D. Fletcher, MD*
10:54 - 11:00	**Pregnancy and Child-Bearing After Posterior Spinal Fusion for AIS** *A. Noelle Larson, MD*
11:00 - 11:06	**The Future of Psychosocial and Qualitative Research Applied to AIS** *Brandon A. Ramo, MD*
11:06 - 11:18	**Discussion**

11:18 - 11:33 Foyer 1

Refreshment Break

MEETING AGENDA

Program (topics, timing, and faculty) is subject to change.

Part 3: Long-Term Outcomes of Adult Spine Deformity Surgery, Update on Current Knowledge and Future Directions

Moderators: Serena S. Hu, MD & Munish C. Gupta, MD, MBA

Invited Lecture

11:33 - 11:43 **Latest Advances in Frailty and Sarcopenia Research: What Spinal Surgeons Need to Know to Care for the Aging Population**
Leocadio Rodríguez-Mañas, MD, PhD
**This speaker is sponsored, in part, by the Sponseller Interdisciplinary Fund*

11:43 - 11:51 **Discussion**

11:51 - 11:58 **Long-Term Results of the Adult Symptomatic Lumbar Scoliosis (ASLS) Cohort**
Michael P. Kelly, MD

11:58 - 12:05 **Are We Improving Our Performance/Outcomes Compared to 10 Years Ago?**
Ferran Pellisé, MD, PhD

12:05 - 12:12 **How Has MIS and Anterior Surgery Changed Our Practice in the Last 10 Yrs**
Juan S. Uribe, MD

12:12 - 12:24 **Discussion**

12:24 - 12:31 **Health Economics Impact on ASD Surgery**
Rajiv K. Sethi, MD

12:31 - 12:38 **The Role of Machine Learning and AI Applied to ASD**
Mitsuru Yagi, MD, PhD

12:38 - 12:45 **The Future Role of Epigenetic Clocks/Senescence in ASD Surgery**
Christopher P. Ames, MD

12:45 - 12:57 **Discussion**

12:57 - 12:59 **Conclusion**
Javier Pizones, MD, PhD & Brian Hsu, MD

13:00 - 13:15 Foyer 1

Lunch Pick-up

13:15 - 14:15

Lunchtime Symposia (LTS) (three concurrent sessions)

13:15 - 14:15 Room 111

LTS 1: Hypo to Hyper Kyphosis: Challenges in Sagittal Plane Management

Moderators: Michelle C. Welborn, MD & Suken A. Shah, MD

13:15 - 13:20 **Pulmonary Peril of Severe Lordosis**
Patrick J. Cahill, MD

13:20 - 13:25 **Construct Selection and Avoiding Anchor Failure in Extremes of the Sagittal Plane**
Steven W. Hwang, MD

13:25 - 13:30 **Discussion**

13:30 - 13:35 **How the Sagittal Plane Implacts Bracing**
Kenny Y. Kwan, MD

13:35 - 13:40 **VBT - The Limitation of the Sagittal Plane**
Stephanie Da Paz, MD

13:40 - 13:45 **Rod Selection and Differential Rod Contouring**
Stefan Parent, MD, PhD

13:45 - 13:50 **Discussion**

13:50 - 13:54 **HGT and Other Adjuncts to Improve Sagittal Fixation**
Teresa Bas, MD, PhD

Program (topics, timing, and faculty) is subject to change.

13:54 - 13:58 **When I Consider a 3 Column Osteotomy**
Michael Ruf, MD

13:58 - 14:02 **When Is Enough Enough - Avoiding Overcorrection**
Amer F. Samdani, MD

14:02 - 14:05 **Discussion**

14:05 - 14:09 **Bringing It Home: Evolution of the Sagittal Plane**
Michael P. Kelly, MD

13:15 - 14:15 Room 112

LTS 2: A Step Towards Improving Pre-Operative Optimization for Deformity Surgery - Creating a Pre-Operative Optimization Conference (POC)

Moderators: Ferran Pellisé, MD, PhD & Mark Weidenbaum, MD

13:15 - 13:19 **The Value of Developing a Pre-Operative Optimization Conference and a Screening Tool for Deformity Surgery**
Mark Weidenbaum, MD

13:19 - 13:24 **From a Practical Standpoint, does Risk Stratification Help Me to Optimize my Complex Deformity Patient?**
Ferran Pellisé, MD, PhD

13:24 - 13:28 **Practical Hard Stops**
Zeeshan M. Sardar, MD

13:28 - 13:33 **Discussion**

Panel 1: Optimizing my Complex Pediatric Deformity Patient

Andre Luis F. Andujar, MD, Martin Repko, MD, PhD, Reuben CC Soh, MBBS, FRCS, & Lindsay M. Andras, MD

13:33 - 13:34 **Case 1: Deformity in a 15 y/o with Metastatic Osteosarcoma**

13:34 - 13:38 **Panel Discussion**

13:38 - 13:43 **Audience Q&A**

13:43 - 13:44 **Case 2: Severe Deformity in a Syndromic Boy <10 years old**

13:44 - 13:48 **Panel Discussion**

13:48 - 13:53 **Audience Q&A**

2: Optimizing my Complex Adult Deformity Patient

Ahmet Alanay, MD, Didik Librianto, MD, PhD, Javier Pizones, MD, PhD, & Mitsuru Yagi, MD, PhD

13:53 - 13:54 **Case 1: Severe Kyphosis in a 65 y/o with Osteoporosis and Cardiopulmonary Disease**

13:54 - 13:58 **Panel Discussion**

13:58 - 14:03 **Audience Q&A**

14:03 - 14:04 **Case 2: Kyphoscoliosis in a 68 y/o s/p Thoracic Endovascular Aortic Repair**

14:04 - 14:08 **Panel Discussion**

14:08 - 14:13 **Audience Q&A**

14:13 - 14:15 **Conclusion**
Ferran Pellisé, MD, PhD & Mark Weidenbaum, MD

13:15 - 14:15 Room 115-117

LTS 3: Surgeon Longevity in Spine Surgery: Helping Our Patients While Protecting Ourselves

Moderators: Eren Kuris, MD & Alan Daniels, MD

13:15 - 13:17 **Introduction and Welcome**
Eren Kuris, MD

MEETING AGENDA

Program (topics, timing, and faculty) is subject to change.

13:17 - 13:21 **Occupational Hazards in Spine Surgery**
Alan H. Daniels, MD

13:21 - 13:29 **The Physical Demands of Spine Surgery**
David L. Skaggs, MD, MMM

13:29 - 13:37 **Radiation Safety in Spinal Deformity Surgery**
Christopher J. Kleck, MD

13:37 - 13:47 **Panel Discussion 1 and Q&A**
Christopher J. Kleck, MD, David L. Skaggs, MD, MMM, Eren Kuris, MD, & Alan H. Daniels, MD

13:47 - 13:55 **Mental Health and Stress Management in Spinal Deformity Surgery**
Todd J. Albert, MD

13:55 - 14:03 **Dealing with Difficult Outcomes and Complications**
Marinus De Kleuver, MD, PhD

14:03 - 14:13 **Panel Discussion 2 and Q&A**
Eren Kuris, MD, Alan H. Daniels, MD, Todd J. Albert, MD, & Marinus De Kleuver, MD, PhD

14:13 - 14:15 **Closing Remarks**
Eren Kuris, MD

14:15 - 14:30

Break

14:30 - 16:00 Room 115-117

Abstract Session 1: Adolescent Idiopathic Scoliosis

Moderators: Joshua M. Pahys, MD & Kota Watanabe, MD, PhD

14:30 - 14:35 **Introduction**

14:35 - 14:39 **Paper #1: The Effect of Night-Time Versus Full-Time Bracing on the Sagittal Profile in Adolescent Idiopathic Scoliosis: A Propensity Score-Matched Study**
Martin Heegaard, MD; Lærke C. Ragborg, MD; Amy L. McIntosh, MD; Megan E. Johnson, MD; Martin Gehrchen, MD, PhD; Daniel J. Sucato, MD, MS; Benny T. Dahl, Md, PhD, DMSc; Soren Ohrt-Nissen, MD, PhD

14:39 - 14:43 **Paper #2: Effectiveness of Nighttime Bracing or Fulltime Bracing in Moderate-Grade Adolescent Idiopathic Scoliosis (AIS)**
Anastasios Charalampidis, MD; Elias Diarbakerli, PhD; Hans Möller, PhD; Allan Abbott, PhD; Paul Gerdhem, PhD

14:43 - 14:47 **Paper #3: Natural Course of Moderate Adolescent Idiopathic Scoliosis: A Mean 25-Year Follow-Up Study**
Masayuki Ohashi, MD, PhD; Kei Watanabe, MD, PhD; Kazuhiro Hasegawa, MD, PhD; Toru Hirano, MD, PhD; Hideki Tashi, MD; Keitaro Minato, MD, PhD; Tatsuo Makino, MD; Masayuki Sato, MD

14:47 - 14:56 **Discussion**

14:56 - 15:00 **Paper #4: Does VBT Cause Disc and Facet Joint Degeneration? An MRI Study with Minimum 5-Years Follow-Up**
Altug Yucekul, MD; Feyzi Kilic, MD; Atahan Durbas; Tais Zulemyan, MSc; Elif Gizem Carus, MS; Aynur Kaval; Gokhan Ergene, MD; Sahin Senay, MD; Pinar Yalinay Dikmen, MD; Sule Turgut Balci, MD; Ercan Karaarslan, MD; Yasemin Yavuz, PhD; Caglar Yilgor, MD; Ahmet Alanay, MD

15:00 - 15:04 **Paper #5: Changing Complication Trends After Anterior Vertebral Body Tethering (AVBT): 10-Year Experience**
Taemin Oh, MD; Cleopatra Nehme, BS; Amer F. Samdani, MD; Joshua M. Pahys, MD; Jessica Steindler, BA; Sarah Nice, BS; Kaitlin Kirk, BS; Amanda Stutman, BS; Camille Brown, BS; Natalie Williams, BS; Emily Nice, BS; Steven W. Hwang, MD

15:04 - 15:08 **Paper #6: What Predicts a Successful Result in Vertebral Body Tethering?**
Julia Todderud, BA; Todd A. Milbrandt, MD, MS; D. Dean Potter, MD; A. Noelle Larson, MD

15:08 - 15:17 **Discussion**

Program (topics, timing, and faculty) is subject to change.

15:17 - 15:21 **Paper #7: Early Detection of Progressive Adolescent Idiopathic Scoliosis by Unsupervised Machine Learning Clustered Bone Microarchitecture Phenotypes: A 3-Year Prospective Longitudinal Study**
Kenneth Guangpu Yang, PhD, MBBS; Adam Yiu-chung Lau, MBBS, FRCS; Wayne Yuk-wai Lee, PhD; Alec Lik-hang Hung, MBBS, MS, FRCS; Tsz-Ping Lam, MBBS, FRCS; Jack Chun-yiu Cheng, MD, FRCS

15:21 - 15:25 **Paper #8: Feasibility of Using Artificial Intelligence to Predict Postoperative Health-Related Quality of Life for Adolescent Idiopathic Scoliosis**
Dusan Kovacevic, MD; Aazad Abbas, MD; Gurjovan Sahi, MD; Johnathan Lex, MD; Jay Toor, MD; Suken A. Shah, MD; Amer F. Samdani, MD; Peter O. Newton, MD; Michael P. Kelly, MD; Harms Study Group; Firoz Miyanji, MD

15:25 - 15:29 **Paper #9: Machine Learning Algorithms for Predicting Future Curve in Female Adolescent Idiopathic Scoliosis Patients Based on the Data from the Minimal Visits**
Shuhei Ohyama, MD; Satoshi Maki, MD, PhD; Toshiaki Kotani, MD, PhD; Yosuke Ogata, MD; Yasushi Iijima, MD, PhD; Tsutomu Akazawa, MD, PhD; Tsuyoshi Sakuma, MD, PhD; Kazuhide Inage, MD, PhD; Shohei Minami, MD, PhD; Seiji Ohtori, MD

15:29 - 15:38 **Discussion**

15:38 - 15:42 **Paper #10: Pulmonary Function at Minimum 10 Years After Segmental Pedicle Screw Instrumentation for Thoracic Adolescent Idiopathic Scoliosis**
Linda Helenius, MD, PhD; Matti Ahonen, MD, PhD; Johanna Syvänen, MD, PhD; Ilkka J. Helenius, MD, PhD

15:42 - 15:46 **Paper #11: Bracing in Severe Skeletally Immature Adolescent Idiopathic Scoliosis – Does a Holding Strategy Change the Surgical Plan?**
Soren Ohrt-Nissen, MD, PhD; Martin Heegaard, MD; Thomas B. Andersen, MD, PhD, DMSc; Martin Gehrchen, MD, PhD; Benny T. Dahl, Md, PhD, DMSc; Niklas Tøndevold, MD, PhD

15:46 - 15:50 **Paper #12: Proximal Femur Maturity Index at Brace Initiation for Adolescent Idiopathic Scoliosis Predicts Curve Progression Risk ‡**
Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; Prudence Wing Hang Cheung, PhD, BDSc (Hons)

15:50 - 16:00 **Discussion**

16:00 - 16:20 Foyer 1

Refreshment Break

16:20 - 18:05 Room 115-117

Abstract Session 2: Adult Spinal Deformity

Moderators: Robert K. Eastlack, MD & Khaled M. Kebaish, MD

16:20 - 16:24 **Paper #13: Factors Associated with Construct Failures in Adult Spine Deformity Patients Matching Ideal Roussouly Type**
Tobi Onafowokan, MBBS; Ankita Das, BS; Jamshaid Mir, MD; Pawel P. Jankowski, MD; Lefko Charalambous, MD; Stephane Owusu-Sarpong, MD; Samuel Montgomery, MD; Nathan Lorentz, MD; Matthew Galetta, MD; Andrew Chen, BS; Neel Anand, MD; Bassel G. Diebo, MD; Alan H. Daniels, MD; Kojo D. Hamilton, MD, FAANS; Han Jo Kim, MD; Zeeshan M. Sardar, MD; Jordan Lebovic, BA; Thomas J. Buell, MD; Aaron Hockley, MD; Nima Alan, MD; M. Burhan Janjua, MD; Daniel M. Sciubba, MD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Dean Chou, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Peter G. Passias, MD

16:24 - 16:28 **Paper #14: Optimizing Lower Instrumented Vertebra Selection in Adult Idiopathic Scoliosis Using Preoperative Upright and Supine Last Touched Vertebra**
Josephine R. Coury, MD; Fthimnir Hassan, MPH; Gabriella Greisberg, BS; Justin Reyes, MS; Alexandra Dionne, BS; Yong Shen, BA; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

16:28 - 16:32 **Paper #15: Anatomical Pelvic Parameters Using the Anterior Pelvic Plane in Healthy Volunteers: A Key for Natural Sagittal Alignment of Adult Spinal Deformity**
Masayuki Ohashi, MD, PhD; Kazuhiro Hasegawa, MD, PhD; Shun Hatsushikano, BS; Kei Watanabe, MD, PhD; Hideki Tashi, MD; Keitaro Minato, MD, PhD; Tatsuo Makino, MD; Masayuki Sato, MD

16:32 - 16:41 **Discussion**

16:41 - 16:45 **Paper #16: Predictive Role of Frax in Postoperative Proximal Junctional Kyphosis with Vertebral Fracture After Adult Spinal Deformity Surgery**
Junya Katayanagi, MD, PhD

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

MEETING AGENDA

Program (topics, timing, and faculty) is subject to change.

16:45 - 16:49	**Paper #17: Enhancing Spinal Deformity Surgery Outcomes: A Novel Approach Using Intraoperative Extended Pelvic Tilt Line Parameters to Predict Mechanical Failure** *Jae-Koo Lee, MD; Seung-Jae Hyun, MD, PhD; Sunho Kim, MD; Seung-Ho Seo, MD; Kwang-Ui Hong, MD*
16:49 - 16:53	**Paper #18: Health Utility Outcomes Following Surgery for Adult Thoracolumbar Spinal Deformity** *David Ben-Israel, MD; Justin S. Smith, MD, PhD; Brian Park, MD; Thomas J. Buell, MD; Michael P. Kelly, MD; Robert K. Eastlack, MD; Jeffrey L. Gum, MD; Virginie Lafage, PhD; Renaud Lafage, MS; Alex Soroceanu, MD, FRCS(C), MPH; Bassel G. Diebo, MD; Eric O. Klineberg, MD; Han Jo Kim, MD; Breton G. Line, BS; Pratibha Nayak, PhD, MBA, MPH; Themistocles S. Protopsaltis, MD; Peter G. Passias, MD; Gregory M. Mundis Jr., MD; K. Daniel Riew, MD; Khaled M. Kebaish, MD; Paul Park, MD; Munish C. Gupta, MD; Frank J. Schwab, MD; Douglas C. Burton, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Shay Bess, MD; Richard Hostin, MD; International Spine Study Group*
16:53 - 17:02	**Discussion**
17:02 - 17:06	**Paper #19: Comparative Study Between Teriparatide and Denosumab on the Prevention of Proximal Junctional Kyphosis: Prospective, Randomized Controlled Trial** *Ho-Joong Kim, MD*
17:06 - 17:10	**Paper #20: Perioperative Change in Bone Quality Following Thoracolumbar Fusion and Its Effects on Postoperative Outcomes** *Hannah A. Levy, MD; Caden Messer, BS; Tissiana Vallecillo, BS; Zachariah W. Pinter, MD; Anthony L. Mikula, MD; Mohamad Bydon, MD; Jeremy L. Fogelson, MD; Benjamin D. Elder, MD, PhD; Bradford L. Currier, MD; Ahmad Nassr, MD; Brett A. Freedman, MD; Arjun Sebastian, MD; Brian Karamian, MD*
17:10 - 17:14	**Paper #21: Creating Sustainability in Centers Performing High Volume Adult Spinal Deformity Surgery: Evaluation of the Maryland All-Payer Model** *Andrew Kim, BS; Micheal Raad, MD; Richard Hostin, MD; Shay Bess, MD; Jeffrey L. Gum, MD; Breton G. Line, BS; Pratibha Nayak, PhD, MBA, MPH; Virginie Lafage, PhD; Renaud Lafage, MS; Kojo D. Hamilton, MD, FAANS; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Lawrence G. Lenke, MD; Alex Soroceanu, MD, FRCS(C), MPH; Justin S. Smith, MD, PhD; Christopher P. Ames, MD; Bassel G. Diebo, MD; Eric O. Klineberg, MD; Alan H. Daniels, MD; Han Jo Kim, MD; Robert K. Eastlack, MD; Michael P. Kelly, MD; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Khaled M. Kebaish, MD; International Spine Study Group*
17:14 - 17:23	**Discussion**
17:23 - 17:27	**Paper #22: Influence of Implant Density on Mechanical Complications in Adult Spinal Deformity Surgery** *Yann Philippe Charles, MD, PhD; Francois Severac, MD; Sleiman Haddad, MD, PhD, FRCS; Caglar Yilgor, MD; Ahmet Alanay, MD; Ibrahim Obeid, MD; Louis Boissiere, MD; Frank S. Kleinstueck, MD; Markus Loibl, MD; Javier Pizones, MD, PhD; Ferran Pellisé, MD, PhD; European Spine Study Group; Susana Núñez Pereira, MD*
17:27 - 17:31	**Paper #23: Achieving Correction and Mitigating Complications in Adult Spinal Deformity Through an Anterior-Posterior Combined Approach: 1 or 2-Level Apical Segment Interbody Fusion is Enough?** *Dongkyu Kim, MD; Kyunghyun Kim, MD, PhD*
17:31 - 17:35	**Paper #24: Spinal Deformity Surgery in Patients with Movement Disorders: Trade-Off Between Increased Complications and Improved Long-Term Quality of Life** *Omar Zakieh, MBBS; Hani Chanbour, MD; Ambika Paulson, MD; Walter Navid, BS; Iyan Younus, MD; David C. Liles, MD; Ranbir Ahluwalia, MD; Christopher M. Bonfield, MD; Julian Lugo-Pico, MD; Amir M. Abtahi, MD; Byron F. Stephens, MD; Scott Zuckerman, MD, MPH*
17:35 - 17:44	**Discussion**
17:44 - 17:48	**Paper #25: The Prioritized Correction of Deformity at Osteotomy Site: A Novel Technique for Preventing Sagittal Translation in 3CO of Adult Spinal Deformities** *Chen Ling, MD, PhD; Zhen Liu, PhD; Jie Li, MD; Yanjie Xu, MD; Zezhang Zhu, PhD; Yong Qiu, PhD*
17:48 - 17:52	**Paper #26: Pedicle Subtraction Osteotomies Vs Anterior Column Reconstruction: Examining the Rates of Pseudoarthrosis** *Michael R. McDermott, DO; Kyle Barner, DO; Andre Jakoi, MD; Alfredo J. Guiroy, MD; Ashish Patel, MD; Joshua Bunch, MD*

Program (topics, timing, and faculty) is subject to change.

17:52 - 17:56	**Paper #27: 513 Three-Column Osteotomies for Adult Spinal Deformity: A Single Surgeon Experience over 17 Years** *Winward Choy, MD; Jaemin A. Kim, Research Assistant; Terry Nguyen, Research Assistant; Tony Catalan, BS; Austin Lui, MS; Ping-Yeh Chiu, MD; David Mazur-Hart, MD; Vedat Deviren, MD; Christopher P. Ames, MD; Aaron J. Clark, MD*
17:56 - 18:05	**Discussion**

18:05 - 18:20

Break

18:20 - 19:40 Room 115-117

Opening Ceremonies*

18:20 - 18:25	**Welcome to Barcelona** *Ferran Pellisé, MD, PhD*
18:25 - 18:28	**Presidential Message** *Marinus de Kleuver, MD, PhD*
18:28 - 18:35	**Acknowledgement of SRS Donors** *Michael P. Kelly, MD*
18:35 - 18:38	**Douglas C. Burton, MD Best Adult Deformity Paper Announcement** *Douglas C. Burton, MD*
18:38 - 18:40	**SRS-Cotrel Foundation Basic Science Research Grant Award** *Nicholas Plais, MD*
18:40 - 18:42	**Biedermann Innovation Award Winner & Award Update Announcement** *Markku Biedermann, MD*
18:42 - 18:49	**Presentation of the Blount Humanitarian Award** *Alexandre F. Cristante, MD, PhD, FRCS(C)*
18:49 - 18:52	**Importance of Our Corporate Partners** *Han Jo Kim, MD*
18:52 - 19:10	**Acknowledgment of Corporate Supporters** *Han Jo Kim, MD*
19:10 - 19:15	**Introduction of Howard Steel Lecturer** *Marinus de Kleuver, MD, PhD*
19:15 - 19:35	**Howard Steel Lecture** *Bruno Dubois*
19:35 - 19:40	**Closing Remarks** *Marinus de Kleuver, MD, PhD*

19:40 - 22:00 Banquet Hall

Welcome Reception*

A hosted reception featuring hors d'oeuvres, cocktails, and reunions with colleagues and friends will immediatly follow the Opening Ceremonies. If you would like to purchase guest ticket(s), you may do so at the registration desk located on the Ground Level, Entrance Hall C.

MEETING AGENDA

Program (topics, timing, and faculty) is subject to change.

09:00 - 10:50 Room 115-117

Abstract Session 3: Quality/Safety/Value/Complications

Moderators: Aaron J. Buckland, MBBS, FRCSA & Naomi Hosogane, MD, PhD

09:00 - 09:05 **Introduction**

09:05 - 09:09 **Paper #28: Nadir Hemoglobin is Associated with Length of Stay Following Adult Spinal Deformity Surgery, but is Unaffected by Strict Transfusion Thresholds**
Jeffrey L. Gum, MD; Steven D. Glassman, MD; Mladen Djurasovic, MD; Justin Mathew, MD; Morgan Brown, MS; Christy L. Daniels, MS; Colleen Mahoney, BA; Leah Y. Carreon, MD

09:09 - 09:13 **Paper #29: Long-Term Reoperation Risk of Thoracic to Pelvis Instrumentation for Spinal Deformity: A Longitudinal Study of 7,060 Patients**
Paal Nilssen, BA; Nakul Narendran, BA; David L. Skaggs, MD, MMM; Corey T. Walker, MD; Christopher Mikhail, MD; Edward K. Nomoto, MD; Alexander Tuchman, MD

09:13 - 09:17 **Paper #30: Higher Intraoperative Blood Loss is Associated with Increased Risk of Intraoperative Neuromonitoring Data Loss for the Type 3 Spinal Cord Shape During Spinal Deformity Surgery**
Chun Wai Hung, MD; Fthimnir Hassan, MPH; Nathan J. Lee, MD; Steven G. Roth, MD; Justin K. Scheer, MD; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

09:17 - 09:26 **Discussion**

09:26 - 09:30 **Paper #31: Accurate Scoring System Predicts Cord-Level Intraoperative Neuromonitoring (IONM) Loss During Spinal Deformity Surgery: A Machine Learning Algorithm**
Nathan J. Lee, MD; Lawrence G. Lenke, MD; Varun Arvind, MD, PhD; Ted Shi, BS; Alexandra Dionne, BS; Chidebelum Nnake, BS; Mitchell Yeary, BS; Michael Fields, MD, BS; Matthew Simhon, MD; Anastasia Ferraro, BS; Matthew Cooney, BS; Erik Lewerenz, BS; Justin Reyes, MS; Steven G. Roth, MD; Chun Wai Hung, MD; Justin K. Scheer, MD; Thomas M. Zervos, MD; Earl D. Thuet, BS; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Benjamin D. Roye, MD, MPH; Michael G. Vitale, MD, MPH; Fthimnir Hassan, MPH

09:30 - 09:34 **Paper #32: Complementary Performance of Somatosensory Evoked Potential (SSEP) as Intraoperative Neuromonitoring in Spinal Deformity Surgery - Results from a Prospective Multicenter Study ‡**
So Kato, MD, PhD; Lawrence G. Lenke, MD; Kristen E. Jones, MD, FAANS; Sigurd H. Berven, MD; Christopher J. Nielsen, MD; Saumyajit Basu, MS(orth), DNB(orth), FRCSEd; Michael P. Kelly, MD; Justin S. Smith, MD, PhD; Samuel Strantzas, MSc, DABNM; Stephen J. Lewis, MD, FRCS(C)

09:34 - 09:38 **Paper #33: Intraoperative Neuromonitoring Has Poor Correlation with Postop Neurological Deficits in Non-Cord Level Adult Deformity Surgery**
Zeeshan M. Sardar, MD; Alekos A. Theologis, MD; Ganesh Swamy, MD, PhD; Go Yoshida, MD, PhD; Michael P. Kelly, MD; Thorsten Jentzsch, MD, MSc; Samuel Strantzas, MSc, DABNM; Saumyajit Basu, MS(orth), DNB(orth), FRCSEd; Kenny Y. Kwan, MD; Justin S. Smith, MD, PhD; Ferran Pellisé, MD, PhD; So Kato, MD, PhD; Munish C. Gupta, MD; Christopher P. Ames, MD; Kristen E. Jones, MD, FAANS; Anastasios Charalampidis, MD; Brett Rocos, MD, FRCS; Lawrence G. Lenke, MD; Stephen J. Lewis, MD, FRCS(C)

09:38 - 09:47 **Discussion**

09:47 - 09:51 **Paper #34: Cost-Effectiveness of Operative Vs Nonoperative Treatment of Adult Symptomatic Lumbar Scoliosis with Eight Year Follow-Up ‡**
Leah Y. Carreon, MD; Steven D. Glassman, MD; Justin S. Smith, MD, PhD; Michael P. Kelly, MD; Elizabeth L. Yanik, PhD; Christine Baldus, RN; Vy Pham, MD, MPH; David Ben-Israel, MD; Jon D. Lurie, MD, MS; Charles C. Edwards, MD; Lawrence G. Lenke, MD; Oheneba Boachie-Adjei, MD; Jacob M. Buchowski, MD; Charles H. Crawford III, MD; Stephen J. Lewis, MD, FRCS(C); Tyler Koski, MD; Stefan Parent, MD, PhD; Virginie Lafage, PhD; Munish C. Gupta, MD; Han Jo Kim, MD; Christopher P. Ames, MD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Keith H. Bridwell, MD

09:51 - 09:55 **Paper #35: Opioid Usage in Adult Spinal Deformity: Can We Move the Needle Before Incision?**
Michelle Gilbert, PA-C; Aiyush Bansal, MD; Rakesh Kumar, MBBS; Joseph Strunk, MD; Daniel Warren, MD; Jennifer Kelly, PhD; Murad Alostaz, BS; Venu M. Nemani, MD, PhD; Jean-Christophe A. Leveque, MD; Philip K. Louie, MD; Rajiv K. Sethi, MD

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Program (topics, timing, and faculty) is subject to change.

09:55 - 09:59 **Paper #36: Durability of Substantial Clinical Benefit Leading to Optimal Outcomes in Adult Spinal Deformity Corrective Surgery: A Minimum 5-Year Analysis**
Jamshaid Mir, MD; Ankita Das, BS; Tobi Onafowokan, MBBS; Nima Alan, MD; Matthew Galetta, MD; Nathan Lorentz, MD; Renaud Lafage, MS; Bassel G. Diebo, MD; M. Burhan Janjua, MD; Dean Chou, MD; Justin S. Smith, MD, PhD; Virginie Lafage, PhD; Andrew J. Schoenfeld, MD; Daniel M. Sciubba, MD; Peter G. Passias, MD, Brett Rocos, MD, FRCS

09:59 - 10:08 **Discussion**

10:08 - 10:12 **Paper #37: Optimizing Bone Health for the Prevention of Revision Adult Spinal Deformity Surgery: A Break-Even Analysis**
Andrew Kim, BS; William G. Elnemer, BS; Marc Greenberg, MD; Khaled M. Kebaish, MD

10:12 - 10:16 **Paper #38: Preoperative Anabolic Bone Therapy Significantly Reduces Spinopelvic Mechanical Complications and Pseudarthrosis in Adult Spinal Deformity Surgery**
Omar Zakieh, MBBS; Hani Chanbour, MD; Ambika Paulson, MD; Walter Navid, BS; Mitchell Bowers, MD; Iyan Younus, MD; David C. Liles, MD; Ranbir Ahluwalia, MD; Julian Lugo-Pico, MD; Amir M. Abtahi, MD; Scott Zuckerman, MD, MPH; Byron F. Stephens, MD

10:16 - 10:20 **Paper #39: Impact of Advanced Hemodynamic Monitoring on Post-Operative Complications in Multi-Level Posterior Thoracolumbar Fusions**
Leah Y. Carreon, MD; Steven D. Glassman, MD; Desiree Chappell, CRNA; Steven Garvin, CRNA; Anna Lavelle, MSN, CRNA; Jeffrey L. Gum, MD; Mladen Djurasovic, MD; Wael Saasouh, MD

10:20 - 10:29 **Discussion**

10:29 - 10:33 **Paper #40: Posterior Spinal Fusion Outcomes in Boys and Girls: Should We Be Treating Them the Same?**
Julia Todderud, BA; Harms Study Group; Michelle Claire Marks, PT; Nicholas D. Fletcher, MD; Peter O. Newton, MD; A. Noelle Larson, MD

10:33 - 10:37 **Paper #41: Artificial Intelligence and Pediatric Scoliosis Education: A Comparative Analysis Assessing the Accuracy of AI-Generated Information**
Xochitl M. Bryson, BA; Marleni Albarran, BS; Nicole S. Pham, MPH; Taylor R. Johnson, MD; Grant D. Hogue, MD; Jaysson T. Brooks, MD; Kali R. Tileston, MD; Craig R. Louer, MD; Ron El-Hawary, MD; Meghan N. Imrie, MD; James F. Policy, MD; Daniel Bouton, MD; Arun R. Hariharan, MD; Sara Van Nortwick, MD; Vidyadhar V. Upasani, MD; Jennifer M. Bauer, MD; Andrew Tice, MD; John S. Vorhies, MD

10:37 - 10:41 **Paper #42: Risk Stratification for Early Postoperative Infection in Pediatric Spinal Deformity Correction: Development and Validation of the Pediatric Scoliosis Infection Risk Score (PSIR Score)**
Vivien Chan, MD, MS, FRCS(C); Geoffrey Shumilak, MD, FRCPC, MPh; Matiar Jafari, MD, PhD; Michael G. Fehlings, MD, PhD, FRCS(C); Michael Yang, MD, MS, FRCS(C), MBiotech; David L. Skaggs, MD, MMM

10:41 - 10:50 **Discussion**

10:50 - 11:10 Foyer 1

Refreshment Break

11:10 - 13:15 Room 115-117

Abstract Session 4: Quality/Safety/Value/Complications II, Harrington Lecture and Lifetime Achievement Awards

Moderators: Anand Veeravagu, MD, FAANS & Gregory M. Mundis Jr., MD

11:10 - 11:14 **Paper #43: The Radiographic, Pulmonary, and Clinical Outcomes of Patients with Severe Rigid Spinal Deformities Treated Via Halo-Pelvic Traction**
Junlin Yang, MD, PhD; Wenyuan Sui, MD, PhD

11:14 - 11:18 **Paper #44 : Activity Capacity in Children with Early Onset Scoliosis Compared to Pulmonary Function (Spirometry) and Patient Reported Outcomes**
Mark Belio, MA; Malvika Choudhari, BS; Robin C. Johnson, RRT; Di Hu, MS; Stephanie D. Davis, MD; Erik D. Hanson, PhD; Feng-Chang Lin, PhD; James O. Sanders, MD

11:18 - 11:22 **Paper #45: Utility of Preoperative Echocardiogram for Large Curve Scoliosis Patients**
Chidebelum Nnake, BS; Alondra Concepción-González, BA; Matan Malka, BA; Emma Berube, MD; Nicole Bainton, CPNP; Michael G. Vitale, MD, MPH; Benjamin D. Roye, MD, MPH

11:22 - 11:31 **Discussion**

MEETING AGENDA

Program (topics, timing, and faculty) is subject to change.

11:31 - 11:35 **Paper #46: DNA-Based Epigenetic Age is a Better Predictor of Complication than Chronological Age and Frailty**
Quante Singleton, MD; Rohit Bhan, MD, MS; Yu Zhang, MS; Nisha Kale, MD; Christopher P. Ames, MD; Bo Zhang, PhD; Michael P. Kelly, MD; Nicholas A. Pallotta, MD, MS; Brian J. Neuman, MD

11:35 - 11:39 **Paper #47: Optimization is a Moving Target: A Continuous Modifiable Frailty Index Reflecting Optimization Prior to Complex Adult Spinal Deformity (ASD) Intervention**
Peter G. Passias, MD; Ankita Das, BS; Justin S. Smith, MD, PhD; Renaud Lafage, MS; Bassel G. Diebo, MD; Alan H. Daniels, MD; Jamshaid Mir, MD; Tobi Onafowokan, MBBS; Kojo D. Hamilton, MD, FAANS; Breton G. Line, BS; Thomas J. Buell, MD; Juan S. Uribe, MD; Michael Y. Wang, MD; Richard G. Fessler, MD; Pierce D. Nunley, MD; Neel Anand, MD; Michael P. Kelly, MD; Themistocles S. Protopsaltis, MD; Robert K. Eastlack, MD; Gregory M. Mundis Jr., MD; David O. Okonkwo, MD, PhD; Khaled M. Kebaish, MD; Alex Soroceanu, MD, FRCS(C), MPH; Justin K. Scheer, MD; Jeffrey Mullin, MD; Praveen V. Mummaneni, MD, MBA; Dean Chou, MD; Han Jo Kim, MD; Richard Hostin, MD; Munish C. Gupta, MD; Lawrence G. Lenke, MD; Douglas C. Burton, MD; Frank J. Schwab, MD; Christopher P. Ames, MD; Virginie Lafage, PhD; Christopher I. Shaffrey, MD; Shay Bess, MD; International Spine Study Group

11:39 - 11:43 **Paper #48: The Role of Preoperative S. Aureus Colonization in S. Aureus Postoperative Infections Following Elective Posterior Spinal Surgery**
Aditya Joshi, BS; Rachel S. Bronheim, MD; Amit Jain, MD; Khaled M. Kebaish, MD; Hamid Hassanzadeh, MD

11:43 - 11:52 **Discussion**

11:52 - 11:56 **Paper #49: Early Reoperations Do Not Adversely Affect Long Term Pain and Activity Scores in Adult Deformity Patients**
Sarthak Mohanty, BS; Fthimnir Hassan, MPH; Nathan J. Lee, MD; Justin K. Scheer, MD; Chun Wai Hung, MD; Steven G. Roth, MD; Erik Lewerenz, BS; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

11:56 - 12:00 **Paper #50: Impact of Durability on Potential to Achieve Cost/Qaly Within the Willingness-To-Pay (WTP) Thresholds for ASD Surgery: It is Impossible Unless We Avoid Reoperations**
Jeffrey L. Gum, MD; Pratibha Nayak, PhD, MBA, MPH; Richard Hostin, MD; Breton G. Line, BS; Shay Bess, MD; Lawrence G. Lenke, MD; Renaud Lafage, MS; Justin S. Smith, MD, PhD; Jeffrey Mullin, MD; Michael P. Kelly, MD; Bassel G. Diebo, MD; Thomas J. Buell, MD; Justin K. Scheer, MD; Virginie Lafage, PhD; Eric O. Klineberg, MD; Han Jo Kim, MD; Peter G. Passias, MD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Alan H. Daniels, MD; Alex Soroceanu, MD, FRCS(C), MPH; Gregory M. Mundis Jr., MD; Themistocles S. Protopsaltis, MD; Kojo D. Hamilton, MD, FAANS; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; International Spine Study Group

12:00 - 12:04 **Paper #51: The Safety and Accuracy of Radiation-Free Spinal Navigation Using an Ultrashort, Scoliosis-Specific Bonemri-Protocol Compared to CT**
Peter Lafranca, MD; Yorck Rommelspacher, MD, PhD; Sebastian Walter, MD, PhD; Sander Muijs, MD, PhD; Tijl van der Velden, PhD; Yulia Shcherbakova, PhD; René M. Castelein, MD, PhD; Keita Ito, MD, PhD; Peter R. Seevinck, PhD; Tom Schlösser, MD, PhD

12:04 - 12:13 **Discussion**

12:13 - 12:17 **Paper #52: Neuromuscular Blocking Agent Use in Adolescent Idiopathic Scoliosis Surgery: A Safety Assessment**
Hope M. Gehle, BS; Austin J. Allen, BS; Lukas G. Keil, MD; Jessica H. Heyer, MD; Becki Cleveland, PhD; Joseph D. Stone, MD; James O. Sanders, MD; Stuart L. Mitchell, MD

12:17 - 12:21 **Paper #53: Intraoperative Neuromonitoring (IONM) Alerts in Cord Level Surgeries for Severe Spinal Deformities – Do Appropriate Corrective Measures Prevent Neurodeficit - Results of Spinal Deformity Intraoperative Monitoring (SDIM) Study**
Saumyajit Basu, MS(Orth), DNB(Orth), FRCSEd; Stephen J. Lewis, MD, FRCS(C); David W. Polly, MD; So Kato, MD, PhD; Eric O. Klineberg, MD; Kristen E. Jones, MD, FAANS; Brett Rocos, MD, FRCS; Samuel Strantzas, MSc, DABNM; Mario Ganau, MD, PhD; David E. Lebel, MD, PhD; Christopher J. Nielsen, MD

12:21 - 12:25 **Paper #54: What Events Are Associated with Intraoperative Neuromonitoring Alerts in Spinal Deformity Surgeries? Results from the Prospective, Multicentre Spinal Deformity Intraoperative Monitoring (SDIM) Study**
Kenny Y. Kwan, MD; Yong Qiu, PhD; Ahmet Alanay, MD; Andre Luis F. Andujar, MD; Elias Elias, MD, MS; Stephen J. Lewis, MD, FRCS(C); Samuel Strantzas, MSc, DABNM

12:25 - 12:35 **Discussion**

Program (topics, timing, and faculty) is subject to change.

12:35 - 12:40 **Harrington Lecture Introduction**
Marinus de Kleuver, MD, PhD

12:40 - 13:00 **Harrington Lecture**
Steven D. Glassman, MD

13:00 - 13:15 **Presentation of the Lifetime Achievement Awards**
Laurel C. Blakemore, MD & Suken A. Shah, MD

13:15 - 13:30 Foyer 2

Lunch Pick-up

13:30 - 15:00

Industry Workshops* (five concurrent sessions)

Each workshop is programmed by a single-supporting company and will feature presentations on topics selected by the company.

Please see page 223 for Workshop descriptions.

Please note: CME credits are not available for Industry Workshops

15:00 - 15:10 Foyer 1

Refreshment Break

15:10 - 16:55

Abstract Sessions 5A & 5B (two concurrent sessions)

15:10 - 16:55 Room 115-117

Abstract Session 5A: Adult Spinal Deformity II

Moderators: Rajiv K. Sethi, MD & Raymond J. Hah, MD

15:10 - 15:14 **Paper #55: Sarcopenia Using L3 and L4 Normalized Total Psoas Area Predicts Early Postoperative Mobility and Perioperative Adverse Events After Adult Spinal Deformity Surgery**
Takashi Hirase, MD, MPH; Han Jo Kim, MD; Chukwuebuka Achebe, BS; Myles Allen, MbChB; Gregory Kazarian, MD; Michael Mazzucco, BS; Hiroyuki Nakarai, MD; Francis C. Lovecchio, MD

15:14 - 15:18 **Paper #56: Lower Hounsfield Units and Severe Paraspinal Sarcopenia Are Independent Predictors of Increased Risk for Proximal Junctional Kyphosis and Failure Following Thoracolumbar Fusions Terminating in the Upper Thoracic Spine**
Zachariah W. Pinter, MD; Anthony L. Mikula, MD; Giorgos Michalopoulos, MD; Nikita Lakomkin, MD; Zach Pennington, MD; Ahmad Nassr, MD; Brett A. Freedman, MD; Arjun Sebastian, MD; Mohamad Bydon, MD; Jeremy L. Fogelson, MD; Benjamin D. Elder, MD, PhD

15:18 - 15:22 **Paper #57: Sarcopenia as a Predictor of Prolonged Length of Stay in Adult Spinal Deformity Surgery**
Chukwuebuka Achebe, BS; Han Jo Kim, MD; Takashi Hirase, MD, MPH; Myles Allen, MbChB; Robert Uzzo, MBA; Tejas Subramanian, BS; Chad Z. Simon, BS; Atahan Durbas, MD; Jung Mok, MD; Austin Kaidi, MD; Kasra Araghi, BS; Justin T. Samuel, BS; Cole Kwas, BS; Michael Mazzucco, BS; Matthew E. Cunningham, MD, PhD; Francis C. Lovecchio, MD

15:22 - 15:31 **Discussion**

15:31 - 15:35 **Paper #58: Machine Learning Finds the Sweet Spot Between Under Correction Leading to Pseudarthrosis and over Correction Leading to Proximal Junctional Kyphosis**
Sarthak Mohanty, BS; Justin Reyes, MS; Josephine R. Coury, MD; Erik Lewerenz, BS; Fthimnir Hassan, MPH; Joseph M. Lombardi, MD; Ronald A. Lehman, MD; Zeeshan M. Sardar, MD; Lawrence G. Lenke, MD; Multi-Ethnic Alignment Normative Study (MEANS) Group

MEETING AGENDA

Program (topics, timing, and faculty) is subject to change.

15:35 - 15:39	**Paper #59: Radiomics-Powered Radiographic Image Analysis for Enhanced Mechanical Complications Prediction and Surgical Planning in Adult Spine Deformity** *Ferran Pellisé, MD, PhD; Sleiman Haddad, MD, PhD, FRCS; Susana Núñez Pereira, MD; Caglar Yilgor, MD; Maggie Barcheni, MS; Anika Pupak, BS; Manuel Ramirez Valencia, MD; Javier Pizones, MD, PhD; Ahmet Alanay, MD; Ibrahim Obeid, MD; Frank S. Kleinstueck, MD; Fabio Galbusera, PhD; Oleguer Sagarra, PhD; European Spine Study Group*
15:39 - 15:43	**Paper #60: Nomogram to Predict Unplanned Intensive Care Unit Admission Following Adult Spinal Deformity** *Mohammad Daher, BS; Andrew Xu, BS; Sarah Criddle, MD; Mariah Balmaceno-Criss, BS; Lawrence G. Lenke, MD; Virginie Lafage, PhD; Christopher P. Ames, MD; Douglas C. Burton, MD; Stephen J. Lewis, MD, FRCS(C); Renaud Lafage, MS; Robert K. Eastlack, MD; Munish C. Gupta, MD; Gregory M. Mundis Jr., MD; Jeffrey L. Gum, MD; Kojo D. Hamilton, MD, FAANS; Richard Hostin, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Breton G. Line, BS; Shay Bess, MD; Bassel G. Diebo, MD; Eric O. Klineberg, MD; Alan H. Daniels, MD; International Spine Study Group*
15:43 - 15:52	**Discussion**
15:52 - 15:56	**Paper #61: Modified Pedicle Subtraction Osteotomy for Osteoporotic Vertebral Compression Fractures: A Retrospective Study of 104 Patients** *Junyu Li, MD; Jiahao Zhang, MD; Siming Xian, MD; Wenbin Bai, MD; Yihao Liu, MD; Zhuoran Sun, MD; Yongqiang Wang, MD; Miao Yu, MD; Weishi Li, MD; Yan Zeng, MD*
15:56 - 16:00	**Paper #62: Critical Analysis of Clinical Failures Despite Appropriate Realignment in Adult Spinal Deformity** *Jamshaid Mir, MD; Brett Rocos, MD, FRCS; Ankita Das, BS; Tobi Onafowokan, MBBS; Daniel B. Chen, BS; Nathan Lorentz, MD; Stephane Owusu-Sarpong, MD; Neel Anand, MD; Bassel G. Diebo, MD; Kojo D. Hamilton, MD, FAANS; Han Jo Kim, MD; Andrew Chen, BS; Zeeshan M. Sardar, MD; Jordan Lebovic, BA; Djani Robertson, MD; Praveen V. Mummaneni, MD, MBA; Nima Alan, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Christopher I. Shaffrey, MD; Dean Chou, MD; M. Burhan Janjua, MD; Justin S. Smith, MD, PhD; Peter G. Passias, MD, Kristen E. Jones, MD, FAANS*
16:00 - 16:04	**Paper #63: Behavioral Patterns of Mechanical Complications in Adult Deformity Surgery** *Riccardo Raganato, MD; Alejandro Gomez-Rice, MD, PhD; Lucía Moreno-Manzanaro, BS; Fernando Escamez, MD; Gloria Talavera, MD; Jose Miguel Sánchez-Márquez, MD, PhD; Nicomedes Fernández-Baíllo, MD; Francisco Javier S. Perez-Grueso, MD; Frank S. Kleinstueck, MD; Ibrahim Obeid, MD; Ahmet Alanay, MD; Ferran Pellisé, MD, PhD; Javier Pizones, MD, PhD; European Spine Study Group*
16:04 - 16:13	**Discussion**
16:13 - 16:17	**Paper #64: The Varus Knee Phenomenon in Spinal Deformity Patients** *Alex Ha, MD; Taikhoom M. Dahodwala, MD, MBBS; Xavier E. Ferrer, MD; Lawrence G. Lenke, MD; Scott Zuckerman, MD, MPH; Mena G. Kerolus, MD; Josephine R. Coury, MD; Daniel Hong, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD*
16:17 - 16:21	**Paper #65: Effects of Knee Osteoarthritis on Compensatory Mechanisms Post-Spinal Deformity Correction** *Yoon Ha Hwang, MD; Kyunghyun Kim, MD, PhD; Yoon Ha, MD, PhD; Jaeyoung So, MD*
16:21 - 16:25	**Paper #66: Impact of Knee Osteoarthritis and Arthroplasty on Full Body Sagittal Alignment in Adult Spinal Deformity Patients** *Mohammad Daher, BS; Alan H. Daniels, MD; Mariah Balmaceno-Criss, BS; Manjot Singh, BS; Renaud Lafage, MS; Lawrence G. Lenke, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; Stephen J. Lewis, MD, FRCS(C); Eric O. Klineberg, MD; Robert K. Eastlack, MD; Munish C. Gupta, MD; Gregory M. Mundis Jr., MD; Jeffrey L. Gum, MD; Kojo D. Hamilton, MD, FAANS; Richard Hostin, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Breton G. Line, BS; Shay Bess, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; Bassel G. Diebo, MD; International Spine Study Group*
16:25 - 16:34	**Discussion**

Program (topics, timing, and faculty) is subject to change.

16:34 - 16:38 **Paper #67: Does Achievement of Ideal L1PA Using Mis Techniques in Asd Correction Lead to Better Outcomes?**
Robert K. Eastlack, MD; Ryan Khanna, MD; Gregory M. Mundis Jr., MD; Peter G. Passias, MD; Dean Chou, MD; Michael P. Kelly, MD; Richard G. Fessler, MD; Paul Park, MD; Michael Y. Wang, MD; Adam S. Kanter, MD; Kojo D. Hamilton, MD, FAANS; David O. Okonkwo, MD, PhD; Pierce D. Nunley, MD; Neel Anand, MD; Juan S. Uribe, MD; Jay D. Turner, MD; Shay Bess, MD; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Vivian Le, MPH; Praveen V. Mummaneni, MD, MBA; International Spine Study Group

16:38 - 16:42 **Paper #68: The T4-L1-Hip Axis Captures the Roussouly Concepts Using Continuous Measures**
Jeffrey M. Hills, MD; Lawrence G. Lenke, MD; Zeeshan M. Sardar, MD; Jean-Charles Le Huec, MD, PhD; Stephane Bourret, PhD; Kazuhiro Hasegawa, MD, PhD; Hee-Kit Wong, FRCS; Dennis Hey, MD, MBBS, FRCS; Gabriel KP Liu, MD; Mouna Chelli-Bouaziz, MD; Michael P. Kelly, MD

16:42 - 16:46 **Paper #69: Characteristics of L1PA Based on Corrections in the Proximal Vs. Distal Lumbar Spine for Adult Sagittal Plane Imbalance**
Chad Z. Simon, BS; Han Jo Kim, MD; Myles Allen, MbChB; Tejas Subramanian, BS; Atahan Durbas, MD; Tomoyuki Asada, MD; Samuel Adida, MS; Chukwuebuka Achebe, BS; Takashi Hirase, MD, MPH; Robert Uzzo, MBA; Jung Mok, MD; Austin Kaidi, MD; Michael Mazzucco, BS; Kasra Araghi, BS; Justin T. Samuel, BS; Cole Kwas, BS; Hiroyuki Nakarai, MD; Gregory Kazarian, MD; Joshua Zhang, BS; Michael P. Kelly, MD; Matthew E. Cunningham, MD, PhD; Francis C. Lovecchio, MD

16:46 - 16:55 **Discussion**

15:10 - 16:55 Room 112

Abstract Session 5B: Adolescent Idiopathic Scoliosis II

Moderators: Alpaslan Senkoylu, MD & Firoz Miyanji, MD, FRCSC

15:10 - 15:14 **Paper #70: A Multipurpose Adolescent Idiopathic Scoliosis Specific Short MRI Protocol: Feasibility Study in Volunteers**
Yulia Shcherbakova, PhD; Peter Lafranca, MD; Wouter Foppen, MD, PhD; Tijl van der Velden, PhD; René M. Castelein, MD, PhD; Keita Ito, MD, PhD; Tom Schlosser, MD, PhD; Peter R. Seevinck, PhD

15:14 - 15:18 **Paper #71: Intraoperative CT Based Pedicle Screw Navigation in Pediatric Spine Deformity Has Minimal Impact on Screw Accuracy for an Experienced Surgeon**
Vishal Sarwahi, MD; Sayyida Hasan, BS; Keshin Visahan, BS; Katherine Eigo, BS; Aravind Patil, MD, BS; Anuj Gupta, MD; Effat Rahman, BS; David Essig, MD; Yungtai Lo, PhD; Jon-Paul P. DiMauro, MD; Terry D. Amaral, MD

15:18 - 15:22 **Paper #72: Radiographic Adaptation Between Standing and Sitting Positions of Subjects with Adolescent Idiopathic Scoliosis**
Maria Karam; Emmanuelle Wakim; Maria Asmar; Abir Massaad, PhD; Mohammad I. Karam, PhD; Aren Joe Bizdikian, MD, MS; Georges El Haddad; Marc Boutros, BS; Marc Mrad; Gilles Prince, MD; Ibrahim Hamati; Guy Awad; Moustapha Rteil; Joe Azar; Nadim Freiha; Claudio Vergari, PhD; Ismat Ghanem, MD, MS; Rami Rachkidi, MD, MS; Ayman Assi, PhD

15:22 - 15:31 **Discussion**

15:31 - 15:35 **Paper #73: Prevalence and Prognosis of Right Scapular Pain Following Surgical Treatment of Adolescent Idiopathic Scoliosis: A Prospective Study to Guide Preoperative Counselling**
Antoine Dionne, BS; Julie Joncas, RN; Soraya Barchi, BSc; Stefan Parent, MD, PhD; Jean-Marc Mac-Thiong, MD, PhD

15:35 - 15:39 **Paper #74: Increased Main Thoracic Curve Correction is Associated with Worse Postop Radiographic Shoulder Balance, Especially in Lenke 1A Curves with Balanced Shoulders Preop**
Matan Malka, BA; Ritt Givens, BS; Kevin Lu, MS; Emma Berube, MD; Thomas M. Zervos, MD; Stefan Parent, MD, PhD; Michael P. Kelly, MD; Lawrence G. Lenke, MD; Michael G. Vitale, MD, MPH; Harms Study Group; Benjamin D. Roye, MD, MPH

15:39 - 15:43 **Paper #75: Do Postoperative Medial Shoulder, Lateral Shoulder and Neck Imbalance Improve over Time? An Analysis of 120 Lenke 1 and 2 Adolescent Idiopathic Scoliosis (AIS) Patients with a Minimum of 5-Year Follow-Up**
Chris Yin Wei Chan, MD, MSOrth; Weng Hong Chung, MD, MSOrth; Yuki Mihara, MD, PhD; Siti Mariam Mohamad, BSc; Chee Kidd Chiu, MBBS, MSOrth; Mun Keong Kwan, MBBS, MSOrth

15:43 - 15:52 **Discussion**

MEETING AGENDA

Program (topics, timing, and faculty) is subject to change.

15:52 - 15:56 **Paper #76: Anterior Release is Not Needed to Restore Kyphosis in Moderate AIS with Hypokyphosis**
Craig R. Louer, MD; Jacquelyn S. Pennings, PhD; Maty Petcharaporn, BS; Arun R. Hariharan, MD; John S. Vorhies, MD; Michael P. Kelly, MD; Suken A. Shah, MD; Peter O. Newton, MD; Harms Study Group; Burt Yaszay, MD

15:56 - 16:00 **Paper #77: A Large Comparison Study Demonstrates Little to No Difference in Deformity Correction when Using Ponte Osteotomies for Lenke 1 and 2 AIS Curves**
Daniel J. Sucato, MD, MS; Suken A. Shah, MD; Michael G. Vitale, MD, MPH; Amer F. Samdani, MD; Peter O. Newton, MD; A. Noelle Larson, MD; Harms Study Group

16:00 - 16:04 **Paper #78: Importance of Thoracic Kyphosis and Global Sagittal Plane Restoration in the Surgical Treatment of AIS Patients with Preoperative Cervical Sagittal Malalignment**
Baris Peker, MD; Onur Levent Ulusoy, MD; Hamisi M. Mraja, MD; Ugur Yuzuguldu, MD; Bilge K. Yilmaz, MD; Halil Gok, MD; Emre Kurt, MD; Sepehr Asadollahmonfared, MD; Tunay Sanli, BE, MA; Meric Enercan, MD; Selhan Karadereler, MD; Azmi Hamzaoglu, MD

16:04 - 16:13 **Discussion**

16:13 - 16:17 **Paper #79: Thirty Years Later: The Lingering Effects of Adolescent Idiopathic Scoliosis Surgery with Third Generation Implants on Quality of Life ‡**
Antonia Matamalas, MD, PhD; Juan Bago, MD, PhD; Francisco Javier S. Perez-Grueso, MD; Lucía Moreno-Manzanaro, BS; Javier Pizones, MD, PhD; Carlos Villanueva Leal, MD, PhD; Susana Núñez Pereira, MD; Sleiman Haddad, MD, PhD, FRCS; Ferran Pellisé, MD, PhD

16:17 - 16:21 **Paper #80: Enhanced Care Delivery and Patient Experiences for Kids with Scoliosis: Smart Digital Strategies to Link Patients and Care Services ‡**
J Paige Little, PhD; Sinduja Suresh, PhD; Maree T. Izatt, BPhy; Annabelle Stubbs, BEng; Addison Suhr, BSc; Simon Gatehouse, MD, FRCS; Robert D. Labrom, MD, FRCS; Geoffrey N. Askin, MD, FRCS

16:21 - 16:25 **Paper #81: Serum Titanium Levels Remain Elevated 6 Years and Beyond from Spinal Instrumentation in Children**
Peter J. Cundy, MBBS; William J. Cundy, FRACS; Georgia Antoniou, BS

16:25 - 16:34 **Discussion**

16:34 - 16:38 **Paper #82: How Does Posterior Fusion Affects Muscle Activation Pattern in Adolescent Idiopathic Scoliosis: A Walking EMG Analysis**
Bhavuk Garg, MS

16:38 - 16:42 **Paper #83: AIS Patients with Distinct Lenke Types Adopt Different Kinematic Strategies During Walking**
Maria Asmar; Maria Karam; Emmanuelle Wakim; Abir Massaad, PhD; Mohammad I. Karam, PhD; Aren Joe Bizdikian, MD, MS; Georges El Haddad; Marc Boutros, BS; Marc Mrad; Gilles Prince, MD; Ibrahim Hamati; Guy Awad; Joe Azar; Moustapha Rteil; Nadim Freiha Claudio Vergari, PhD; Helene Pillet, PhD; Ismat Ghanem, MD, MS; Rami Rachkidi, MD, MS; Ayman Assi, PhD

16:42 - 16:46 **Paper #84: Patient's Perceived Flexibility After a Spinal Fusion**
Vishal Sarwahi, MD; Katherine Eigo, BS; Sayyida Hasan, BS; Himanshu Rao, BS; Brittney Moncrieffe, BS; Kiara Thompson, BS; Hannah Travers, BS; Effat Rahman, BS; Sanjeev Suratwala, MD; Yungtai Lo, PhD; Terry D. Amaral, MD; Keshin Visahan, BS

16:46 - 16:55 **Discussion**

17:00 - 18:30

Networking Sessions Hosted by Industry*

Please see page 225 for more information.

Please note: CME credits are not available for industry hosted cocktail events.

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Program (topics, timing, and faculty) is subject to change.

09:00 - 10:50 Room 115-117

Abstract Session 6: Hibbs Award-Nominated Papers

Moderators: Ivan Cheng, MD & Mitsuru Yagi, MD, PhD

09:00 - 09:05 **Welcome & Introduction to the Hibbs Award**
Ivan Cheng, MD & Mitsuru Yagi, MD, PhD

09:05 - 09:11 **Paper #85: Pulmonary Function in Patients with Idiopathic Scoliosis 40 Years After Diagnosis §**
Lærke C. Ragborg, MD; Casper Dragsted, MD, PhD; Soren Ohrt-Nissen, MD, PhD; Jann Mortensen, MD, DMSc; Martin Gehrchen, MD, PhD; Benny T. Dahl, Md, PhD, DMSc

09:11 - 09:17 **Paper #86: Halo-Gravity Traction Prior to Growing Rod Insertion: Which Curves Can Benefit? §**
Ambika Paulson, MD; Hui Nian, PhD; Jeffrey E. Martus, MD; John T. Smith, MD; Paul D. Sponseller, MD, MBA; John B. Emans, MD; Michelle C. Welborn, MD; Pediatric Spine Study Group; Craig R. Louer, MD

09:17 - 09:23 **Paper #87: Pneumonia Induced Mortality and Risk of Pneumonia in Children with Cerebral Palsy with Scoliosis Treated with and Without Surgery §**
Matti Ahonen, MD, PhD; Ira Jeglinsky-Kankainen, PhD; Mika Gissler, PhD; Ilkka J. Helenius, MD, PhD

09:23 - 09:37 **Discussion**

09:37 - 09:43 **Paper #88: Long-Term Outcomes of Operative Versus Nonoperative Treatment for Adult Symptomatic Lumbar Scoliosis (ASLS): Durability of Treatment Effects and Impact of Related Serious Adverse Events Through 8-Year Follow-Up §‡**
Justin S. Smith, MD, PhD; Michael P. Kelly, MD; Elizabeth L. Yanik, PhD; Christine Baldus, RN; Vy Pham, MD, MPH; David Ben-Israel, MD; Jon D. Lurie, MD, MS; Charles C. Edwards, MD; Steven D. Glassman, MD; Lawrence G. Lenke, MD; Oheneba Boachie-Adjei, MD; Jacob M. Buchowski, MD; Leah Y. Carreon, MD; Charles H. Crawford III, MD; Stephen J. Lewis, MD, FRCS(C); Tyler Koski, MD; Stefan Parent, MD, PhD; Virginie Lafage, PhD; Munish C. Gupta, MD; Han Jo Kim, MD; Christopher P. Ames, MD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Keith H. Bridwell, MD

09:43 - 09:49 **Paper #89: Assessment of Modern Iatrogenic Flatback Syndrome: Nearly 70% of Short Lumbar Fusions Had Undercorrection of L4-S1 Lordosis §**
Bassel G. Diebo, MD; Manjot Singh, BS; Mariah Balmaceno-Criss, BS; Mohammad Daher, BS; Lawrence G. Lenke, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; Stephen J. Lewis, MD, FRCS(C); Eric O. Klineberg, MD; Renaud Lafage, MS; Robert K. Eastlack, MD; Munish C. Gupta, MD; Gregory M. Mundis Jr., MD; Jeffrey L. Gum, MD; Kojo D. Hamilton, MD, FAANS; Richard Hostin, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Christopher I. Shaffrey, MD; Breton G. Line, BS; Praveen V. Mummaneni, MD, MBA; Pierce D. Nunley, MD; Justin S. Smith, MD, PhD; Jay D. Turner, MD; Frank J. Schwab, MD; Juan S. Uribe, MD; Shay Bess, MD; Virginie Lafage, PhD; Alan H. Daniels, MD; International Spine Study Group

09:49 - 09:55 **Paper #90: Exploring the Indications, Failures, and Treatment of Complications After a C2 to Pelvis Fusion §**
Nathan J. Lee, MD; Fthimnir Hassan, MPH; Ted Shi, BS; Anastasia Ferraro, BS; Chun Wai Hung, MD; Steven G. Roth, MD; Justin K. Scheer, MD; Zeeshan M. Sardar, MD; Joseph M. Lombardi, MD; Lawrence G. Lenke, MD; Ronald A. Lehman, MD

09:55 - 10:09 **Discussion**

10:09 - 10:15 **Paper #91: Vitamin A Deficiency Induces Congenital Vertebral Malformation Via Retinoic Acid Signaling Mediated Sclerotome Dysplasia †**
Xu'an Huang, MD; Yingxi Chen, PhD; Yuchang Zhou, PhD; Jiafeng Dai, MD; Yang Jiao, MD; Zhen Wang, MD; Haoyu Cai, MD; Junduo Zhao, MBBS; Heng Sun, MD; Bolun Qu, MD; Yizhen Huang, MD; Dahai Zhu, PhD; Yong Zhang, PhD; Jianxiong Shen, MD

10:15 - 10:21 **Paper #92: Experimental Study on the Asymmetric Growth of Vertebral Growth Plate and Neurocentral Synchondrosis Modulated with Microwave Ablation Under CT-Guided for Correcting Early Onset Scoliosis in Immature Porcine †**
Jin Zhou, MD; Jingming Xie, MD; Yingsong Wang, MD; Zhi Zhao, MD; Tao Li, MD; Zhiyue Shi, MD; Ying Zhang, MD; Tingbiao Zhu, MD; Quan Li, MD; Ni Bi, MD

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

MEETING AGENDA

Program (topics, timing, and faculty) is subject to change.

10:21 - 10:27 **Paper #93: Examination of an Epigenetic Biomarker for Risk Stratification in Adult Spinal Deformity Surgeries †**
Michael P. Kelly, MD; Lawrence G. Lenke, MD; Justin S. Smith, MD, PhD; Shay Bess, MD; Justin K. Scheer, MD; Breton G. Line, BS; Virginie Lafage, PhD; Renaud Lafage, MS; Eric O. Klineberg, MD; Ferran Pellisé, MD, PhD; Mitsuru Yagi, MD, PhD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; International Spine Study Group

10:27 - 10:33 **Paper #94: Efficacy of Topical TXA in Reducing Blood Loss and Transfusion Rates in Spine Surgery: A Double-Blinded Randomized Controlled Trial †**
Brett Kilb, MD; Shaina Sim, BS; Matthew McDermid, BS; Arvindera Ghag, MD; Robert H. Cho, MD; Firoz Miyanji, MD

10:33 - 10:49 **Discussion**

10:49 - 10:50 **Audience Vote**

10:50 - 11:10 Foyer 1

Refreshment Break

11:10 - 13:00

Abstract Session 7: Adult Spinal Deformity III & Presidential Address

Moderators: Cristiano M. Menezes, MD, PhD & Jacob M. Buchowski, MD

11:10 - 11:14 **Paper #95: Residual Pelvic Compensation After Spinal Reconstruction: The Role of Psoas Sarcopenia**
Chukwuebuka Achebe, BS; Han Jo Kim, MD; Takashi Hirase, MD, MPH; Myles Allen, MbChB; Robert Uzzo, MBA; Chad Z. Simon, BS; Tejas Subramanian, BS; Atahan Durbas, MD; Jung Mok, MD; Austin Kaidi, MD; Kasra Araghi, BS; Justin T. Samuel, BS; Cole Kwas, BS; Michael Mazzucco, BS; Samuel Adida, MS; Matthew E. Cunningham, MD, PhD; Francis C. Lovecchio, MD

11:14 - 11:18 **Paper #96: Maintaining Stability at the Lumbosacral-Pelvic Region in Adult Spinal Deformity Surgery Without SI Joint Fusion: Are Four Pelvic Screws Superior to Two Pelvic Screws?**
Sarthak Mohanty, BS; Stephen Stephan, MD; Christopher Mikhail, MD; Andrew Platt, MD; Joshua Baksheshian, MD; Erik Lewerenz, BS; Fthimnir Hassan, MPH; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

11:18 - 11:22 **Paper #97: Does Normalizing T4-L1PA Relationship in Long-Segment Fusions Independently Reduce Mechanical Complications and Improve Patient Reported Outcomes?**
Sarthak Mohanty, BS; Zeeshan M. Sardar, MD; Michael P. Kelly, MD; Josephine R. Coury, MD; Justin Reyes, MS; Fthimnir Hassan, MPH; Nathan J. Lee, MD; Justin K. Scheer, MD; Steven G. Roth, MD; Chun Wai Hung, MD; Joseph M. Lombardi, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

11:22 - 11:31 **Discussion**

11:31 - 11:35 **Paper #98: Is Cortical Breach at the Upper Instrumented Vertebra Associated with Increased Risk of Proximal Junctional Kyphosis?**
Samuel K. Ezeonu, BA; Juan D. Rodriguez-Rivera, BS; Nicholas S. Vollano, BS, MBS; Alyssa E. Capasso, BS; Constance Maglaras, PhD; Tina Raman, MD; Themistocles S. Protopsaltis, MD

11:35 - 11:39 **Paper #99: Comparison of Elderly Patients with Spinal Deformity Fused from the Upper Versus the Lower Thoracic/Thoracolumbar Spine to the Sacrum. Prospective Evaluation of Elderly Deformity Surgery (PEEDS) Study**
Zeeshan M. Sardar, MD; Roy Miller, MS; Scott Zuckerman, MD, MPH; Stephen J. Lewis, MD, FRCS(C); Marinus de Kleuver, MD, PhD; Yong Qiu, PhD; Yukihiro Matsuyama, MD, PhD; Lawrence G. Lenke, MD; Ahmet Alanay, MD; Ferran Pellisé, MD, PhD; Kenneth M. Cheung, MD, MBBS, FRCS; Maarten Spruit, MD; David W. Polly, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Michael P. Kelly, MD; Benny T. Dahl, Md, PhD, DMSc; Sigurd H. Berven, MD

11:39 - 11:43 **Paper #100: Upper Instrumented Vertebra Pedicle Screw Loosening Following Complex Adult Spinal Deformity Surgery: Incidence and Outcome Analysis of 147 Cases**
John D. Arena, MD; Yohannes Ghenbot, MD; Connor Wathen, MD; Gabrielle Santangelo, MD; Mert Marcel Dagli, MD; Joshua L. Golubovsky, MD; Ben Gu, MD; Dominick Macaluso, PhD; Jang Yoon, MD, MSc; William C. Welch, MD; Ali Ozturk, MD

Program (topics, timing, and faculty) is subject to change.

11:43 - 11:52 **Discussion**

11:52 - 11:56 **Paper #101: Proximal Junctional Degeneration and Failure: A Novel Classification and Clinical Implications**
Riza Mert Cetik, MD; Steven D. Glassman, MD; John R. Dimar, II, MD; Mitchell J. Campbell, MD; Mladen Djurasovic, MD; Charles H. Crawford III, MD; Jeffrey L. Gum, MD; Kirk Owens, MD; Kathryn McCarthy Mullooly, MD; Leah Y. Carreon, MD

11:56 - 12:00 **Paper #102: Risk of Upper Instrumented Vertebra Fracture in Adult Spinal Deformity Surgery Associated with Insertion of Oversized Screws Relative to Pedicle Width**
Shin Oe, MD; Yu Yamato, MD, PhD; Tomohiko Hasegawa, MD, PhD; Go Yoshida, MD, PhD; Tomohiro Banno, MD, PhD; Hideyuki Arima, MD, PhD; Koichiro Ide, MD; Tomohiro Yamada, MD; Yuh Watanabe, MD; Kenta Kurosu, MD; Yukihiro Matsuyama, MD, PhD

12:00 - 12:04 **Paper #103: Beyond Kyphosis: Modes of Failure at the Proximal Junction in Adult Spinal Deformity**
Virginie Lafage, PhD; Ayman Mohamed, MD; Christopher Katchis, MD; Alan H. Daniels, MD; Bassel G. Diebo, MD; Christopher P. Ames, MD; Shay Bess, MD; Douglas C. Burton, MD; Robert K. Eastlack, MD; Munish C. Gupta, MD; Richard Hostin, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Eric O. Klineberg, MD; Gregory M. Mundis Jr., MD; David O. Okonkwo, MD, PhD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Renaud Lafage, MS; Frank J. Schwab, MD; International Spine Study Group

12:04 - 12:13 **Discussion**

12:13 - 12:16 **2025 IMAST Preview**
Meric Enercan, MD & Kristen Jones, MD, FAANS

12:16 - 12:19 **2025 Annual Meeting Preview**
A. Noelle Larson, MD

12:19 - 12:22 **2025 Regional Courses Preview**
Martin Repko, MD, PhD

12:22 - 12:28 **Acknowledge 2024 Research Grant Recipients**
Peter G. Passias, MD

12:28 - 12:35 **Acknowledgement of 2024 Awards & Scholarships Winners**
Alexandre F. Cristante, MD, PhD, FRCS(C)

12:35 - 12:40 **Introduction of the President**
Laurel C. Blakemore, MD

12:40 - 13:00 **Presidential Address**
Marinus de Kleuver, MD, PhD

13:15 - 14:30 Room 211-212

SRS Member Business Meeting and Lunch* (lunch will be served in room)

13:15 – 13:45 Room 112

Non-Member Lunch & Information Session* (lunch will be served in Foyer 2)

14:30 - 14:45

Break

14:45 - 16:30

Abstract Sessions 8A & 8B (two concurrent sessions)

14:45 - 16:30 Room 115-117

Abstract Session 8A: Cervical Deformity and Early Onset Scoliosis

Moderators: Stephen J. Lewis, MD, MSc, FRCSC & Alan H. Daniels, MD

14:45 - 14:49 **Paper #104: Safety of Cervical Pedicle Screw Navigation Based on AI-Generated, MRI-Based Synthetic-CT Versus CT**
Peter Lafranca, MD; Yorck Rommelspacher, MD, PhD; Sander Muijs, MD, PhD; Sebastian Walter, MD, PhD; Tijl van der Velden, PhD; René M. Castelein, MD, PhD; Keita Ito, MD, PhD; Peter R. Seevinck, PhD; Tom Schlosser, MD, PhD

MEETING AGENDA

Program (topics, timing, and faculty) is subject to change.

14:49 - 14:53	**Paper #105: The Gap Between Surgeon Goal and Achieved Sagittal Alignment in Adult Cervical Spinal Deformity (CSD) Surgery** *Justin S. Smith, MD, PhD; David Ben-Israel, MD; Michael P. Kelly, MD; Virginie Lafage, PhD; Renaud Lafage, MS; Eric O. Klineberg, MD; Han Jo Kim, MD; Breton G. Line, BS; Themistocles S. Protopsaltis, MD; Peter G. Passias, MD; Robert K. Eastlack, MD; Gregory M. Mundis Jr., MD; K. Daniel Riew, MD; Khaled M. Kebaish, MD; Paul Park, MD; Munish C. Gupta, MD; Jeffrey L. Gum, MD; Alan H. Daniels, MD; Bassel G. Diebo, MD; Justin K. Scheer, MD; Richard Hostin, MD; Alex Soroceanu, MD, FRCS(C), MPH; Kojo D. Hamilton, MD, FAANS; Thomas J. Buell, MD; Stephen J. Lewis, MD, FRCS(C); Lawrence G. Lenke, MD; Jeffrey Mullin, MD; Frank J. Schwab, MD; Douglas C. Burton, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Shay Bess, MD; International Spine Study Group*
14:53 - 14:57	**Paper #106: Complications, Morbidity, and Mortality Following Corrective Surgery for Cervical Deformity Among Geriatric Cohorts** *Andrew Kim, BS; Yesha Parekh, MD; Wesley M. Durand, MD; Shay Bess, MD; Douglas C. Burton, MD; Jeffrey L. Gum, MD; Munish C. Gupta, MD; Richard Hostin, MD; Khaled M. Kebaish, MD; Michael P. Kelly, MD; Han Jo Kim, MD; Eric O. Klineberg, MD; Virginie Lafage, PhD; Gregory M. Mundis Jr., MD; Paul Park, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; K. Daniel Riew, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Christopher P. Ames, MD; Sang Hun Lee, MD; International Spine Study Group*
14:57 - 15:06	**Discussion**
15:06 - 15:10	**Paper #107: Relationship Between Global Sagittal Alignment After Adolescent Idiopathic Scoliosis Surgery and the Evolution of Sagittal Cervical Alignment 10 Years Post-Intervention** *Laura Telleria, MD; Juan Carlos Gutierrez-Gomez, MD; Irene Zarcos, MD; Paloma Martinez-Ureña, MD; Miguel Angel Castrillo, MD, PhD; Javier Cobo, MD, PhD; Alejandro Gomez-Rice, MD, PhD*
15:10 - 15:14	**Paper #108: Release of Sternocleidomastoid Muscle Surgery for Neglected Congenital Muscular Torticollis Improves Global Spinal Alignment** *Haruki Funao, MD, PhD; Ryo Mizukoshi, MD; Nao Otomo, MD; Norihiro Isogai, MD, PhD; Mitsuru Yagi, MD, PhD*
15:14 - 15:18	**Paper #109: Clinical, Radiographic, and MRI Findings Guide Surgical Decision-Making in Skeletal Dysplasia Cervical Instability** *Bryan Menapace, MD; William G. Mackenzie, MD; Jeffrey Campbell, MD; Colleen Ditro, RN, DNP, CPNP; Kenneth J. Rogers, PhD; W.G. Stuart Mackenzie, MD*
15:18 - 15:27	**Discussion**
15:27 - 15:31	**Paper #110: The Effect of the Spring Distraction System on Vertebral Bodies and Intervertebral Discs in Patients with Early Onset Scoliosis** *Casper S. Tabeling, MD; Peter Lafranca, MD; Justin V. Lemans, MD; Keita Ito, MD, PhD; Tom P. Schlösser, MD, PhD; René M. Castelein, MD, PhD; Moyo C. Kruyt, MD, PhD*
15:31 - 15:35	**Paper #111: Machine Learning Based Predictors for Unplanned Return to the Operating Room in Early Onset Scoliosis Treated with Magnetically Controlled Growing Rods** *Bahar Shahidi, PhD; Hazem Elsebaie, MD, FRCS; Fernando Rios, MD; Pearce B. Haldeman, BS; Bailee Monjazeb, BS; William Kerr, BS; Peter O. Newton, MD; Gregory M. Mundis Jr., MD; Pediatric Spine Study Group; Behrooz A. Akbarnia, MD*
15:35 - 15:39	**Paper #112: Documenting the Variation of Proximal Foundation Construct and Their Correlation with Unplanned Return to the Operating Room in Children with Magnetically Controlled Growing Rods** *Bahar Shahidi, PhD; Fernando Rios, MD; Hazem Elsebaie, MD, FRCS; Bailee Monjazeb, BS; William Kerr, BS; Joshua M. Pahys, MD; Steven W. Hwang, MD; Amer F. Samdani, MD; Lindsay M. Andras, MD; Matthew E. Oetgen, MD; Peter O. Newton, MD; Burt Yaszay, MD; Peter F. Sturm, MD; Michael G. Vitale, MD, MPH; Paul D. Sponseller, MD, MBA; Gregory M. Mundis Jr., MD; Behrooz A. Akbarnia, MD; Pediatric Spine Study Group*
15:39 - 15:48	**Discussion**
15:48 - 15:52	**Paper #113: Is Early Onset Scoliosis Immune to Quality Improvement? Complication Data Analysis Via the Modified Clavien-Dindo-Sink Classification** *Lucas Hauth, BS; Margaret Bowen, BS; Patrick J. Cahill, MD; John M. Flynn, MD; Benjamin D. Roye, MD, MPH; Selina C. Poon, MD; Michael J. Heffernan, MD; Sumeet Garg, MD; Pediatric Spine Study Group; Jason B. Anari, MD*

Program (topics, timing, and faculty) is subject to change.

15:52 - 15:56 **Paper #114: Growth Guidance Surgery: Predictors of Optimal Vs Suboptimal Performers**
William G. Elnemer, BS; Myung-Jin Cha, BS; Gregory Benes, BS; Lindsay M. Andras, MD; Behrooz A. Akbarnia, MD; David B. Bumpass, MD; Scott J. Luhmann, MD; Richard E. McCarthy, MD; Pediatric Spine Study Group; Paul D. Sponseller, MD, MBA

15:56 - 16:00 **Paper #115: Risk of Proximal Junctional Kyphosis After Revision of Growing Rod Constructs**
Chidebelum Nnake, BS; Alondra Concepción-González, BA; Matan Malka, BA; Ritt Givens, BS; Simon Blanchard, BS; Ron El-Hawary, MD; Michael G. Vitale, MD, MPH; Pediatric Spine Study Group; Benjamin D. Roye, MD, MPH

16:00 - 16:09 **Discussion**

16:09 - 16:13 **Paper #116: Osteotomies at the Time of Graduation Surgery: How Much Do We Get from Them?**
Tyler Tetreault, MD; Tiffany N. Phan, BA; Tishya Wren, PhD; Michael J. Heffernan, MD; John B. Emans, MD; Lawrence I. Karlin, MD; Amer F. Samdani, MD; Michael G. Vitale, MD, MPH; Pediatric Spine Study Group; Lindsay M. Andras, MD

16:13 - 16:17 **Paper #117: Lessons Learned After 20 Years of Using VEPTR in Early Onset Scoliosis**
Norman Ramirez, MD; Alexandra Claudio-Marcano, MD; John T. Smith, MD; John B. Emans, MD; Amer F. Samdani, MD; Mark A. Erickson, MD; John M. Flynn, MD; Norberto J. Torres-Lugo, MD; Gerardo Olivella, MD; Pediatric Spine Study Group

16:17 - 16:21 **Paper #118: Long-Term Surgical Outcomes and Operative Timing Analysis in One-Stage Posterior Lumbosacral Hemivertebra Resection: A Minimum 2-Year Follow-Up Study**
Qianyu Zhuang, MD; Zhuosong Bai, MD; Haoran Zhang, MD; Yuechuan Zhang, PhD; Xiangjie Yin, MD; Yunze Han, MD; Yiqiao Zhang, MD; Jianguo T. Zhang, MD

16:21 - 16:30 **Discussion**

14:45 - 16:30 Room 112

Abstract Session 8B: Kyphosis and Basic Science

Moderators: G. Ying Li, MD & Jwalant S. Mehta, FRCS (Orth), MCh (Orth), MS (Orth), D Orth

14:45 - 14:49 **Paper #119: Flexible Posterior Vertebral Tethering for the Management of Scheuermann's Kyphosis(SK): Correction by Using Growth Modulation**
Mehmet Aydogan, MD; Tuna Pehlivanoglu, MD; Yigit Erdag, MD; Umut D. Akturk, MD; Abdulhalim Akar, MD

14:49 - 14:53 **Paper #120: Outcomes of Pediatric and Young Adult Kyphotic Deformities Treated with Vertebral Column Resections at an Srs-Outreach Site in West Africa with 5-Year Follow-Up**
Kwadwo Poku Yankey, MD; Derrick Owusu Nyantakyi, MPH; Arthur Sackeyfio, MD; Jessie Rapoza, MS; Irene A. Wulff, MD; Oheneba Boachie-Adjei, MD; Kushagra Verma, MD, MS; Liliane Luu, BS

14:53 - 14:57 **Paper #121: Diagnostic Challenges and Consequences of Neonatal Vertebral Osteomyelitis: A Case Series**
Talissa O. Generoso, MD; Rubens Furlan Neto, MD; Luca E. Cordeiro, MD; Luiz Müller Avila, MD; Carlos A. Aguiar, MD; Luis E. Munhoz da Rocha, MD

14:57 - 15:06 **Discussion**

15:06 - 15:10 **Paper #122: Posterior Corrective Surgery for Type Ii Congenital Kyphosis: SRS-Schwab Grade 4 Osteotomy or Vertebral Column Resection?**
Yong Qiu, PhD; Hongru Ma, MD; Benlong Shi, PhD; Zezhang Zhu, PhD

15:10 - 15:14 **Paper #123: Decision of Pedicle Subtraction Osteotomy Vertebra in Surgical Correction for Ankylosing Spondylitis with Thoracolumbar Kyphosis**
Yong-Chan Kim, MD, PhD; Tae-Hoon Kim, MD, PhD; Young-Jik Lee, MD; Sung-Min Kim, MD; XiongJie Li, MD; Romeo II G. Galapon, MD; Min-Gyu Kim, MD

15:14 - 15:18 **Paper #124: Selection of Proximal Fusion Level in Osteoporotic Vertebral Compression Fracture with Spinal Kyphosis: the Guidence of Hounsfield Unit**
Junyu Li, MD; Yiqiao Zhang, MD; Ben Wang, MD; Xueshi Tian, MD; Zhuoran Sun, MD; Yongqiang Wang, MD; Miao Yu, MD; Weishi Li, MD; Yan Zeng, MD

15:18 - 15:27 **Discussion**

MEETING AGENDA

Program (topics, timing, and faculty) is subject to change.

15:27 - 15:31 **Paper #125: Opportunistic Monitoring of Bone Mineral Density Using a Stereoradiography Dual Energy System**
Saba Pasha, PhD; Russell Chow ; Darryl Lau, MD; Christopher I. Shaffrey, MD; Tyler Koski, MD

15:31 - 15:35 **Paper #126: AI-Powered 3D Reconstructions from Stereo-Radiographs: is 3D Ready for Primetime**
Justin Dufresne ; Rachelle Imbeault ; Lulu Zhou, PhD; Marjolaine Roy-Beaudry, MSc; Thierry Cresson, PhD; Stefan Parent, MD, PhD

15:35 - 15:39 **Paper #127: Novel Trizonal Membrane for Bone Generation in a Rabbit Posterolateral Spine Fusion Model**
Takashi Hirase, MPH; Ava Brozovich, MD; Austin Q. Nguyen, MD; Enrica De Rosa, MS; Comron Saifi, MD; Francesca Taraballi, PhD; Weiner K. Bradley, MD

15:39 - 15:48 **Discussion**

15:48 - 15:52 **Paper #128: A Transcriptomic Assessments of Pulmonary Development Based on Porcine Model of Early-Onset Scoliosis Combined with Thoracic Insufficiency Syndrome Treated by a Novel Growth-Friendly Device**
Ying Zhang, MD; Jingming Xie, MD; Yingsong Wang, MD; Zhiyue Shi, MD; Quan Li, MD; Tao Li, MD; Ni Bi, MD; Zhi Zhao, MD; Jin Zhou, MD

15:52 - 15:56 **Paper #129: Tethering of Kyphotic Deformities in the Hyperkyphotic Porcine Model: Insights for All Vertebral Growth Modulation**
Matthew A. Halanski, MD; Cameron Jeffers, BS; David M. Bennett, MD; Brittney Kokinos, MS; Susan Hamman, MD; Ellen Leiferman, DVM; Max Twedt, BS; James Sypherd ; Thomas Crenshaw, PhD

15:56 - 16:00 **Paper #130: Zebrafish Pre-Clinical Models Implicate Oxidative Stress-Induced Intervertebral Extracellular Matrix Defects in Adolescent Idiopathic Scoliosis, and Identify Elevated Spine Stiffness as a Prognostic Biomarker**
Josh Gopaul, BS; Patrick Pumputis ; Ran Xu ; Jenica VanGennip, PhD; Nikan Fakhari, PhD; Jerome Baranger, PhD; David E. Lebel, MD, PhD; Olivier Villemain, MD, PhD; Brian Ciruna, PhD

16:00 - 16:09 **Discussion**

16:09 - 16:13 **Paper #131: Machine Learning Clustering of Preoperative Fitness and Its Prognostic Value Following Deformity Correction**
Sarthak Mohanty, BS; Fthimnir Hassan, MPH; Larae Klarenbeek-Mitchell, PT, DPT, OCS; David Ruderman, PT, DPT; Eric Schaum, PT, DPT; Erik Lewerenz, BS; Zeeshan M. Sardar, MD; Joseph M. Lombardi, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

16:13 - 16:17 **Paper #132: Insights from Wearable Biometrics After ASD Surgery: Does Wearable Biometric Data (WBD) Correlate to Complications and 30-Day Readmission Better than Traditional Pros?**
Rohit Bhan, MD, MS; Salim Yakdan, MD, MSCI; Jacob Greenberg, MD; Brian J. Neuman, MD

16:17 - 16:21 **Paper #133: Computer-Aided Planning of Surgical Fusion Level for Adolescent Idiopathic Scoliosis Based on Deep Learning Models**
Zhong He, MD; Wu-Jun Li, PhD; Neng Lu, MS; Xiaodong Qin, PhD; Yi Chen, MD; Zhen Liu, PhD; Xipu Chen, MD; Yong Qiu, PhD; Zezhang Zhu, PhD; Xiaodong Qin, PhD

16:21 - 16:30 **Discussion**

16:30 - 16:50 Foyer 1

Refreshment Break

16:50 - 18:35 Room 115-117

Abstract Session 9: Adolescent Idiopathic Scoliosis III and Non-Operative Treatment Methods

Moderators: Amy L. McIntosh, MD & Ahmet Alanay, MD

16:50 - 16:54 **Paper #134: Distribution of Curve Flexibility in Idiopathic Scoliosis - A Descriptive Study**
Simon Blanchard, BS; Matan Malka, BA; Ritt Givens, BS; Michael G. Vitale, MD, MPH; Benjamin D. Roye, MD, MPH

Program (topics, timing, and faculty) is subject to change.

16:54 - 16:58	**Paper #135: Association Between Lower Bone Mineral Density and Increased Cobb Angle in Adolescent Idiopathic Scoliosis** *Takahiro Shibata, MD, PhD; Kazuki Takeda, MD, PhD; Satoshi Suzuki, MD, PhD; Toshiki Okubo, MD, PhD; Masahiro Ozaki, MD, PhD; Osahiko Tsuji, MD, PhD; Narihito Nagoshi, MD, PhD; Morio Matsumoto, MD, PhD; Masaya Nakamura, MD, PhD; Kota Watanabe, MD, PhD*
16:58 - 17:02	**Paper #136: Development of Scoliview: An Artificial Intelligence Tool for the Automated and Reproducible Calculation of Cobb Angles** *Germán Casabó-Vallés, MS; Gisselle Pérez-Machado, PhD; Rosa M. Egea-Gámez, MD, PhD; Judit Sánchez-Raya, MD, PhD; Inmaculada Vilalta-Vidal, MD; Pedro Rubio Belmar, MD, PhD; Judith Salat, PhD; María Gallán, MD; Carles Fabres-Martin, MD; Paloma Bas Hermida, MD; Carmen Martínez-González, MD; Juan Bago, MD, PhD; Marta Gómez, MD; Miquel Bovea, MS; Rafael Gonzalez-Diaz, MD, PhD; Rocio Garcia-Garcia, MS; Amalia Capilla, PhD; Eva García-López, PhD; José Luis García-Giménez, PhD; Teresa Bas, MD, PhD; Salvador Mena, PhD*
17:02 - 17:11	**Discussion**
17:11 - 17:15	**Paper #137: Improvement in Axial Rotation with Bracing Reduces Risk of Curve Progression in Patients with Adolescent Idiopathic Scoliosis** *Michael Fields, MD, BS; Christina C. Rymond, BA; Ritt Givens, BS; Matan Malka, BA; Matthew Simhon, MD; Hiroko Matsumoto, PhD; Gerard F. Marciano, MD; Afrain Z. Boby, MS, BS; Benjamin D. Roye, MD, MPH; Michael G. Vitale, MD, MPH*
17:15 - 17:19	**Paper #138: Socioeconomic Disparity Limits Opportunity for Conservative Management of Adolescent Idiopathic Scoliosis** *Jennifer A. Dermott, BSc(PT), MSc; Liisa Jaakkimainen, MD, PhD; Teresa To, PhD; Maryse Bouchard, MD, FRCS(C); Andrew Howard, MD, MS; David E. Lebel, MD, PhD*
17:19 - 17:23	**Paper #139: Effects of Schroth Scoliosis Specific Exercise in Adolescent Idiopathic Scoliosis - A Prospective, Randomized Clinical Trial** *Kenny Y. Kwan, MD; Lee Yin Goh, MS; Aldous CS Cheng, BS; Anjaly Saseendran, BS*
17:23 - 17:32	**Discussion**
17:32 - 17:36	**Paper #140: Rapid Response During Spinal Deformity Surgery Can Successfully Save Spinal Cord Function Using Intraoperative Monitoring** *Munish C. Gupta, MD; Alekos A. Theologis, MD; Ganesh Swamy, MD, PhD; Go Yoshida, MD, PhD; Michael P. Kelly, MD; Thorsten Jentzsch, MSc; Samuel Strantzas, MSc, DABNM; Saumyajit Basu, MS(Orth), DNB(Orth), FRCSEd; Kenny Y. Kwan, MD; Justin S. Smith, MD, PhD; Ferran Pellisé, MD, PhD; So Kato, MD, PhD; Zeeshan M. Sardar, MD; Christopher P. Ames, MD; Kristen E. Jones, MD, FAANS; Anastasios Charalampidis, MD; Brett Rocos, MD, FRCS; Lawrence G. Lenke, MD; Stephen J. Lewis, MD, FRCS(C)*
17:36 - 17:40	**Paper #141: The Effect of Intravenous Infusion of Lidocaine on Intraoperative Neurophysiological Monitoring During Adolescent Idiopathic Scoliosis Surgery** *Mohd Shahnaz Hasan, MBBS; Chong Huey Nee, MBBS; Lee Zheng-Yii, PhD; Chee Kidd Chiu, MBBS, MSOrth; Chris Yin Wei Chan, MD, MSOrth; Mun Keong Kwan, MBBS, MSOrth; Siti Nadzrah Yunus, MBBS*
17:40 - 17:44	**Paper #142: Intensive Rehabilitative Treatment for AIS Patients with a Major Curve of 40-60° Who Refused Surgery** *Tianyuan Zhang, PhD; Wenyuan Sui, MD; Yaolong Deng, MD; Huang Zifang, MD, PhD; Junlin Yang, MD, PhD*
17:44 - 17:53	**Discussion**
17:53 - 17:57	**Paper #143: Optimal Selection of Lower Instrumented Vertebra Can Minimize Distal Junctional Kyphosis After Posterior Spinal Fusion for Thoracic Adolescent Idiopathic Scoliosis** *Yusuke Hori, MD, PhD; Akira Matsumura, MD, PhD; Takashi Namikawa, MD, PhD; Norihiro Isogai, MD, PhD; Luiz Silva, MD; Burak Kaymaz, MD; Petya Yorgova, MS; Peter G. Gabos, MD; Nicholas D. Fletcher, MD; Michael P. Kelly, MD; Harry L. Shufflebarger, MD; Peter O. Newton, MD; Burt Yaszay, MD; Paul D. Sponseller, MD, MBA; Baron S. Lonner, MD; Amer F. Samdani, MD; Firoz Miyanji, MD; Harms Study Group; Suken A. Shah, MD*
17:57 - 18:01	**Paper #144: Is Next-Day Discharge After Posterior Spinal Fusion for Adolescent Idiopathic Scoliosis Safe?** *Alyssa Barre, MD; Andrew Kirk, MD; Vincent Prusick, MD; Ryan D. Muchow, MD; Caitlin Conley, PhD, Vishwas R. Talwakar, MD*

Program (topics, timing, and faculty) is subject to change.

18:01 - 18:05 **Paper #145: Local Wound Infiltration Reduces Acute Postoperative Opioid Requirements in Adolescent Idiopathic Scoliosis ‡**
Craig M. Birch, MD; Sydney Lee, BS; K. Mikayla Flowers Zachos, MA; Grant D. Hogue, MD; M. Timothy Hresko, MD; Shanika De Silva, PhD; Daniel Hedequist, MD

18:05 - 18:14 **Discussion**

18:14 - 18:18 **Paper #146: Outcomes of Revision Surgeries Following Index Anterior Vertebral Body Tethering**
Cleopatra Nehme, BS; Amer F. Samdani, MD; Joshua M. Pahys, MD; Taemin Oh, MD; Jessica Steindler, BA; Sarah Nice, BS; Kaitlin Kirk, BS; Amanda Stutman, BS; Camille Brown, BS; Natalie Williams, BS; Steven W. Hwang, MD

18:18 - 18:22 **Paper #147: Outcomes of Anterior Versus Posterior Growth Modulation Surgery for Adolescent Idiopathic Scoliosis (AIS)**
Glenys Poon, MBBS, MRCS; Leok-Lim Lau, FRCS; Hee-Kit Wong, FRCS; Gabriel KP Liu, MD

18:22 - 18:26 **Paper #148: When is Growth the Greatest? Spine and Total Body Growth in Idiopathic Scoliosis Through Sanders Maturation Stages 2, 3A, 3B, and 4**
Yusuke Hori, MD, PhD; Bryan Menapace, MD; Norihiro Isogai, MD, PhD; Sadettin Cifti, MD; Burak Kaymaz, MD; Luiz Silva, MD; Kenneth J. Rogers, PhD; Petya Yorgova, MS; Peter G. Gabos, MD; Suken A. Shah, MD

18:26 - 18:35 **Discussion**

20:00 - 22:00

Farewell Reception* (ticket required)
Open to all registered attendees and guests of registered attendees. Registration is required and tickets must be purchased in advance. Tickets are $50 for registered attendees and guest tickets may be purchased for $150 per guest.

‡ = SRS Funded Research Grant

Program (topics, timing, and faculty) is subject to change.

09:00 - 11:10 Room 115-117

Abstract Session 10: Adult Spinal Deformity IV & Miscellanous, Hibbs Award Presentation and Transfer of Presidency

Moderators: Venu M. Nemani, MD, PhD & Hamid Hassanzadeh, MD

09:00 - 09:04 **Paper #149: Which Complications Impact Satisfaction Among Patients with Adult Spinal Deformity (ASD)?**
Kojo D. Hamilton, MD, FAANS; Rohit P. Kumar, BA; Nitin Agarwal, MD; Lawrence G. Lenke, MD; Peter G. Passias, MD; Eric O. Klineberg, MD; Virginie Lafage, PhD; Shay Bess, MD; Justin S. Smith, MD, PhD; Jeffrey L. Gum, MD; Renaud Lafage, MS; Jeffrey Mullin, MD; Michael P. Kelly, MD; Bassel G. Diebo, MD; Thomas J. Buell, MD; Justin K. Scheer, MD; Breton G. Line, BS; Han Jo Kim, MD; Khaled M. Kebaish, MD; Raj S. Lavadi, MBBS; Robert K. Eastlack, MD; Alan H. Daniels, MD; Alex Soroceanu, MD, FRCS(C), MPH; Gregory M. Mundis Jr., MD; Richard Hostin, MD; Themistocles S. Protopsaltis, MD; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; International Spine Study Group

09:04 - 09:08 **Paper #150: Perioperative Infection Prophylaxis with Vancomycin is a Significant Risk Factor for Deep Surgical Site Infection in Spine Surgery**
Gregory Kazarian, MD; Francis C. Lovecchio, MD; Jung Mok, MD; Yusef Jordan, MD; Mitchell A. Johnson, BS; Takashi Hirase, MD, MPH; Han Jo Kim, MD

09:08 - 09:12 **Paper #151: Spine Shape Vs Alignment: Which Determines the Best Outcomes in Adult Spinal Deformity?**
Nicholas S. Vollano, BS, MBS; Themistocles S. Protopsaltis, MD; Renaud Lafage, MS; Alex Soroceanu, MD, FRCS(C), MPH; Jeffrey L. Gum, MD; Munish C. Gupta, MD; Lawrence G. Lenke, MD; Kojo D. Hamilton, MD, FAANS; Justin S. Smith, MD, PhD; Robert K. Eastlack, MD; Gregory M. Mundis Jr., MD; Han Jo Kim, MD; Richard Hostin, MD; Khaled M. Kebaish, MD; Bassel G. Diebo, MD; Alan H. Daniels, MD; Eric O. Klineberg, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Shay Bess, MD; Virginie Lafage, PhD; International Spine Study Group

09:12 – 09:21 **Discussion**

09:21 - 09:25 **Paper #152: Proximal Junctional Kyphosis After Prophylactic Tethers in Adult Spinal Deformity: Incidence, Mechanism and Risk Factors for Proximal Junctional Failure**
Francis C. Lovecchio, MD; Takashi Hirase, MD, MPH; Michael Mazzucco, BS; Virginie Lafage, PhD; Renaud Lafage, MS; Frank J. Schwab, MD; Shay Bess, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Gregory M. Mundis Jr., MD; Bassel G. Diebo, MD; Robert K. Eastlack, MD; Eric O. Klineberg, MD; Han Jo Kim, MD; International Spine Study Group

09:25 - 09:29 **Paper #153: Postoperative Thoracic Kyphosis Morphology Following Adult Spinal Deformity Surgery: An Analysis of Fused and Unfused Segments**
Renaud Lafage, MS; Jonathan C. Elysee, BS; Alan H. Daniels, MD; Bassel G. Diebo, MD; Christopher Katchis, MD; Christopher P. Ames, MD; Shay Bess, MD; Douglas C. Burton, MD; Robert K. Eastlack, MD; Munish C. Gupta, MD; Richard Hostin, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Eric O. Klineberg, MD; Gregory M. Mundis Jr., MD; David O. Okonkwo, MD, PhD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

09:29 - 09:33 **Paper #154: Identifying Risk of Proximal Junctional Kyphosis Prior to Choosing Upper Instrumented Vertebra**
Jeffrey M. Hills, MD; Han Jo Kim, MD; Lawrence G. Lenke, MD; Justin S. Smith, MD, PhD; Shay Bess, MD; Breton G. Line, BS; Virginie Lafage, PhD; Renaud Lafage, MS; Eric O. Klineberg, MD; Jeffrey L. Gum, MD; Khaled M. Kebaish, MD; Gregory M. Mundis Jr., MD; Alex Soroceanu, MD, FRCS(C), MPH; Richard Hostin, MD; Themistocles S. Protopsaltis, MD; Kojo D. Hamilton, MD, FAANS; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; Michael P. Kelly, MD; International Spine Study Group

09:33 - 09:42 **Discussion**

09:42 - 09:46 **Paper #155: Hip Range of Motion Predicts Outcomes Following Spinal Fusion Surgery in Adult Spinal Deformity Patients**
Shane Burch, MD; Andrew Sawires, MD

MEETING AGENDA

Program (topics, timing, and faculty) is subject to change.

09:46 - 09:50 **Paper #156: Increased Posterior Pincer Might Increase the Risk of Hip Osteoarthritis in Adult Spinal Deformity with High Pelvic Retroversion**
Elena Jaber, MS; Rami Rachkidi, MD, MS; Abir Massaad, PhD; Ali Rteil, MS; Elma Ayoub, MS; Maria Saadé, MS; Celine Chaaya, MS; Elio Mekhael, BS; Nabil Nassim, BS; Rami Rhayem, BS; Mohammad I. Karam, PhD; Ismat Ghanem, MD, MS; Virginie Lafage, PhD; Wafa Skalli, PhD; Ayman Assi, PhD

09:50 - 09:54 **Paper #157: Patterns and Predictors of Mechanical Complications Following 3-Column Osteotomies for Correction of Adult Thoracolumbar Spinal Deformity with 2 Years of Follow Up**
Winward Choy, MD; Jaemin A. Kim, Research Assistant; Terry Nguyen, Research Assistant; Tony Catalan, BS; Austin Lui, MS; Ping-Yeh Chiu, MD; David Mazur-Hart, MD; Aaron J. Clark, MD; Vedat Deviren, MD; Christopher P. Ames, MD

09:54 - 10:03 **Discussion**

10:03 - 10:07 **Paper #158: Adjacent Segment Disease (AdSD) After Spinal Fusion in the Uk Biobank (UKB)**
Rohit Bhan, MD, MS; Vy Pham, MD, MPH; Elizabeth L. Yanik, PhD; Brian J. Neuman, MD

10:07 - 10:11 **Paper #159: Does Strategy Derived from the Ghailane-Gille Classification for Degenerative Spondylolisthesis of the Lumbar Spine Affect Surgical Outcome: A Match-Mismatch Study**
Soufiane Ghailane, MD; Houssam Bouloussa, MD, MS; Matthieu Campana, MD; Jean Etienne Castelain, MD; Olivier Gille, MD, PhD; Vincent Challier, MD

10:11 - 10:15 **Paper #160: Contemporary Guidelines for Acetabular Positioning in Hip Arthroplasty May Jeopardize Hip Dislocation for Select ASD Patients**
Marc Boutros, BS; Mohammad Daher, BS; Ayman Assi, PhD; Gilles Prince, MD; Mohammad I. Karam, PhD; Christopher P. Ames, MD; Shay Bess, MD; Alan H. Daniels, MD; Munish C. Gupta, MD; Richard Hostin, MD; Michael P. Kelly, MD; Han Jo Kim, MD; Eric O. Klineberg, MD; Lawrence G. Lenke, MD; Pierce D. Nunley, MD; Peter G. Passias, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Renaud Lafage, MS; Bassel G. Diebo, MD; Virginie Lafage, PhD; International Spine Study Group

10:15 - 10:24 **Discussion**

10:24 - 10:28 **Paper #161: Comparison of Reoperation Rates for Anterior Cervical Discectomy and Fusion and Cervical Disc Arthroplasty: A Retrospective Cohort Study from a Multicenter Healthcare System**
Samir AlSalek, BS; Richard N. Chang, PhD; Shayan U. Rahman, MD; Harsimran S. Brara, MD; Daniel Hirt, MD; Heather A. Prentice, PhD; Jessica Harris, MS; Maya Harary, MD; Hunter G. Richards, BS; Azim N. Laiwalla, MD; Kern H. Guppy, MD, PhD

10:28 - 10:32 **Paper #162: Deep Learning Classification of Pediatric Spinal Radiographs**
Kellen Mulford, PhD; Christina M. Regan, BS; Julia Todderud, BA; Charles P. Nolte; Zachariah W. Pinter, MD; Cody C. Wyles, MD; Bardia Khosravi, MD; Pouria Rouzrokh, MD; Hilal Maradit Kremers, MD; A. Noelle Larson, MD

10:32 - 10:36 **Paper #163: PROMIS and ODI Tools: Clinically Useful Predictors of Abnormal MRIs in Pediatric Back Pain?**
Devan J. Devkumar, BSA; Karina A. Zapata, PhD, PT, DPT; Chan-Hee Jo, PhD; Brandon A. Ramo, MD

10:36 - 10:45 **Discussion**

10:45 - 10:55 **Presentation of the Hibbs Award(s)**
Javier Pizones, MD, PhD & Brian Hsu, MD

10:55 - 11:05 **Transfer of the Presidency Introduction**
Marinus de Kleuver, MD, PhD

11:05 - 11:10 **Transfer of the Presidency Speech**
Laurel C. Blakemore, MD

11:10 - 11:30 Foyer 1

Refreshment Break

Program (topics, timing, and faculty) is subject to change.

11:30 - 13:15 Room 115-117

Abstract Session 11: Neuromuscular and Miscellaneous

Moderators: Saumyajit Basu, MS(Orth), DNB(Orth), FRCSEd & W.G. Stuart Mackenzie, MD

11:30 - 11:34 **Paper #164: Hemivertebra Resection in Children Below 3-Years-Of-Age: Safety Profile, Clinical and Radiographic Outcomes**
Bing Wui Ng, MD; Altug Yucekul, MD; Nuri Demirci; Yilmaz Kilic, MD; Feyzi Kilic, MD; Aynur Kaval; Elif Gizem Carus, MS; Tais Zulemyan, MSc; Caglar Yilgor, MD; Ahmet Alanay, MD

11:34 - 11:38 **Paper #165: Trends in Blood Loss and Transfusion in Patients with Cerebral Palsy Undergoing Posterior Spinal Fusion for Neuromuscular Scoliosis**
Terrence G. Ishmael, MBBS; Steven W. Hwang, MD; Joshua M. Pahys, MD; Suken A. Shah, MD; Paul D. Sponseller, MD, MBA; Peter O. Newton, MD; Nicholas D. Fletcher, MD; Amer F. Samdani, MD; Harms Study Group; Tracey P. Bastrom, MA

11:38 - 11:42 **Paper #166: Trends in Readmission Rates After Spinal Fusion for Neuromuscular Scoliosis: A 12-Year Retrospective Analysis**
Aladine A. Elsamadicy, MD; James Cross; Joshua M. Pahys, MD; Amer F. Samdani, MD; Paul D. Sponseller, MD, MBA; Suken A. Shah, MD; Peter O. Newton, MD; Firoz Miyanji, MD; Harms Study Group; Steven W. Hwang, MD

11:42 - 11:51 **Discussion**

11:51 - 11:55 **Paper #167: Multicenter Assessment of Closure Technique for Reducing Short-Term Wound Complications in Pediatric Neuromuscular Scoliosis**
Jason Z. Amaral, BS; McKenna C. Noe, BS; Rebecca Schultz, BS; Tristen N. Taylor, BS; Kennedy Morey, BS, ATC; John T. Anderson, MD; Richard Schwend, MD; Brian G. Smith, MD

11:55 - 11:59 **Paper #168: What Happens if You Wait? Larger Curves Require More Resources for Less Correction in Neuromuscular Scoliosis**
Brandon Yoshida, MD; Jacquelyn Valenzuela-Moss, BS; Tyler Tetreault, MD; Tishya Wren, PhD; Nico Silverman-Lloyd, BS; Tiffany N. Phan, BA; Lindsay M. Andras, MD; Michael J. Heffernan, MD

11:59 - 12:03 **Paper #169: Does Spine Fusion Limit Ambulatory Status in Spina Bifida Patients with Severe Spine Deformity?**
Ambika Paulson, MD; Ryan Seltzer, MD; Kyle Graham, MPH; Douglass Clayton, MD; Jeffrey E. Martus, MD; Gregory A. Mencio, MD; Craig R. Louer, MD

12:03 - 12:12 **Discussion**

12:12 - 12:16 **Paper #170: Adult Consequences of Neurofibromatosis Type1 Patients Who Had Spinal Deformity Surgeries**
Arihiko Tsukamoto, MD; Koki Uno, MD, PhD; Teppei Suzuki, MD, PhD; Masaaki Ito, MD, PhD; Keita Nakashima, MD

12:16 - 12:20 **Paper #171: A Changing EOS Phenotype in SMA: Nusinersen Use is Associated with Increased Curve Magnitude and Kyphosis at the Time of Index Surgery**
John S. Vorhies, MD; Nicole S. Pham, MPH; Xochitl M. Bryson, BA; Marleni Albarran, BS; Majella Vaughan, MPH; Amy L. McIntosh, MD; Brandon A. Ramo, MD; Daniel Bouton, MD; Brian D. Snyder, MD, PhD; Michael G. Vitale, MD, MPH; John T. Smith, MD; Benjamin D. Roye, MD, MPH; Patrick J. Cahill, MD; Ian Hollyer, MD; Jaysson T. Brooks, MD; Ron El-Hawary, MD; Pediatric Spine Study Group

12:20 - 12:24 **Paper #172: Spine MRI in Patients with Arthrogryposis is Compulsory Due to High Rates of Tethered Cord/Low-Lying Conus Medullaris and Scoliosis**
Hans K. Nugraha, MD; Arun R. Hariharan, MD; Aaron Huser, DO; Kaveh Asadi, MD; David S. Feldman, MD; W.G. Stuart Mackenzie, MD

12:24 - 12:33 **Discussion**

12:33 - 12:37 **Paper #173: Redefining Physiological Whole-Body Alignment According to Pelvic Incidence: Normative Values and Prediction Models**
Marc Khalifé, MD, PhD, MS; Wafa Skalli, PhD; Claudio Vergari, PhD; Pierre Guigui, MD; Valérie Attali, MD, PhD; Rémi Valentin; Olivier Gille, MD, PhD; Virginie Lafage, PhD; Han Jo Kim, MD; Ayman Assi, PhD; Emmanuelle Ferrero, MD, PhD

12:37 - 12:41 **Paper #174: Not All Are Created Equal: Lumbosacral Anatomy is Different in Pediatric Spondylolysis**
Nakul Narendran, BA; Ryan Finkel, MD; Paal Nilssen, BA; Daniel Farivar, BS; Joshua Langberg, BS; Melodie F. Metzger, PhD; David L. Skaggs, MD, MMM; Kenneth D. Illingworth, MD

MEETING AGENDA

SATURDAY, SEPTEMBER 14, 2024

Program (topics, timing, and faculty) is subject to change.

12:41 - 12:45 **Paper #175: Spondylolisthesis in Children Younger than 10 Years: Who Will Progress to a High Grade Slip?**
Sofía Frank, PhD; Julie Joncas, RN; Soraya Barchi, BSc; Stefan Parent, MD, PhD; Hubert Labelle, MD; Jean-Marc Mac-Thiong, MD, PhD

12:45 - 12:54 **Discussion**

12:54 - 12:58 **Paper #176: Social Determinants of Health Predict Patient Reported Outcomes 2-Years Following Surgery for Grade 2 Spondylolisthesis: A QOD Study**
Vardhaan Ambati, MS; Kai-Ming Gregory Fu, MD; Timothy J. Yee, MD; Jay D. Turner, MD; Juan S. Uribe, MD; Andrew K. Chan, MD; Anthony L. Asher, MD; Domagoj Coric, MD; Michael S. Virk, MD, PhD; Christopher I. Shaffrey, MD; Oren Gottfried, MD; Eric Potts, MD; Mohamad Bydon, MD; Michael Y. Wang, MD; Paul Park, MD; Steven D. Glassman, MD; Kevin T. Foley, MD; Cheerag D. Upadhyaya, MD, MSc, MBA; Dean Chou, MD; Mark E. Shaffrey, MD; Erica F. Bisson, MD, MPH; Anthony M. DiGiorgio, DO, MHA; Praveen V. Mummaneni, MD, MBA

12:58 - 13:02 **Paper #177: Incidental Dural Tears During Pediatric Posterior Spinal Fusions**
Paal Nilssen, BA; Edward Compton, BS; Stephan Stephen, MD; Lindsay M. Andras, MD; David L. Skaggs, MD, MMM; Kenneth D. Illingworth, MD

13:02 - 13:06 **Paper #178: Hydrogen Peroxide Fogging Reduces Spinal Surgical Site Infections: A QSVI Project**
Lorena Floccari, MD; Matthew Holloway, MD; Richard Steiner, PhD; Todd F. Ritzman, MD; Michael Bigham, MD

13:06 - 13:15 **Discussion**

13:15

SRS 59th Annual Meeting Concludes

ABSTRACTS

The Scoliosis Research Society gratefully acknowledges Stryker for supporting the Charging Stations.

PODIUM PRESENTATION ABSTRACTS

1. THE EFFECT OF NIGHT-TIME VERSUS FULL-TIME BRACING ON THE SAGITTAL PROFILE IN ADOLESCENT IDIOPATHIC SCOLIOSIS: A PROPENSITY SCORE-MATCHED STUDY

Martin Heegaard, MD; Lærke C. Ragborg, MD; Amy L. McIntosh, MD; Megan E. Johnson, MD; Martin Gehrchen, MD, PhD; Daniel J. Sucato, MD, MS; Benny T. Dahl, Md, PhD, DMSc; Soren Ohrt-Nissen, MD, PhD

Hypothesis

The sagittal profile is similar post bracing, irrespective of the bracing regimen.

Design

Retrospective consecutive cohort study.

Introduction

Recent research indicates that brace treatment in adolescent idiopathic scoliosis (AIS) may induce hypokyphosis or even flat back deformity. Whether this effect differs between night-time bracing (NTB) and full-time bracing (FTB) is unknown. The current study aims to investigate the impact of NTB and FTB on the sagittal profile in AIS patients.

Methods

We included skeletally immature AIS patients with main curves ranging from 25-45° treated with either NTB or FTB. The two cohorts were propensity-score matched on Risser stage, age, major curve size, and global kyphosis at brace initiation. Coronal and sagittal radiographic parameters were gathered at the initiation and completion of brace treatment.

Results

Two-hundred seventy patients were eligible for inclusion. The matched cohorts included 73 patients in each group. The groups were well-matched although, in the NTB group, 85% were females compared with 69% in the FTB group (p=0.019). In the coronal plane, curve progression >5° was seen in 63% in the NTB group and 43% in FTB (p=0.012). Progression to >50° was seen in 45% vs. 29% (p=0.040), respectively. The global kyphosis increased during bracing from 33±12° to 37±13° in the NTB group compared to a decrease from 32±12° to 30±12° in the FTB group (p=0.001). Ten percent (n=7) were hypokyphotic (global kyphosis <20°) post bracing in the NTB group compared with 25% (n=18) in the FTB group (p=0.016). Pelvic incidence (PI) and sacral slope (SS) were similar post bracing between the two groups, with pelvic tilt (PT) being slightly different (PI: NTB 46° ±10, FTB 44° ±9, p=0.270; SS: NTB 39° ±8, FTB 40° ±9, p=0.530; PT: NTB 7° ±7, FTB 4° ±7, p=0.022).

Conclusion

Patients treated with a NTB were statistically more likely to experience frontal plane curve progression >5° (63%) and progression to a surgical magnitude (45%) when compared to FTB patients. Despite the frontal plane curve progression, the NTB group had more normal sagittal alignment, with fewer patients exhibiting global hypokyphosis (<20°) than the FTB at the completion of bracing.

2. EFFECTIVENESS OF NIGHTTIME BRACING OR FULLTIME BRACING IN MODERATE-GRADE ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS)

Anastasios Charalampidis, MD; Elias Diarbakerli, PhD; Hans Möller, PhD; Allan Abbott, PhD; Paul Gerdhem, PhD

Hypothesis

Fulltime bracing would demonstrate superior effectiveness compared to nighttime bracing in the treatment of patients with AIS.

Design

Prospective clinical trial.

Introduction

Effectiveness of nighttime bracing or fulltime bracing in patients with moderate-grade AIS is controversial.

Methods

We compared individuals 9-17 years with moderate-grade AIS(25° to 40°) and at least one year of remaining growth and treated with a nighttime bracing as part of a randomized controlled trial to non-participants treated with a fulltime bracing. Patients were included in the study from January 10, 2013, through October 23, 2018. 45 individuals were treated with nighttime bracing and 44 individuals with fulltime bracing. All were followed minimum until skeletal maturity unless surgery occurred before maturity. In case of curve progression of more than 6 degrees in the nighttime brace group individuals were offered transition to a fulltime bracing. Surgery was offered if curve sizes were 45 degrees or larger. Information about any operations was recorded until 31st December 2023 from the patient´s medical charts, corresponding to a range of 5-10 years from brace treatment start.

Results

The median age for the entire population was 12.8 (IQR;1.8) Age, gender, BMI, menarche for girls and Risser grade did not differ significantly between the two groups (all p≥ 0.1). The median radiographic follow-up time after brace start and until the last available radiograph did not differ significantly between the night-time and the full-time brace group (33 (24) vs 33 (27); p=0.9). At the last available follow-up, no significant differences were observed between the two groups with regards to the magnitude of the major curve (p=0.7). Female gender (odds ratio [OR] 6.5; 95% confidence interval [CI] 1.12 to 37.38), lower Risser grade (OR 1.6; 95% CI 1.01 to 2.67) and larger curve size at the beginning of brace treatment (OR 0.7; 95% CI 0.65 to 0.87) increased odds for curve progression ≥ 45 degrees. 11 patients in the nighttime brace group and 6 in the fulltime brace group underwent surgery (OR 2.0; 95% CI 0.7 to 6.1). The mean time from brace start to surgery did not differ significantly between the two groups (33 (18) vs 31(13); p=0.2.

Conclusion

Night-time bracing including a possibility to transition to full-time brace in case of progression demonstrated comparable effectiveness in the treatment of moderate-grade AIS.

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

PODIUM PRESENTATION ABSTRACTS

3. NATURAL COURSE OF MODERATE ADOLESCENT IDIOPATHIC SCOLIOSIS: A MEAN 25-YEAR FOLLOW-UP STUDY

Masayuki Ohashi, MD, PhD; Kei Watanabe, MD, PhD; Kazuhiro Hasegawa, MD, PhD; Toru Hirano, MD, PhD; Hideki Tashi, MD; Keitaro Minato, MD, PhD; Tatsuo Makino, MD; Masayuki Sato, MD

Hypothesis

Moderate adolescent idiopathic scoliosis (AIS) curves might continue to progress after skeletal maturity (SM) and negatively affect health-related quality of life (HRQOL) in middle age.

Design

A long-term follow-up study

Introduction

Previous studies for AIS indicate that curves <30° at SM rarely progress, while those >45°–50° continue to progress in adulthood and require surgical treatment. However, whether intervention or long-term follow-up is necessary for moderate curves between 30° and 40° remains unclear.

Methods

Of 155 nonoperatively treated patients with AIS who had major curve between 30° and 40° at SM (Risser 4), 58 patients (55 women) aged ≥30 years at the final follow-up were included (follow-up rate=37.4%). Curve type at SM was thoracic curve type in 24 patients, thoracolumbar/lumbar (TL/L) in 16, and double curve in 18. HRQOL questionnaires included SF-12, SRS-22, Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ), and ODI. HRQOL scores were compared to age- and sex-matched healthy participants (Control, n=58).

Results

The mean age was 14.2 years at SM and 39.9 years at the survey, with a mean follow-up duration of 25.7 years. The mean Cobb angles of major curve [SM (n=58)/around 18 years of age (n=37)/final (n=47)] were 35.6°/40.1°/48.3° with annual increases of 1.5° from SM to the age of 18 years (n=37), 0.2° from the age of 18 years to the final follow-up (n=37), and 0.5° from SM to the final follow-up (n=47). At the final follow-up, major curves progressed to >50° in 45.9% of patients, 82.4% of whom had already had major curves ≥40° at the age of 18 years. Conversely, patients demonstrated generally favorable HRQOL scores, including mental health, which were comparable with the control group, excluding SRS-22 self-image (AIS 2.8 vs. Control 3.5, p <0.001). Four patients (curve types; thoracic in 1 patient, TL/L in 2, and double in 1) underwent spinal fusion after this survey.

Conclusion

Although the curve progression declined with age, >40% of moderate curves at SM were >50° during mean 25-year follow-up. Therefore, moderate curves, especially those with ≥40° at the age approximately 18 years, are warranted for further follow-up. Additionally, the patients should be informed that the curves were associated with negative self-image, although it did not always cause significant psychosocial issues.

4. DOES VBT CAUSE DISC AND FACET JOINT DEGENERATION? AN MRI STUDY WITH MINIMUM 5-YEARS FOLLOW-UP

Altug Yucekul, MD; Feyzi Kilic, MD; Atahan Durbas; Tais Zulemyan, MSc; Elif Gizem Carus, MS; Aynur Kaval; Gokhan Ergene, MD; Sahin Senay, MD; Pinar Yalinay Dikmen, MD; Sule Turgut Balci, MD; Ercan Karaarslan, MD; Yasemin Yavuz, PhD; *Caglar Yilgor, MD*; Ahmet Alanay, MD

Hypothesis

VBT may cause degeneration at both intermediate and adjacent levels.

Design

Retrospective analysis of a prospectively collected data

Introduction

VBT is believed to prevent disc and facet degeneration due to its less rigid nature. While VBT's flexibility may be advantageous, the potential for compression-induced degeneration needs further research. The aim was to analyze the changes in the intermediate and adjacent levels, at least 5 years after surgery.

Methods

Demographic, perioperative, clinical and radiographic data were collected. Skeletal maturity and height were assessed at each follow-up. Curve behavior and mechanical complications were recorded. Whole spine MRI was obtained preoperatively on a routine basis. Follow-up MRI (between T2-S1) was obtained at a minimum of 5 years post-op. Disc and facet scores were compared using McNemar's Test and Related Samples Marginal Homogeneity Test.

Results

Out of the first 49 consecutive patients operated between 2014-2018, 35 (71.4%) were included. 34 (97%) were female. Mean age was 12.6 (9.5–16). Median Sanders was 4 (1-7). Mean preop major curve was 49 (40-73) degrees. 28 had a thoracic VBT, while 4 had thoracolumbar and 3 had bilateral. A median of 7 (5-11) levels were tethered. Preop mean height of 155.1 (130-178) was increased to 162.7 (147-189) at the latest f-up. At the time of the MRI (mean 72.5±14.8 (60−119) months), the median Sanders was 8 (7-8). Analyses of changes in thoracic disc and facet scores revealed no differences (p>0.05). For the lumbar levels, 23 patients were graded as normal both at preop and postop. 3 patients that already had multilevel facet degeneration did not show any deterioration. However, 2 patients that had single level disc degeneration had a 1-point increase. Of the remaining 7 patients that were graded normal at preop, 2 experienced disc, 2 experienced facet, while 3 experienced both disc and facet degeneration, all of which were mild and located at the lower adjacent segments.

Conclusion

Intermediate discs and facet joints were preserved after

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

growth modulation with VBT surgery at a mean of 72.5 months of follow-up. 6% of the patients experienced deterioration of previously degenerated discs, while lower adjacent facets had a mild degeneration in 20% of the patients. Studies in larger cohorts with longer follow-up are warranted to have more in-depth analyses of the effects of relative stabilization and altered biomechanical loads.

5. CHANGING COMPLICATION TRENDS AFTER ANTERIOR VERTEBRAL BODY TETHERING (AVBT): 10-YEAR EXPERIENCE

Taemin Oh, MD; Cleopatra Nehme, BS; Amer F. Samdani, MD; Joshua M. Pahys, MD; Jessica Steindler, BA; Sarah Nice, BS; Kaitlin Kirk, BS; Amanda Stutman, BS; Camille Brown, BS; Natalie Williams, BS; Emily Nice, BS; *Steven W. Hwang, MD*

Hypothesis
Overall complication rates have decreased over time but also transitioned from early overcorrection to more undercorrection and breakages.

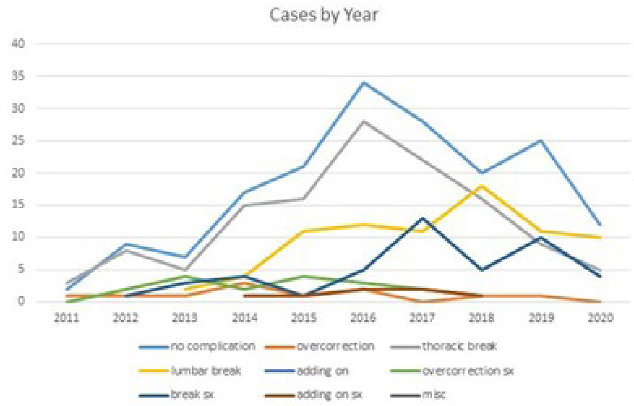
Design
Single center retrospective study

Introduction
aVBT is an alternative surgery to treat scoliosis but is associated with unique complications such as overcorrection, breakage, and adding-on. We reviewed our series of complications from over a decade.

Methods
We reviewed all patients who underwent aVBT between 2011-2020 with 2-year follow-up (f/u) and identified those who had complications. We divided patients into 3 groups due to case volume: 2011-2015, 2016-2017, and 2018-2020. Complications were categorized as follows: tether breakage (n=133), overcorrection (n=41), adding-on (n=11), curve progression (n=10), and miscellaneous (n=4). Breakage was defined as >5° interscrew angle change between any f/u or largest Cobb >35° at last f/u + >5° change in Cobb between f/u intervals. Baseline demographics, radiographic parameters, and complication rates were compared across the groups.

Results
200/388 patients (52%) developed complications and 75 (19%) required additional surgery with a mean f/u of 55.9 ± 22.3 months. Mean age was 12.6 ± 1.4 years, with F:M ratio of 9:1, and the vast majority were skeletally immature. 65% of patients underwent single thoracic tethers. Over time, there has been an increase in age at surgery (p<0.05), curve magnitude (p<0.05), more patients with closed triradiate cartilages (p<0.05) and a trend towards more double or lumbar curves (p=0.09). Type of complications have changed significantly over time (p<0.05) with overcorrection occurring in 13% of cases [2011-2015] then decreasing to 4% and 2% subsequently (p<0.05). The incidence of breakage was 49% [2011-2016] then 55% [2016-2017] then 59% [2018-2020], with respective revision surgery rates of 6% to 11% to 13% (p>0.05). There has been a significant increase in number of lumbar breakage and decrease in thoracic breakage (p<0.05) likely related to more double and lumbar aVBTs. The mean thoracic Cobb of the entire cohort was 24 ± 14° at last f/u. However the mean f/u was shorter (38 vs. 56 vs. 79 months, p<0.05) in the more recent group.

Conclusion
Our 10-year experience with aVBT reflects the lessons learned where overcorrection and associated revision surgery have diminished over time with a subsequent increase in breakages and surgery.



6. WHAT PREDICTS A SUCCESSFUL RESULT IN VERTEBRAL BODY TETHERING?

Julia Todderud, BA; Todd A. Milbrandt, MD, MS; D. Dean Potter, MD; *A. Noelle Larson, MD*

Hypothesis
We hypothesize that lower preoperative curve magnitude and greater intraoperative correction correlate with VBT success.

Design
Retrospective review of 87 patients aged 9 to 16 treated with VBT surgery at a single institution with 2-year surgical outcomes.

Introduction
Vertebral body tethering (VBT) is a non-fusion alternative for management of pediatric scoliosis that allows for growth and flexibility of the spine. However, current rates of revision for VBT range 14%-25%. Current indications for VBT are skeletally immature AIS patients with a flexible major curve of 30-65 degrees and failure of bracing. This study aims to evaluate perioperative factors influencing the success of VBT.

Methods
Success of VBT was defined as a major Cobb <35 degrees and no re-operation at the two-years. 70 patients were considered successful (80%), 17 patients were considered unsuccessful (20%). The peri-operative factors associated with these patient populations were stratified and compared to evaluate potential characteristics for predicting VBT outcomes. Evaluations of significance were performed via two-sample t-tests.

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

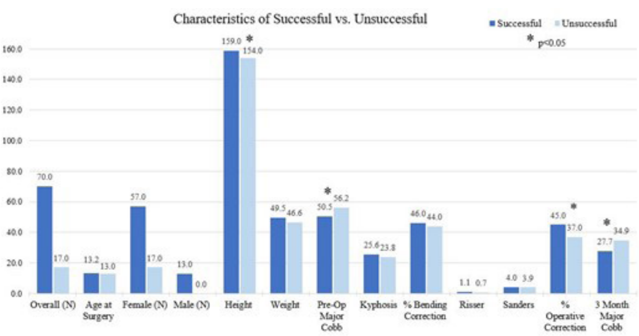
PODIUM PRESENTATION ABSTRACTS

Results

Perioperative factors such as BMI, age, Risser/Sanders score, pre-operative major cobb, percent correction on bending films, and percent correction at 3 months post-operative visit were considered in evaluation of contributors to tethering outcomes. Of the 17 patients not considered successful 4 had suspected cord breakage and 8 (9%) underwent reoperation, with 3 of the reoperations due to overcorrection. The VBT patients who were successful showed significantly higher percent correction at first erect (45% compared to 37%, p<0.01), lower preoperative major cobb angles (50.5 compared to 56.2, p<0.01), and preoperative greater height (159 cm compared to 154 cm, p=0.02). They also demonstrated significantly better correction with lower Cobb angles at 3 months compared to the unsuccessful group (27.7 compared to 34.9, p<0.01). Values for pre-operative kyphosis, correction with bending, weight, Risser score, and Sanders score did show differences between the patient groups but did not reach significance.

Conclusion

Patients with smaller curve magnitudes, greater standing height, and with greater pre-operative correction tended toward better outcomes at 2-year follow-up. These results indicate a need for maximizing intraoperative correction and careful patient selection.



Perioperative metrics of successful and unsuccessful VBT patients.

7. EARLY DETECTION OF PROGRESSIVE ADOLESCENT IDIOPATHIC SCOLIOSIS BY UNSUPERVISED MACHINE LEARNING CLUSTERED BONE MICROARCHITECTURE PHENOTYPES: A 3-YEAR PROSPECTIVE LONGITUDINAL STUDY

Kenneth Guangpu Yang, PhD, MBBS; *Adam Yiu-chung Lau, MBBS, FRCS*; Wayne Yuk-wai Lee, PhD; Alec Lik-hang Hung, MBBS, MS, FRCS; Tsz-Ping Lam, MBBS, FRCS; Jack Chun-yiu Cheng, MD, FRCS

Hypothesis

Bone microarchitecture phenotype is an important early detectable prognostic factor for progressive AIS.

Design

A longitudinal cohort study

Introduction

Abnormal bone qualities are known prognostic factors of curve progression in AIS. Recent unsupervised machine learning study from 11 high-resolution peripheral QCT (HRpQCT) generated parameters have identified 3 bone microarchitecture phenotype clusters in AIS of prognostic values on curve progression to surgical threshold from the first visit. This study aimed to investigate whether bone microarchitecture phenotype could predict risk of curve progression in early AIS girls (Cobb:10-20º).

Methods

AIS girls at Thumb Ossification Composite Index (TOCI) 4-6 (Sanders SSMS 2-5) corresponding to peak height velocity were recruited. Femoral neck was scanned by DXA and distal radius by HRpQCT at their first visit. Bone phenotypes were clustered by our established unsupervised machine learning model. Patients were followed up longitudinally at 6-month interval for 3 years.

Results

106 AIS girls (11.8±0.9y/o; Cobb:14.7±3.2º) without prior bracing were recruited at their first visit. Features of their bone phenotype clusters were in line with our previous reports. Phenotype-1 had normal bone qualities. Phenotype-2 had smaller bone volume and lower DXA Z-score. Phenotype-3 had lower cortical BMD and deranged trabecular microarchitecture with accompanying lower DXA Z-score. (Fig. 1A) No significant differences of spinal profile were found between the 3 bone phenotype clusters at baseline. During the 3-year follow-up, 15 girls in Phenotype-2 (adjOR=5.39) and 15 girls in Phenotype-3 (adjOR=3.67) had curve progression ≥ 6º (comparing with 7 girls in Phenotype-1) with their predictive values being significantly higher than DXA Z-score. (Fig. 1B)

Conclusion

Bone Microarchitecture Phenotype 2 and 3 were found to have significantly higher prognostic value for curve progression in early AIS (Cobb:10-20º) at their first visit reflecting the importance of bone qualities in the etiopathogenesis of AIS. This together with our previous report on prediction of curve progression to surgical threshold could have important clinical implications. We might consider starting early bracing, PSSE and nutritional intervention for the high-risk group with curve less than the current recommended bracing threshold.

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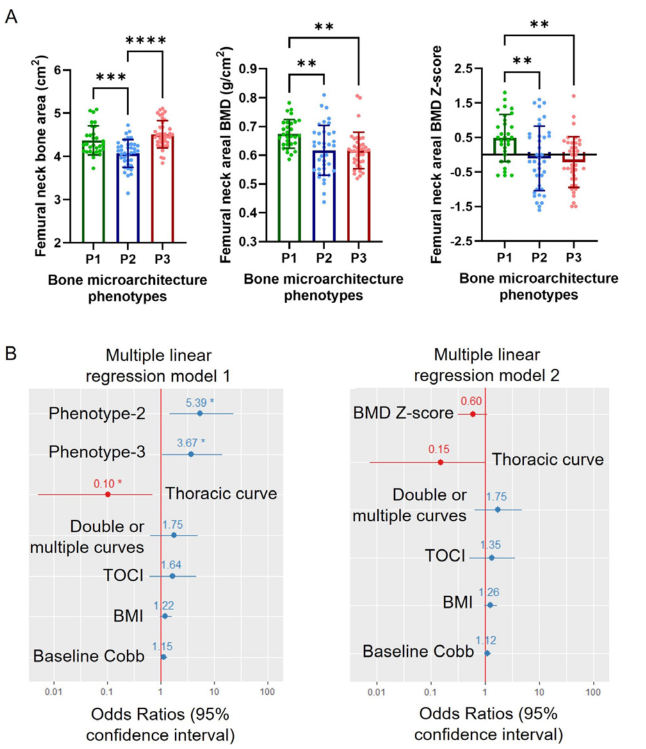


mean score by evaluating the coefficient of determination (R2) and the number of times the prediction was within a predesignated value of the actual score (i.e. buffer accuracy).

Results

A total of 1,417 patients were included. The stochastic gradient descent (SGD) model had the highest R2 for all SRS-22 scores (0.31–0.64). For 0.5-buffer accuracy, the linear regression model performed best for the satisfaction (66.2%), self-image (70.1%), pain (65.7%), and total SRS-22 scores (80.9%), while the SGD model performed best for the mental health (54.9%) and general function SRS-22 scores (79.9%). The SGD model had the highest 1-buffer accuracy across all SRS-22 scores (87.4%–97.2%). All MLMs, except for the AdaBoost model, outperformed the mean estimates on all accuracy metrics across each outcome.

Conclusion

MLMs accurately predicted the difference in HRQoL outcomes for AIS patients using preoperative and intraoperative factors. Findings provide key insights into the feasibility of implementing MLMs to guide operative planning and counsel patients on expected outcomes of surgical management. Future work should aim to optimize these factors to ultimately maximize patient outcomes.

Table 1. Training and testing results for the machine learning models predicting differences in total Scoliosis Research Society-22 scores.

Model Name	Coefficient of Determination (R^2)	0.25-Buffer Accuracy (%)	0.5-Buffer Accuracy (%)	1-Buffer Accuracy (%)
Training				
Mean Estimates	0	43.0	75.0	95.1
Linear Regression	0.36	51.3	84.7	97.9
Stochastic Gradient Descent	0.35	51.4	84.3	97.8
K-Nearest Neighbour	0.46	54.5	84.9	98.7
Random Forest	0.89	90.0	98.9	99.9
AdaBoost	0.28	38.7	73.7	99.9
Neural Network	0.75	74.0	95.1	99.8
Testing				
Mean Estimates	0	39.5	70.1	93.2
Linear Regression	0.35	51.9	80.9	96.9
Stochastic Gradient Descent	0.35	52.2	80.3	97.2
K-Nearest Neighbour	0.29	44.4	78.4	96.3
Random Forest	0.34	47.8	79.6	96.9
AdaBoost	0.20	40.7	71.9	96.3
Neural Network	0.24	45.1	75.9	96.3

8. FEASIBILITY OF USING ARTIFICIAL INTELLIGENCE TO PREDICT POSTOPERATIVE HEALTH-RELATED QUALITY OF LIFE FOR ADOLESCENT IDIOPATHIC SCOLIOSIS

Dusan Kovacevic, MD; Aazad Abbas, MD; Gurjovan Sahi, MD; Johnathan Lex, MD; Jay Toor, MD; Suken A. Shah, MD; Amer F. Samdani, MD; Peter O. Newton, MD; Michael P. Kelly, MD; Harms Study Group; Firoz Miyanji, MD

Hypothesis

Machine learning models will not accurately predict Health-Related Quality of Life (HRQoL) outcomes for AIS surgery at 2 yrs post-op.

Design

Prospective, multicenter

Introduction

The impact on Health-Related Quality of Life (HRQoL) following scoliosis surgery is well-documented, however, there is limited consensus on preoperative and intraoperative strategies to optimize HRQoL outcomes following surgery. Accurate prediction of postoperative outcomes can guide operative planning, ultimately leading to better HRQoL. This feasibility study aimed to generate machine learning models (MLMs) using preoperative and intraoperative variables to accurately predict postoperative HRQoL outcomes following AIS surgery.

Methods

A prospective, longitudinal, multicenter database was queried to identify Lenke 1 or 5 curves with minimum 2yr f/u. MLMs were generated using various preoperative and intraoperative factors to predict the difference in SRS-22 scores from preoperative assessment to 2 yr f/u. MLMs were compared to a model that estimates the

9. MACHINE LEARNING ALGORITHMS FOR PREDICTING FUTURE CURVE IN FEMALE ADOLESCENT IDIOPATHIC SCOLIOSIS PATIENTS BASED ON THE DATA FROM THE MINIMAL VISITS

Shuhei Ohyama, MD; Satoshi Maki, MD, PhD; Toshiaki Kotani, MD, PhD; Yosuke Ogata, MD; Yasushi Iijima, MD, PhD; Tsutomu Akazawa, MD, PhD; Tsuyoshi Sakuma, MD, PhD; Kazuhide Inage, MD, PhD; Shohei Minami, MD, PhD; Seiji Ohtori, MD

Hypothesis

The machine learning (ML)-based model using items commonly evaluated based on minimal visits accurately predicts future curves in female patients with adolescent idiopathic scoliosis (AIS).

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

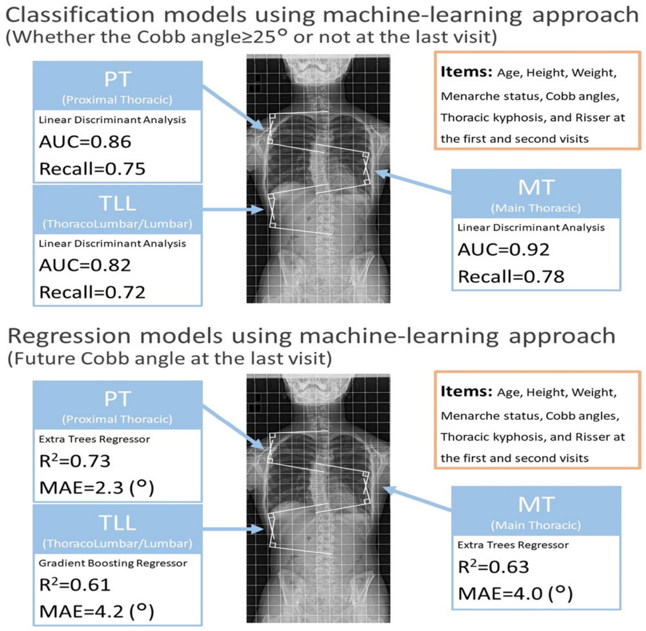
Design
Retrospective cohort study.

Introduction
Identifying the risk of AIS progression is important in determining treatment strategies. Previous models predicting future curves for patients with AIS had difficulty adapting to the routine practice because these models required numerous visits and detailed radiographically features. Several studies have investigated ML-based models for AIS prediction. However, those utilizing an ML approach to predict the progression of AIS from data of minimal visits have shown limited accuracy.

Methods
We studied 887 girls with AIS. Patient data, including demographic and radiographic data were collected at the first, second, and last visits. Angular progression was defined as a Cobb angle greater than 25 degrees for each of the proximal thoracic (PT), main thoracic (MT), and thoracolumbar/lumbar (TLL) curves at the last visit. ML algorithms were employed to develop individual binary classification models and individual regression models for each type of curve (PT, MT, and TLL) using PyCaret in Python. Multiple models were explored and analyzed, with the selection of optimal models based on the area under the curve (AUC) and Recall scores for binary classification models and coefficient of determination (R2) and median absolute error (MAE) for regression models. For all models, we evaluated Shapley Additive Explanations (SHAP) values.

Results
Regarding binary classification models, the best-performing models for PT, MT, and TLL progression had AUCs of 0.86, 0.92, and 0.82 and recall values of 0.75, 0.78, and 0.72, respectively. Regarding regression models, the best-performing models for Cobb angles of PT, MT, and TLL at the last visits had R2 of 0.73, 0.63, and 0.61 and MAE values of 2.3, 4.0, and 4.2, respectively. The most significant factors predicting progression varied for each model.

Conclusion
The ML-based model using items commonly evaluated at the first and second visit accurately predicted angle and progression at the last visit in female patients with AIS.



Model performance for predicting the progression and future curves of each curve

10. PULMONARY FUNCTION AT MINIMUM 10 YEARS AFTER SEGMENTAL PEDICLE SCREW INSTRUMENTATION FOR THORACIC ADOLESCENT IDIOPATHIC SCOLIOSIS

Linda Helenius, MD, PhD; Matti Ahonen, MD, PhD; Johanna Syvänen, MD, PhD; *Ilkka J. Helenius, MD, PhD*

Hypothesis
We hypothesized that pulmonary function would improve during the follow-up as more effective correction of AIS can be obtained using current standard treatment than with hook or hybrid constructs.

Design
A prospective cohort study.

Introduction
Adolescent idiopathic scoliosis with thoracic curves is associated with reduced pulmonary function preoperatively. It remains unclear how much pulmonary improvement can be obtained using pedicle screw instrumentation at long-term follow-up.

Methods
Out of 64 consecutively surgically treated patients with thoracic AIS (Lenke 1-4, 6) using pedicle screw instrumentation, 50 (mean age at surgery 14.7 years, 44 females) participated in a prospective 10-year follow-up study (mean FU 12.2 years). Preoperative major curve averaged 57° (SD 8.5°) with a remaining curve of 15° (SD 6.3°) at 10-year follow-up. They were evaluated using clinical examination, spinal radiographs, and spirometry preoperatively and at 10-year follow-up. The preoperative percentage predicted values were adjusted for the height loss caused by the scoliosis according to curve size.

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Results

Preoperatively 49% (20/41) had forced vital capacity (FVC) or forced expiratory volume in one second (FEV1) below 80% of the predicted normal values representing pulmonary function impairment. FVC improved from preoperative 3.29 L (SD 0.78L) to 3.87 L (0.79L) at 10-year follow-up (p<0.001). This improvement averaged 510 mL (SD 560 mL) in patients having both preoperative and 10-year follow-up measurements available. The percentage predicted values for FVC showed an improvement from 83% preoperatively to 86% at 10-year follow-up (p=0.048). At 10-year follow-up 38% (19/50) of the patients had FVC or FEV1 below 80% of the predicted values.

Conclusion

FVC improved by a mean of 510 ml from preoperative to 10-year follow-up in patients undergoing pedicle screw instrumentation for thoracic AIS. Despite 75% scoliosis correction and significant improvement of absolute lung volume values, more than one-third of these surgically treated otherwise healthy young adults fulfilled the criteria for pulmonary function impairment at 10-year follow-up.

Table 1. Patient demographic data and pulmonary function

	Mean ± SD	Range
Age at surgery	14.7 ± 1.9	10 to 18
Age at final follow-up	26.9 ± 2.1	21 to 31
Preoperative		
Major curve (°)	56.5 ± 8.5	45 to 78
Thoracic kyphosis (°)	21.6 ± 11.9	2 to 54
Lenke classification		
1	25	
2	11	
3	7	
4	3	
6	8	
10-year FU		
Major curve (°)	13.8 ± 5.9	4 to 31
Thoracic kyphosis (°)	21.7 ± 8.8	7 to 60
Correction (%)	75 ± 11	39 to 92
Surgical data		
Number of levels fused	11.6 ± 1.3	8 to 15
Surgical time (h)	4.2 ± 0.8	2.7 to 5.8
Intraoperative bloodloss (mL)	694 ± 377	230 to 1800
Pulmonary function	preoperative	10-year FU
FVC (L)	3.29 ± 0.78	3.80 ± 0.75
FVC (%)	83 ± 12	86 ± 11
FEV_1 (L)	2.86 ± 0.60	3.05 ± 0.63
FEV_1 (%)	81 ± 12	83 ± 10

11. BRACING IN SEVERE SKELETALLY IMMATURE ADOLESCENT IDIOPATHIC SCOLIOSIS - DOES A HOLDING STRATEGY CHANGE THE SURGICAL PLAN?

Soren Ohrt-Nissen, MD, PhD; Martin Heegaard, MD; Thomas B. Andersen, MD, PhD, DMSc; Martin Gehrchen, MD, PhD; Benny T. Dahl, Md, PhD, DMSc; Niklas Tøndevold, MD, PhD

Hypothesis

Curve flexibility is maintained during night-time bracing in skeletally immature adolescent idiopathic scoliosis (AIS) with curves in the surgical range.

Design

Retrospective consecutive cohort study

Introduction

Management of skeletally immature AIS patients with curves in the surgical range is challenging. Fusion surgery in AIS should ideally be carried out in skeletally mature patients to reduce the risk of adding-on or crankshaft. A few studies have shown an effect of bracing in AIS curves larger than 40°. In early-onset scoliosis, the principle of casting and bracing as a delay tactic prior to surgery is well known but is not well described in AIS patients.

Methods

We included a consecutive cohort of 89 AIS patients with curves ≥ 45°. All patients had an estimated growth potential but not deemed suitable for vertebral body tethering. All patients were eventually treated with fusion surgery and all patients had side-bending radiographs prior to both bracing and surgery. Curves were classified as structural or nonstructural according to Lenke at both timepoints.

Results

The main curve progressed by a mean of 12±10° and the secondary curve by 8±8°. Flexibility of the main curve decreased from 50±19% to 44±19% (p=0.001) and the lumbar curve from 85±21% to 77±22% (p=0.005). In 69 patients (79%) the Lenke category did not progress during bracing. In 14 patients (15%), the progression in Lenke type occurred in the thoracic region (i.e. Lenke type 1 to type 2) while 6 patients (7%) progressed in the lumbar region (i.e., Type 1 to type 3). In the 69 patients that did not progress, we found that the last touched vertebra moved distally by one or two levels in 26 patients.

Conclusion

This is the first study to describe a decrease in curve flexibility during bracing in severe AIS. However, this had only a modest impact on the surgical strategy. Bracing as a holding strategy can be applied but the risk of losing flexibility in the lumbar spine should be outweighed against the risks of premature fusion surgery.

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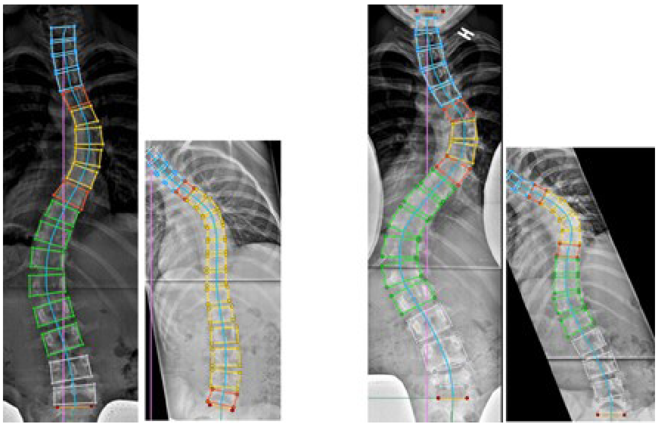
PODIUM PRESENTATION ABSTRACTS



A 45-degree Lenke 1A curve before bracing. At the time of surgery both curves have progressed, and the lumbar curve is now structural with a lumbar Cobb angle on bending films of 33 degrees.

12. PROXIMAL FEMUR MATURITY INDEX AT BRACE INITIATION FOR ADOLESCENT IDIOPATHIC SCOLIOSIS PREDICTS CURVE PROGRESSION RISK ‡

Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; Prudence Wing Hang Cheung, PhD, BDSc (Hons)

Hypothesis

The Proximal Femur Maturity Index (PFMI) at brace initiation for adolescent idiopathic scoliosis (AIS) can predict curve progression risk.

Design

Prospective study.

Introduction

The PFMI can be used to assess skeletal maturity on existing whole-spine radiographs without additional radiation. However, the relationship between the PFMI at the initiation of bracing for AIS and subsequent curve progression remains unknown. This study aimed to investigate the relationship between the PFMI and curve progression, and the predictability of risks to adulthood curve progression and surgical thresholds based on the PFMI grade at brace initiation.

Methods

202 patients with AIS who were prescribed underarm bracing according to the Scoliosis Research Society criteria and had good brace-wear compliance. The patients were followed from brace initiation until complete skeletal maturity. Longitudinal data on the coronal Cobb angle and skeletal maturity assessments using Risser staging, Sanders staging, the distal radius and ulna classification, and the PFMI were collected. Each patient was assessed on whether the major curve progressed to ≥40° (adulthood deterioration) and ≥50° (the surgical threshold). Logistic regressions were used to predict probabilities of curve progression to the 2 thresholds, adjusted for factors that were significant in univariate analyses.

Results

The PFMI correlated with the other skeletal maturity indices (r_s = 0.60 to 0.72, $p < 0.001$ for all). The pre-brace PFMI grade correlated with progression to ≥40° (r_{rb} = −0.30, $p < 0.001$) and to ≥50° (r_{rb} = −0.20, p = 0.005). Based on regression models ($p < 0.001$) adjusted for the pre-brace major Cobb angle and curve type, brace initiation at PFMI grades 2 and 3 for a curve of ≥30° had predicted risks of 30% (95% confidence interval [CI], 4% to 55%) and 12% (95% CI, 7% to 17%), respectively, for progression to the surgical threshold. Brace initiation at PFMI grade 5 had 0% progression risk.

Conclusion

The PFMI can be used for predicting curve progression and prognosticating brace outcomes in AIS. Patients with brace initiation at PFMI grade 4 for a curve of <30° or at grade 5 were unlikely to progress to the adulthood deterioration or surgical threshold. In comparison, skeletally immature patients initiating bracing at a PFMI grade of ≤3 for a major curve of ≥30° had a higher risk of progression despite compliant brace wear.

13. FACTORS ASSOCIATED WITH CONSTRUCT FAILURES IN ADULT SPINE DEFORMITY PATIENTS MATCHING IDEAL ROUSSOULY TYPE

Tobi Onafowokan, MBBS; Ankita Das, BS; Jamshaid Mir, MD; *Pawel P. Jankowski, MD*; Lefko Charalambous, MD; Stephane Owusu-Sarpong, MD; Samuel Montgomery, MD; Nathan Lorentz, MD; Matthew Galetta, MD; Andrew Chen, BS; Neel Anand, MD; Bassel G. Diebo, MD; Alan H. Daniels, MD; Kojo D. Hamilton, MD, FAANS; Han Jo Kim, MD; Zeeshan M. Sardar, MD; Jordan Lebovic, BA; Thomas J. Buell, MD; Aaron Hockley, MD; Nima Alan, MD; M. Burhan Janjua, MD; Daniel M. Sciubba, MD; Justin S. Smith, MD, PhD; Christopher I. Shaffrey, MD; Dean Chou, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Peter G. Passias, MD

Hypothesis

To investigate factors associated with mechanical complications in patients with restored ideal Roussouly type.

Design

Retrospective cohort

Introduction

Restoring ASD patients' ideal Roussouly type is reported to prevent mechanical complications. There remain patients with restored ideal Roussouly type who still suffer these complications. The associated factors are incompletely understood.

Methods

ASD patients with complete data from baseline (BL) to 2 years (2Y) were stratified by matching ideal Roussouly (R) types as described by Latouissat: type 1 & 2 corresponding to pelvic incidence (PI) < 45°, type 3 to PI 45°–60°, & type 4 to PI >60°. Patients matching ideal R types postop and sustaining mechanical complications (Rouss+Mech+) were further isolated. Means comparison tests and logistic regressions were used to analyze differences and associations between groups.

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Results
464 patients were included (Age:60.4 ± 14.9 years, BMI:27.5 ± 5.8 kg/m2, CCI:1.67 ± 1.66). 74% of patients were female. At BL, 8.2% of patients were R type 1, 51.8% type 2, 26.6% type 3 and 13.2% type 4. 41.5% of patients matched ideal R type (43.1% type 1, 30.4% type 2, 40.6% type 3 and 84.9% type 4, p<0.001). Post-op, 50.7% of patients matched ideal R type (40.3% type 1, 43.4% type 2, 55.8% type 3 and 74.6% type 4, p<0.001). At 2 years post-op, patients matching ideal R type experienced lower mechanical complications [MCs] (13% vs 86%, p<0.001). MC rates by R type in patients matching ideal R type (Rouss+Mech+) were 11.1% in type 1, 13.9% type 2, 12.7% type 3 and 15.3% type 4, p=0.930). Factors associated with MC in Rouss+Mech+ were under-correction by persistent pelvic incidence-lumbar lordosis mismatch (OR 1.1, 95% CI 1.1-1.2, p<0.001) and lower limb arthritis (OR 2.4, 1.2-4.9, p=0.024). Rouss+Mech+ had lower rates of matching in sagittal age-adjusted score compared to Rouss+Mech- at BL (27.3 vs 33.8%, p<0.001), postop (27.3 vs 31.4%, p<0.001), and at all timepoints up to 2 years. Rouss+Mech+ also had higher rates of reoperation at 2 years (58.3% vs 16.7%, p<0.001).

Conclusion
Although uncommon, patients matched to ideal Roussouly shape post-op may still experience mechanical complications. Inadequate realignment and lower limb arthritis are associated with increased risk within two years, and thus warrant consideration during ASD surgery planning.

14. OPTIMIZING LOWER INSTRUMENTED VERTEBRA SELECTION IN ADULT IDIOPATHIC SCOLIOSIS USING PREOPERATIVE UPRIGHT AND SUPINE LAST TOUCHED VERTEBRA

Josephine R. Coury, MD; Fthimnir Hassan, MPH; Gabriella Greisberg, BS; Justin Reyes, MS; Alexandra Dionne, BS; Yong Shen, BA; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

Hypothesis
Selecting the supine last touched vertebra (LTV) as the lower instrumented vertebra (LIV) in Adult Idiopathic Scoliosis (AdIS) yields alignment outcomes similar to upright LTV.

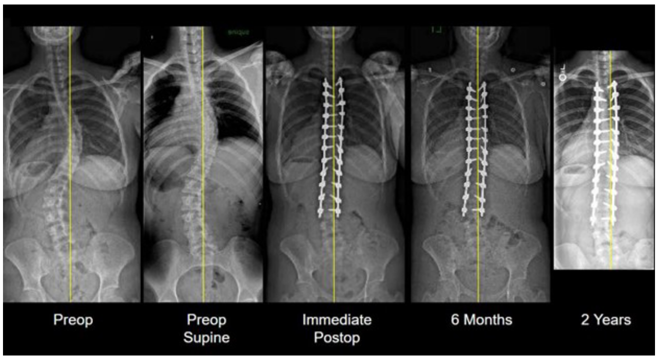
Design
Retrospective Cohort

Introduction
LIV selection in AdIS presents challenges in achieving optimal alignment while minimizing fused motion segments. Traditionally in adolescent scoliosis, the LTV on upright films is selected, however recent literature supports using the supine LTV. This study compared LTV as LIV on upright and supine radiographs.

Methods
AdIS patients fused proximal to the sacrum and ≥2-year follow-up were included. Radiographic measurements occurred pre/post surgery, at 6 months, and 1 and 2 years. 6 groups were formed based on LTV/LIV: 1)upright LTV=supine LTV=LIV; 2)upright LTV=LIV; 3)supine LTV=LIV. Modifiers A/B indicated if LTV was crossed at/medial versus lateral to the pedicle.

Results
55 AdIS patients were identified with 2.6year follow-up (R=2-6), significant coronal deformity (ave. curve 57°, R=34°-136°), and LIV between T12-L5. Trunk shift decreased from 18mm preop to 7mm at 2 years(F=10.33,p<0.01). C7-SVA improved from 23mm preop to 11mm in 2 years(F=9.58,p<0.01). Distal disc angle decreased from 2.8° to 0.7° in 2 years(F=8.18,p<0.01). No distal adding on, junctional kyphosis, or revision surgery occurred. The most notable differences were observed between groups A(n=36) and B(n=17). At 6 months and 2 years, the distance from CSVL to LIV was lower in groups 1A(n=6), 2A(n=18), 3A(n=13) versus 1B(n=3), 2B(n=6), 3B(n=9)(3.7vs7.5,F=9.0,p=0.004; 3.2vs6.9,F=6.7,p=0.01). This distinction was seen immediately postop and at 2 years in trunk shift(10.8vs18.4,F=4.03,p=0.05; 5.2vs9.3,F=5.3,p=0.03) and at 2 years in C7-SVA(7.6vs16.5,F=14.9,p=0.003). Group 3B had a larger distance from CSVL to LIV at 6 months compared to 1A/2A(8.0vs2.3/2.8,F=2.7,p<0.03). Trunk shift was lower in 2A vs 3B immediately and at 6 months(7.4vs23.3,F=2.6,p=0.07; 5.22vs18.7,F=2.2,p=0.01). C7-SVA was lower immediately and at 2 years in 2A vs 3B(11.0vs 26.0,F=2.85,p=0.03; 7.2vs18.3,F=3.38,p=0.01). No other differences were found.

Conclusion
Supine LTV touching the pedicle is a viable LIV strategy in AdIS. Preoperative CSVL lateral to the LIV pedicle correlates with residual trunk shift and CSVL-LIV distance.



24F Grade 3A (upright LTV=L5, supine LTV=L3) fused to L3 with minimal residual deformity

15. ANATOMICAL PELVIC PARAMETERS USING THE ANTERIOR PELVIC PLANE IN HEALTHY VOLUNTEERS: A KEY FOR NATURAL SAGITTAL ALIGNMENT OF ADULT SPINAL DEFORMITY

Masayuki Ohashi, MD, PhD; Kazuhiro Hasegawa, MD, PhD; Shun Hatsushikano, BS; Kei Watanabe, MD, PhD; Hideki Tashi, MD; Keitaro Minato, MD, PhD; Tatsuo Makino, MD; Masayuki Sato, MD

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

PODIUM PRESENTATION ABSTRACTS

Hypothesis
Anatomical pelvic parameters based on the anterior pelvic plane (APP) are correlated with sagittal spinal parameters in the standing position.

Design
A cross-sectional study

Introduction
We aimed to estimate the natural standing sagittal alignment in patients with adult spinal deformity (ASD), firstly investigating the normative values of anatomical pelvic parameters based on the APP in a healthy population and to clarify the relationships between the anatomical pelvic parameters and standing sagittal parameters.

Methods
We analyzed the images of biplanar slot-scanning full body stereoradiography in 140 healthy Japanese volunteers (mean age, 39.5 years; 59.3% female). Anatomical sacral slope (SS) and pelvic tilt (PT) (aSS and aPT, respectively) were calculated as the angles of the SS and PT in reference to the APP (Figure). We analyzed bivariate correlations between the anatomical pelvic parameters and standing sagittal parameters.

Results
The mean APPA was 0.7° ± 6.4° (range, −16.8° to 15.5°), indicating that the pelvis was tilted anteriorly by an average of 0.7°. Further, the mean values of the pelvic incidence (PI), aSS, and aPT were 50° (28.8°–74.2°), 36.8° (18.3°–64.9°), and 13.2° (−0.6° to 28.7°), respectively. Anatomical pelvic parameters were significantly correlated with standing sagittal parameters, except for cervical lordosis and T4–12 thoracic kyphosis (TK) (Table). aPT and aSS were significantly correlated with several sagittal parameters which were not correlated with PI. L4–S1 lumbar lordosis was significantly correlated with aPT (r = -0.271, p = 0.001) and aSS (rs = 0.264, p = 0.002) but not with PI. Moreover, the distance between the center of the acoustic meati and gravity line was significantly correlated with aPT (r = -0.260, p = 0.002), and T1–12 TK was significantly correlated with aSS (rs = 0.172, p = 0.042).

Conclusion
We found novel relationships between the anatomical characteristics of pelvis (aPT and aSS) and standing sagittal parameters, which were not represented by PI. Therefore, this novel measurement concept based on the APP, and our results from a healthy population, may aid the precise estimation of natural standing sagittal alignments using anatomical pelvic parameters in patients with ASD.

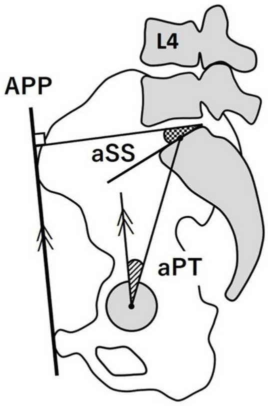


Table: Correlations between anatomical and standing sagittal parameters

	PI	aPT	aSS
Age	0.05	-0.064	0.151
BMI	-0.153	-0.122	-0.037
CAM-GL	-0.105	-0.260**	0.052
SVA	0.205*	-0.006	0.244**
T1 pelvic angle	0.668***	0.507***	0.343***
Cervical lordosis	0.022	-0.048	0.133
T1-12 TK	0.067	-0.122	0.172*
T4-12 TK	0.028	-0.131	0.128
L1-S1 LL	0.475***	0.036	0.514***
L4-S1 LL	0.051	-0.271**	0.264**
PT	0.657***	0.571***	0.294***
SS	0.628***	0.046	0.641***

CAM-GL, distance between the center of the acoustic meati and gravity line.
*p <0.05, **p <0.01, ***p<0.001

Anatomical pelvic parameters based on anterior pelvic plane (PI, aSS, and aPT) and correlations with standing sagittal parameters

16. PREDICTIVE ROLE OF FRAX IN POSTOPERATIVE PROXIMAL JUNCTIONAL KYPHOSIS WITH VERTEBRAL FRACTURE AFTER ADULT SPINAL DEFORMITY SURGERY

Junya Katayanagi, MD, PhD

Hypothesis
FRAX, an osteoporosis assessment tool, can predict the occurrence of postoperative proximal junctional kyphosis (PJK) with vertebral fracture (VF) in adult spinal deformity (ASD) surgery patients.

Design
Retrospective cohort study

Introduction
A retrospective study included 127 ASD surgery patients (mean age 67.7 years, mean follow-up 7.7 years). Inclusion criteria were ASD patients aged ≥50, abnormal radiographic variables, and corrective spinal fusion of six or more segments. FRAX, BMD, and various surgical intervention factors were assessed. PJK with VF was defined according to Yagi-Boachie classification. Statistical analyses included Mann-Whitney test, Fisher's exact test, Kaplan-Meier analysis, and Cox proportional hazards regression.

Methods
This retrospective study included 127 ASD patients who underwent corrective surgery. Inclusion criteria comprised patients aged ≥ 50 years, abnormal radiographic variables, corrective long spinal fusion of six or more segments, and a postoperative follow-up of 2 years or more. FRAX scores, BMD measurements, surgical intervention factors, and outcomes related to PJK with VF were analyzed. Statistical analyses included Kaplan-Meier survivorship analysis, and Cox proportional hazards regression.

Results
Postoperative PJK occurred in 31.5% of patients, with 65% being PJK with VF. FRAX (MOF > 15%) and lower instrumented vertebra (LIV) level were independent risk factors for PJK with VF, and the hazard ratio was 2.52 and 9.03 respectively. The median time to PJK with VF occurrence

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was 2.0 months, with 73% occurring within 6 months postoperatively.

Conclusion

FRAX (MOF > 15%) and LIV (caudal to S1) are identified as independent risk factors for postoperative PJK with VF in ASD surgery patients. Early intervention for osteoporosis, guided by FRAX, may reduce the risk of PJK with VF. Surgeons should consider FRAX in preoperative evaluations for ASD surgery to enhance patient outcomes and reduce complications.

17. ENHANCING SPINAL DEFORMITY SURGERY OUTCOMES: A NOVEL APPROACH USING INTRAOPERATIVE EXTENDED PELVIC TILT LINE PARAMETERS TO PREDICT MECHANICAL FAILURE

Jae-Koo Lee, MD; Seung-Jae Hyun, MD, PhD; Sunho Kim, MD; Seung-Ho Seo, MD; Kwang-Ui Hong, MD

Hypothesis

This study hypothesizes that intraoperative extended pelvic tilt (ePT) line parameters can be a reliable predictor of postoperative mechanical failure (MF) in spinal deformity surgeries, thereby aiding in improving surgical planning and patient outcomes.

Design

A retrospective single-center study.

Introduction

Spinal deformity surgery relies heavily on preoperative planning using angular parameters. However, accurately predicting patient alignment in an erect position intraoperatively is a significant challenge. This study introduces an innovative approach, utilizing intraoperative parameters based on an ePT line to predict postoperative outcomes and alignments.

Methods

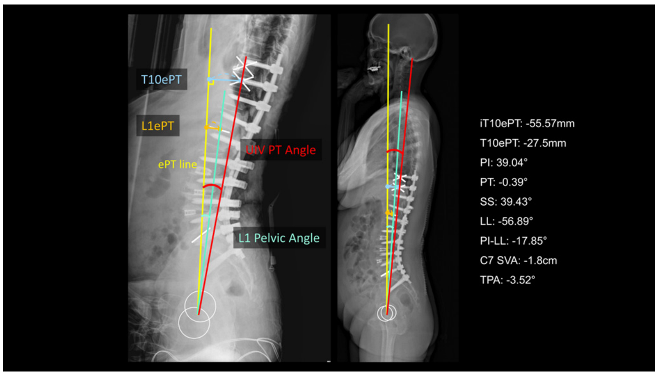
The study involved 46 patients who underwent surgery for degenerative sagittal imbalance with sacropelvic fixation and UIV from T8 to 11 from 2014 to 2019, ensuring a minimum follow-up of two years. Patients were stratified into two groups based on the occurrence of mechanical failure. A detailed analysis encompassed demographic, surgical, and radiographic parameters, with a focus on the novel ePT line, delineated as a line intersecting both bifemoral head points and the sacral endplate center. Intraoperative parameters such as the T10/L1ePT metric, L1 pelvic angle (L1PA), and UIVPTA were introduced and analyzed. The cut-off values for each parameter were established using Youden's index to maximize sensitivity and specificity.

Results

Out of the 46 patients, 25 suffered from mechanical failure. Significant differences were observed between the MF and non-MF groups in terms of T10ePT (12.7 ± 45.0mm vs. 46.5 ± 51.3mm, p=0.02), L1ePT (24.2 ± 31.3mm vs. 45.7 ± 35.1mm, p=0.04), L1PA (5.1 ± 6.4° vs. 9.1 ± 6.9°, p=0.048), and UIVPTA (1.6 ± 6.8° vs. 7.0 ± 7.7°, p=0.017). Binary logistic regression revealed significant odds ratios for T10ePT (5.41, CI: 1.41-20.77), L1PA (5.54, CI: 1.30-23.67), and UIVPTA (5.69, CI: 1.56-20.76), highlighting their predictive value for MF.

Conclusion

This first-of-its-kind study demonstrates that incorporating linear measurements with angular parameters in intraoperative ePT line assessments can predict MF in spinal deformity surgeries. Achieving targeted values intraoperatively could reduce MF risks, suggesting a novel approach for surgical planning. These findings have potential implications for improving patient outcomes in spinal deformity surgeries.



ePT line parameter

18. HEALTH UTILITY OUTCOMES FOLLOWING SURGERY FOR ADULT THORACOLUMBAR SPINAL DEFORMITY

David Ben-Israel, MD; Justin S. Smith, MD, PhD; Brian Park, MD; Thomas J. Buell, MD; Michael P. Kelly, MD; Robert K. Eastlack, MD; Jeffrey L. Gum, MD; Virginie Lafage, PhD; Renaud Lafage, MS; Alex Soroceanu, MD, FRCS(C), MPH; Bassel G. Diebo, MD; Eric O. Klineberg, MD; Han Jo Kim, MD; Breton G. Line, BS; Pratibha Nayak, PhD, MBA, MPH; Themistocles S. Protopsaltis, MD; Peter G. Passias, MD; Gregory M. Mundis Jr., MD; K. Daniel Riew, MD; Khaled M. Kebaish, MD; Paul Park, MD; Munish C. Gupta, MD; Frank J. Schwab, MD; Douglas C. Burton, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Shay Bess, MD; Richard Hostin, MD; International Spine Study Group

Hypothesis

Health utility significantly improves following surgery for thoracolumbar ASD.

Design

Retrospective analysis of prospectively collected multicenter registry data

Introduction

Health utility is a fundamental patient reported outcome which assesses the impact of a disease or treatment on a patient's quality of life and is critical in performing cost-effectiveness analyses. This is particularly relevant in ASD which portends high treatment risks and costs. Currently there is a paucity of published data detailing the expected change in utility following surgery.

Methods

Patients within a surgical prospective multicentered ASD registry with SF-36 data and ≥2 years follow-up were

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included. SF-6D utility was calculated using US health preferences. ΔUtility was defined as the difference between ≥2 year and preoperative SF-6D, and was dichotomized into < 0 (bad) and ≥ MCID=0.033 (good). Linear and logistic regression were used to explore factors associated with ΔUtility and probability of good outcome, respectively.

Results

Of the 1487 included patients, 1073 (72.3%) were female, with a preoperative median [IQR] age of 64.4 [55.5, 70.4], ODI of 46 [34, 58], and SRS-22r of 2.8 [2.3, 3.2]. Surgery involved a median of 10 [8, 14] fused levels, with 256 (17.2%) having a 3-column osteotomy. Median preoperative SF-6D, ≥2 year SF-6D, and ΔUtility were 0.556 [0.485, 0.616], 0.649 [0.579, 0.757], and 0.0840 [0.016, 0.166] respectively. The 696 (70.6%) patients with good outcome had a median ΔUtility of 0.130 [0.077, 0.202], which is similar to that seen following total hip arthroplasty. In multivariate linear regression, higher preoperative NRS back and leg pain were both associated with greater ΔUtility (β = 0.00380, p = 0.041 and β = 0.00258, p = 0.048 respectively) while PJK leading to revision surgery was associated with decreased ΔUtility (β = -0.0539, p = 0.0023). Multivariate logistic regression revealed that a 3-column osteotomy was associated with lower likelihood of a good outcome (OR=0.549, p=0.0052).

Conclusion

Surgery for thoracolumbar ASD imparts significant improvement in SF-6D utility, with a median increase of 0.0840. This represents the highest quality available evidence for predicting the expected postoperative utility in ASD. Significant factors on multivariate analyses included NRS back and leg pain, 3-column osteotomy, and PJK requiring revision surgery, all of which represent pertinent areas of future research.

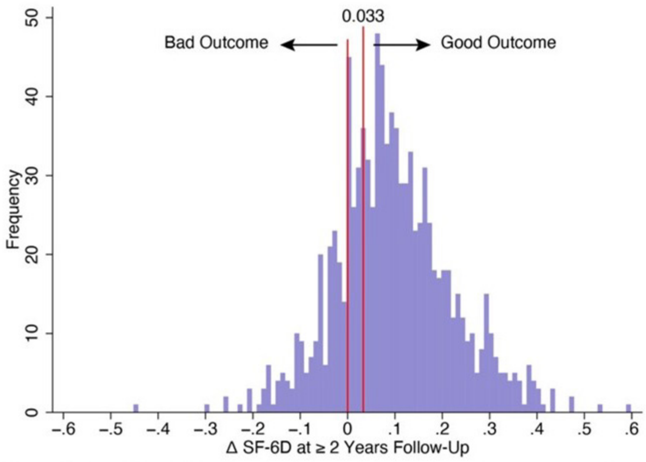

Figure 1: Distrubtion of the difference between ≥ 2 year follow-up and preoperative SF-6D Utility following surgery for thoracolumbar ASD

19. COMPARATIVE STUDY BETWEEN TERIPARATIDE AND DENOSUMAB ON THE PREVENTION OF PROXIMAL JUNCTIONAL KYPHOSIS: PROSPECTIVE, RANDOMIZED CONTROLLED TRIAL

Ho-Joong Kim, MD

Hypothesis

Teriparatide treatment is effective in preventing PJK (Proximal Junctional Kyphosis) in patients with osteoporosis undergoing ASD (Adult Spinal Deformity) surgery.

Design

Prospective, randomized controlled trial

Introduction

The purpose of this ramdomized controlled trial was to compare the incidence of Proximal Junctional Kyphosis(PJK) in patients with osteoporosis receiving teriparatide or denosumab after adult spinal deformity (ASD) surgery.

Methods

Each 32 ASD patients were randomly assigned to parathyroid hormone group and denosumab group. The treatment with teriparatide or denosumab for both groups was conducted from three months before surgery to three months after surgery, based on the standard regimen for each medication. The primary outcome of this trial was the occurrence of PJK or PJF within one year post adult spinal deformity surgery. Secondary outcomes included Patient-reported outcomes (PROs), Bone Mineral Density (BMD), and Dual-energy X-ray Absorptiometry (DEXA) t-score.

Results

In the primary outcome, regarding PJK (Proximal Junctional Kyphosis) incidence, the teriparatide group had a lower rate of 16.7%, compared to 30.8% in the denosumab group, but this difference was not statistically significant (p=0.243 in a modified intention to treat analysis). However, for PJF (Proximal Junctional Failure) incidence, the teriparatide group exhibited a significantly lower rate of 0.0%, as opposed to 19.2% in the denosumab group. In the secondary outcome, at the 1-year follow-up, there were no significant differences in hip Bone Mineral Density (BMD) and DEXA t-score between the two groups. Postoperatively, the teriparatide group showed a significantly lower score in the Visual Analog Scale (VAS) for back pain and a significantly higher score in EQ-5D and SRS-22 pain score. There were no significant differences in other patient-reported outcome measures.

Conclusion

In patients with osteoporosis undergoing ASD surgery, the rate of PJF was lower in those receiving teriparatide treatment compared to those receiving denosumab treatment. In terms of patient-reported outcomes related to pain, patients who received teriparatide treatment showed better results compared to those who received denosumab treatment.

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20. PERIOPERATIVE CHANGE IN BONE QUALITY FOLLOWING THORACOLUMBAR FUSION AND ITS EFFECTS ON POSTOPERATIVE OUTCOMES

Hannah A. Levy, MD; Caden Messer, BS; Tissiana Vallecillo, BS; Zachariah W. Pinter, MD; Anthony L. Mikula, MD; Mohamad Bydon, MD; Jeremy L. Fogelson, MD; Benjamin D. Elder, MD, PhD; Bradford L. Currier, MD; Ahmad Nassr, MD; Brett A. Freedman, MD; Arjun Sebastian, MD; Brian Karamian, MD

Hypothesis

In long-construct thoracolumbar fusions, there will be a postoperative decrease in CT vertebral Hounsfield Units (HUs) inside the fusion mass and an increase in HUs at the proximal instrumented and adjacent vertebral level that is more pronounced if junctional complications occur.

Design

Retrospective Cohort Analysis

Introduction

Preoperative CT HUs have been previously associated with adverse outcomes after spinal fusion including pseudoarthrosis, screw loosening, and reoperation. No existing studies have investigated the preoperative to postoperative change in vertebral HUs after spinal fusion.

Methods

All adult patients who underwent posterior thoracolumbar fusion (upper instrumented vertebrae [UIV]: T10-L2 to pelvis) for deformity at an academic center between 2010-2018 were retrospectively identified. Preoperative and postoperative HUs were assessed on axial CT images in the cranial, middle, and caudal cut of UIV+1, UIV, L3, L4, and L5 vertebral bodies, outside of the region of hardware and artifact in postoperative CTs, by two reviewers with interrater correlations. Primary outcomes included fusion status on CT (one-year) and proximal junctional kyphosis (PJK) and failure (PJF) on final XR (>2 years postoperatively). Paired t-tests compared pre- to post-operative changes in HUs. Logistic regressions determined if perioperative HU changes (Δ) predicted complications independent of preoperative HUs. Receiver operating curve (ROC) analyses determined the probability of PJK and PJF based on ΔHUs.

Results

A total of 136 patients were included. The average pre- to post-operative change in HUs in the UIV+1, UIV, L3, L4, and L5 vertebral bodies were 59.2 ($p<0.001$), 83.6 ($p<0.001$), 30.8 ($p=0.005$), 5.0 ($p=0.640$), and 2.5 ($p=0.912$) respectively, with all interrater correlations >85%. Decrease in L3 (OR=0.997, $p=0.008$) and L4 (OR=0.998, $p=0.017$) ΔHUs independently predicted fusion. On logistic regression UIV+1 ΔHUs (OR=1.01, $p<0.001$) independently predicted PJK and UIV ΔHUs (OR=1.002, $p=0.006$) independently predicted PJF. ROC identified an optimal UIV+1 ΔHUs cutoff of 73.9 (AUC=0.71) and UIV ΔHUs cutoff of 109.6 (AUC=0.73) to predict PJK and PJF, respectively.

Conclusion

Perioperative decreases in mid-construct HUs secondary to stress shielding predicted successful fusion. However, perioperative increases in upper construct and adjacent level HUs predicted proximal junctional complications.

21. CREATING SUSTAINABILITY IN CENTERS PERFORMING HIGH VOLUME ADULT SPINAL DEFORMITY SURGERY: EVALUATION OF THE MARYLAND ALL-PAYER MODEL

Andrew Kim, BS; Micheal Raad, MD; Richard Hostin, MD; Shay Bess, MD; Jeffrey L. Gum, MD; Breton G. Line, BS; Pratibha
Nayak, PhD, MBA, MPH; Virginie Lafage, PhD; Renaud Lafage, MS; Kojo D. Hamilton, MD, FAANS; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Lawrence G. Lenke, MD; Alex Soroceanu, MD, FRCS(C), MPH; Justin S. Smith, MD, PhD; Christopher P. Ames, MD; Bassel G. Diebo, MD; Eric O. Klineberg, MD; Alan H. Daniels, MD; Han Jo Kim, MD; Robert K. Eastlack, MD; Michael P. Kelly, MD; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Douglas
C. Burton, MD; Khaled M. Kebaish, MD; International Spine
Study Group

Hypothesis

Reimbursement for adult spinal deformity (ASD) surgery under the Maryland All-Payer Model (MAPM) will be higher than the Medicare Severity-Diagnosis Related Group (MS-DRG) model.

Design

Multicenter prospective study

Introduction

The MAPM is a healthcare payment system that ensures all payors pay the same rate for healthcare services. The MS-DRG model is used by all other states, where payments are influenced by factors such as geographic location and teaching hospital status. With Medicare allowable rates underestimating direct costs of ASD surgery by approximately $17,000, the MAPM ensures the sustainability of centers performing high volume ASD surgery on Medicare patients. The purpose of this study is to examine differences in reimbursement and inpatient length of stay (LOS) in ASD surgery between the MAPM and MS-DRG models.

Methods

A total of 416 ASD patients were examined. MS-DRG reimbursements were calculated using the CMS Pricer tool, while reimbursements for the MAPM were compiled from a single institution from 1,783 patient accounts. Payments for the most common ASD MS-DRG codes (453, 454, 455, 456, 457, 458, 460) were analyzed for fiscal years 2018-2023. Average inpatient LOS was calculated for each MS-DRG code and payer model. Univariate analysis was performed to assess for differences in mean reimbursements and LOS between models.

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

PODIUM PRESENTATION ABSTRACTS

Results
From 2018-2023, overall mean reimbursements for ASD surgery were significantly lower under the MS-DRG model compared to the MAPM ($59,198.59 vs $77,246.28; p<0.001). Mean reimbursement payments for MS-DRG codes 453 ($144,730.73 vs $86,574.54), 454 ($95,316.99 vs $57,716.02), 455 ($55,409.23 vs $39,291.13), 456 ($127,043.70 vs $72,380.38), 457 ($98,011.94 vs $60,669.77), and 460 ($57,207.78 vs $38,856.31) were higher under the MAPM compared to the MS-DRG model (p<0.001). Mean LOS was lower in the MAPM for MS-DRG code 453 (p=0.046) and higher for code 457 (p<0.001). For all other codes, no significant difference in LOS was observed.

Conclusion
ASD surgery reimbursements are higher overall under the MAPM compared to the MS-DRG model with similar inpatient LOS. These results highlight how the MAPM can create financial sustainability in centers performing high volume ASD surgery on Medicare patients.

Table 1. Reimbursement and LOS by MS-DRG code between models

MS-DRG Code	MS-DRG Model Mean (SD)	Maryland All-Payer Model Mean (SD)	p-value
453 - Combined anterior/posterior spinal fusion with MCC			
Total (*n*)	46	85	
Reimbursement	86,574.54 (19,229.26)	144,730.73 (79,766.41)	< **0.001**
LOS, *days*	9.31 (4.36)	7.50 (4.57)	**0.046**
454 - Combined anterior/posterior spinal fusion with CC			
Total (*n*)	181	332	
Reimbursement	57,716.02 (12,208.51)	95,316.99 (39,626.34)	< **0.001**
LOS, *days*	7.23 (5.85)	7.50 (4.57)	0.599
455 - Combined anterior/posterior spinal fusion without CC/MCC			
Total (*n*)	25	146	
Reimbursement	39,291.13 (10,003.48)	55,409.23 (13,439.77)	< **0.001**
LOS, *days*	4.04 ± (1.09)	4.03 (1.77)	0.977
456 - Spinal fusion except cervical with spinal curvature or malignancy or infection or extensive fusions with MCC			
Total (*n*)	21	65	
Reimbursement	72,380.38 (8,310.69)	127,043.70 (86,087.43)	< **0.001**
LOS, *days*	13.79 (18.51)	16.77 (17.15)	0.515
457 - Spinal fusion except cervical with spinal curvature or malignancy or infection or extensive fusions with CC			
Total (*n*)	96	287	
Reimbursement	60,669.77 (12,213.56)	98,011.94 (42,487.77)	< **0.001**
LOS, *days*	6.43 (2.95)	8.99 (7.10)	< **0.001**
458 - Spinal fusion except cervical with spinal curvature or malignancy or infection or extensive fusions without CC/MCC			
Total (*n*)	29	65	
Reimbursement	45,158.86 (7,037.20)	51,813.92 (32,989.71)	0.125
LOS, *days*	4.06 (2.09)	3.94 (2.28)	0.793
460- Spinal fusion except cervical without MCC			
Total (*n*)	18	803	
Reimbursement	38,856.31 (8,865.15)	57,207.78 (26,530.69)	< **0.001**
LOS, *days*	6.28 (3.95)	5.12 (3.86)	0.208
Overall			
Total (*n*)	416	1,783	
Reimbursement	59,198.59 (16,926.18)	77,246.28 (26,106.95)	< **0.001**

MS-DRG: Medicare Severity Diagnosis-Related Group; *MCC*: major complicating or comorbid condition; *CC*: complicating or comorbid condition; *LOS*: length of stay

22. INFLUENCE OF IMPLANT DENSITY ON MECHANICAL COMPLICATIONS IN ADULT SPINAL DEFORMITY SURGERY

Yann Philippe Charles, MD, PhD; Francois Severac, MD; Sleiman Haddad, MD, PhD, FRCS; Caglar Yilgor, MD; Ahmet Alanay, MD; Ibrahim Obeid, MD; Louis Boissiere, MD; Frank S. Kleinstueck, MD; Markus Loibl, MD; Javier Pizones, MD, PhD; Ferran Pellisé, MD, PhD; European Spine Study Group; Susana Núñez Pereira, MD

Hypothesis
In adult spinal deformity surgery, the use of double rods and interbody cages are intended to decrease rod strain and the risk for pseudarthrosis. Rigid instrumentation might increase stress at construct extremities and the risk for proximal junctional kyphosis/failure (PJK/PJF) or screw loosening.

Design
Retrospective register study.

Introduction
The purpose of this study was to analyze how rod characteristics, screw density and cages could influence the incidence of mechanical complications compared to patient-related factors and alignment.

Methods
Multi-center register data of patients with T9-T11 to pelvis instrumentation and follow-up ≥2 years was analyzed. Relative lumbar lordosis (RLL) and relative sagittal alignment (RSA) was measured. Surgical data included rod characteristics, pedicle screw density and interbody cages. Univariate logistic regression models analyzed the impact of patient- and implant-related factors on complications. Multivariable models were then used for clinically relevant and significant (p<0.2) variables.

Results
Among 302 patients, pseudarthrosis was evidenced in 24.1%. On univariate analysis Odds Ratio (OR) was 0.74 for ≥3 cages (p=0.452), 0.48 for double rods (p=0.008), 4.30 for high screw density 1.5-2 (p=0.001). Patient-related factors were non-significant. On multivariate analysis OR was 0.59 for double rods (p=0.084) and 4.67 for screw density 1.5-2 (p=0.005). PJK/PJF occurred in 19.2%. Age >60 had an OR 2.83 (p=0.023), postoperative RSA malaligned OR 2.84 (p=0.030), severely malaligned OR 6.54 (p<0.001). Implant characteristics were non-significant. On multivariate analysis OR was 1.25 for age >60 (p=0672), 2.56 for malaligned RSA (p=0.068), 6.37 for severely malaligned RSA (p<0.001). Screw loosening without PJF was present in 8.9%. On univariate analysis OR was 0.95 for ≥3 cages (p=0.920), 1.64 for double rods (p=0.235), 0.25 for screw density 1.5-2 (p=0.011). Patient-related factors were non-significant. On multivariate analysis OR for screw density 1.5-2 was 0.23 (p=0.022).

Conclusion
Double rods decrease the risk for pseudarthrosis. Cages seem to have a secondary role in load sharing. High screw density does not prevent from pseudarthrosis. Postoperative malalignment and age mainly influence the risk for PJK/PJF. Implant characteristics have a minor influence and rigid constructs don't increase the risk. High density screw constructs have a lower risk for screw loosening.

23. ACHIEVING CORRECTION AND MITIGATING COMPLICATIONS IN ADULT SPINAL DEFORMITY THROUGH AN ANTERIOR-POSTERIOR COMBINED APPROACH: 1 OR 2-LEVEL APICAL SEGMENT INTERBODY FUSION IS ENOUGH?

Dongkyu Kim, MD; Kyunghyun Kim, MD, PhD

Hypothesis
To assess the adequacy of 1 or 2-level apical segment interbody fusion for achieving correction and mitigating complications in adult spinal deformity through an

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anterior-posterior combined approach compared to posterior only approach.

Design

Retrospective study from prospective consecutively collected database from a single institution.

Introduction

Adult spinal deformity (ASD) can be effectively treated by posterior approach, but at the expense of invasive osteotomies and excessive blood loss. Addition of anterior approach in ASD correction surgery can reduce the invasiveness of the surgery, but major anterior-related complications are also reported. There is still debate regarding which approach is more favorable, and the optimal strategy of combining anterior approach is not yet established.

Methods

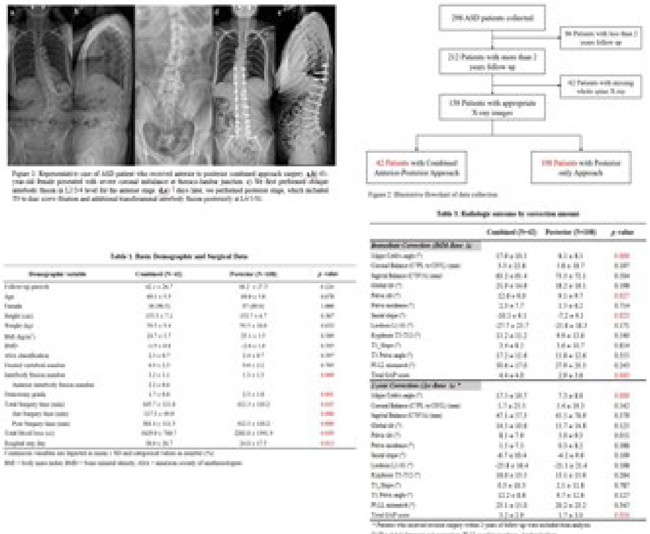
Between January 2014 and May 2021, a cohort of 150 ASD patients with a minimum follow-up period of 2 years was collected. Of the 150 ASD patients, 108 underwent a posterior-only surgical approach (P group), whereas 42 underwent a combined approach surgery (AP group). Comprehensive baseline demographic and surgery-related data were collected. Serial standing radiographs of radiological parameters were acquired at baseline, immediately postoperatively, and 2 years postoperatively. Various clinical outcomes were assessed and the incidents of complications were recorded.

Results

AP group showed significantly less invasive osteotomy (1.7 vs. 2.3, p=0.001), less total blood loss (1629.0 cc vs. 2202.8 cc, p=0.049), and a shorter duration of surgery during the posterior stage (301.4 min vs. 412.3 min, p<0.001). AP group achieved more significant correction in coronal imbalance, as measured by Cobb angle correction (17.5 vs. 7.3, p<0.001). Additionally, AP group demonstrated a statistically significant improvement in the Global Alignment and Proportion (GAP) score compared to P group, regarding sagittal imbalance correction. Both groups exhibited comparable clinical outcomes, complication rates, and fusion rates, with no statistically significant differences noted.

Conclusion

Apical one or two level anterior lumbar interbody fusion combined with posterior approach showed superior coronal correction and comparable sagittal correction with less invasive osteotomy and less blood loss without occurrence of major complications.



24. SPINAL DEFORMITY SURGERY IN PATIENTS WITH MOVEMENT DISORDERS: TRADE-OFF BETWEEN INCREASED COMPLICATIONS AND IMPROVED LONG-TERM QUALITY OF LIFE

Omar Zakieh, MBBS; Hani Chanbour, MD; Ambika Paulson, MD; Walter Navid, BS; Iyan Younus, MD; David C. Liles, MD; Ranbir Ahluwalia, MD; Christopher M. Bonfield, MD; Julian Lugo-Pico, MD; Amir M. Abtahi, MD; Byron F. Stephens, MD; Scott Zuckerman, MD, MPH

Hypothesis

Patients with movement disorders undergoing adult spinal deformity (ASD) surgery have a worse postoperative course compared to patients without movement disorders.

Design

Retrospective cohort study.

Introduction

Movement disorders have been associated with poor outcomes after ASD surgery. In a cohort of patients undergoing ASD surgery, we sought to: 1) describe the operations performed in patients with movement disorders, 2) determine the impact of movement disorders on mechanical complications, reoperations, and patient-reported outcome measures (PROMs).

Methods

A single-institution, retrospective cohort study was performed for patients with a movement disorder undergoing ASD surgery from 2009-21. Inclusion criteria were: ≥5-level fusion, spinal deformity, and 2-year follow-up. Postoperative outcomes included mechanical complications, reoperations, and patient-reported outcome measures. A 3-1 propensity matching was performed, based on age, sex, BMI, and prior surgery.

Results

Among 238 patients undergoing ASD surgery, 10 (4.2%) had a movement disorder. Five (50.0%) had Parkinson's Disease and 5 (50.0%) had Essential Tremor. No significant difference was found in the type of surgery performed between patients with and without movement

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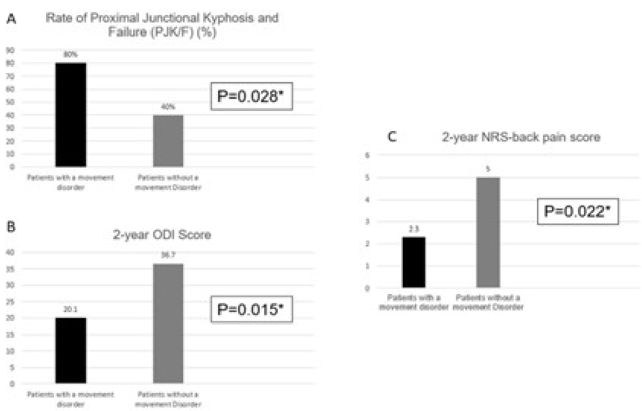
disorders, including total instrumented levels (p=0.101), three-column osteotomy (p=0.361), and pelvic instrumentation (p=0.729). No significant difference was found in preoperative or postoperative radiographic variables. Patients with movement disorders developed a higher rate of proximal junctional kyphosis and failure (PJK/F) (80% vs. 40%, p=0.028) without a significant difference in other mechanical complications or reoperations. Patients with movement disorders had better 2-year ODI (20.1±12.5 vs. 36.7±14.3, p=0.015) and 2-year NRS-back pain (2.3±2.5 vs. 5.0±2.4, p=0.022) than patients without movement disorders.

Conclusion

Patients with and without movement disorders ultimately undergo similar ASD operations. Despite a two-fold higher PJK/F rate, movement disorder patients reported better disability and pain at 2-years postoperative compared to non-movement disorder patients.



25. THE PRIORITIZED CORRECTION OF DEFORMITY AT OSTEOTOMY SITE: A NOVEL TECHNIQUE FOR PREVENTING SAGITTAL TRANSLATION IN 3CO OF ADULT SPINAL DEFORMITIES

Chen Ling, MD, PhD; *Zhen Liu, PhD*; Jie Li, MD; Yanjie Xu, MD; Zezhang Zhu, PhD; Yong Qiu, PhD

Hypothesis

The prioritized correction is a straight-forward technique to effectively avoid the massive blood loss and sagittal translation caused by 3-COs in ASD surgery.

Design

A retrospective study.

Introduction

In the surgery for rigid adult spinal deformity (ASD), 3-column osteotomies (3-COs) enable substantial correction but the risk of sagittal translation (ST) is high. Here, we proposed “prioritized correction with multiple rod construct” to reduce the risk of ST in the 3-CO procedure for ASD.

Methods

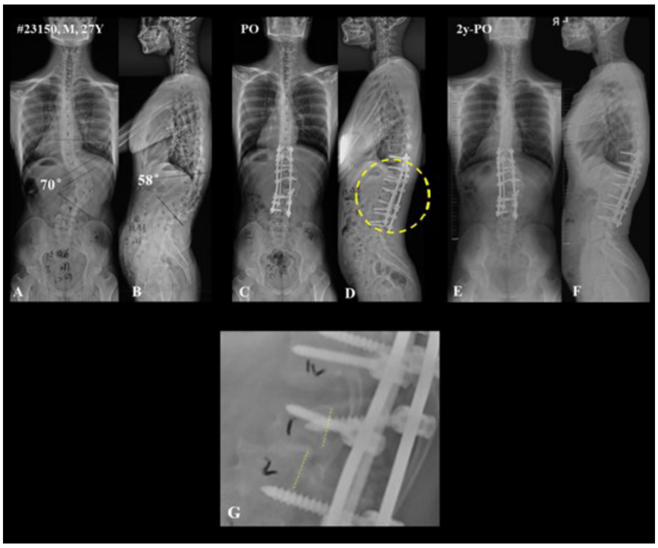
Data of ASD patients who underwent 3-column osteotomies with a minimum 2-year follow-up was collected. Patients were devided: prioritized correction with multiple rod constructs (PC-MRC) group and traditional multiple-rod constructs (M-RC) group. The PC-MRC technique was using one or two short rods to close the osteotomy site when the osteotomy was completed, then restoring the global alignment by the correction maneuver of two long rods. Radiographic and clinical parameters were evaluated preoperatively, postoperatively, and at final follow-up.

Results

A total of 101 patients (mean age: 45.5 years; mean follow-up time: 24.9 months; PC-MRC group: 65 cases; M-RC group: 36 cases; PSO: 64 cases; VCR: 37 cases) were included. The PC-MRC group had significantly shorter operation time and lower estimated blood loss (p=0.045 and 0.007, respectively). The mean correction rate for GK angle was 54.7%±17.0% and 58.3%±18.5%, with no statistical significance (p=0.828 and 0.546, respectively). No significant loss of correction was observed at the final follow-up. ST occurred in 1 case (1.5%) in PC-MRC group and 9 cases (25%) in M-RC group, showing statistical significance (X2=14.296, p<0.001). 5 of the 9 ST cases in M-RC group went through IONM events and developed new neurologic deficit. The total incidence of neurological injury were 5 (7.7%) vs 8 (22.2%) cases between PC-MRC and M-RC groups, respectively, showing statistical significance (X2=4.362, p<0.037).

Conclusion

The prioritized correction with multiple rod construct offers a versatile and rigid fixation for 3-columns osteotomy in ASD Patients with significant correction of global deformity. This is a straight-forward technique can effectively avoid the massive blood loss and sagittal translation caused by 3-COs, and minimize the risk of neurological complication.



M-RC case of patient who developed sagittal translation

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26. PEDICLE SUBTRACTION OSTEOTOMIES VS ANTERIOR COLUMN RECONSTRUCTION: EXAMINING THE RATES OF PSEUDOARTHROSIS

Michael R. McDermott, DO; Kyle Barner, DO; Andre Jakoi, MD; Alfredo J. Guiroy, MD; Ashish Patel, MD; *Joshua Bunch, MD*

Hypothesis
Anterior Column reconstruction with a hyperlordotic implant will have a lower rate of pseudoarthrosis than a pedicle subtraction osteotomy.

Design
Retrospective Cohort

Introduction
Restoring physiologic sagittal and segmental alignment is crucial for improving postoperative outcomes and preventing adjacent segment disease in patients with symptomatic spinal pathologies. Larger sagittal corrections can be accomplished through an anterior column reconstruction (ACR) or a pedicle subtraction osteotomy (PSO). PSOs are maximally invasive and require substantial bony removal to achieve the desired correction. On the other hand, ACR is minimally invasive and achieves correction through the placement of a hyperlordotic implant. Due to the instability that is created through the techniques, fusion may be difficult to achieve. This study was designed to examine the rate of pseudoarthrosis and other surgical parameters of ACR compared to PSO.

Methods
A retrospective review was conducted on patients who underwent an ACR or PSO at two centers. Preoperative and first postoperative radiographic films were measured. Surgical characteristics were recorded and statistically analyzed. The presence or absence of Pseudoarthrosis was confirmed on CT imaging.

Results
Forty-four (44) patients were included in the study, eighteen (18) of which underwent correction with an ACR, and twenty-six (26) had a PSO. Each patient had a single ACR or PSO as part of a multilevel construct, with a total of 317 instrumented levels. The average EBL was significantly lower for the ACR group (287 ± 365 ml) vs the PSO group (1451.2 ± 661 ml, p = <0.0001). There was no difference in length of stay between ACR (4.2 ± 2.5 days) and PSO (4.6 ± 1.3 days). The preoperative lumbar lordosis (LL) was 26.0° ± 11.6. Both ACR and PSO significantly increased the LL (24.7° ± 7.4° vs 23.3 ± 11.5° respectively), and there was no statistical difference in the LL increase between techniques (p = 0.65). The average follow-up for the cohort was 30.5 ± 8.7 months. 4% (1/26) of patients in the PSO group developed pseudoarthrosis compared to 0% (0/18) in the ACR group, these rates were not statistically different (P = 0.41)

Conclusion
ACR and PSO are viable options for size-able sagittal spine correction. ACR is less invasive and has a lower estimated blood loss. There was no difference in lordosis correction or pseudoarthrosis rates in this study.

27. 513 THREE-COLUMN OSTEOTOMIES FOR ADULT SPINAL DEFORMITY: A SINGLE SURGEON EXPERIENCE OVER 17 YEARS

Winward Choy, MD; Jaemin A. Kim, Research Assistant; Terry Nguyen, Research Assistant; Tony Catalan, BS; Austin Lui, MS; Ping-Yeh Chiu, MD; David Mazur-Hart, MD; Vedat Deviren, MD; *Christopher P. Ames, MD*; Aaron J. Clark, MD

Hypothesis
Rates of complications following three column osteotomies have decreased in the modern era.

Design
retrospective cohort study

Introduction
Advances in surgical techniques have aimed to address have historically high rates of complications following three- column osteotomies (3CO). Here we report the largest single center series of 3CO over 17 years in literature to detail the evolution of 3CO and its complication profile.

Methods
Patients undergoing surgery with 3CO for the correction of thoracolumbar adult spinal deformity (ASD) performed by the senior author from 2006 to 2023 were included. Clinical, demographic and radiographic data were retrospectively collected and analyzed. Patients with minimum of 2 years of radiographic follow were included in the assessment of postoperative mechanical failures.

Results
512 patients undergoing 82 (16%) thoracic, 423 (82.6%) lumbar, and 7 (1.3%) sacral 3CO were included. There were 344 (67.1%) pedicle subtraction osteotomies and 148 (32.8%) vertebral column resections. Ligamentoplasty was performed in 40.2%, bone morphogenic protein was used in 35.7%, and multi-rod constructs were used in 70.1% of cases. Overall rate of perioperative complications was 31.3%. Rate of medical complications was 24.6%, most commonly cardiopulmonary (n= 57), infectious (n= 19) and gastrointestinal (n=13). Rate of surgical complications was 8.0% and postoperative neurological deficit was 4.2%. The 1-, 2-, and 5- year reoperation rates were 5.8%, 13.3% and 42%, respectively. The most common indications for reoperation was rod fracture (n = 56), pseudoarthrosis (n = 51), and proximal junctional failure (n = 44). Subgroup analysis by surgical year (2006-16 vs 2017-22) demonstrated significantly decreased rates of rod fracture (3.1 cs 40.2%, p < 0.001), pseudoarthrosis (4.6 vs 28.2%, p <0.001) and proximal junctional kyphosis (17.2 vs 29.3, p = 0.006) in the modern era.

Conclusion
3CO remains a powerful tool in ASD and advances in surgical technique and implementation of preventative measures have resulted in significant decreases in associated complications in the modern era.

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PODIUM PRESENTATION ABSTRACTS

28. NADIR HEMOGLOBIN IS ASSOCIATED WITH LENGTH OF STAY FOLLOWING ADULT SPINAL DEFORMITY SURGERY, BUT IS UNAFFECTED BY STRICT TRANSFUSION THRESHOLDS

Jeffrey L. Gum, MD; Steven D. Glassman, MD; Mladen Djurasovic, MD; Justin Mathew, MD; Morgan Brown, MS; Christy L. Daniels, MS; Colleen Mahoney, BA; Leah Y. Carreon, MD

Hypothesis

Rigid transfusion threshold (RTT) for hemoglobin (Hgb) < 7.5g/dl following ASD surgery leads to longer a longer hospital length of stay (LOS).

Design

Retrospective chart review

Introduction

It is common for patients to require allogenic blood transfusion(s) following adult spinal deformity (ASD) surgery. Following the COVID-19 pandemic, the American Red Cross experienced the worst blood bank shortage in history, resulting in more rigid transfusion thresholds across the United States. The high transfusion rate after ASD surgery coupled with this blood shortage provides opportunity to understand the impact rigid transfusion thresholds following ASD surgery.

Methods

Patients undergoing > 5 level fusions for ASD from 1/1/2021-6/30/2021 (Restricted (RES)) and 3/1/2022-8/31/2022 (Unrestricted (UR)) were identified and compared with respect to demographic, operative and postoperative outcomes including LOS.

Results

A total of ninety-four ASD patients were identified, 43 in the UR interval and 51 in the RES interval. There was no difference in any demographic or surgical parameters (Table). There was no difference in mean nadir Hgb between the cohorts. There was a higher percentage of patients that had a nadir Hgb < 7.5 g/dl in the RES interval (17 patients, 33%) vs UR (8 patients, 17%) but there was no difference the total number of patients reaching nadir values below 9.5, 8.5, or 7.5 g/dl. There was a difference in LOS between these within each cohort. Analysis of all 94 patients revealed that LOS was significantly longer with nadir Hgb values ranging from 8.2 days (<7.5g/dl; 25 patients (27%)), to 6.6 days (7.5-8.5g/dl; 18 patients (19%)), to 5.1 days (8.5-9.5g/dl; 16 patients (17%)), to 3.6 days (>9.5g/dl, 35 patients (37%)).

Conclusion

Implementation of rigid transfusion thresholds following ASD surgery did not appear to impact nadir Hgb values nor LOS. Lower nadir postoperative Hgb values were associated with a longer LOS. Further investigation to understand this association could be beneficial for more objective transfusion recommendations with the potential to reduce length of stay.

	Transfusion Unrestricted	Transfusion Restricted	
N	43	51	
Sex, N (%)			0.533
Females	23 (53%)	31 (61%)	
Males	20 (47%)	20 (39%)	
Age, years, Mean (SD)	56.56 (17.77)	60.12 (16.21)	0.317
BMI, kg/m², Mean (SD)	29.27 (7.88)	32.07 (6.63)	0.131
Estimated Blood Loss, cc, Mean (SD)	517.44 (316.14)	583.24 (426.97)	0.394
Operative Time, min Mean (SD)	266.81 (80.81)	291.88 (101.49)	0.186
Lowest Post-Op Hb, Mean (SD)	9.26 (1.50)	9.03 (2.07)	0.730
Lowest Hb Categorical			0.091
≤7.5	8 (19%)	17 (33%)	
>7.5 / ≤8.5	10 (23%)	8 (16%)	
>8.5 / ≤9.5	11 (26%)	5 (10%)	
≥9.5	14 (33%)	21 (41%)	
LOS, days, Mean (SD)	5.37 (3.71)	5.88 (4.55)	0.551

Mean LOS Pre and Post Transfusion Restriction Stratified by Lowest Hb during Post-operative stay			
	Transfusion Unrestricted	Transfusion Restricted	p-value
N	43	51	
Lowest Hb Categorical			0.275**
≤7.5	7.75 (3.11)	8.35 (6.51)	
>7.5 / ≤8.5	6.50 (5.50)	6.75 (2.25)	
>8.5 / ≤9.5	5.36 (2.87)	4.40 (2.79)	
≥9.5	3.21 (1.58)	3.90 (2.1)	
p-value	0.024*	0.016*	

*within cohort difference (ANOVA)
**between cohort (Pre vs Post) difference

29. LONG-TERM REOPERATION RISK OF THORACIC TO PELVIS INSTRUMENTATION FOR SPINAL DEFORMITY: A LONGITUDINAL STUDY OF 7,060 PATIENTS

Paal Nilssen, BA; Nakul Narendran, BA; David L. Skaggs, MD, MMM; Corey T. Walker, MD; Christopher Mikhail, MD; Edward K. Nomoto, MD; *Alexander Tuchman, MD*

Hypothesis

Reoperation rates following thoracolumbar surgery for spinal deformity are high and associated with patient factors and surgical technique.

Design

Retrospective cohort

Introduction

Most data on thoracolumbar deformity outcome comes from relatively small study groups of surgeons who specialize in complex deformity surgery. While these prospective registries provide high quality data, one must consider if these results align with practices across the United States. The combined ISSG and ESSG dataset, including 1151 surgical patients, reported a 2-year reoperation rate of 20%. We performed a larger-scale assessment of reoperation risk in deformity patients undergoing thoracic to pelvis surgery.

Methods

The PearlDiver database was queried for spinal deformity patients (scoliosis, kyphosis, spondylolisthesis, sagittal plane deformity) undergoing at minimum, a T11-pelvis operation (2010-2020). CPT codes identified lumbar arthrodesis procedures that included pelvic fixation and ≥7 levels of posterior instrumentation on the same day. Minimum follow-up was 2 years. Reoperations included subsequent arthrodesis, decompression, osteotomy, device insertion, and pelvic fixation procedures. Multivariant regression analysis described associations between variables and reoperation risk.

Results
7,060 patients met criteria (mean age: 63.6 ±11.1 years, ECI: 5.0 ±3.6, follow-up: 5.7 ±2.7 years). Overall reoperation rate was 23.2%. Reoperation rate at 2- and 5-year was 16.9% and 22.1% respectively. 10-year reoperation-free probability was 73.7% (95% CI: 72.4-74.9%). Multivariant analysis revealed higher reoperation risk for patients with kyphosis. Patients who received interbody cages had a lower reoperation risk. No association was found between the presence or absence of osteotomy procedures and reoperation risk. Age and ECI did not independently influence reoperation.

Conclusion
This study, representing a real-world cohort of over six times the largest current prospective data set, found a 2-year reoperation rate of 17%, similar to previous studies, suggesting study group findings are applicable to a broader population. Preoperative kyphosis was associated with higher reoperation risk, while the use of interbody cages was protective. Age, medical comorbidities, and osteotomies did not predict reoperations.

Multivariant regression comparing variables with reoperation risk.		
	Odds Ratio	95% CI
Medical Comorbidity		
Osteopenia	0.96	0.83-1.10
Osteoporosis	0.95	0.82-1.13
Diabetes	0.96	0.82-1.14
Smoking	1.06	0.93-1.23
Myelopathy	1.15	0.94-1.40
Radiculopathy	1.11	0.98-1.26
Inflammatory	1.12	0.95-1.31
Infection	1.10	0.81-1.49
Obesity	0.81	0.66-1.00
Prior surgery	1.09	0.96-1.24
Prior trauma	1.14	0.98-1.32
Diagnosis		
Scoliosis	0.95	0.84-1.07
Kyphosis	**1.45**	**1.00-1.31**
Sagittal plane deformity	0.95	0.77-1.16
Spondylolisthesis	1.05	0.93-1.18
Surgical Characteristics		
ALIF	**0.76**	**0.65-0.88**
TLIF	**0.87**	**0.77-0.98**
No interbody	1.23	0.88-1.70
Posterior column osteotomy	0.81	0.57-1.16
Three column osteotomies	0.81	0.59-1.10
No Osteotomy	0.74	0.51-1.18
Bone morphogenic protein	1.09	0.97-1.22

Multivariant Regression for Reoperation Risk

30. HIGHER INTRAOPERATIVE BLOOD LOSS IS ASSOCIATED WITH INCREASED RISK OF INTRAOPERATIVE NEUROMONITORING DATA LOSS FOR THE TYPE 3 SPINAL CORD SHAPE DURING SPINAL DEFORMITY SURGERY

Chun Wai Hung, MD; Fthimnir Hassan, MPH; Nathan J. Lee, MD; Steven G. Roth, MD; Justin K. Scheer, MD; *Joseph M. Lombardi, MD*; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

Hypothesis
For spinal deformity procedures with type 3 spinal cord shapes, there is increased risk of IONM loss with perioperative variables including larger deformities, increased degree of correction, and higher blood loss.

Design
Retrospective cohort study

Introduction
Within the spinal cord shape classification system (SCSCS), type 3 spinal cords (actual cord deformation on apical axial MRI scan) have been shown to be associated with much higher risk of intraoperative neuromonitoring (IONM) data loss. The current study is to identify whether there are variables among type 3 cord shapes that further predicts the likelihood of IONM changes within this subgroup.

Methods
This is a retrospective cohort study of consecutive patients with type 3 spinal cords undergoing spinal deformity surgery from a single academic institution between 2016-2023. The primary outcome examined was whether there was IONM data loss. Demographic, clinical, operative, and radiographic variables were compared in those patients with and without IONM data loss.

Results
A total of 79 patients with type 3 spinal cords meeting the inclusion criteria were identified. Of these, 30 pts (38%) had IONM data loss, while 49 pts (62%) did not. In comparing the IONM loss group with the no IOMN change group, there were no differences between the groups in age or BMI. There were no significant differences in the mean preoperative coronal deformity angular ratio (C-DAR), sagittal DAR (S-DAR), or total DAR (T-DAR). In addition, there were no significant differences in the mean change in C-DAR, S-DAR, or T-DAR between the groups when comparing the postoperative versus preoperative measurements. There was no difference in proportion of patients with a vertebral column resection (VCR), or in the mean instrumented number of levels. However, there was a significantly higher estimated blood loss (EBL) (1320 +/- 614 vs 1049 +/- 468, p = 0.03) in the IONM loss group.

Conclusion
In this largest reported cohort patients with type 3 spinal cords undergoing spinal deformity surgery, somewhat surprisingly, the only factor found to be significantly associated with risk of IONM data loss higher EBL. Thus this is important for deformity surgeons to realize when treating this specific group of high risk patients.

31. ACCURATE SCORING SYSTEM PREDICTS CORD-LEVEL INTRAOPERATIVE NEUROMONITORING (IONM) LOSS DURING SPINAL DEFORMITY SURGERY: A MACHINE LEARNING ALGORITHM

Nathan J. Lee, MD; *Lawrence G. Lenke, MD*; Varun Arvind, MD, PhD; Ted Shi, BS; Alexandra Dionne, BS; Chidebelum Nnake, BS; Mitchell Yeary, BS; Michael Fields, MD, BS;

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PODIUM PRESENTATION ABSTRACTS

Matthew Simhon, MD; Anastasia Ferraro, BS; Matthew Cooney, BS; Erik Lewerenz, BS; Justin Reyes, MS; Steven G. Roth, MD; Chun Wai Hung, MD; Justin K. Scheer, MD; Thomas M. Zervos, MD; Earl D. Thuet, BS; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Benjamin D. Roye, MD, MPH; Michael G. Vitale, MD, MPH; Fthimnir Hassan, MPH

Hypothesis
Machine learning(ML) can create an accurate scoring system to preoperatively predict cord-level IONM data loss.

Design
Retrospective review of single surgeon prospective, consecutively collected patient data

Introduction
An accurate knowledge of a patient's risk for IONM cord-level loss prior to deformity correction is important for the informed decision-making process, but no prediction tool currently exists.

Methods
1,106 patients (adult=735, pediatric=371) who had spinal deformity surgery from 2015-2023 were reviewed. 205 periop variables were included (demographics, diagnosis, medical history, physical exam, operative factors, labs, preop/intraop x-rays, preop MRI/CT). IONM cord-level data was reviewed with the senior member of the IONM team. A stepwise ML approach using random forest analysis and multivariate logistic regression was performed. Pts. were randomly allocated into training(50%) and testing(50%) cohorts. Threshold values for features were calculated from the trained random forest model, and feature scores were derived by rounding up feature weights from the logistic regression model. Variables in the final scoring calculator were selected to optimize predictive performance (accuracy, sensitivity, specificity and area under the receiver operating characteristic curve (AUROC)). Analysis was performed using scikit-learn(v.0.24.2) in Python(v.3.9.18).

Results
Through the ML process, a total of 7 features were designated to be included in the scoring system: Spinal Cord Shape Type 3(score=2), Conus level below L2(score=2), Preop Upright Largest Cobb ≥75º(score=2), Upper Instrumented Vertebra in the Cervical spine(score=2), Preop to Intraop Decrease in Hematocrit ≥12(score=1), Total Deformity Angular Ratio(TDAR)≥25(score=1), and Three Column Osteotomy(3CO)(score=1). Patients with increasing cumulative scores had dramatically increased rates of IONM cord-level loss, with a cumulative score ≤ 2 having an IONM cord-level loss rate of 0.8% vs. score ≥7 rate of 95%. When evaluated on the test cohort, the scoring system achieved an accuracy of 90.3%, sensitivity of 80%, specificity of 91%, and an AUROC of 0.85.

Conclusion
This is the first study to provide an ML derived scoring system using perioperative variables which accurately predicted IONM cord-level loss during pediatric and adult spinal deformity surgery with over 90% reliability.

Variables	Score
Spinal Cord Type III	2
Level of Conus Below L2	2
Preop Upright Largest Cobb ≥75°	2
Upper Instrumented Vertebra = Cervical Level	2
Preop to Intraop Decrease in Hct ≥ 12	1
Total Deformity Angular Ratio ≥ 25	1
Cord Level Three Column Osteotomy	1

	Cummulative Score	Positive (Count)	Negative (Count)	Rate
Low Risk	0 - 1	5	863	0.6%
	2	3	103	3%
Moderate Risk	3	7	47	13%
	4	7	20	26%
	5	9	10	47%
	6	5	6	45%
High Risk	7	3	1	75%
	8	7	0	100%
	9	4	0	100%
	10	5	0	100%
	11	1	0	100%

Fig.

32. COMPLEMENTARY PERFORMANCE OF SOMATOSENSORY EVOKED POTENTIAL (SSEP) AS INTRAOPERATIVE NEUROMONITORING IN SPINAL DEFORMITY SURGERY - RESULTS FROM A PROSPECTIVE MULTICENTER STUDY ‡

So Kato, MD, PhD; Lawrence G. Lenke, MD; Kristen E. Jones, MD, FAANS; Sigurd H. Berven, MD; Christopher J. Nielsen, MD; Saumyajit Basu, MS(orth), DNB(orth), FRCSEd; Michael P. Kelly, MD; Justin S. Smith, MD, PhD; Samuel Strantzas, MSc, DABNM; Stephen J. Lewis, MD, FRCS(C)

Hypothesis
The utilization of somatosensory evoked potential (SSEP) enhances the sensitivity of intraoperative neuromonitoring (IONM) for predicting postoperative neurological deficits.

Design
Prospective international multicenter cohort study.

Introduction
The use of multimodal IONM has been advocated for ensuring safety in spinal deformity surgery. SSEPs monitor the functional integrity of the dorsal column pathways. The significance of incorporating SSEP alongside motor evoked potential (MEP) and/or electromyography (EMG) in preventing neurological deficits remains unclear.

Methods
Twenty international centers prospectively documented IONM, demographic details, radiographic findings, and

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surgical events for complex spinal deformity surgery. Patients aged 10-80 years, with a coronal or sagittal major Cobb>80°, or undergoing posterior column or 3-column osteotomy, were included. SSEPs were predominantly recorded after simulation of posterior tibial and/or peroneal nerves. Ulnar nerves were used as controls. An IONM alert was defined as a >50% loss of amplitude in SSEP or MEP from baseline or sustained EMG activity >10 seconds. Neurological examinations were performed pre- and post-operatively, with the occurrence of new neurological deficits being meticulously recorded.

Results

Among 546 cases, SSEP alerts were identified in 20 (3.7%), either alone (4/20), or in combination with MEP/EMG (16/20), whereas MEP/EMG alerts occurred in 75 cases (13.7%). Post-operative new motor deficits were observed in 60 (11.0%), and new sensory deficits were recorded in 17 of 523 valid data (3.3%). All cases with post-operative motor or sensory deficits with intra-operative SSEP alerts (8 and 4 cases, respectively) were also associated with MEP/EMG alerts, while no neurological deficits were documented after isolated SSEP alerts (4 cases, 0.7%). Consequently, the addition of SSEP to MEP/EMG did not result in an enhancement of the sensitivity in predicting post-operative neurological deficits.

Conclusion

Although multimodal IONM has been deemed beneficial for predicting post-operative neurological deficits by comprehensively assessing spinal cord function, it was revealed that the current protocol and threshold of SSEP did not contribute to improved safety in complex spinal deformity surgery. Further studies are warranted to establish the optimal protocol for IONM.

33. INTRAOPERATIVE NEUROMONITORING HAS POOR CORRELATION WITH POSTOP NEUROLOGICAL DEFICITS IN NON-CORD LEVEL ADULT DEFORMITY SURGERY

Zeeshan M. Sardar, MD; Alekos A. Theologis, MD; <u>Ganesh Swamy, MD, PhD</u>; Go Yoshida, MD, PhD; Michael P. Kelly, MD; Thorsten Jentzsch, MD, MSc; Samuel Strantzas, MSc, DABNM; Saumyajit Basu, MS(orth), DNB(orth), FRCSEd; Kenny Y. Kwan, MD; Justin S. Smith, MD, PhD; Ferran Pellisé, MD, PhD; So Kato, MD, PhD; Munish C. Gupta, MD; Christopher P. Ames, MD; Kristen E. Jones, MD, FAANS; Anastasios Charalampidis, MD; Brett Rocos, MD, FRCS; Lawrence G. Lenke, MD; Stephen J. Lewis, MD, FRCS(C)

Hypothesis

In non-cord level spinal deformity surgery, postop neural deficits are incompletely associated with intraop neuromonitoring (IONM) alerts.

Design

Prospective, international, multi-center cohort

Introduction

The purpose of this study is to evaluate rates of new neural deficits relative to IONM alerts in non-cord-level spinal deformity surgery.

Methods

20 international centers prospectively documented IONM (EMG, SSEP and MEP), demographics, radiographic findings, and surgical events of adult patients undergoing spinal deformity surgery. Inclusion criteria: neurologically intact, major Cobb>80° or surgery involving any osteotomy. IONM change was defined as loss of amplitude>50% in SSEP or MEP from baseline or sustained EMG activity lasting>10 seconds

Results

Of 197 patients, 22(11.2%) had an IONM alert. More patients were undergoing revision surgery during an alert compared to those with no alert (40.9% vs. 18.9%, p = 0.026). IONM alerts did not correlate with cobb angle, deformity angular ratio, sagittal vertical axis, or coronal vertical axis. There were a total of 26 alerts in 22 patients - 4 (18.2%) had 2 IONM alerts, while the other 18(81.8%) had 1 alert. MEPs were affected in 21 of 26 alerts (80.8%) and 15(71.4%) of those were recovered. SSEPs were affected in 8 of 26 alerts (30.7%). Lastly, EMGs were affected in only 2(7.7%). 5 of 21 MEP alerts (23.8%) were bilateral, whereas 16(76.2%) were unilateral. The most frequent event preceding an MEP change was an osteotomy in 6(28.6%) of 21 patients. The most frequent non-surgical event preceding an MEP alert was technical in 5(23.8%), followed by systemic (low blood pressure/anemia) and anesthetic in 3 patients each (14.3%). 33 of 197 patients (16.8%) developed a new postop neural deficit. Of these patients, 24(72.7%) had no IONM alert. In the presence of an IONM alert 9 of 22 (40.9%) had a new neural deficit. IONM alert had a crude negative predictive value (NPV) of 86.1%

Conclusion

In non-cord level spinal deformity surgery, IONM alerts occurred in 11.2% of patients with osteotomy being the most frequent preceding surgical event. A new postop neural deficit was observed in 16.8% of all patients, and in 41% of patients with a IONM alert. A surprisingly high 73% of postop neural deficits occurred in patients who did not have an alert. This highlights the need for further refinement of IONM techniques for non-cord level surgery

34. COST-EFFECTIVENESS OF OPERATIVE VS NONOPERATIVE TREATMENT OF ADULT SYMPTOMATIC LUMBAR SCOLIOSIS WITH EIGHT YEAR FOLLOW-UP ‡

<u>Leah Y. Carreon, MD</u>; Steven D. Glassman, MD; Justin S. Smith, MD, PhD; Michael P. Kelly, MD; Elizabeth L. Yanik, PhD; Christine Baldus, RN; Vy Pham, MD, MPH; David Ben-Israel, MD; Jon D. Lurie, MD, MS; Charles C. Edwards, MD; Lawrence G. Lenke, MD; Oheneba Boachie-Adjei, MD; Jacob M. Buchowski, MD; Charles H. Crawford III, MD; Stephen J. Lewis, MD, FRCS(C); Tyler Koski, MD; Stefan Parent, MD, PhD; Virginie Lafage, PhD; Munish C. Gupta, MD; Han Jo Kim, MD; Christopher P. Ames, MD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Keith H. Bridwell, MD

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Hypothesis

Operative treatment for Adult Symptomatic Lumbar Scoliosis (ASLS) is more cost-effective than non-operative treatment.

Design

Secondary data analysis of the NIH sponsored study on ASLS.

Introduction

The appropriate treatment approach for ASLS is still widely debated. While nonoperative care has not been shown to reliably improve outcomes, operative treatment is costly with high revision rates. The purpose of this study is to perform a cost-effectiveness analysis comparing operative versus nonoperative care for ASLS eight years after enrollment.

Methods

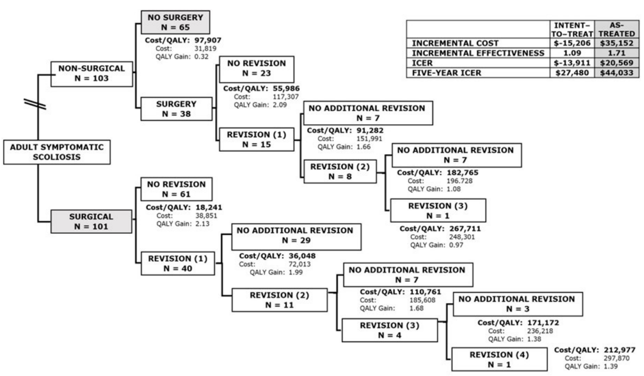
Patients with eight-year follow-up data were identified. Costs for index and revision surgeries and non-operative modalities were determined using Medicare Allowable rates. Medication costs were determined using the RedBook and indirect costs were calculated based on reported employment status and income. Quality Adjusted Life Years (QALYs) were determined using the SF6D.

Results

There were 101 cases in the Operative (Op) and 103 in the Non-operative (Non-Op) group with complete eight year data. Thirty-eight patients (37%) in the NonOp group had surgery from 3 to 72 months after enrollment. An As-Treated analysis including only cases who never had surgery (N=65) or cases with complete eight-year post-operative data (N=101) showed that operative treatment was favored with an ICER of $20,569 per QALY gained which is within Willingness-to-Pay (WTP) thresholds. An Intent-to-treat analysis demonstrated greater QALY gains and lower cost in the Op group (ICER = $-13,911). However, Intent-to-treat analysis may be confounded by crossovers to operative treatment as well as the variability in the timing of surgery in the NonOp group.

Conclusion

Operative treatment was more cost-effective than non-operative treatment for ASLS at eight-year follow-up. The ICER continued to improve as compared to the five-year values ($20,569 vs. $44,033).



	INTENT-TO-TREAT	AS-TREATED
INCREMENTAL COST	$-15,206	$35,152
INCREMENTAL EFFECTIVENESS	1.09	1.71
ICER	$-13,911	$20,569
FIVE-YEAR ICER	$27,480	$44,033

35. OPIOID USAGE IN ADULT SPINAL DEFORMITY: CAN WE MOVE THE NEEDLE BEFORE INCISION?

Michelle Gilbert, PA-C; Aiyush Bansal, MD; Rakesh Kumar, MBBS; Joseph Strunk, MD; Daniel Warren, MD; Jennifer Kelly, PhD; Murad Alostaz, BS; Venu M. Nemani, MD, PhD; Jean-Christophe A. Leveque, MD; Philip K. Louie, MD; Rajiv K. Sethi, MD

Hypothesis

The application of a standardized preoperative opioid program can reduce opioid consumption after adult spinal deformity surgery even in chronic opioid users.

Design

Prospective cohort study.

Introduction

High opioid utilization prior to adult spinal deformity (ASD) surgery has been associated with poor surgical/functional outcomes and persistent elevated postoperative opioid usage. No studies have described the effect of preoperative weaning or opioid-reduction strategies on postoperative opioid use. The purpose of our study is to evaluate the impact of a standardized preoperative opioid program on postoperative opioid usage in patients undergoing thoracolumbar spinal deformity surgery.

Methods

A control group of 75 patients undergoing elective thoracolumbar fusion for adult spinal deformity from October 2020 to 2021 were compared with an intervention group of 98 surgical patients from November 2022 to 2023. Preoperative opioid use was assessed using a color-coded system based on morphine equivalent dosages (MEDs), benzodiazepine (BZD) use, and substance use disorder history: GREEN 1 (0 MED), GREEN 2 (0-20 MED), YELLOW (20-50 MED), ORANGE (50-120 MED), and RED (>120, or >50 with +BZD or a substance disorder). Chronic users (YELLOW, ORANGE, or RED patients) received a pre-surgery program including pain clinic consultation and a virtual pain coping course. RED category patients needed to demonstrate a 50% MED reduction before surgery. Data on six-week and six-month post-operative MED, patient outcomes, length of stay (LOS), opioid use, demographics, psychiatric diagnoses, and ASA classification were gathered.

Results

The intervention group showed a significant reduction in MED at six months post-op in the highest use categories (RED and ORANGE, preoperative MED > 50), with a mean decrease of -237 MED (P=.04) versus the control non-intervention ORANGE/RED groups. This reduction was not associated with any change in hospital LOS or increase in post-discharge phone calls.

Conclusion

The preoperative opioid reduction program had the greatest effect on opioid consumption in patients with high preoperative opioid use (MED > 50). Contrary to previous reports demonstrating continued high postoperative usage in patients with high preoperative opioid use, this result suggests another avenue for preoperative surgical optimization.

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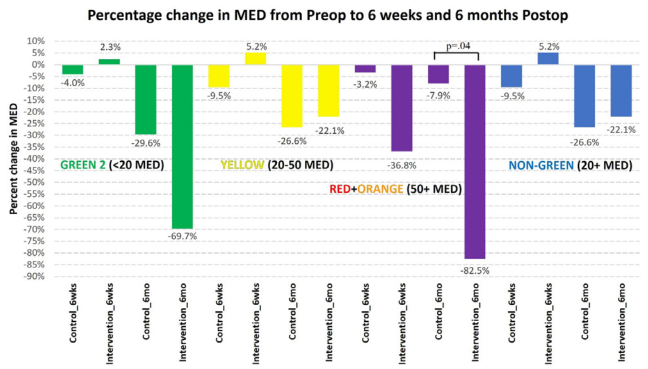
Percentage change in MED from preop for each ppioid category at 6 weeks and 6 months postop.



36. DURABILITY OF SUBSTANTIAL CLINICAL BENEFIT LEADING TO OPTIMAL OUTCOMES IN ADULT SPINAL DEFORMITY CORRECTIVE SURGERY: A MINIMUM 5-YEAR ANALYSIS

Jamshaid Mir, MD; Ankita Das, BS; Tobi Onafowokan, MBBS; Nima Alan, MD; Matthew Galetta, MD; Nathan Lorentz, MD; Renaud Lafage, MS; Bassel G. Diebo, MD; M. Burhan Janjua, MD; Dean Chou, MD; Justin S. Smith, MD, PhD; Virginie Lafage, PhD; Andrew J. Schoenfeld, MD; Daniel M. Sciubba, MD; Peter G. Passias, MD; Brett Rocos, MD, FRCS

Hypothesis

PFactors associated with the long-term durability of outcomes in ASD patients can give insight into improving patient care.

Design

Retrospective cohort

Introduction

Clinical outcomes for adult spinal deformity patients has been extensively reported on, however factors associated with sustaining two year (2Y) substantial clinical benefit (SCB) till five year (5Y) remains unclear.

Methods

Operative ASD patients fused from at least L1 to sacrum with baseline (BL) to 5-year (5Y) follow-up were included. Substantial clinical benefit (SCB) for ODI, PCS, NRS-back, NRS-leg, SRS-22r were assessed based on previously published values. Factors were evaluated based on meeting optimal outcomes (OO) at 2Y (2+) and 5Y (5+). Furthermore, 2+ was isolated and evaluated based on meeting 5+ OO (2+5+) or not 5- (2+5-). Optimal Outcome (OO) was defined as: no reoperation, major mechanical failure, proximal junctional failure (PJF), and [meeting either: (1) substantial clinical benefit (SCB) for Oswestry Disability Index (ODI) (decrease of >18.8), or (2) ODI <15 and Scoliosis Research Society (SRS-22r) Total>4.5].

Results

330 ASD patients met inclusion, with 46% meeting SCB for ODI at 2Y and at 5Y. 78.5% of those who achieved 2Y SCB went on to achieve 5Y SCB. This rate was lower for optimal outcomes, with 41% achieving OO at 2Y (2+), while 37% met at 5Y (5+). 80% of the 2+ cohort meeting 5+ (32% of the total cohort). Regaining activity postoperatively had 4x higher odds of maintaining OO from 2Y to 5Y (p<.05). Osteoporosis rates, although equivocal at baseline, were higher at the last follow-up in those who met 2Y OO but failed to meet 5Y. The odds of achieving OO at 5Y in 2+ decreased by 47% for each additional comorbidity and decreased by 74% in those that had lower extremity paresthesias at BL (both p<.05). Controlling analysis depicted decreased number of levels fused, decreased correction of SVA and increased correction in PI-LL to be predictive of maintaining 2Y OO till 5Y.

Conclusion

Substantial clinical benefit was met 46% of ASD patients at 5Y, with the durability of optimal outcomes seen in 30% of patients till 5 years postoperatively. Higher rates of medical complications were seen in those who failed to achieve and maintain optimal outcomes till 5Y. Frailty and comorbidity burden were significant factors associated with the achievement of OO at 2Y and its durability till 5Y.

37. OPTIMIZING BONE HEALTH FOR THE PREVENTION OF REVISION ADULT SPINAL DEFORMITY SURGERY: A BREAK-EVEN ANALYSIS

Andrew Kim, BS; William G. Elnemer, BS; Marc Greenberg, MD; Khaled M.Kebaish, MD

Hypothesis

Preoperative bone health optimization will be cost-effective in the prevention of revision surgery among adult spinal deformity (ASD) patients, regardless of treatment modality.

Design

Break-even economic analysis

Introduction

Before spinal reconstructive surgery, all patients over the age of 65 and those under the age of 65 with certain risk factors, such as chronic glucocorticoid use or high fracture risk, are recommended to undergo bone health evaluation. Despite increased risk of complications and worse outcomes in patients with osteoporosis, minimal research has examined the cost-effectiveness of preoperative bone optimization in the prevention of revision ASD surgery.

Methods

The product cost of a DXA scan and the total 2-year cost of revision ASD surgery were obtained from institutional records. 2-year ASD revision rates among patients with osteoporosis were obtained from the literature. An open-access database was used to determine the mean retail price for Teriparatide, Denosumab, and Zoledronic acid. Total optimization costs included the costs of a DXA scan and treatment modality. Costs were adjusted for inflation using the Consumer Price Index to 2023 U.S. dollars. A break-even economic analysis was performed to determine the absolute risk reduction (ARR) to economically justify each treatment. ARR was then used to calculate the number needed to treat (NNT) to prevent a single revision ASD surgery while remaining cost-effective.

Results

The cost of a DXA scan and revision ASD surgery was \$349.28 and \$147,731.78 using institutional values. The cost of treating revision ASD surgery with DXA and Teriparatide, Denosumab, and Zoledronic acid was \$4,410.32, \$3,832.78, and \$1,552.61, respectively. Each treatment modality was cost-effective at literature low, literature high, and the weighted average rates for revision ASD surgery. Teriparatide was economically justified if the initial revision decreased by 2.99% (NNT=34), Denosumab with an ARR of 2.59% (NNT=39), and Zoledronic Acid with an ARR of 1.05% (NNT=96).

Conclusion

Preoperative bone health optimization among ASD patients undergoing surgery is highly cost-effective in the prevention of revision surgery due to osteoporosis.

Drug	Dose	Frequency	Mean Unit Cost, \$	DXA Unit Cost, \$	Total Cost, \$
Teriparatide	20 mcg/dose	Daily (2 months preop)	2,030.52 (28 doses)	349.28	4,410.32
Denosumab	60 mg/mL	Biannually	1741.75	349.28	3,832.78
Zoledronic Acid	5 mg/100 mL	Annually	1203.33	349.28	1,552.61

[a]All prices obtained from an online drug database; [b]Costs represented in U.S. dollars

Table 1. Total cost of bone optimization strategy by treatment

Drug	Initial ASD Revision Rate, %	Final ASD Revision Rate, %	ARR, %	NNT
Teriparatide	19.71[a]	16.72	2.99	34
	22.05[b]	19.03	2.99	34
	40.50[c]	37.51	2.99	34
Denosumab	19.71[a]	17.12	2.59	39
	22.05[b]	19.46	2.59	39
	40.50[c]	37.91	2.59	39
Zoledronic Acid	19.71[a]	18.66	1.05	96
	22.05[b]	21.00	1.05	96
	40.50[c]	39.45	1.05	96

*Presumes cost of revision ASD surgery is \$147,731.78 (U.S. dollars); *ASD* = adult spinal deformity; *ARR* = absolute risk reduction; *NNT* = number needed to treat; [a]Low revision rate obtained from literature; [b]Weighted literature revision rate; [c]High revision rate obtained from literature

Table 2. Cost-effectiveness of bone optimization strategies in the prevention revision adult spinal deformity surgery

$$S_{total} \times C_r \times IR_i = (S_{total} \times C_d) + (S_{total} \times C_r \times IR_f)$$

Solving for IR_f yields:

$$IR_f = \frac{(IR_i \times C_r) - C_d}{C_r}$$

S_{total} = total annual surgeries; C_r = cost of revision ASD surgery; C_d = total cost of bone health optimization strategy; IR_i = initial revision rate; IR_f = break-even revision rate

Figure 1. Equation used to calculate the break-even revision rate (Adapted from Hatch MD, Daniels SD, Glerum KM, Higgins LD. The cost-effectiveness of vancomycin for preventing infections after shoulder arthroplasty: a break-even analysis. *J Shoulder Elbow Surg.* 2017;26(3):472-477)

Table 1. Total cost of bone optimization strategy by treatment

38. PREOPERATIVE ANABOLIC BONE THERAPY SIGNIFICANTLY REDUCES SPINOPELVIC MECHANICAL COMPLICATIONS AND PSEUDARTHROSIS IN ADULT SPINAL DEFORMITY SURGERY

Omar Zakieh, MBBS; Hani Chanbour, MD; Ambika Paulson, MD; Walter Navid, BS; Mitchell Bowers, MD; Iyan Younus, MD; David C. Liles, MD; Ranbir Ahluwalia, MD; Julian Lugo-Pico, MD; Amir M. Abtahi, MD; Scott Zuckerman, MD, MPH; Byron F. Stephens, MD

Hypothesis

A longer regimen of anabolic bone medication for adult spinal deformity (ASD) surgery prevents mechanical complications and improves postoperative outcomes in patients with osteopenia and osteoporosis.

Design

Retrospective cohort study

Introduction

A paucity of research exists regarding benefits of longer anabolic bone therapy on ASD surgery outcomes. In a cohort of osteopenic and osteoporotic patients undergoing ASD surgery, we sought to determine the impact of anabolic bone therapy on: 1) mechanical complications, 2) reoperations, and 3) patient-reported outcome measures (PROMs).

Methods

A single-institution, retrospective cohort study was performed for osteopenic and osteoporotic patients undergoing ASD surgery from 2009-21. Inclusion criteria were: ≥5-level fusion, sagittal/coronal deformity, and 2-year follow-up. Osteopenia/osteoporosis were defined as t-score <-1.5 and <-2.5, respectively. The primary exposure was length of anabolic bone medication administration (days). Postoperative outcomes included mechanical complications, reoperations, and PROMs. Multivariable regression analysis controlled for age, BMI, and t-score.

Results

Among 116 patients with osteopenia (66.4%) or osteoporosis (33.6%) undergoing ASD surgery, 42 (36.2%) were administered an anabolic bone agent, including teriparatide (85.7%), abaloparatide (11.9%) or romosozumab (2.4%), with a mean duration of 457.0±591.0days. Anabolics: patients administered anabolic bone medication had significantly fewer spinopelvic mechanical complications (26.2% vs. 32.4%, p=0.036), and pseudarthrosis (19.0% vs. 40.5%, p=0.018) than patients who did not receive anabolic medications, with no difference in reoperations or PROMs. On multivariable regression, anabolic medication administration decreased the odds of pseudarthrosis (OR=0.31, 95%CI=0.12-0.80, p=0.015), and spinopelvic mechanical complications (OR=0.40, 95%CI=0.17-0.96, p=0.040). Duration: no association was found between the duration of anabolic medication and mechanical complications, reoperations, or PROMs (all p>0.05).

Conclusion

In a cohort of osteopenic and osteoporotic patients undergoing ASD surgery, patients administered anabolic

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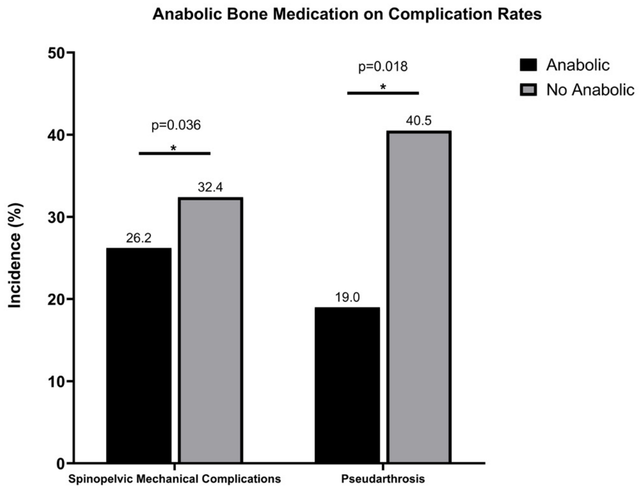
bone therapy had a significantly lower pseudarthrosis rate and fewer spinopelvic complications. This reduction in mechanical complications did not translate to a significant difference in patient reported outcomes.



39. IMPACT OF ADVANCED HEMODYNAMIC MONITORING ON POST-OPERATIVE COMPLICATIONS IN MULTI-LEVEL POSTERIOR THORACOLUMBAR FUSIONS

Leah Y. Carreon, MD; *Steven D. Glassman, MD*; Desiree Chappell, CRNA; Steven Garvin, CRNA; Anna Lavelle, MSN, CRNA; Jeffrey L. Gum, MD; Mladen Djurasovic, MD; Wael Saasouh, MD

Hypothesis
Intra-op advanced hemodynamic monitoring decreases post-op complications in thoracolumbar fusions

Design
Observational comparative cohort

Introduction
Intra-Operative Hypotension (IOH) is a widely accepted factor in triggering neuro-monitoring alerts during deformity correction. Its impact on post-op complications is less well studied. The Hypotension Prediction Index (HPI) uses AI to predict hypotension and its possible causes, helping the anesthesia team make timely decisions to administer vasopressors, inotropes or fluids. This study determines if HPI software decreases episodes of IOH resulting in a decrease in post-op complications.

Methods
Adult patients undergoing elective, multi-level posterior thoracolumbar fusion, with BP monitoring with an a-line using HPI software were identified. A similar set of patients in whom the HPI software was not used were also identified. Demographic and surgical data, minutes of IOH and hypertension, volume of IVF, colloids, blood products and vasopressors administered intra-op; urine output, volume of IVF, colloids and blood products administered 4 hours post-op; number and type of post-op complications were collected.

Results
The HPI and Non-HPI groups were similar in sex, age, BMI, ASA grade, number of surgical levels, estimated blood loss and operative time. A longer duration of IOH was seen in the Non-HPI group (13.3mins) compared to the HPI group (8.1mins, p=0.032). Longer duration of hypertension in the Non-HPI group (1.4mins) was also seen compared to the HPI group (0.5mins, p=0.029). Except for colloids intra-op, the volume of IVF and blood products administered intra-op and 4 hours post-op were similar. Urine output 4 hours post-op was greater in the HPI group (819.1mL) compared to the Non-HPI group (619.8mL, p=0.022). There was a greater number of patients in the Non-HPI group who had a surgical site infection requiring return to the operating room (13% vs 2%, p=0.027), post-op nausea and vomiting requiring medication (14% vs 0, p=0.004) and post-op cognitive dysfunction (19% vs 6%, p=0.049).

Conclusion
The use of HPI to predict IOH before its actual occurrence allows the anesthesia team to proactively prevent it. Using advanced hemodynamic monitoring may also decrease intra-op hypertensive events. This is associated with a lower prevalence of post-op complications and decreased length of stay.

Table 1	Non-HPI	HPI	
	70	47	
Males, N (%)	38 (54%)	24 (51%)	0.850
Age, Mean (SD)	62.0 (11.9)	61.1 (13.0)	0.358
Body Mass Index, kg/m2, Mean (SD)	31.9 (6.4)	32.6 (7.2)	0.216
ASA Grade, Mean (SD)	2.8 (0.6)	2.9 (0.5)	0.210
Number of Surgical Levels, Mean (SD)	4.6 (2.6)	4.4 (2.4)	0.593
Estimated Blood Loss, mL, Mean (SD)	556.3 (445.2)	611.3 (619.0)	0.601
Operative time, minutes, Mean (SD)	260.2 (87.2)	267.8 (88.0)	0.649

Table 2	Non-HPI	HPI	
	Mean (SD)	Mean (SD)	
Duration of hypotension, mins	13.5 (19.1)	8.1 (10.7)	**0.029**
Duration of hypertension (MAP≥140mmHg), mins	1.4 (3.23, 0-17)	0.5 (1.0, 0-5)	**0.032**
Intra-operative			
Intravenous Fluids, mL	2644.1 (858.7)	2780.0 (751.0)	0.184
Colloids, mL	357.1 (293.6)	457.4 (326.9)	**0.047**
pRBC transfused, mL	96.0 (200.9)	116.8 (231.4)	0.348
Cell Saver Infused, mL	192.4 (237.1)	206.1 (235.5)	0.123
Fresh Frozen Plasma, mL	0	7.2 (49.3)	0.161
Vasopressors, mcg	912.2 (2671.4)	530.2 (453.2)	0.294
Post-operative			
Intravenous Fluids, mL	251.4 (194.2)	183.3 (165.2)	0.179
Colloids, mL	57.5 (362.5)	16.0 (80.8)	0.161
pRBC transfused, mL	48.0 (125.9)	59.6 (174.5)	0.383
Fresh Frozen Plasma, mL	0	23.8 (163.4)	0.169
Urine Output, mL	619.8 (475.5)	819.1 (542.5)	**0.022**
Urine Output, mL/Kg/Hr	1.7 (1.3)	2.3 (1.7)	**0.020**
Length of Hospital stay, days	6.0 (4.4)	4.6 (2.4)	**0.017**

40. POSTERIOR SPINAL FUSION OUTCOMES IN BOYS AND GIRLS: SHOULD WE BE TREATING THEM THE SAME?

Julia Todderud, BA; Harms Study Group; Michelle Claire Marks, PT; *Nicholas D. Fletcher, MD*; Peter O. Newton, MD; A. Noelle Larson, MD

Hypothesis
Female patients will have better post-operative outcomes such as curve correction and rates of complications when compared to male patients.

Design
Prospective, multicenter study.

Introduction
Posterior spinal fusion for management of adolescent idiopathic scoliosis has continued to advance and improve outcomes for pediatric patients. With this study, we aim to compare and provide current evaluations

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regarding the perioperative outcomes of spinal fusion for girls and boys.

Methods
This study employed a review of prospectively collected data for patients who underwent posterior spinal fusion at 23 sites between 2002 and 2021. All patients had preoperative and two-year follow-up and were evaluated for curve correction, complications, surgery metrics, and patient reported outcomes. We only included patients with Cobb angles between 40-60 degrees in order to achieve matched cohorts.

Results
A total 2269 patients were included in this study: 1833 girls, 436 boys. At time of surgery, mean age was 15.1 years for girls and 16.3 years for boys. Boys were significantly taller and heavier than the girls. Preoperative curve magnitude was similar between the two groups (major Cobb 50.3 in girls and 50.8 in boys, p=0.09). Boys had a greater number of levels fused (10.8 vs 10.6), longer operative times (275.2 minutes versus 256.8 minutes), shorter post-operative stays (4.3 days vs 4.7 days), and greater estimated blood loss (1023 ml versus 678.9 ml) compared to girls. At two-year follow-up, there was no significant difference between girls and boys for proximal thoracic, thoracic, and lumbar Cobb values. SRS scores for patient reported outcomes were similar in boys and girls. 236 girls experienced complications compared to 47 boys (12.9% versus 10.8% of their cohorts, p=0.23). Boys had higher complication rates related to medical and transfusion complications, while in all other categories girls had higher rates.

Conclusion
At two-years following spinal fusion for AIS, boys and girls exhibit similar percent curve correction and SRS scores. Boys have greater body habitus, longer surgeries, and greater blood loss, but shorter post-operative stays.

		Girls	Boys	P -Value
N of Patients		**1833**	**436**	-
Age at Surgery		15.1	16.3	**<0.001**
Height Initial (cm)		160.8	172.0	**<0.001**
Weight Initial (kg)		55.2	64.4	**<0.001**
N Levels Instrumented		10.6	10.8	**0.019**
Stay (Days)		4.7	4.3	**<0.001**
Surgery Time (min)		256.8	275.2	**<0.001**
EBL (mL)		678.9	1023.0	**<0.001**
Initial Cobb	Prox Thoracic	23.6	25.4	**0.002**
	Thoracic	46.8	47.5	0.171
	Lumbar	36.9	34.6	**<0.001**
Initial Cobb	Major Curve	50.3	50.8	0.09
2 Year Cobb	Prox Thoracic	15.4	14.9	0.232
	Thoracic	20.1	19.6	0.278
	Lumbar	16.0	16.0	0.989
2 Year Cobb	Major Curve	22.8	22.5	0.45
% Correction	Thoracic	52.4%	55.0%	0.089
	Lumbar	51.3%	46.7%	**0.028**
SRS Score at 2 Years	Pain	4.4	4.4	0.985
	Self-Image	4.4	4.4	0.210
	Function	4.5	4.5	0.815
	Mental Health	4.2	4.1	0.612
	Satisfaction	4.6	4.6	0.786

Table 1: Perioperative values for population characteristics, operative metrics, curve measurements, correction, and patient-reported outcomes.

41. ARTIFICIAL INTELLIGENCE AND PEDIATRIC SCOLIOSIS EDUCATION: A COMPARATIVE ANALYSIS ASSESSING THE ACCURACY OF AI-GENERATED INFORMATION

Xochitl M. Bryson, BA; Marleni Albarran, BS; Nicole S. Pham, MPH; Taylor R. Johnson, MD; Grant D. Hogue, MD; Jaysson T. Brooks, MD; Kali R. Tileston, MD; Craig R. Louer, MD; Ron El-Hawary, MD; Meghan N. Imrie, MD; James F. Policy, MD; Daniel Bouton, MD; Arun R. Hariharan, MD; Sara Van Nortwick, MD; Vidyadhar V. Upasani, MD; Jennifer M. Bauer, MD; Andrew Tice, MD; *John S. Vorhies, MD*

Hypothesis
Artificial intelligence language models provide reliable responses to frequently asked questions about pediatric scoliosis

Design
Survey

Introduction
Artificial intelligence(AI) large language models (LLM) are increasingly popular. Patients and families are increasingly likely to use LLM when conducting internet-based research, so it is important to understand the abilities and limitations of this technology in disseminating accurate medical information. We used an expert panel to compare LLM-generated and society-authored responses to frequently asked questions about pediatric scoliosis.

Methods
We used 3 publicly available LLMs to answer 15 frequently asked questions (FAQs) regarding pediatric scoliosis. The FAQs were from the Pediatric Orthopedics Society of North America, Scoliosis Research Society, American Academy of Orthopaedic Surgeons, and the Pediatric Spine Foundation. We gave minimal training to LLM, only specifying the response length and requesting answers at a 5th-grade reading level. A 15-question survey was distributed to an expert panel, who were given an AI and a physician-generated response and asked to select which they preferred or neither. They were asked to individually grade their agreement with their responses on a Likert scale.

Results
Panel members had a mean of 9.9 years of experience post-fellowship (range: 3-23 years). Overall the panel reported equivalent agreement with AI generated vs physician-generated responses (Figure 1). For 40% of questions the panel favored physician written responses and for 33% it favored AI. For 20% of questions the panel felt responses were equally good and for 7% there was a tie between AI and “equally good”. For one physician-generated response and one AI-generated response, the error bars of the expert panel mean score for accuracy and appropriateness fell below neutral, indicating a consensus near disagreement with the response.

Conclusion
The expert panel review, AI delivered accurate and appropriate responses as frequently as physician-authored FAQ responses from professional Society web-

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sites. In two instances, AI responses were perceived as more appropriate and favorable. Further research and greater sample size are needed to assess the reliability and precision of AI in addressing commonly asked questions.

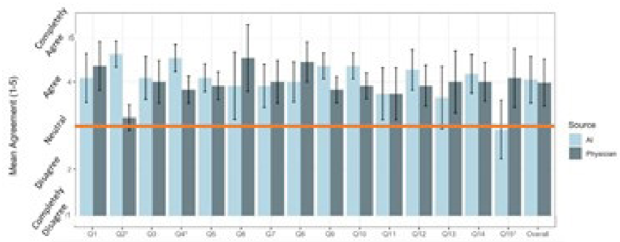

Figure 1A

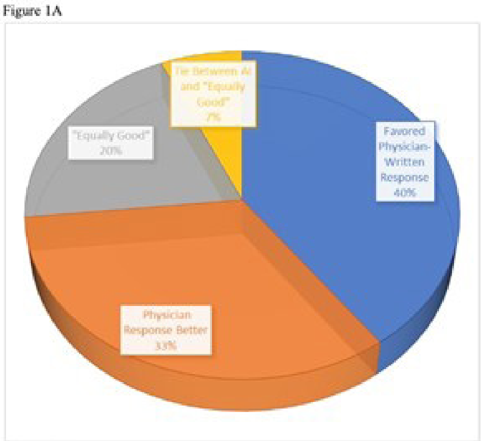

Figure 1B

Figure1A: Panelist agreement with FAQ responses 1- 5 1B: preference for AI versus physician responses

42. RISK STRATIFICATION FOR EARLY POSTOPERATIVE INFECTION IN PEDIATRIC SPINAL DEFORMITY CORRECTION: DEVELOPMENT AND VALIDATION OF THE PEDIATRIC SCOLIOSIS INFECTION RISK SCORE (PSIR SCORE)

Vivien Chan, MD, MS, FRCS(C); Geoffrey Shumilak, MD, FRCPC, MPh; Matiar Jafari, MD, PhD; Michael G. Fehlings, MD, PhD, FRCS(C); Michael Yang, MD, MS, FRCS(C), MBiotech; David L. Skaggs, MD, MMM

Hypothesis
The objective of this study was to investigate factors associated with 30-day postoperative infection in pediatric patients who received posterior spinal deformity correction to create and validate a predictive model.

Design
Retrospective review of prospectively collected data.

Introduction
Postoperative infection after spinal deformity correction in pediatric patients is associated with significant costs. Identifying risk factors associated with postoperative infection would help surgeons identify high-risk patients that may require interventions to minimize infection risk.

Methods
The NSQIP Pediatric database for years 2016-2021 was used for this study. Patients were included if they received posterior arthrodesis for scoliosis or kyphosis correction. The outcome of interest was 30-day postoperative infection. Multivariable logistic regression analysis using likelihood ratio backward selection method was used to identify significant risk factors for 30-day infection to create the Pediatric Scoliosis Infection Risk Score (PSIR Score). ROC curve analysis, predicted probabilities, and Hosmer Lemeshow goodness-of-fit test were done to assess the scoring system on a validation cohort.

Results
A total of 31,742 patients were included in the study. The 30-day infection rate was 2.2%. Reoperation rate in patients who had a post-operative infection was 59.4%. In our multivariable regression analysis, high BMI (OR=1.01, p<0.001), presence of open wound (OR=3.18, p<0.001), presence of ostomy (OR=1.51, p<0.001), neuromuscular etiology (OR=1.56, p=0.009), previous operation (OR=1.74, p<0.001), increasing ASA class (OR=1.43, p<0.001), increasing operation time in hours (OR=1.11, p<0.001), and use of only minimally invasive techniques (OR=4.26, p<0.001) were associated with increased risk of 30-day post-operative infection. Intraoperative antibiotics (B=0.71, p=0.003) were associated with reduced risk of 30-day postoperative infection. The area under the curve was 0.780 and 0.740 for the derivation cohort and validation cohort, respectively.

Conclusion
We found 5 patient factors and 3 surgeon-controlled factors associated with risk. The Pediatric Scoliosis Infection Risk Score (PSIR) Score can be applied for risk stratification and to investigate implementation of novel protocols to reduce infection rates in high-risk patients.

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Meeting Information
Meeting Agenda
Abstracts
Industry Workshops
Disclosures
Author Index
About SRS

PODIUM PRESENTATION ABSTRACTS

	Points
BMI > 27	3
Presence of open wound	4
Presence of ostomy	2
Operative time > 5 hours	1
Neuromuscular scoliosis	2
Previous operation	2
Minimally invasive technique	5
ASA class	
1	1
2	2
3	3
4	4

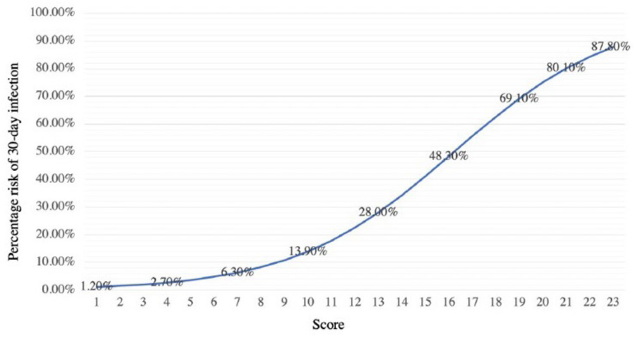

Figure 1. PSIR Score for risk of 30-day infection in pediatric patients after deformity correction surgery.

43. THE RADIOGRAPHIC, PULMONARY, AND CLINICAL OUTCOMES OF PATIENTS WITH SEVERE RIGID SPINAL DEFORMITIES TREATED VIA HALO-PELVIC TRACTION

Junlin Yang, MD, PhD; Wenyuan Sui, MD, PhD

Hypothesis

Patients with severe rigid kyphoscoliosis who underwent preoperative HPT exhibited better radiographic correction of the deformity, and pulmonary function, and required fewer osteotomies compared to the HGT group. Thus, HPT may be useful for severe rigid spinal deformity patients with pulmonary dysfunction.

Design

A retrospective study

Introduction

The severe rigid deformity patients with pulmonary dysfunction could not tolerate complicated corrective surgery. Preoperative traction are used to reduce the curve magnitude and improve the pulmonary function before surgery, including halo-gravity traction (HGT) and halo-pelvic traction (HPT).

Methods

81 cases of severe rigid kyphoscoliosis treated with preoperative traction prior to corrective surgery for spinal deformity between 2016 and 2019 were retrospectively reviewed. Two patient groups were compared, HPT group (N = 30) and HGT group (N = 51). Patient demographics, coronal and sagittal Cobb angles and correction rates, pulmonary function, traction time, osteotomy grade, and postoperative neurological complications were recorded for all cases.

Results

The coronal Cobb angle was corrected from 140.67 ± 2.63 to a mean of 120.17 ± 2.93° in the HGT group, and from 132.32 ± 4.96 to 87.59 ± 3.01° in the HPT group (mean corrections 15.33 ± 1.53 vs. 34.86 ± 3.11 %) (P =0.001). The mean major sagittal curve decreased from 134.28 ± 3.77 to 113.03 ± 4.57° in the HGT group and from 129.60 ± 8.45 to 65.61 ± 7.86° in the HPT group (P < 0.001); the mean percentage corrections were 16.50 ± 2.13 and 44.09 ± 9.78 % (P < 0.001). A significant difference in the pulmonary function test results was apparent between the two groups; the mean improvements in the FVC% of the HGT and HPT groups were 6.76 ± 1.85 and 15.6 ± 3.47 % (P = 0.024). The HPT group tended to exhibit more FEV% improvement than the HGT group, but the difference was not significant (5.15 ± 2.27 vs. 11.76 ± 2.22 %, P = 0.91).

Conclusion

Patients with severe rigid kyphoscoliosis who underwent preoperative HPT exhibited better radiographic correction of the deformity, and pulmonary function, and required fewer osteotomies compared to the HGT group. Thus, HPT may be useful for severe rigid spinal deformity patients with pulmonary dysfunction.

44. ACTIVITY CAPACITY IN CHILDREN WITH EARLY ONSET SCOLIOSIS COMPARED TO PULMONARY FUNCTION (SPIROMETRY) AND PATIENT REPORTED OUTCOMES

Mark Belio, MA; Malvika Choudhari, BS; Robin C. Johnson, RRT; Di Hu, MS; Stephanie D. Davis, MD; Erik D. Hanson, PhD; Feng-Chang Lin, PhD; James O. Sanders, MD

Hypothesis

Metabolic Equivalents of Task (METs) reflects activity capacity in children with early onset scoliosis.

Design

Cross Sectional Pilot

Introduction

The primary outcome of importance in early onset scoliosis, pulmonary function, is challenging to measure in children. Surrogate measures, including thoracic length and Cobb angle, poorly predict patient outcomes. Activity capacity as determined by metabolic equivalents of task (MET) is a potentially useful alternative. The purpose of this study is to assess MET values for varying intensity activities in children with EOS and its relationships with PFT, scoliosis characteristics, and patient-reported outcomes measures.

Methods

Basal metabolic rate and physical activity MET values were measured using indirect calorimetry. MET values were computed while performing video games representing low (bowling), moderate (boxing), and high intensity (active running) activities, and treadmill walking at low,

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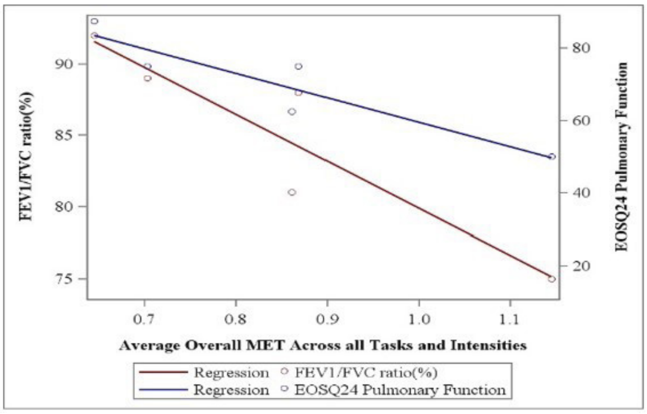
moderate, and high intensity. MET values were compared to age-matched compendium values for similar tasks. Pulmonary function was assessed using spirometry with % predicted based on arm span. Patient Reported Outcome (EOSQ24) results were obtained for each subject. A linear mixed model was used to assess differences between groups. Pearson correlation coefficients assessed relationships between variables.

Results

8 children (ages 6-16y, 4M,4F) completed testing. Etiologies were 3 Cong, 3 Syndromic, 2 idiopathic. 5 had severe restriction of FVC and FEV1 <50% predicted. Children with EOS had a 0.6 lower mean MET value compared to published METy values ($p<0.001$). Increased intensity corresponded with increased MET values comparing hard to moderate and easy intensities ($P<0.001$). Average percent predicted MET values across all tasks had a strong negative correlation with FEV1/FVC ($R=-0.927$, $p=0.024$) and EOSQ24 pulmonary function domain across all tasks ($R=-0.992$, $p=0.026$).

Conclusion

This study found the MET values in children with EOS were directionally similar to values in normal children. Children unable to generate higher MET values appear to self-limit their activity. Lower FEV1/FVC corresponded to higher MET values and low EOSQ24 pulmonary function domain scores. Children with pulmonary impairment indicative of obstructive disease require increased energy to perform activities.



METs compared to PFTs and EOSQ24 PF

45. UTILITY OF PREOPERATIVE ECHOCARDIOGRAM FOR LARGE CURVE SCOLIOSIS PATIENTS

Chidebelum Nnake, BS; Alondra Concepción-González, BA; Matan Malka, BA; Emma Berube, MD; Nicole Bainton, CPNP; Michael G. Vitale, MD, MPH; Benjamin D. Roye, MD, MPH

Hypothesis

Screening preoperative echocardiograms in scoliosis patients with >90° curves do not contribute to peri-operative risk or anesthetic management.

Design

Single center retrospective cohort

Introduction

Severe scoliosis can affect thoracic organs, potentially leading to cardiovascular abnormalities. Thus, echocardiograms have been suggested for use in pre-operative screening in patients with significant scoliosis. However, the utility of preoperative heart screenings in patients without known or suspected heart problems isn't well understood. This study aims to find the incidence of cardiac findings in patients with severe scoliosis >90° without cardiac history.

Methods

Chart review was performed from 2018-2023. Inclusion criteria were scoliosis patients with curves≥90° and screening echocardiogram performed within six months of spine surgery. Patients with a previous cardiac history, diagnosis associated with cardiac co-morbidities (e.g. connective tissue disease), or primary sagittal plane deformity were excluded. Echocardiogram reports and peri-operative clinical notes from involved services (including orthopedics, cardiology, and anesthesia) were reviewed.

Results

50 patients met inclusion criteria. Mean age at surgery was 14.0±4.9 years old (range 2-33). Mean major Cobb was 108.06±18.73° (range 90-160°). 37 (74.0%) patients had a normal echocardiogram report. Six patients (12.0%) had mild dilation of the aortic sinus or root, four (8.0%) had mild valvular regurgitation, one patient had a small atrial septal defect, and one had a trace pericardial effusion. No patient had any changes made to their perioperative plan. One patient was advised to see a cardiologist postoperatively. Eight patients (16%) received vasopressors to raise blood pressure to meet preset goal mean arterial pressure, but only one of these 8 had a positive echocardiogram (mild valvular insufficiency), which wasn't seen as a contributing factor to the use of pressors.

Conclusion

This study suggests that screening echocardiograms for patients without a cardiac history or related symptoms don't contribute to the evaluation of perioperative risk or anesthetic management. Creating clear, evidence-based guidelines for the utilization of perioperative testing, like echocardiograms, can reduce the social, time, and financial burdens on families. Such guidelines are vital for appropriate risk assessment and proper utilization of healthcare resources.

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Table 1. Diagnosis of Patients Among Each Etiology

Neuromuscular (n=27)		Congenital (n=6)		AIS/JIS (n=9)		Syndromic (n=8)	
Quadriplegic Cerebral Palsy	n=16	Thoracic Insuffiency	n=1	Adolescent Idiopathic Scoliosis	n=5	Riley-Day Syndrome	n=1
Alexander's Disease	n=1	Escobar Syndrome	n=2	Juvenile Idiopathic Scoliosis	n=4	Chromosomal Abnormality of Unknown Significance	n=2
Chromosome 2 Microdeletion	n=1	Campomelic Dysplasia	n=1			Bruck Syndrome	n=1
Rett Syndrome	n=1	Congenital Scoliosis	n=1			FNLB Deletion	n=1
Babinski-Nageotte Syndrome	n=1	Thoracic Kyphoscoliosis	n=1			Neurofibromatosis	n=2
Spina Bifida	n=1					Trisomy 9	n=1
Pontocerebellar Hypoplasia Type 1B	n=1						
Moyamoya	n=1						
VRK1 Mutation	n=1						
Hemiplagic Cerebral Palsy	n=1						
Central Myopathy	n=1						
Infantile Neuroaxonal Dystrophy	n=1						

Etiology Distribution

46. DNA-BASED EPIGENETIC AGE IS A BETTER PREDICTOR OF COMPLICATION THAN CHRONOLOGICAL AGE AND FRAILTY

Quante Singleton, MD; Rohit Bhan, MD, MS; Yu Zhang, MS; Nisha Kale, MD; Christopher P. Ames, MD; Bo Zhang, PhD; Michael P. Kelly, MD; Nicholas A. Pallotta, MD, MS; Brian J. Neuman, MD

Hypothesis

DNA-based epigenetic age (EA) better predicts acute complications after ASD surgery than chronological age (CA).

Design

Prospective

Introduction

The prevalence of symptomatic ASD is increasing with an aging population, with surgical complication rates of 37%-71%. Prior studies propose increased CA and frailty as risk factors for complications, but this may be due to differences in EA, suggestive of a patient's underlying biological reserve in response to stress. DNA methylation assays have emerged as the gold-standard for determining EA. We investigated the relationship between EA and complications within 6 weeks after ASD surgery.

Methods

ASD patients provided blood samples on the day of surgery. DNA methylation of PBMCs was analyzed using a genome-wide methylation analysis tool. EA was calculated using the Horvath biological clock (DNAmAge) algorithm. Edmonton Frailty Index (EFI) was collected at the pre-operative visit. EFI, EA, and CA were assessed as risk factors for complications reasonably related to a patient's biology. Parametric and non-parametric analyses were used to assess significance.

Results

30 surgical ASD patients were enrolled. 15 (50%) were revisions. 21 patients (70%) received all-posterior and 9 (30%) underwent anterior-posterior surgery. 7 (23%) received a three-column osteotomy and average levels fused was 11.9 (SD=3.7). Complications were pulmonary emboli (N=2), death (N=1), reoperation for dehiscence (N=1), altered mental status (N=5), and acute kidney injury (N=4). There were no 30-day readmissions. Mean EA and CA were significantly different (71.2 vs 68.4, p=0.009). For patients who experienced a post operative complication (N=14, 47%) there was an association with EA>CA (86%) compared to CA>EA (14%, p = 0.038). The difference between EA and CA (EA-CA) was greater in patients that had a complication (5.07 vs 0.87, p=0.029). There was no association of EFI for frailty between complication groups. Between complication groups, there was no difference in mean CA (67.7 vs 69.0, p=0.596), EA (73.0 vs 69.7, p=0.12), or EFI (4.3 vs 3.7, p=0.468).

Conclusion

Preliminary findings suggest EA>CA has greater association with perioperative complication after ASD surgery than EFI, EA, or CA alone. Further studies with more patients are warranted to investigate epigenetic stressors linked to changes in EA. These patient-specific factors can be used to improve risk-stratification in ASD surgeries.

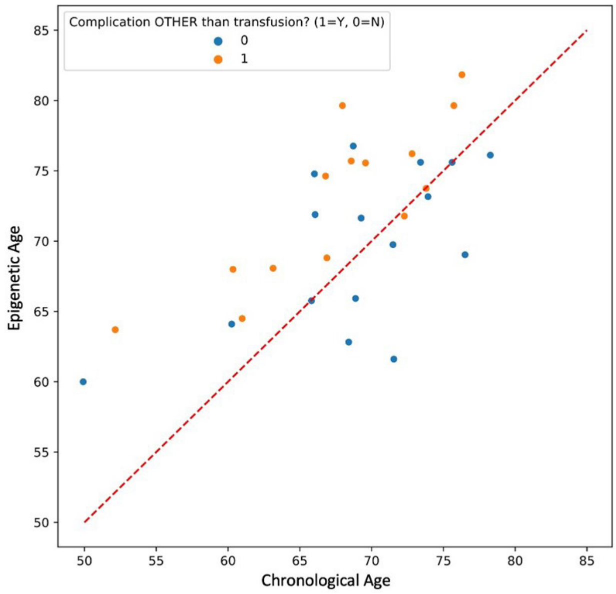

Figure 1: Scatterplot of patients that experienced complications (orange) and no complications (blue). The dotted line represents equal EA (DNAmAge) and CA.

47. OPTIMIZATION IS A MOVING TARGET: A CONTINUOUS MODIFIABLE FRAILTY INDEX REFLECTING OPTIMIZATION PRIOR TO COMPLEX ADULT SPINAL DEFORMITY (ASD) INTERVENTION

Peter G. Passias, MD; Ankita Das, BS; Justin S. Smith, MD, PhD; Renaud Lafage, MS; Bassel G. Diebo, MD; Alan H. Daniels, MD; Jamshaid Mir, MD; Tobi Onafowokan, MBBS; Kojo D. Hamilton, MD, FAANS; Breton G. Line, BS; Thomas J. Buell, MD; Juan S. Uribe, MD; Michael Y. Wang, MD; Richard G. Fessler, MD; Pierce D. Nunley, MD; Neel Anand, MD; Michael P. Kelly, MD; Themistocles S. Protopsaltis, MD; Robert K. Eastlack, MD; Gregory M. Mundis Jr., MD; David O. Okonkwo, MD, PhD; Khaled M. Kebaish, MD; Alex Soroceanu, MD, FRCS(C), MPH; Justin K. Scheer, MD; Jeffrey Mullin, MD; Praveen V. Mummaneni, MD, MBA; Dean Chou, MD; Han Jo Kim, MD; Richard Hostin, MD; Munish C. Gupta, MD; Lawrence G. Lenke, MD; Douglas C. Burton, MD; Frank J. Schwab, MD; Christopher P. Ames, MD; Virginie Lafage, PhD; Christopher I. Shaffrey, MD; Shay Bess, MD; International Spine Study Group

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Hypothesis
Optimization of frailty may improve peri/postoperative outcomes.

Design
Retrospective cohort study of prospectively enrolled database

Introduction
Many surgeons have expanded preoperative surgical planning to not only account for individualized alignment goals but also medical optimization where possible.

Methods
Operative patients with complete BL and 1Y data were analyzed via descriptive statistics and means comparison followed by virtual analysis. Tenets of the modified ASD Frailty Index (m-ASD-FI) that represented modifiable health factors were isolated. Regression analyses was applied to understand the relative value of optimization of each factor.

Results
359 patients met inclusion criteria(mean age: 60.4±15.1 yrs, BMI 27.3±5.6 kg/m², CCI 0.95±1.4, mASD-FI 7.6±3.1, EBL 1523.1±1224.4 mL, op time 423.7±139.9 mins, LOS 7.15±5.6 days). 35 patients were considered "optimized" in all categories, while 324 patients were "non-optimized". In factor-by-factor virtual analysis, BMI-optimized patients were less prone to in-hospital complications (OR 0.6, p=0.043) or deep wound infection (OR 0.2, p=0.018) and more likely to attain 1Y GAP proportionality(OR 2.6, p=0.004). CM-optimized patients were less likely to experience a cardiac event (OR 0.2, p=0.012) or experience prolonged ICU stay (OR 0.3, p=0.034). Osteoporosis-optimized patients were more likely to improve in Schwab modifiers (OR 3.1, p=0.008). Depression-optimized patients were significantly less likely to report symptomatic radiographic decompensation (OR 0.4, p=0.016). Diabetes-optimized patients were less likely to experience severe radiographic complications, including PJK, requiring intervention (OR 0.13, p=0.014). Those optimized in ≥3 domains had a significantly decreased likelihood of encountering a spine-related complication (OR 0.9, p=0.002) including PJK (OR 0.15, p=0.026) and likelihood of attaining alignment at 1 year significantly increased (OR 3.98, p=0.01). Amongst those virtually optimized across all domains, fully optimized patients were less likely to experience in-hospital adverse events (OR 0.6, p=0.039).

Conclusion
Optimization of frailty is a worthwhile endeavor that may lessen complications and improve retention of alignment. This virtual analysis depicts the possibility of multiplicative effects to optimizing each factor.

Table 1.

Contributing Factor	OR	p-value
BMI-optimized		
In Hospital AE	0.59 [0.35-0.98]	0.043
Deep Wound Infection	.24 [0.08-0.783]	0.018
Lessened # of Comorbidities		
Prolonged ICU Stay	0.27 [0.08-.90]	0.034
Cardiopulmonary AE	0.23 [0.06-0.73]	0.012
Depression-optimized		
Symptomatic Radiographic Complications	0.41 [0.20-0.85]	0.016
Diabetes-optimized		
Spine-related AE	0.43 [0.21-0.91]	0.03
PJK Requiring Intervention	0.13 [0.03-0.66]	0.014
Osteoporosis-optimized		
Schwab Improvement by 1Y	3.1 [1.4-7.0]	.008
Multiple Domains Optimized (3+)		
Intra-Op AE	0.27 [0.09-0.83]	0.022
PJK	0.16 [0.03-0.80]	0.026
Alignment at 1Y	3.98 [1.4-11.4]	0.01
Fully Optimized (Every Domain)		
In Hospital AE	0.59 [0.35-0.97]	0.039

48. THE ROLE OF PREOPERATIVE S. AUREUS COLONIZATION IN S. AUREUS POSTOPERATIVE INFECTIONS FOLLOWING ELECTIVE POSTERIOR SPINAL SURGERY

Aditya Joshi, BS; Rachel S. Bronheim, MD; Amit Jain, MD; Khaled M. Kebaish, MD; *Hamid Hassanzadeh, MD*

Hypothesis
Preoperative S. aureus colonization is associated with increased odds of S. aureus postoperative deep incisional, bloodstream, and organ space infections.

Design
Multicenter retrospective cohort.

Introduction
Surgical site infections (SSIs) are a major postoperative complication in spinal surgery that receive extensive prophylaxis with decolonization measures and intra-wound antibiotics. The growing literature suggests preoperative S. aureus colonization is predictive of superficial S. aureus SSIs. However, there is limited discussion on the role of preoperative colonization in postoperative S. aureus deep incisional, organ space, and bloodstream infections following elective instrumented spinal surgery.

Methods
This is a retrospective analysis of data collected prospectively in an international, multicenter database of 3,311 patients who underwent multilevel posterior open spinal surgery with instrumentation. Multivariate logistic regression was utilized to determine the independent

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effect of preoperative S. aureus colonization, susceptibility, and colonization region on postoperative infection.

Results

1,168 patients (35.3%) had preoperative S. aureus colonization. 68 patients (2.1%) developed a S. aureus postoperative infection. Multivariable analysis demonstrated preoperative colonization was associated with increased odds of S. aureus superficial surgical site infection (SSI) (OR: 1.65) and bloodstream infection (BSI) (OR: 1.79). Factors associated with increased odds of postoperative infections included preoperative colonization (OR: 1.67), nasal colonization (OR: 1.03) relative to throat colonization, number of vertebrae fused (OR: 1.15), and BMI (OR: 1.06). Prophylactic decolonization was associated with decreased odds of postoperative infection (OR: 0.6). Chlorhexidine wash (OR: 0.4), intranasal mupirocin (OR: 0.13), and a combination of decolonization measures (OR: 0.56) was associated with decreased odds of postoperative infection.

Conclusion

Preoperative S. aureus is associated with increased odds of S. aureus superficial SSI and BSI. Compared to throat colonization, nasal colonization is associated with increased odds of postoperative infection. Intranasal mupirocin is associated with lower odds of infection relative to a combination of decolonization measures. Further analysis should explore optimal decolonization regimens to implement for at risk patients.

S. Aureus Infection	# of cases	Univariate (OR 95%CI)	P value	Multivariate (OR 95% CI)	P value
Superficial Surgical Site	24	1.65 (1.19-2.31)	0.003	1.65 (1.17-2.33)	0.004
Deep Incisional	23	1.74 (1.01-2.99)	0.047	1.7 (0.96-3)	0.067
Bloodstream	18	1.77 (0.98-4.03)	0.171	1.79 (1.07-4.18)	0.017
Organ Space	3	0.96 (0.29-3.21)	0.952	1.17 (0.34-3.99)	0.799

49. EARLY REOPERATIONS DO NOT ADVERSELY AFFECT LONG TERM PAIN AND ACTIVITY SCORES IN ADULT DEFORMITY PATIENTS

Sarthak Mohanty, BS; Fthimnir Hassan, MPH; Nathan J. Lee, MD; Justin K. Scheer, MD; Chun Wai Hung, MD; Steven G. Roth, MD; *Erik Lewerenz, BS*; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

Hypothesis

Early complications that are effectively addressed following ASD surgery do not adversely affect two-year outcomes.

Design

Retrospective

Introduction

ASD surgery carries a formidable complication and reoperation rate. The effect of early, resolved reoperations on long-term quality of life is debated, bearing significance for patient counseling.

Methods

ASD patients who underwent spinal fusion at a single institution from 2015-2021 with minimum two years' follow-up were included. Patients without readmissions or reoperations(No Reops) were compared to those requiring early reoperation resolved by 6M post-index procedure(Early Reop) cohort. Outcomes included 2Y PROs, PRO improvements, and MCID attainment. Question 22 from the SRS-22r, assessing likelihood of choosing the same treatment, was separately evaluated. 48 patients were necessary to detect a 0.1-point difference in PRO improvement with 95% power.

Results

238 patients [211(89%) had No Reops; 27(11%) had Early Reop] were included. Early reoperations were associated with PJK/DJK(29.63%, n=8), implant dislodgement(18.52%, n=5), and pedicle/vertebral fracture(14.81%, n=4). Other complications, each at 7.41%(n=2), included painful implants, screw breakage, motor deficits, and spinal cord injury. Between cohorts, there was no differences in demographics, operative characteristics, baseline alignment, and preop PROs. PRO improvement was not significantly different for SRS Activity(0.67 vs 0.54,p=0.392), Pain(1.08 vs 0.88,p=0.291), Appearance(1.35 vs 1.12,p=0.179), Mental Health(0.36 vs 0.33,p=0.840), Satisfaction(1.36 vs 0.93,p=0.098), Total score(0.91 vs 0.74,p=0.152), and ODI(−17 vs −15,p=0.564). MCID achievement was comparable for SRS Activity(59% vs 52%,p=0.536), Pain(74% vs 59%,p=0.115), Appearance(82% vs 78%,p=0.269), Mental Health(36% vs 37%,p>0.999), Satisfaction(82% vs 74%,p=0.149), and ODI(61% vs 70%,p=0.403). SRS total score MCID attainment was greater for No Reops Cohort(82% vs 70%,p=0.048). In addition, a greater proportion of No Reop patients endorsed that they would choose the same operative management(86% vs 70%,p=0.046) if they had to choose again.

Conclusion

Early reoperations within 6 months after ASD surgery that addresses the reason for the revision surgery, does not adversely affect two-year functional and pain outcomes. However, only 70% would choose the same treatment again vs 86% of those who didn't undergo a reoperation.

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

	No Reoperations [N=211]	Early Reoperation [N=27]	P Value
Baseline, Preoperative			
SRS Activity	3.06 (0.06)	2.98 (0.15)	0.66
SRS Pain	2.58 (0.06)	2.54 (0.14)	0.8103
SRS Appearance	2.47 (0.05)	2.59 (0.09)	0.4216
SRS Mental Health	3.64 (0.06)	3.77 (0.13)	0.4378
SRS Satisfaction	2.93 (0.07)	3.06 (0.19)	0.5757
SRS Total	2.94 (0.04)	2.98 (0.09)	0.7536
ODI	40.1 (1.27)	43.04 (2.44)	0.4212
Two Years Postop			
SRS Activity	3.73 (0.06)	3.52 (0.14)	0.2188
SRS Pain	3.66 (0.06)	3.42 (0.18)	0.2068
SRS Appearance	3.83 (0.06)	3.71 (0.17)	0.4977
SRS Mental Health	4 (0.06)	4.1 (0.11)	0.5275
SRS Satisfaction	4.29 (0.06)	3.98 (0.17)	0.0802
SRS Total	3.85 (0.05)	3.72 (0.13)	0.3443
ODI	22.98 (1.24)	28.07 (3.13)	0.1618
Two Year - SRS22r Question 22			
Would you have the same management again if you had the same condition?			
"Probably Not" or "Definitely Not"	9 (4.27)	2 (7.41)	**0.0456**
"Not Sure"	20 (9.48)	6 (22.22)	
"Probably Yes" or "Definitely Yes"	182 (86.26)	19 (70.37)	
Change in PROs			
SRS Activity	0.67 (0.05)	0.54 (0.13)	0.3924
SRS Pain	1.08 (0.06)	0.88 (0.17)	0.291
SRS Appearance	1.35 (0.06)	1.12 (0.15)	0.1794
SRS Mental Health	0.36 (0.05)	0.33 (0.12)	0.8398
SRS Satisfaction	1.36 (0.09)	0.93 (0.28)	0.0978
SRS Total	0.91 (0.04)	0.74 (0.12)	0.1522
ODI	-16.93 (1.15)	-14.96 (3.15)	0.5638
MCID in PROs			
SRS Activity	125 (59.24)	14 (51.85)	0.5355
SRS Pain	156 (73.93)	16 (59.26)	0.1153
SRS Appearance	172 (81.52)	21 (77.78)	0.2688
SRS Mental Health	76 (36.02)	10 (37.04)	>0.9999
SRS Satisfaction	173 (81.99)	20 (74.07)	0.1493
SRS Total	173 (81.99)	19 (70.37)	**0.048**
ODI	128 (60.66)	19 (70.37)	0.4029

Table 1. Baseline, two-year, changes in patient reported outcomes, and MCID attainment
Legend. Table presents a comparison between patients who experienced no reoperations or readmissions and those who underwent an early reoperation, which was resolved within six months following the index procedure. MCID the SRS22r Question 22 present counts, with the corresponding percentage of the total for each column indicated in parentheses.

50. IMPACT OF DURABILITY ON POTENTIAL TO ACHIEVE COST/QALY WITHIN THE WILLINGNESS-TO-PAY (WTP) THRESHOLDS FOR ASD SURGERY: IT IS IMPOSSIBLE UNLESS WE AVOID REOPERATIONS

Jeffrey L. Gum, MD; Pratibha Nayak, PhD, MBA, MPH; Richard Hostin, MD; Breton G. Line, BS; Shay Bess, MD; Lawrence G. Lenke, MD; Renaud Lafage, MS; Justin S. Smith, MD, PhD; Jeffrey Mullin, MD; Michael P. Kelly, MD; Bassel G. Diebo, MD; Thomas J. Buell, MD; Justin K. Scheer, MD; Virginie Lafage, PhD; Eric O. Klineberg, MD; Han Jo Kim, MD; Peter G. Passias, MD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Alan H. Daniels, MD; Alex Soroceanu, MD, FRCS(C), MPH; Gregory M. Mundis Jr., MD; Themistocles S. Protopsaltis, MD; Kojo D. Hamilton, MD, FAANS; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; International Spine Study Group

Hypothesis
ASD surgeries are unlikely to achieve the WHO WTP threshold of 150K or 250K, within 2-yrs of surgery, regardless of the number of reoperations.

Design
Retrospective Review of a prospective, multicenter registry

Introduction
ASD surgeries are costly and carry high complication rates. Increased scrutiny because of the high-cost is evident. With such a high index cost, the only way ASD surgeries will meet WTP thresholds is sustained durability. Our goal is to examine the impact of reoperations on WTP thresholds.

Methods
ASD patients with >4 level fusion and minimum 2-year follow-up were included. Index and total episode of care (EOC) cost in 2022 dollars were calculated using average itemized direct costs obtained from the administrative hospital records. Cumulative QALY gained were calculated from the change in pre-op to 2-yr post-op SF-6D scores. Durability was defined based on sustaining QALY gain 2-yrs post-op and reaching WTP of 150K or 250K. Cox proportion hazards regression assessed the effect of number of reoperations for 150K-WTP or 250K-WTP in separate models adjusting for patient, surgical, and sagittal deformity characteristics.

Results
Of 1299 patients eligible, 826 (64%) had complete data. The mean age was 61.9+13.4 years, 73% were female, and 93% Caucasians. At 2-yrs, 507 (61%) patients maintained QALY gain with 76 (15%) patients achieving cost/qaly below 150K and 182 (36%) patients below 250K. No significant baseline differences in age, gender, BMI, frailty, SRS-Schwab sagittal deformity, surgical invasiveness, surgical approach, 3-column osteotomies, or LOS. Reoperation rates were lower in patients achieving 150K-WTP (6.6% vs 22.7%; p=0.001) and 250K-WTP (7.1% vs 27.7%, p<0.001). Multivariate Cox model identified that for every additional reoperation there is 88% (HR: 0.12, 95% CI: 0.09-0.16) and 84% (HR: 0.16, 95% CI: 0.12-0.21) increased hazard of not achieving the WTP threshold of 150K and 250K.

Conclusion
Reoperations are the single most important factor driving the potential to achieve WTP threshold for ASD surgery at 2-yrs. A single reoperation is associated with >80% hazard of not achieving durability at societal WTP 150K or 250K. Efforts to identify and mitigate risk factors associated with reoperations will increase the value of ASD surgery.

51. THE SAFETY AND ACCURACY OF RADIATION-FREE SPINAL NAVIGATION USING AN ULTRASHORT, SCOLIOSIS-SPECIFIC BONEMRI-PROTOCOL COMPARED TO CT

Peter Lafranca, MD; Yorck Rommelspacher, MD, PhD; Sebastian Walter, MD, PhD; Sander Muijs, MD, PhD; Tijl van der Velden, PhD; Yulia Shcherbakova, PhD; René M. Castelein, MD, PhD; Keita Ito, MD, PhD; Peter R. Seevinck, PhD; *Tom Schlösser, MD, PhD*

Hypothesis
MRI-based synthetic-CT spinal navigation is non-inferior to CT for the safety and accuracy of pedicle screw placement at thoracic and lumbar levels.

Design
Investigator-initiated experimental safety study, supported by a Scoliosis Research Society grant.

Introduction
Spinal navigation systems require pre- and/or intra-operative 3D imaging. For all patients, but especially young patients with spinal deformities that require surgical correction, it is important to minimize exposures to

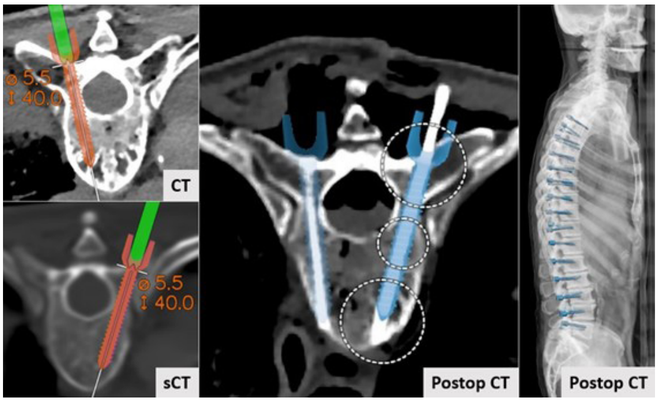
PODIUM PRESENTATION ABSTRACTS

ionizing radiation due to an increased risk of developing cancer later in life. We developed a 14-min scoliosis-specific MRI-protocol that provides both T2 MRI and AI-generated synthetic-CT scans. This investigator-initiated and SRS-funded cadaver study aims to test whether the safety and accuracy of MRI-based synthetic-CT spinal navigation is non inferior to CT.

Methods
Of 5 cadavers the total spines were scanned with both thin-slice CT and the scoliosis-specific BoneMRI-protocol. Four spine surgeons independently performed surface matching for navigated placement of 2.5mm k-wires in all pedicles from T3 to L5. Randomization for CT vs synthetic CT, surgeon, and side was performed with a 1:1 ratio. A postoperative CT was acquired, virtual screws with predefined sizes were simulated on the k-wires, and screw position was verified by an independent researcher. Medial breach rate was assessed using the Gertzbein-Robbins classification, while grade A and B were considered satisfactory screw position.

Results
Surface matching was possible on all levels and sides with both modalities. A total of 140 k-wires were inserted. For both modalities, there were no major breaches exceeding the pedicle cortex >2mm. Of the CT-guided screws, 49 were grade A, 21 grade B. For synthetic CT-guided screws, 60 were grade A and 10 grade B.

Conclusion
MRI-based, AI-generated synthetic-CT spinal navigation is feasible and noninferior to conventional CT for insertion of thoracic and lumbar pedicle screws. The use of radiation-free spinal navigation in pediatric spinal deformity surgery is promising and should be further explored.



Screenshots of intraoperative planning on both CT and sCT. Images of postoperative virtual screws placed over k-wires.

52. NEUROMUSCULAR BLOCKING AGENT USE IN ADOLESCENT IDIOPATHIC SCOLIOSIS SURGERY: A SAFETY ASSESSMENT

Hope M. Gehle, BS; Austin J. Allen, BS; Lukas G. Keil, MD; Jessica H. Heyer, MD; Becki Cleveland, PhD; Joseph D. Stone, MD; James O. Sanders, MD; *Stuart L. Mitchell, MD*

Hypothesis
There will be no difference in neuromonitoring alerts or postoperative neurological deficits or complications in patients who receive non-depolarizing neuromuscular blocking agents (nNMBAs) to facilitate exposure compared to those who do not receive nNMBAs during posterior spinal fusion surgery (PSF) in adolescent idiopathic scoliosis (AIS) patients.

Design
Retrospective Cohort

Introduction
Neurological complications are a key concern during deformity correction surgery for patients with AIS. With use of nNMBAs (e.g., rocuronium) during exposure, there is concern that neuromonitoring may be compromised, even with reversal, and may mask neuromonitoring alerts or result in an increase in postoperative neurological complications. We sought to evaluate the safety for use of nNMBAs to facilitate exposure in pediatric PSF as this practice has not been investigated.

Methods
All consecutive AIS patients who underwent PSF at a single academic institution between 2014-2022 were included. Baseline patient comorbidities, utilization of nNMBAs and/or reversal agents, intra-operative blood loss, and surgical complications were recorded for all patients. Patients were categorized into two groups for analysis based on nNMBA utilization (- nNMBA or + nNMBA). Descriptive statistics and Chi-square or Fisher's exact test for categorical variables and Wilcoxon Sign Rank test were utilized to assess differences in outcomes between groups.

Results
327 patients met all selection criteria and were included. Of these, 49 (15%) did not receive any nNMBA (- nNMBA) and 278 (85%) did receive a nNMBA (+ NMBA). Baseline patient characteristics including sex, age, race, BMI, comorbidities, curve magnitude, number of levels fused, and ASA classification were overall similar between the two groups. There were no significant differences in rate of intraoperative neuromonitoring changes (p=0.78), postoperative neurological deficits (p=0.25), or rate of postoperative complications (p=0.85). Clavien-Dindo-Sink grade of complications were statistically similar despite minor differences (Table 1).

Conclusion
Use of nNMBAs to facilitate exposure during PSF for AIS appears safe as it is not associated with any differences in severity of complications or rates of neuromonitoring alerts, postoperative neurological changes, or complications.

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Table 1: Comparison of postoperative complications based on NMBA status.

Characteristics	Overall n=327	- nNMBA n=49	+ nNMBA n=278	P value
Intra-Op Neuromonitoring Changes (%)	27 (8.3%)	3 (6.1%)	24 (8.6%)	0.78
with postop neuro deficit (%)	5 (1.5%)	1 (2.0%)	4 (1.4%)	0.56
without postop neuro deficit (%)	22 (6.7%)	2 (4.1%)	20 (7.2%)	0.55
Post-Op Neuro Changes in Absence of Neuromonitoring Changes (%)	15 (4.6%)	2 (4.1%)	13 (4.7%)	1.00
Postoperative neurological deficit				
None	308 (94.2%)	46 (93.9%)	262 (94.2%)	0.25
Flank Numbness	8 (2.4%)	1 (2.0%)	8 (2.9%)	
LE Numbness	5 (1.5%)	1 (2.0%)	4 (1.4%)	
UE Paresthesias	2 (0.6%)	1 (2.0%)	1 (0.4%)	
Gluteal Numbness	1 (0.3%)	--	1 (0.4%)	
LE Weakness	1 (0.3%)	--	1 (0.4%)	
Transient urinary retention	1 (0.3%)	--	1 (0.4%)	
Radiculopathy	1 (0.3%)	--	1 (0.4%)	
Total Number of Complications				
No Complications (%)	256 (78.3%)	38 (77.6%)	218 (78.4%)	0.59
One Complication (%)	63 (19.3%)	9 (18.4%)	54 (19.4%)	
Two Complications (%)	7 (2.1%)	2 (4.1%)	5 (1.8%)	
Three Complications (%)	1 (0.3%)	--	1 (0.4%)	
Any Complications (%)	71 (21.7%)	11 (22.4%)	60 (21.6%)	0.85
Maximum Clavien-Dindo-Sink Complication Grade**				
No Complications (%)	256 (78.3%)	38 (77.6%)	218 (78.4%)	0.81
Grade One (%)	57 (17.4%)	9 (18.4%)	48 (17.3%)	
Grade Two (%)	7 (2.1%)	2 (4.1%)	5 (1.8%)	
Grade Three (%)	3 (0.9%)	--	3 (1.1%)	
Grade Four (%)	3 (0.9%)	--	3 (1.1%)	
Grade Five (%)	1 (0.3%)	--	1 (0.4%)	

***Note: Some patients experienced more than 1 complication, so the highest CDS grade complication is reported here.*

Table 1: Comparison of postoperative complications based on non-depolarizing NMBA status.

53. INTRAOPERATIVE NEUROMONITORING (IONM) ALERTS IN CORD LEVEL SURGERIES FOR SEVERE SPINAL DEFORMITIES - DO APPROPRIATE CORRECTIVE MEASURES PREVENT NEURODEFICIT - RESULTS OF SPINAL DEFORMITY INTRAOPERATIVE MONITORING (SDIM) STUDY

Saumyajit Basu, MS(Orth), DNB(Orth), FRCSEd; Stephen J. Lewis, MD, FRCS(C); David W. Polly, MD; So Kato, MD, PhD; Eric O. Klineberg, MD; Kristen E. Jones, MD, FAANS; Brett Rocos, MD, FRCS; Samuel Strantzas, MSc, DABNM; Mario Ganau, MD, PhD; David E. Lebel, MD, PhD; Christopher J. Nielsen, MD

Hypothesis

Appropriate measures can resolve most (but not all) IONM alerts in surgeries for severe spinal deformities.

Design

Prospective, international multicentric study

Introduction

IONM alerts are commonly encountered in severe spinal deformity surgeries, but prospective multicentric data is lacking regarding resolution measures and the ultimate neurodeficit.

Methods

20 international centers prospectively documented surgical events of patients undergoing spinal deformity correction (Cobb>80°) with MEP, SSEP and EMG monitoring. The standardized data collection form had details of all IONM alerts, including events leading to it and corrective measures taken. Detailed neurological examination was performed at baseline, immediately post-op and at discharge. An alert was defined as a loss of amplitude of >50% in SSEP or MEP from baseline or EMG activity > 10 seconds.

Results

Out of 349 cord level surgeries, alerts occurred 81 times in 57 cases (16.3%) - 24 had multiple alerts. 78 out of 81 alerts (96.3%) had MEP drop (44 unilateral, 34 bilateral) either alone or with SSEP/EMG. 16.6% of PCOs, 15.6% of PSOs and 22.7% of VCRs had alerts. Unilateral MEP drops were most associated with osteotomy (57.9%); for bilateral drops, it was rod capturing (64%). During the osteotomy, 88.4% occurred during decompression on the concavity – screw placement, osteotomy closure or interbody cage placement hardly ever produced alerts. For non-surgical events technical cause was most frequent (9.1%) in unilateral changes, and depth of anaesthesia (26.5%) in bilateral changes. The commonest resolution in unilateral MEP loss was implant removal; for bilateral loss it was rod removal. Out of all 78 MEP alerts, 12.8% got steroids, 11.5% had their correction lessened and 11.5% got ignored. 80.8% alerts recovered fully in </= 4.7 minutes. 18.2% of unilateral and 20.6% of bilateral alerts did not recover. 22.8% of those who had and 4.8% of those who did not have an alert had neurodeficit, which occurred in 7.7% of the whole cohort.

Conclusion

16.3% of surgeries had IONM alerts; 96% were MEP drops. Alerts most often occurred during decompression for osteotomies (unilateral) or rod capture (bilateral). With an appropriate response, 80% recovered but 20% did not. A false negative of 5% needs to be resolved in future studies.

Details of MEP alerts in cord level patients by type of MEP change

Variable	Type of MEP change: Unilateral N = 44	Bilateral N = 34	Total N = 78	P value
Event preceding the alert, n (%)#	44	34	78	
Systemic (eg. low blood pressure; anemia)	1 (2.3)	1 (2.9)	2 (2.6)	
Anesthesia	2 (4.5)	9 (26.5)	11 (14.1)	
Technical (eg, malpositioned lead; recording interference)	4 (9.1)	8 (23.5)	12 (15.4)	
Surgical cause	38 (86.4)	25 (73.5)	63 (80.8)	
If surgical cause, please specify, n (%)#	38	25	63	
Exposure	0 (0.0)	0 (0.0)	0 (0.0)	
Implant Placement	7 (18.4)	4 (16.0)	11 (17.5)	
Osteotomy/Release	22 (57.9)	4 (16.0)	26 (41.3)	
Correction/Rod Placement	8 (21.1)	16 (64.0)	24 (38.1)	
Traction	2 (5.3)	0 (0.0)	2 (3.2)	
Other	2 (5.3)	3 (12.0)	5 (7.9)	
Implant Placement, n (%)	6	4	10	0.286‡
Concave	3 (50.0)	3 (75.0)	6 (60.0)	
Convex	3 (50.0)	0 (0.0)	3 (30.0)	
Neutral	0 (0.0)	1 (25.0)	1 (10.0)	
Osteotomy Type (1), n (%)	22	3	25	0.391‡
Posterior column osteotomy (PCO; Type 2)	15 (68.2)	1 (33.3)	16 (64.0)	
Pedicle subtraction osteotomy (PSO; Type 3;4)	2 (9.1)	0 (0.0)	2 (8.0)	
Vertebral column resection (VCR; Type 5;6)	5 (22.7)	2 (66.7)	7 (28.0)	
Osteotomy Type (2), n (%)#	22	4	26	
Decompression	17 (77.3)	3 (75.0)	20 (76.9)	
Osteotomy closure	2 (9.1)	1 (25.0)	3 (11.5)	
Interbody placement	1 (4.5)	0 (0.0)	1 (3.8)	
Other	2 (9.1)	0 (0.0)	2 (7.7)	
Response to alert, n (%)#	44	34	78	
Elevate BP	16 (36.4)	23 (67.6)	39 (50.0)	
Give blood	9 (20.5)	10 (29.4)	19 (24.4)	
Adjust anesthesia	8 (18.2)	12 (35.3)	20 (25.6)	
Technical	1 (2.3)	3 (8.8)	4 (5.1)	
Rod removal	4 (9.1)	9 (26.5)	13 (16.7)	
Implant removal	8 (18.2)	4 (11.8)	12 (15.4)	
Osteotomy opened	1 (2.3)	0 (0.0)	1 (1.3)	
Osteotomy closed	2 (4.5)	1 (2.9)	3 (3.8)	
Adjust traction	2 (4.5)	3 (8.8)	5 (6.4)	
Steroids	8 (18.2)	2 (5.9)	10 (12.8)	
Decompression	3 (6.8)	3 (8.8)	6 (7.7)	
Lessen Correction	3 (6.8)	6 (17.6)	9 (11.5)	
Complete case	5 (11.4)	4 (11.8)	9 (11.5)	
Case terminated	0 (0.0)	1 (2.9)	1 (1.3)	
Other	18 (40.9)	3 (8.8)	21 (26.9)	

Fig 1

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

PODIUM PRESENTATION ABSTRACTS

54. WHAT EVENTS ARE ASSOCIATED WITH INTRAOPERATIVE NEUROMONITORING ALERTS IN SPINAL DEFORMITY SURGERIES? RESULTS FROM THE PROSPECTIVE, MULTICENTRE SPINAL DEFORMITY INTRAOPERATIVE MONITORING (SDIM) STUDY

Kenny Y. Kwan, MD; Yong Qiu, PhD; Ahmet Alanay, MD; Andre Luis F. Andujar, MD; Elias Elias, MD, MS; Stephen J. Lewis, MD, FRCS(C); Samuel Strantzas, MSc, DABNM

Hypothesis

IONM alerts occur more frequently after specific intraoperative maneuvers.

Design

Prospective, multicentre cohorts.

Introduction

Multimodal IONM is the standard of care for spinal deformity surgeries. Our current understanding of the occurrence of IONM alerts during spinal deformity surgeries is limited. The purpose of this study was to determine whether IONM alerts were associated with specific intraoperative maneuvers.

Methods

Patients between aged 10 and 80 with Cobb angle >80o and/or requiring posterior or 3 column osteotomy using multimodal neuromonitoring with EMG, SSEP and MEP were recruited. An alert was defined as SSEP amplitude loss > 50%; MEP amplitude loss > 50% in two of three muscle groups and/or EMG sustained activity for > 10 seconds. Patients were divided into cord level surgery if curve correction was at or above the conus medullaris, and non-cord level if below the conus.

Results

546 patients (349 cord level, 197 non-cord level) were recruited into the study. IONM alerts were recorded in 79 patients (14.5%): 81 alerts occurred in 57 patients (16.3%) at cord level, and 26 alerts occurred in 22 patients (11.2%) at non-cord level. For cord level surgeries, 78/81 alerts had MEP changes (44 unilateral; 34 bilateral MEP changes). The commonest surgical event prior to a unilateral MEP change was an osteotomy/release (57.9%) and correction/rod placement (64%) prior to bilateral MEP change. Unilateral changes most commonly occurred in patients with type 2 osteotomy (68.2%) and type 5 or 6 osteotomy (66.7%) for bilateral changes. IONM alert occurred more frequently during decompression on the concave side (76.5%) in unilateral MEP changes. For non-cord level surgeries, 21/26 alerts had MEP changes (16 unilateral; 5 bilateral). The most frequent event was osteotomy/release prior to unilateral (50%) and bilateral (66.7%) MEP changes. For non-surgical events prior to alert in cord level surgeries, technical was most frequent (9.1%) in unilateral changes; anaesthesia (26.5%) and technical (23.5%) were most frequent in bilateral MEP changes. For non-cord level surgeries, technical (25%) was most frequent in unilateral changes; systemic events (low blood pressure; anaemia (20%); technical (20%))in bilateral MEP changes.

Conclusion

Specific events are associated with different kinds of IONM alerts.

55. SARCOPENIA USING L3 AND L4 NORMALIZED TOTAL PSOAS AREA PREDICTS EARLY POSTOPERATIVE MOBILITY AND PERIOPERATIVE ADVERSE EVENTS AFTER ADULT SPINAL DEFORMITY SURGERY

Takashi Hirase, MD, MPH; Han Jo Kim, MD; Chukwuebuka Achebe, BS; Myles Allen, MbChB; Gregory Kazarian, MD; Michael Mazzucco, BS; Hiroyuki Nakarai, MD; Francis C. Lovecchio, MD

Hypothesis

Sarcopenia measured by L3 and L4 normalized total psoas area (NTPA) are associated with lower early postoperative mobility and higher rates of perioperative adverse events (AEs) among patients undergoing adult spinal deformity (ASD) surgery.

Design

Retrospective cohort study

Introduction

Sarcopenia measured by NTPA has been shown to predict perioperative outcomes after various types of spine surgery. However, there is limited data regarding its association with postoperative mobility and AEs in ASD surgery. The purpose of this study was to determine the relationship between NTPA and postoperative mobility and AEs among patients undergoing ASD surgery.

Methods

Patients that underwent ASD surgery at a single-center (2014-2023) were included in the study. Sarcopenia was analyzed by using NTPA at the L3 and L4 mid-vertebral body on preoperative magnetic resonance imaging (MRI). Receiver operating characteristic (ROC) curve analysis was used to determine gender-specific NTPA cut-off values for predicting perioperative AEs. Patients were categorized as sarcopenic if both L3 and L4 NTPA were below the cut-off values. Multivariate logistic regression was conducted to identify confounding predictors of perioperative AEs.

Results

279 patients (102 males, 177 females, mean age 61.2 ± 15.2 years) were included. ROC curve analysis demonstrated L3 NTPA <805 mm²/m² for males and <505 mm²/m² for females and L4 NTPA <912 mm²/m² for males and <714 for females mm²/m² as cut-off values predicting perioperative AEs. 103 patients (36.9%, 42 males, 61 females) were below these cut-off values and were in the sarcopenia cohort. The remaining 176 patients (63.1%, 60 males, 116 females) were in the non-sarcopenia cohort. There was no difference in the 5-item modified frailty index between the cohorts (p=0.844). The sarcopenia group had a higher overall perioperative AEs (70.9% vs 39.2%, p<0.001), and lower ambulation distances on postoperative day 1 and 2 compared to the non-sarcopenia group (p=0.024, p=0.043, respectively). On multivariate analysis, there were no other predictors of perioperative AEs.

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Conclusion

Sarcopenia measured by L3 and L4 NTPA is associated with lower early postoperative mobility and higher rates of perioperative AEs among patients undergoing ASD surgery.

Table 1: Characteristics and Perioperative Outcomes of the Study Population

Variable	Sarcopenia (n=103)	No Sarcopenia (n=176)	*P* Value
L3 NTPA, mm^2/m^2 (mean, SD)	469.0 ± 140.0	712.8 ± 201.7	<0.001*
L4 NTPA, mm^2/m^2 (mean, SD)	647.8 ± 147.4	924.2 ± 217.0	<0.001*
Age, years (mean, SD)	60.1 ± 16.5	61.7 ± 14.4	0.428
BMI, kg/m^2 (mean, SD)	25.9 ± 4.8	28.9 ± 6.4	<0.001*
ASA class (mean, SD)	2.3 ± 0.5	2.3 ± 0.5	0.814
CCI (mean, SD)	1.9 ± 1.4	2.0 ± 1.5	0.724
Smoker, n (%)	4 (3.9)	4 (2.3)	0.435
Diabetes, n (%)	10 (9.7)	15 (8.5)	0.741
mFI-5 (mean, SD)	0.93 ± 0.94	0.95 ± 0.89	0.844
DEXA t-score, (mean, SD)	-1.8 ± 1.6	-1.7 ± 1.1	0.765
BMD, mg/cc K_2HPO_4 (mean, SD)	114.1 ± 31.7	101.1 ± 36.4	0.278
EBL, mL (mean, SD)	1135.7 ± 1116.6	913.3 ± 774.3	0.079
Operative time, min (mean, SD)	255.1 ± 88.9	256.3 ± 101.1	0.920
Post-operative LOS (hours) (mean, SD)	140.5 ± 81.3	137.5 ± 65.1	0.750
30-day Reoperation (n, %)	2 (1.9)	3 (1.7)	0.889
30-day Readmission (n, %)	2 (1.9)	3 (1.7)	0.889
Perioperative Adverse Events (n, %)			
Any adverse events	73 (70.9)	69 (39.2)	<0.001*
Post-op anemia requiring transfusion	42 (40.8)	31 (17.6)	<0.001*
Ileus	16 (15.5)	14 (8.0)	0.049*
Urinary retention	14 (13.6)	11 (6.3)	0.038*
Wound complication (dehiscence, infection)	1 (0.9)	2 (1.1)	0.897
Delirium	8 (7.8)	6 (3.4)	0.107
Atelectasis	2 (1.9)	1 (0.6)	0.284
UTI	2 (1.9)	1 (0.6)	0.284
DVT	2 (1.9)	2 (1.1)	0.582
Epidural hematoma	1 (0.9)	1 (0.6)	0.704
Postoperative Ambulation Distance, ft (mean, SD)			
POD 1	42.5 ± 59.0	63.6 ± 79.3	0.021*
POD 2	89.7 ± 81.9	116.5 ± 106.1	0.028*
POD 3	112.4 ± 82.7	121.2 ± 85.4	0.473
POD 4	128.8 ± 100.6	122.9 ± 79.1	0.704

**Statistically significant values*
SD, standard deviation; NTPA, Normalized Total Psoas Area; BMI, body mass index; ASA, American Society for Anesthesiologists; CCI, Charlson Comorbidity Index; DEXA, dual energy X-ray absorptiometry; EBL, estimated blood loss; LOS, length of stay; UTI, urinary tract infection; DVT, deep vein thrombosis; POD, postoperative day

56. LOWER HOUNSFIELD UNITS AND SEVERE PARASPINAL SARCOPENIA ARE INDEPENDENT PREDICTORS OF INCREASED RISK FOR PROXIMAL JUNCTIONAL KYPHOSIS AND FAILURE FOLLOWING THORACOLUMBAR FUSIONS TERMINATING IN THE UPPER THORACIC SPINE

Zachariah W. Pinter, MD; *Anthony L. Mikula, MD*; Giorgos Michalopoulos, MD; Nikita Lakomkin, MD; Zach Pennington, MD; Ahmad Nassr, MD; Brett A. Freedman, MD; Arjun Sebastian, MD; Mohamad Bydon, MD; Jeremy L. Fogelson, MD; Benjamin D. Elder, MD, PhD

Hypothesis

Severe paraspinal sarcopenia and lower Hounsfield Units (HU) at the upper instrumented vertebra (UIV) will be independent predictors of increased risk of developing proximal junctional complications including proximal junctional kyphosis (PJK) and proximal junctional failure (PJF).

Design

Retrospective review

Introduction

The purpose of the present study was to assess the impact of sarcopenia on the development of PJK and PJF following thoracolumbar spine fusion surgery from the upper thoracic spine to the pelvis using opportunistic evaluation of paraspinal fatty degeneration on preoperative MRI.

Methods

We performed a retrospective review of patients who underwent posterior spine fusion surgery that extended caudally to the pelvis and terminated cranially between T1-6 between 2010 and 2017. The cohort was divided into two groups: (1) patients without PJK or PJF and (2) patients with PJK and/or PJF. These subgroups were then compared based upon demographics, preoperative and 1-year postoperative sagittal alignment parameters, bone mineral density (BMD), and paraspinal sarcopenia. We utilized student's T-test and ANOVA to compare means within and between groups, respectively. Multivariable analyses were performed to determine risk factors for PJK and PJF. P values <0.05 were considered significant.

Results

We identified 81 patients for inclusion in this study. Mean HU at the UIV was 186.1 ± 47.5 in the cohort of patients without PJK or PJF, which was substantially higher than values recorded in the PJK/PJF subgroup (142.4 ± 40.2) (P<0.001). Severe multifidus sarcopenia was identified at a much higher rate in the subgroup of patients who developed proximal junction pathology (66.7%) than in the subgroup of patients who developed neither PJK nor PJF (8.0%; P<0.001). Multivariate analysis demonstrated both low HU at the UIV and moderate-severe paraspinal sarcopenia to be risk factors for the development of PJK and PJF.

Conclusion

The results of this study suggest severe paraspinal sarcopenia and diminished bone density at the UIV impart an increased risk of developing PJK and PJF in patients undergoing thoracolumbar fusions from the upper thoracic spine to the pelvis, while markers of systemic frailty such as mFI and CCI are not associated with an increased risk of these complications.

TABLE 5. Odds Ratios for Development of Proximal Junctional Kyphosis

Variable	Odds Ratio	95% Confidence Interval	P value
Age	1.1	0.99 - 1.23	0.07
Gender (Female)	1.6	0.36 - 7.1	0.54
Mean UIV HU	0.84	0.72 - 0.98	**0.03**
Moderate-Severe Multifidus Sarcopenia	23.8	5.5 - 103.8	**<0.001**

*Abbreviations: BMI (Body Mass Index), UIV (upper instrumented vertebra), HU (Hounsfield Units)

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PODIUM PRESENTATION ABSTRACTS

57. SARCOPENIA AS A PREDICTOR OF PROLONGED LENGTH OF STAY IN ADULT SPINAL DEFORMITY SURGERY

Chukwuebuka Achebe, BS; *Han Jo Kim, MD;* Takashi Hirase, MD, MPH; Myles Allen, MbChB; Robert Uzzo, MBA; Tejas Subramanian, BS; Chad Z. Simon, BS; Atahan Durbas, MD; Jung Mok, MD; Austin Kaidi, MD; Kasra Araghi, BS; Justin T. Samuel, BS; Cole Kwas, BS; Michael Mazzucco, BS; Matthew E. Cunningham, MD, PhD; Francis C. Lovecchio, MD

Hypothesis
Sarcopenia is associated with increased length of stay (LOS) after adult spinal deformity (ASD) surgery.

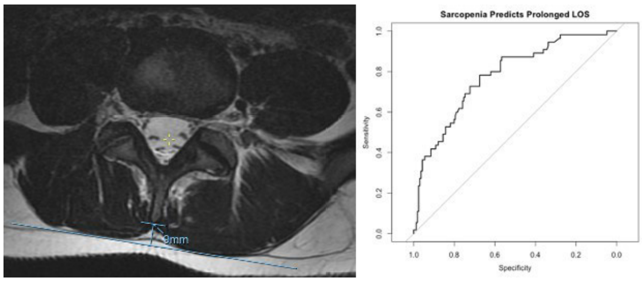
Design
Retrospective single-center cohort study

Introduction
ASD surgery is plagued by variations in episodes of care. By understanding how muscle health influences early recovery, predictive models may better anticipate patient and health care system needs after surgery.

Methods
This retrospective single-center study included patients undergoing 5 or more levels of fusion to the pelvis for a diagnosis of ASD (2013-2021). Sarcopenia was assessed by normalized psoas muscle cross sectional area (NTPA) at L3 and L4 levels and lumbar crossing indentation value (LCIV) at the L4/L5 intervertebral disc, using preoperative MRI scans. The lowest quartile in sex-specific muscle health metrics was deemed sarcopenic according to the corresponding metric. Prolonged LOS was defined as exceeding the 75th percentile. Multivariate logistic regression was performed to control for ASA classification, estimated blood loss (EBL), and number of instrumented levels.

Results
221 patients (71 males, 150 females, mean age 63 ± 10.9 years) were included in the study. The 75th percentile of LOS was 157 hrs. Analysis revealed that non-sarcopenic status, as assessed by LCIV, was significantly associated with decreased odds of prolonged LOS (OR = 0.305, CI = 0.147-0.634, p = 0.0015). Increased EBL was associated with increased odds of prolonged LOS (OR = 1.001, CI = 1.000-1.001, p = 0.0063). The number of spinal levels was also associated with increased odds of prolonged LOS (OR = 1.179, CI = 1.06-1.31, p = 0.0023). The overall model showed good discriminatory power with an AUC = 0.78.

Conclusion
Our findings indicate that certain metrics of muscle health are predictive of length of stay. Further research will be needed to determine whether muscle health may be a modifiable risk factor that can influence early postoperative outcomes.



(Left) LCIV measurement of non-sarcopenic patient. (Right) ROC curve for multivariate logistic regression based on muscle health metrics including NTPA at L3 & L4 and LCIV at L4/L5

58. MACHINE LEARNING FINDS THE SWEET SPOT BETWEEN UNDER CORRECTION LEADING TO PSEUDARTHROSIS AND OVER CORRECTION LEADING TO PROXIMAL JUNCTIONAL KYPHOSIS

Sarthak Mohanty, BS; Justin Reyes, MS; Josephine R. Coury, MD; Erik Lewerenz, BS; Fthimnir Hassan, MPH; Joseph M. Lombardi, MD; Ronald A. Lehman, MD; *Zeeshan M. Sardar, MD*; Lawrence G. Lenke, MD; Multi-Ethnic Alignment Normative Study (MEANS) Group

Hypothesis
Machine learning in asymptomatic volunteers predicts optimal PI-LL values to minimize pseudarthrosis and PJK in ASD correction.

Design
Retrospective with external validation in a single-center cohort

Introduction
Traditional age-adjusted spinopelvic alignment formulas risk under correction in ASD patients. Leveraging machine learning, this study develops surgical PI-LL targets by analyzing alignment in asymptomatic volunteers.

Methods
A predictive model was built for PI-LL mismatch from 468 asymptomatic adults(80% training, 20% validation) across multiple centers. The eXtreme Gradient Boosting algorithm utilized PI, age, & sex. Fig 1B illustrates alignment targets, stratified by age & PI. To validate targets, we analyzed 458 ASD surgical patients with 2Y follow-up. These patients were classified as under-(UC), adequately-(AC), or over-corrected(OC), based on the model's targets±5°(Fig 1B). Key outcomes were pseudarthrosis/implant failure & PJK. Outcomes were analyzed using multivariable regression models, adjusted for significant variables identified in univariate analyses. Data shown as [UC vs AC vs OC,P(ANOVA)].

Results
Mean absolute error between observed & predicted PI-LL were 3.04° & 5.02° for training & validation groups(Fig 1A). In the surgical ASD cohort, 149(32.5%), 159(32.8%),& 150(34.7%) patients were UC, AC, & OC respectively.

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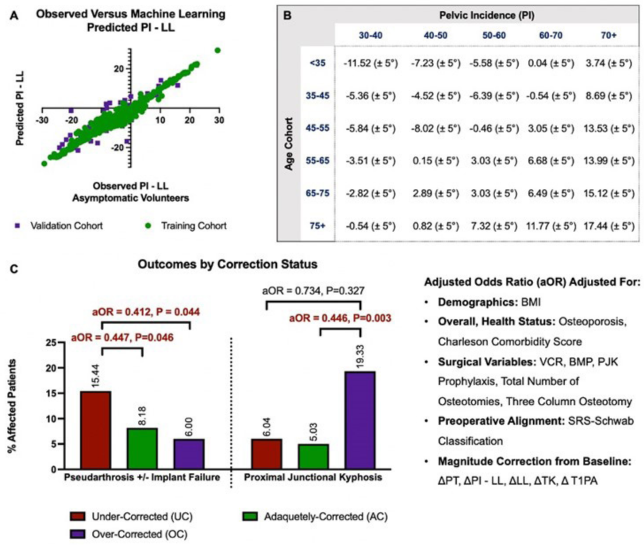
Differences were observed in instrumented levels(12.3 vs 12.7 vs 13.8,P=0.0028), baseline PI-LL(30.3° vs 22.1° vs 17.8°,P<0.0001), & T1PA(30.9° vs 26.0° vs 23.4°,P<0.0001). Pseudarthrosis rate was 9.82%(45/548), with highest incidence in UC cohort(15.4% vs 8.18% vs 6.0%,P=0.0161). PJK rate was 10.0%(46/458), most prevalent in OC group(19.3% vs 6.04% vs 5.03%,P<0.0001). The adjusted multivariable model(P<0.0001, AUC=0.76) found that AC(aOR: 0.45,P=0.046),& OC(aOR: 0.41,P=0.044) had lower odds of pseudarthrosis compared to UC patients(Fig 1C). In an adjusted PJK model(AUC=0.687,P<0.0001), AC had lower odds of PJK compared to OC (OR: 0.45,P=0.0034 (Fig 1C). Both models found the current classification supersedes baseline alignment and magnitude correction in association with pseudarthrosis & PJK.

Conclusion
Machine learning-derived PI-LL targets demonstrate a critical balance in deformity correction. Deviation from these tailored alignment targets increases risk of pseudarthrosis when under corrected and PJK when over corrected.



59. RADIOMICS-POWERED RADIOGRAPHIC IMAGE ANALYSIS FOR ENHANCED MECHANICAL COMPLICATIONS PREDICTION AND SURGICAL PLANNING IN ADULT SPINE DEFORMITY

Ferran Pellisé, MD, PhD; Sleiman Haddad, MD, PhD, FRCS; Susana Núñez Pereira, MD; Caglar Yilgor, MD; Maggie Barcheni, MS; Anika Pupak, BS; Manuel Ramirez Valencia, MD; Javier Pizones, MD, PhD; Ahmet Alanay, MD; Ibrahim Obeid, MD; Frank S. Kleinstueck, MD; Fabio Galbusera, PhD; Oleguer Sagarra, PhD; European Spine Study Group

Hypothesis
Processed image (PrIm) algorithms outperform traditional radiographic measurements (TRM) in predicting postoperative mechanical complications (MC) in adult spinal deformity (ASD).

Design
AI-leveraged retrospective study analyzing preoperative, 6-week and 2-year follow-up data of surgical ASD patients, from a prospective international registry.

Introduction
Radiomics, a technique employing machine learning to extract quantitative features from processed radiographic images, holds promise for improving clinical prediction models. It offers the potential to comprehensively characterize spinal shape and alignment.

Methods
Processed full-spine standing radiographic images were analyzed using an automatic vertebral centroid generation algorithm to map postero-anterior and lateral spinal shape. Distances and angles between each vertebra and the pelvic centroid were automatically obtained. Machine learning models were constructed using Catboost, combining non-radiographic variables (Non-R: demographic, PROMS, surgical), TRM, and PrIm features. AUC-ROC, sensitivity, specificity, and Brier score (0= perfectly calibrated / 1=poor) were used to evaluate prediction accuracy. SHAP values were employed to assess variable contributions and address overfitting/noise.

Results
690 patients (81% female, 52±19 years, 9.7±3.9 fused levels, 18.6% 3CO, 43.5% pelvic fixation, 24.3% MC) were analyzed. The PrIm + Non-R model outperformed the present "Gold Standard" model (TRM + Non-R): AUC-ROC 0.75 vs 0.71 (p=0.009), accuracy 0.72 vs 0.62 (p<0.001), specificity 0.79 vs 0.60 (p<0.001), sensitivity 0.52 vs 0.70 (p<0.001), and Brier score 0.17 vs 0.21 (p<0.001). Adding TRM to PrIm+Non-R model did not improve model estimates (Fig). SHAP adjusted models summed 35 variables and revealed PrIm's superior predictive importance, contributing 66% to the model compared to Non-R (Surgical factors 16%, PROMS 11% and demographics 7%). Personalized SHAP decision plots identified the most critical vertebral centroids associated with MC risk, both globally and individually.

Conclusion
Radiomics, powered by full-spine processed radiographic images, enable the most accurate predictive models for MC in ASD. This novel approach offers clinicians a powerful and time-efficient tool for personalized surgical planning, ultimately enhancing ASD surgical outcomes.

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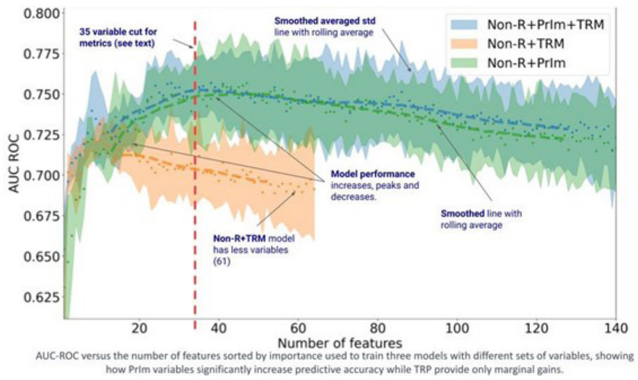


AUC-ROC versus the number of features sorted by importance.

60. NOMOGRAM TO PREDICT UNPLANNED INTENSIVE CARE UNIT ADMISSION FOLLOWING ADULT SPINAL DEFORMITY

Mohammad Daher, BS; Andrew Xu, BS; Sarah Criddle, MD; Mariah Balmaceno-Criss, BS; Lawrence G. Lenke, MD; Virginie Lafage, PhD; Christopher P. Ames, MD; Douglas C. Burton, MD; Stephen J. Lewis, MD, FRCS(C); Renaud Lafage, MS; Robert K. Eastlack, MD; Munish C. Gupta, MD; Gregory M. Mundis Jr., MD; Jeffrey L. Gum, MD; Kojo D. Hamilton, MD, FAANS; Richard Hostin, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Breton G. Line, BS; Shay Bess, MD; Bassel G. Diebo, MD; Eric O. Klineberg, MD; Alan H. Daniels, MD; International Spine Study Group

Hypothesis
A nomogram to predict unplanned ICU admissions following ASD surgery can be created and tested

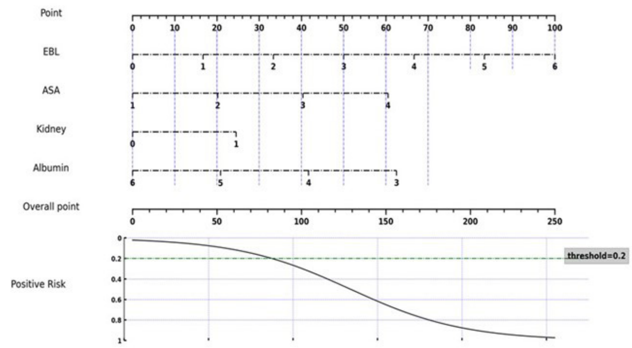
Design
Lasso regression of prospectively collected data.

Introduction
We surveyed spine surgeons and examined patients who were admitted to the ICU outside of the standard protocol. This study then aimed to define a nomogram that predicts ICU admissions within a large study group.

Methods
Patients who underwent ASD surgery were included. Risk factors for ICU admission after spine surgery were identified from previous literature. These variables were added to a Lasso regression to determine the ones with the highest impact on ICU admission. After feature selection, logistic regression was optimized to predict ICU admission. The receiver operating characteristics (ROC) curve was plotted and coefficients as well as odds ratio for each of the selected variables was calculated. The nomogram was developed on 60% of the cohort and tested on 40%.

Results
557 patients were included with 8.2% (46 patients) sustaining major intraoperative or in-hospital medical adverse events requiring moderate or severe intervention, and 22% (125 patients) were admitted to the ICU. Of those, only 20/125 patients had major medical adverse events. Lasso regression identified ASA, pre-operative albumin, kidney disease at baseline, and estimated blood loss (EBL) to be the highest predictors of ICU admission. The ROC curve was plotted for ICU admission with an area under the curve of 0.8. The nomogram was developed to predict ICU admission using these 4 variables (Figure 1). After being tested on 40% of the cohort, it had an accuracy of 78%, a sensitivity of 60% and a specificity of 97%. Furthermore, the model had a threshold of 80 points for ICU admission which could be calculated using points assigned to the values of the 4 included variables. The nomogram may also be able to predict unnecessary ICU admissions, reducing costs by $1560 (median ICU admission cost).

Conclusion
This novel nomogram predicts post-operative ICU admission following ASD surgery utilizing EBL, ASA score, history of kidney disease, and pre-operative Albumin with an accuracy of 78%. While this model helps predict global practice patterns associated with our pool of surgeons, ICU admissions remain an area of need for further research and standardization. Future studies can build on this nomogram to provide guidelines and predictive models for appropriate ICU admission.



61. MODIFIED PEDICLE SUBTRACTION OSTEOTOMY FOR OSTEOPOROTIC VERTEBRAL COMPRESSION FRACTURES: A RETROSPECTIVE STUDY OF 104 PATIENTS

Junyu Li, MD; Jiahao Zhang, MD; Siming Xian, MD; Wenbin Bai, MD; Yihao Liu, MD; Zhuoran Sun, MD; Yongqiang Wang, MD; Miao Yu, MD; Weishi Li, MD; _Yan Zeng, MD_

Hypothesis
Modified PSO can be an effective solution for the treatment of OVCF.

Design
retrospective comparsion

Introduction
Osteoporotic vertebral compression fractures (OVCF) caused by osteoporosis is a common clinical fracture type. There are many surgical treatment options for OVCF, but there is a lack of comparison among different options. Therefore, we counted a total of 104 cases of OVCF operations with different surgical plans, followed

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up the patients, and compared the surgical outcome indications before, after and during the follow-up.

Methods

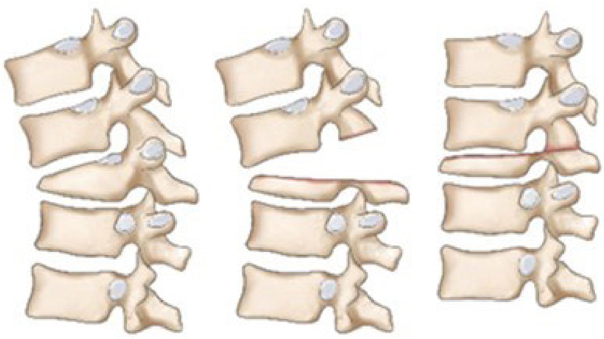
104 patients who underwent posterior osteotomy(Modified PSO, SPO, PSO, VCR) and kyphosis correction surgery at our hospital between April 2006 and August 2021 with a minimum follow-up period of 24 months were included. All cases were injuries induced by a fall incurred while standing or lifting heavy objects without high-energy trauma. The mean CT value was 71 HU, which was below 110 HU, indicating severe osteoporosis. The indications for surgery included gait disturbance due to severe pain with pseudarthrosis, increased kyphotic angle, and progressive neurological symptoms. Pre- and postoperative CL, TLK, TK, PrTK, TKmax, GK, LL, PI, SS, PT, SVA,T-PA,were investigated radiologically. Additionally, We evaluated estimated blood loss, surgical time and perioperative symptom.

Results

The results show, after operation, TLK (39.42±14.26° vs 9.02±8.30°, P<0.001), TK (34.05±17.71°vs 21.83±11.90°, P=0.003), TK max (51.78±11.96°vs 18.35±9.93°, P<0.001), PT (26.31±13.60°vs 14.4±17.84°, P=0.009), SVA (38.44±27.52 vs 21.44±13.02, P=0.010), CL (16.12±15.92° vs 8.15±7.58°, P=0.038) and TPA (24.9±13.18°vs 16.18±10.28°, P=0.045) were improved significantly in modified Pedicle subtraction osteotomy (mPSO). During follow-up, TLK (39.42±14.26°vs 11.68±8.48°, P<0.001) and TK max (51.78±11.96°vs 23.53±9.8°, P<0.001) were improved significantly in Modified PSO group. In additon, estimated blood loss (790ml vs 1198ml, P=0.035), surgical time (244min vs 301min, P=0.010) were favorable in Modified PSO group.

Conclusion

To conclude, mPSO could acquire a favorable degree of kyphosis correction as well as early and high bone union. Compared with other surgical methods, it also has the advantages of less surgical trauma and shorter operation time. It can be an effective solution for the treatment of OVCF.



Improved PSO osteotomy schematic diagram

62. CRITICAL ANALYSIS OF CLINICAL FAILURES DESPITE APPROPRIATE REALIGNMENT IN ADULT SPINAL DEFORMITY

Jamshaid Mir, MD; Brett Rocos, MD, FRCS; Ankita Das, BS; Tobi Onafowokan, MBBS; Daniel B. Chen, BS; Nathan Lorentz, MD; Stephane Owusu-Sarpong, MD; Neel Anand, MD; Bassel G. Diebo, MD; Kojo D. Hamilton, MD, FAANS; Han Jo Kim, MD; Andrew Chen, BS; Zeeshan M. Sardar, MD; Jordan Lebovic, BA; Djani Robertson, MD; Praveen V. Mummaneni, MD, MBA; Nima Alan, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Christopher I. Shaffrey, MD; Dean Chou, MD; M. Burhan Janjua, MD; Justin S. Smith, MD, PhD; Peter G. Passias, MD; Kristen E. Jones, MD, FAANS

Hypothesis

Patient and surgical factors vary in those that develop major mechanical complications despite being proportioned in global alignment and proportionality (GAP) score.

Design

Retrospective cohort

Introduction

The GAP score is a pelvic-incidence-based proportional method of analyzing the sagittal plane that predicts mechanical complications in patients undergoing surgery for adult spinal deformity. Setting surgical goals according to the GAP score may decrease the prevalence of mechanical complications. However, addressing these targets does not always prevent mechanical complications or reoperations.

Methods

Surgical ASD patients fused from at least L1 and proximal to the sacrum with 2-year follow-up were isolated. Proximal and distal junctional kyphosis and/or failure, rod breakage, and other implant-related complications were considered mechanical complications. Cohort was stratified based on GAP categories [Proportioned (GAP-P), Moderately Disproportioned (GAP-MD), and Severely Disproportioned (GAP-SD)]. GAP-P were evaluated based on the development of major mechanical complications and PJF (MMC) vs no MMC (nMMC).

Results

321 patients (64±9 yrs, 78% F, 27.5±5.1 kg/m2, CCI 1.9±1.7, frailty 3.5±1.5) were isolated. By postoperative GAP proportionality: 34% of patients were GAP-P, 39% GAP-MD, and 27% GAP-SD. Although lower than those not proportioned, GAP-P still had 33% MMC, (33% vs 48%, p<.05). Isolating those in GAP-P to evaluate for variances in those that developed MMC, found no difference in baseline patient factors. Preoperatively, MMC had higher lumbosacral coronal Cobb angle (22° vs 17°, p=.045), and T4-T12 kyphosis (37° vs 30°, p=.041) compared to nMMC. The use of PJK prophylaxis was significantly lower in MMC (26% vs 49%, p=0.3). No difference in surgical approach, osteotomies, 3CO, or IBF. Postoperatively, MMC still had higher lumbosacral coronal Cobb angle (8° vs 5°, p=.03), and T2-T12 kyphosis (55 vs 49, p=.04). No difference in other parameters including UIV slope. Patients with postoperative lumbosacral coronal Cobb >5° had a 4x likelihood of MMC (4.2 [1.14-15.48], p=0.031).

Conclusion

Being proportioned according to GAP decreased rates of major mechanical complications and reoperation. Despite that, 30% of patients still developed major mechanical complications and PJF. In those proportioned,

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PODIUM PRESENTATION ABSTRACTS

thoracic kyphosis, and lumbosacral Cobb angle predictive of developing major mechanical complications.

63. BEHAVIORAL PATTERNS OF MECHANICAL COMPLICATIONS IN ADULT DEFORMITY SURGERY

Riccardo Raganato, MD; Alejandro Gomez-Rice, MD, PhD; Lucía Moreno-Manzanaro, BS; Fernando Escamez, MD; Gloria Talavera, MD; Jose Miguel Sánchez-Márquez, MD, PhD; Nicomedes Fernández-Baíllo, MD; Francisco Javier S. Perez-Grueso, MD; Frank S. Kleinstueck, MD; Ibrahim Obeid, MD; Ahmet Alanay, MD; Ferran Pellisé, MD, PhD; Javier Pizones, MD, PhD; European Spine Study Group

Hypothesis
Mechanical complications, often aggregated under a unified composite variable, exhibit substantial variations in nature and characteristics.

Design
Retrospective observational study of adult spinal deformity (ASD) patients from a prospective multicenter database

Introduction
The most prevalent mechanical complications post adult deformity surgery are proximal junctional problems, pseudoarthrosis (PA), and rod breakage (RB). Despite these complications being typically studied together, we hypothesize that they are different entities in nature and characteristics. This study aims to differentiate and cluster their behavioral patterns based on evolution and predisposing factors.

Methods
All ASD operated patients from the database were analyzed for Proximal Junctional Kyphosis (PJK), Proximal Junctional Failure (PJF), pseudarthrosis, rod breakage, and no complications. Kaplan-Meier survival analysis with Log-Rank tests and multivariate Cox regression models, encompassing biological variables, radiographic alignment, and surgical parameters, were utilized to identify complication-related factors.

Results
1,505 patients were analyzed, with 260 (17.3%) developing mechanical complications: PJK (65), PJF (43), PA (56), and RB (96). Similar time-to-event patterns were observed for PJK and PJF (Log-Rank test p=0.446) (160 days [Q1=72; Q3=492]), and PA and RB (Log-Rank test p=0.782) (695 days [Q1=371; Q3=1059]), clustering them in pairs. Survival curves differed significantly between PJK/PJF and PA/RB (Log-Rank test p<0.001). Multivariate models associated (p<0.05) PJK/PJF occurrence with age (OR=1.039), Short Form 36 Physical Component Summary Scale (SF36-PCS) (OR=0.963), and alignment parameters (Relative Lumbar Lordosis [OR=1.025], Relative Spinopelvic Alignment [OR=1.064]), and the number of instrumented levels (OR=1.123). PA/RB occurrence was associated (p<0.05) with age (OR=1.017), Body Mass Index (OR=1.044), SF36-PCS (OR=0.975), alignment parameters (Relative Spinopelvic Alignment [OR=1.034]), and the number of instrumented levels (OR=1.127).

Conclusion
Clustered complications PA/RB exhibit delayed onset compared to PJK/PJF. While influencing variables overlap, PJK/PJF is more related to altered alignment parameters, while PA/RB is more influenced by biological factors.

Table 1. Multivariate Cox Regression Model with PJK/PJF as composite dependent variable

	p	OR	95% CI Min	95% CI Max
Age	0.000	1.039	1.020	1.059
Gender	0.152	1.426	0.878	2.318
BMI	0.859	1.004	0.960	1.050
Smoking	0.625	0.972	0.868	1.089
SF36-PCS	0.003	0.963	0.940	0.987
N instrum levels	0.000	1.123	1.073	1.176
RLL	0.033	1.025	1.002	1.049
RSA	0.000	1.064	1.032	1.098

Table 2. Multivariate Cox Regression Model with PA/RB as composite dependent variable

	p	OR	95% CI Min	95% CI Max
Age	0.034	1.017	1.001	1.033
Gender	0.271	1.315	0.808	2.139
BMI	0.042	1.044	1.002	1.088
Smoking	0.923	0.995	0.906	1.093
SF36-PCS	0.019	0.975	0.955	0.996
N instrum levels	0.000	1.127	1.077	1.178
RLL	0.698	0.995	0.972	1.019
RSA	0.049	1.034	1.000	1.068

Multivariate Cox Regression Models

64. THE VARUS KNEE PHENOMENON IN SPINAL DEFORMITY PATIENTS

Alex Ha, MD; Taikhoom M. Dahodwala, MD, MBBS; Xavier E. Ferrer, MD; Lawrence G. Lenke, MD; Scott Zuckerman, MD, MPH; Mena G. Kerolus, MD; Josephine R. Coury, MD; Daniel Hong, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD

Hypothesis
Spinal deformity patients with severe sagittal and coronal malalignment are predisposed to presenting with the varus knee phenomenon in standing films, which will correct postoperatively when global spine alignment is restored.

Design
A retrospective, single-center case control study.

Introduction
In spinal deformity patients, non-pelvic extraspinal compensatory measures (e.g. hip extension, knee flexion, and ankle dorsiflexion) have been described in the literature to maintain sagittal spinal alignment, however, there is paucity of literature describing coronal compensatory changes. This study aims to present the prevalence of compensatory varus knee phenomenon in spinal deformity patients in the preoperative setting and the effects of postoperative global spinal alignment restoration to the lower extremity mechanical axis.

Methods
A retrospective, single-center radiographic review of 314 patients receiving spinal deformity surgery by a single surgeon between July 2015 to 2018 were included. The mechanical axis deviation (MAD) was the distance

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

measured from the lower extremity mechanical axis to the center of the tibial spine. The varus knee position was defined when the center of the knee was 20 mm lateral to the MA of the lower extremity. Sagittal vertical axis (SVA) and knee flexion angle (KFA) were also measured pre- and postoperatively.

Results

Among the 223 adult patients, 44 (20%) had malalignment preoperatively, with significant improvements in MAD, SVA, and KFA noted postoperatively. Within the malaligned group, the MAD decreased from 28.2±15.6mm to 20.2±17.5mm on the right lower extremity (p=0.02); on the left, MAD decreased from 28.5±16.5mm to 20.2±15.8mm (p=0.003). SVA decreased from 73.2±68.9mm to 39.5±36.0mm (p=0.003). KFA decreased from 15.1±8.0˚ to 12.3±8.9˚ (p=0.009). Among those with varus malalignment, MAD changed on the right from 29.9±17.4mm to 21.1±19.1mm (p<0.001). On the left, MAD changed from 31.8±17.4mm to 20.3±14.1mm (p=0.002). SVA changed from 76.4±73.9mm to 37.8±36.6mm (p<0.001). KFA likewise decreased from 16.1±11.6˚ to 12.6±9.8˚ (p=0.02).

Conclusion

The coronal lower extremity malalignement in spinal deformity patient is present in 19.7% of the adult cohort. More than 50% of adult patients with the varus knee phenomenon self-corrected to neutral lower extremity mechanical axis after spinal deformity correction. Within the varus group, the spinal deformity surgery improved the SVA, KFA, and mechanical axis deviation.

Adult Group (>=19 years) N (%) or Mean±SD	Mechanically Aligned (<20mm) (n=179)	Mechanically Malaligned (>20mm) (n=44)	p-value*
Age (years)	44.5±18.5	50.7±19.6	0.051
Diagnosis			-
AdIS	122 (54.8)	18 (8.1)	
ADS	24 (10.8)	13 (5.8)	
Congenital Scoli	12 (5.4)	0 (0)	
Kyphosis	11 (4.9)	2 (0.9)	
NMS/Syndromic	10 (4.5)	11 (4.9)	
Primary	91 (40.8)	27 (12.1)	0.21
Preop MAD R (mm)	7.4±5.4	28.2±15.6	**<0.0001**
Postop MAD R (mm)	7.5±5.6	20.2±17.5	**<0.0001**
p-value*	0.28	**0.019**	-
Preop MAD L (mm)	7.5±4.7	28.5±16.5	**<0.0001**
Postop MAD L (mm)	7.2±5.7	20.2±15.8	**<0.0001**
p-value*	0.070	**0.0031**	-
Preop SVA (mm)	41.1±44.0	73.2±68.9	**0.0002**
Postop SVA (mm)	28.0±21.8	39.5±36.0	**0.0071**
p-value*	0.12	**0.0027**	-
Preop KFA (°)	7.9±7.0	15.1±8.0	**0.0002**
Postop KFA (°)	7.8±5.9	12.3±8.9	**0.0026**
p-value*	0.53	**0.0087**	-
# of patients with Mechanical Malalignment (%)	7 (3.1)	22 (9.9)	**<0.0001**
Postop varus (%)	7 (3.1)	15 (6.7)	
Postop valgus (%)	0 (0)	7 (3.1)	

65. EFFECTS OF KNEE OSTEOARTHRITIS ON COMPENSATORY MECHANISMS POST-SPINAL DEFORMITY CORRECTION

Yoon Ha Hwang, MD; Kyunghyun Kim, MD, PhD; Yoon Ha, MD, PhD; Jaeyoung So, MD

Hypothesis

In cases of adult spinal deformity with concomitant severe knee osteoarthritis, it is hypothesized that postoperative radiological restoration and clinical improvement may be adversely affected.

Design

Retrospective, propensity score matched cohort study.

Introduction

We investigated the relationship among regional alignments, the chronological sequence of compensatory mechanism changes, restoration of sagittal malalignment, and the effect of knee osteoarthritis on vanishing compensatory mechanism and clinical outcomes in deformity correction surgery.

Methods

We reviewed medical records and EOS radiographs of 75 patients with adult spinal deformity (ASD) undergoing thoracolumbar fusion between May 2018 and June 2022, with a minimum of 2 year of postoperative follow-up. Data collection focused on changes in various spinal and lower extremity alignments, including global angle, pelvic shift, knee angles (KA), and ankle angles (AA). We conducted propensity-matched comparisons to elucidate the impact of (OA) on vanishing compensatory mechanisms between the knee osteoarthritis group (KOA) and the non-knee osteoarthritis group (NKOA) based on the Kellgren-Lawrence Grading (KLG). Additionally, the study assessed patient-reported outcome measures such as the Oswestry Disability Index, Scoliosis Research Society questionnaire, and the 36-Item Short-Form Health Survey.

Results

A significant linear correlation was observed between the change in T1 pelvic angle (Δ TPA) and the changes in various spinal and lower extremity parameters during follow-ups. Meaningful correlation coefficients for thoracic kyphosis, sacro-femoral angle (SFA), and AA, initially not observed, were confirmed during the final follow-up. KOA group exhibited limited restorative changes in compensatory spinal and lower extremities (KA: 1.1 ± 5.5 vs 7.1 ± 9.3, p=0.015). Clinical outcomes showed improvement in both groups, with the NKOA group demonstrating more significant progress in SF-36 (p<0.05).

Conclusion

Restoring sagittal alignment leads to the disappearance of compensatory mechanisms in a temporal pattern, with lower extremity improvements continuing for over a year. Severe knee OA over KLG 3 impedes this restoration and results in poorer clinical outcomes.

Baseline, immediate, and final follow-up data for regional and global parameters are presented, showing sagittal balance restoration differences in knee osteoarthritis (KOA) and NKOA through diagrams.

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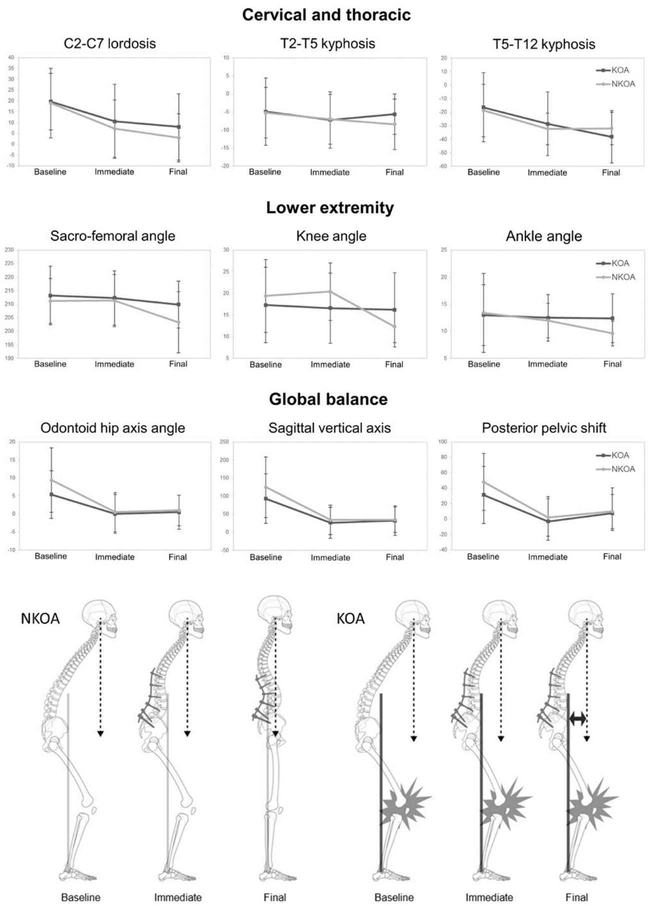
PODIUM PRESENTATION ABSTRACTS



66. IMPACT OF KNEE OSTEOARTHRITIS AND ARTHROPLASTY ON FULL BODY SAGITTAL ALIGNMENT IN ADULT SPINAL DEFORMITY PATIENTS

Mohammad Daher, BS; *Alan H. Daniels, MD*; Mariah Balmaceno-Criss, BS; Manjot Singh, BS; Renaud Lafage, MS; Lawrence G. Lenke, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; Stephen J. Lewis, MD, FRCS(C); Eric O. Klineberg, MD; Robert K. Eastlack, MD; Munish C. Gupta, MD; Gregory M. Mundis Jr., MD; Jeffrey L. Gum, MD; Kojo D. Hamilton, MD, FAANS; Richard Hostin, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Breton G. Line, BS; Shay Bess, MD; Frank J. Schwab, MD; Virginie Lafage, PhD; Bassel G. Diebo, MD; International Spine Study Group

Hypothesis
Knee osteoarthritis (KOA) and arthroplasty (TKA) affect sagittal spinopelvic alignment and patient reported outcome measures (PROMs) in adult spinal deformity (ASD) patients.

Design
Retrospective review of prospectively collected data.

Introduction
Limited studies have examined the impact of KOA and TKA on ASD patients. This study aims to assess how KOA and KA affect full body sagittal alignment parameters and PROMs.

Methods
Patients underwent ASD surgery with pre-operative full-body radiographs were included. OA was graded by two reviewers using the Kellgren Lawrence (KL) classification. In analysis #1: patients were grouped into: bilateral KL<3 (G1), unilateral KL>2 (G2), and bilateral KL>2 (G3). For analysis #2 patients with severe KOA were excluded, and patients were then grouped intopatients with bilateral mild KOA KL<3 (Mild) and patients with unilateral/bilateral (TKA). Patients were propensity-score matched for age, frailty, HOA, PI, and T1PA. Comparative analyses were performed on patient demographics, baseline radiographic sagittal alignment, and/or PROMs (PROMIS, SRS, VR12, ODI). Multivariate regression controlling for age, frailty, PI, T1PA, and KOA, was done to identify independent alignment predictors associated with KOA.

Results
290 patients in analysis#1 (199 G1, 31 G2, 60 G3), G2 and G3 were older (G1: 50.3, G2:63.3, G3:62.3 years) and G2 were frailer G1 (G1: 2.6, G2:4.1) ($p<0.05$). No difference was observed in sex or comorbidities. On univariate analysis, PT, PI-LL, SVA, sacro-femoral, knee flexion, ankle dorsiflexion angles, pelvic shift, and GSA were significantly worse in G2 and G3 (Figure 1). On multivariate analysis, only knee flexion ($R=0.63$, $\beta=0.13$, $p=0.01$) and ankle dorsiflexion ($R=0.47$, $\beta=0.14$, $p=0.02$) angles were independently associated with KOA. In analysis#2 (48 mild OA, 48 TKA), no difference was found in sagittal alignment parameters or PROMs.

Conclusion
ASD patients with severe KOA present with a worse full body sagittal deformity (higher GSA, SVA and PI-LL). However, KOA was only independently associated with greater knee flexion and ankle dorsiflexion. In a matched subanalysis, TKA patients exhibited similar PROMs and radiographic full body alignment vs. patients with mild OA.

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Variable	Bilateral non-severe knee osteoarthritis (n=199)	Unilateral severe knee osteoarthritis (n=31)	Bilateral severe knee osteoarthritis (n=60)	p-value
Pelvic tilt	20.7 ± 11.2	26.3 ± 9.5*	27.0 ± 9.2*	<0.001
PI-LL	8.0 ± 23.7	19.6 ± 19.2*	16.3 ± 20.3*	0.005
Sagittal vertical axis	34.7 ± 55.4	65.4 ± 75.0*	51.7 ± 53.1	0.009
Sacro-Femoral angle	203.6 ± 10.5	205.1 ± 11.1	207.4 ± 8.4*	0.047
Knee flexion angle	-0.02 ± 7.3	7.8 ± 9.4*	4.5 ± 8.7*	<0.001
Ankle dorsiflexion angle	2.3 ± 4.0	6.6 ± 4.5*	5.1 ± 4.1*	<0.001
Pelvic shift	13.1 ± 41.8	34.4 ± 42.1*	30.5 ± 46.1*	0.004
Global sagittal alignment	2.1 ± 5.1	5.7 ± 6.4*	4.5 ± 5.4*	<0.001

*: Statistically significant difference when compared to G1 in post-hoc analysis

Figure 1: Results of Univariate comparison in analysis#1 and anteroposterior and Lateral standing radiographs of patients with bilateral mild knee osteoarthritis (A), unilateral severe knee osteoarthritis (B), bilateral severe knee osteoarthritis (C), and bilateral total knee arthroplasty (D).

67. DOES ACHIEVEMENT OF IDEAL L1PA USING MIS TECHNIQUES IN ASD CORRECTION LEAD TO BETTER OUTCOMES?

Robert K. Eastlack, MD; *Ryan Khanna, MD;* Gregory M. Mundis Jr., MD; Peter G. Passias, MD; Dean Chou, MD; Michael P. Kelly, MD; Richard G. Fessler, MD; Paul Park, MD; Michael Y. Wang, MD; Adam S. Kanter, MD; Kojo D. Hamilton, MD, FAANS; David O. Okonkwo, MD, PhD; Pierce D. Nunley, MD; Neel Anand, MD; Juan S. Uribe, MD; Jay D. Turner, MD; Shay Bess, MD; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Vivian Le, MPH; Praveen V. Mummaneni, MD, MBA; International Spine Study Group

Hypothesis
Achieving optimal L1 PA using MIS correction of ASD will lead to better outcomes and a reduction in revision rates.

Design
Retrospective cohort review of multi-center prospectively collected database

Introduction
Previous research has suggested there is an ideal L1 vertebral pelvic angle (L1PA) and the T4 pelvic angle is nearly equivalent, which aligns the T4-L1 Hip axis. Early data from open technique cohorts suggests that achieving ideal L1 PA after surgical correction is associated with lower rates of surgical revision. We investigated how frequently ideal L1PA was achieved with MIS correction of ASD, as well as its potential impact on mechanical failure and revision risks.

Methods
Inclusion criteria was diagnosis of ASD (scoliosis≥20°, SVA≥5cm, PT≥25°, or TK≥60°) and min 2yr follow-up. Ideal L1PA was defined as (0.5xPelvic Incidence)-21. Patients were determined to have achieved ideal alignment if their 6-week postop XR demonstrated an L1PA within 5 degrees of Ideal L1PA. Logistic regression was performed to assess the effect of L1PA on surgical reoperations and HRQOL.

Results
1108 patients met inclusion criteria. 131 patients were in the MIS group and 973 patients were in the open group. Baseline parameters were similar between MIS and open groups: T4PA (20.0 vs 18.1, p=.107), L1PA (11.7 vs 12.1, p=.698), SVA (68.3 vs 58.9, p=.079), PI-LL (17.3 vs 14.5, p=.101), maximum Cobb (28.4 vs 38.4, p=.09) and pelvic tilt (22.3 vs 23.0, p=.569). 63% of patients in the MIS group achieved ideal L1PA after surgical correction compared to 61% in the open group (p=.342). Preoperative L1 PA decreased on average 2.1 degrees to 9.9 degrees in a combined cohort. Achieving ideal L1PA alignment in the MIS group was associated with reduced risk of reoperation (15% vs. 33%, p<0.01), and greater increase in SRS-22 (0.85 vs 0.40, p<0.01). Achieving ideal L1PA in the open cohort did not result in a reduction in reoperation rate (21% vs 23%, p=.484). In both cohorts, rod breakage rates (4% vs 9%, p=.17) and PJK rates (15.2% vs 12.2%, p=.16) were not different when comparing ideal to nonideal L1PA.

Conclusion
Optimal alignment as defined by L1PA can be achieved similarly to open techniques when utilizing MIS for correcting ASD, and reaching that target successfully may reduce the risk of reoperation and improve outcomes.

68. THE T4-L1-HIP AXIS CAPTURES THE ROUSSOULY CONCEPTS USING CONTINUOUS MEASURES

Jeffrey M. Hills, MD; Lawrence G. Lenke, MD; Zeeshan M. Sardar, MD; Jean-Charles Le Huec, MD, PhD; Stephane Bourret, PhD; Kazuhiro Hasegawa, MD, PhD; Hee-Kit Wong, FRCS; Dennis Hey, MD, MBBS, FRCS; Gabriel KP Liu, MD; Mouna Chelli-Bouaziz, MD; Michael P. Kelly, MD

Hypothesis
The T4-L1-Hip Axis effectively describes spinal shape using continuous measures and is consistent with the Roussouly Classification.

Design
Cross-sectional cohort

Introduction
The Roussouly classification describes 4 normal spine shapes. However, this approach is prone to misclassification bias. The T4-L1-Hip axis describes sagittal alignment by defining the L1 pelvic angle (L1PA) relative to pelvic incidence (PI), and the T4-L1PA mismatch (T4PA – L1PA), with measurement error < 2°. We sought to determine if

the T4-L1-Hip axis approach captures the Roussouly concepts and is consistent with the Roussouly classification.

Methods

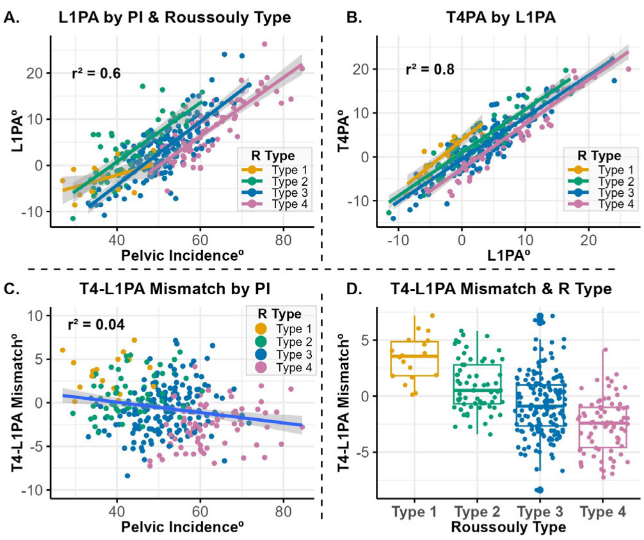
Asymptomatic volunteers ages 18-40 with no signs of disk degeneration or coronal deformity were included. Radiographic measurements were obtained from full spine radiographs (EOS Imaging, SA, France). Roussouly type (R type) was determined for each volunteer. The relationship between L1PA and PI, and T4-L1PA mismatch were examined for each Roussouly type. To determine consistency with the Roussouly classification, a multivariable regression model was fit to estimate Roussouly type by L1PA, PI, and T4-L1PA mismatch.

Results

Of 320 volunteers included, 193 (60%) were female and median age was 37 (IQR, 27-47). Median PI was 52° (45, 58), median L1PA was 4° (0, 8), median T4-L1PA mismatch was -1° (-3, 1). 33 (10%) volunteers were identified as R Type 1, 47 (15%) as Type 2, 161 (50%) as Type 3, and 79 (25%) as Type 4. PI and L1PA were strongly associated (r2 = 0.6) and consistent across R types (Fig 1A). L1PA was strongly associated with T4PA (r2 = 0.8) and consistent across R types (Fig 1B). The T4-L1PA mismatch varied slightly by R type, reflected by the small association with PI (Fig 1C, 1D). A regression model estimating R type by PI, L1PA, and T4-L1PA mismatch showed high discrimination (C = 0.96) and high accuracy (Brier score = 0.056).

Conclusion

L1PA, PI, and the T4-L1PA mismatch effectively captures the Roussouly concepts using continuous measures, offering the opportunity for personalized alignment based upon PI. As precision-medicine moves forward in ASD, alignment targets are needed for the individual, rather than categories, which are prone to misclassification and inter-rater reliability issues.



A) L1PA by PI & R type; B) T4PA by L1PA & R type; C) T4-L1PA Mismatch by PI & R type; D) T4-L1PA Mismatch & R Type

69. CHARACTERISTICS OF L1PA BASED ON CORRECTIONS IN THE PROXIMAL VS. DISTAL LUMBAR SPINE FOR ADULT SAGITTAL PLANE IMBALANCE

Chad Z. Simon, BS; Han Jo Kim, MD; Myles Allen, MbChB; Tejas Subramanian, BS; Atahan Durbas, MD; Tomoyuki Asada, MD; Samuel Adida, MS; Chukwuebuka Achebe, BS; Takashi Hirase, MD, MPH; Robert Uzzo, MBA; Jung Mok, MD; Austin Kaidi, MD; Michael Mazzucco, BS; Kasra Araghi, BS; Justin T. Samuel, BS; Cole Kwas, BS; Hiroyuki Nakarai, MD; Gregory Kazarian, MD; Joshua Zhang, BS; Michael P. Kelly, MD; Matthew E. Cunningham, MD, PhD; *Francis C. Lovecchio, MD*

Hypothesis

Change in L1 pelvic angle (L1PA) depends on change in distal lumbar lordosis (DLL) but not on change in proximal lumbar lordosis (PLL) (Figure).

Design

Single-center retrospective radiographic analysis.

Introduction

Over the last several decades, Cobb angles have been the dominant parameter used to evaluate spinal alignment. However, the limitations of Cobb angles have inspired new research into vertebropelvic angles (VPA) as a novel method to describe alignment. Within this context, the role of Cobb angles in the analysis of sagittal alignment must be re-examined. Here, we aim to clarify the relationships between DLL, PLL, L1PA, and L4PA in the pre- and postoperative radiographic assessment of adult spinal deformity (ASD).

Methods

ASD patients who underwent meaningful (ie, exceeding measurement error) proximal and distal lordosis correction (absolute ΔCobb > 10°) were included (2013-2021). Preoperative and immediate postoperative radiographs were used to determine Cobb angles and VPAs. DLL was defined as L4-S1 Cobb and PLL as L1-L4 Cobb. Unadjusted and adjusted analyses were performed to examine relationships between L1PA, L4PA, and lumbar lordosis (LL).

Results

A total of 99 ASD patients were included with median lumbar lordotic apex of L4. Mean age was 60.6 years, mean BMI was 27.7, and 71.7% were female. Median pre-to-post changes were as follows: ΔLL -20° (IQR -30.8°, -9.2°), ΔPLL -6° (IQR -18.1°, 8.4°), ΔDLL -10.4° (IQR -22.8°, 2.0°), ΔL1PA -5° (IQR -10.0°, -0.0°), and ΔL4PA -0.2° (IQR -2.4°, 2.0°). Univariate correlations demonstrated that ΔLL was correlated with ΔL1PA (r=0.663, p<0.001) and ΔL4PA (r=0.372, p<0.001). Furthermore, ΔDLL was highly correlated to ΔL1PA (r=0.709, p<0.001) and ΔL4PA (r=0.504, p<0.001), while ΔPLL was not correlated to ΔL1PA or ΔL4PA. Multilinear regression adjusting for age, sex, BMI, and preoperative PI showed that ΔDLL was a strong independent predictor of ΔL1PA (model r^2=0.587, p<0.001) and ΔL4PA (model r^2=0.296, p<0.001). ΔPLL was not independently associated with ΔL1PA or ΔL4PA.

Conclusion

ΔL1PA correlates strongly with ΔDLL but not ΔPLL. Distal

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VPAs, such as L4PA, change minimally with ASD correction and may not be useful parameters to assess spinal alignment. Given that Cobb angles and VPAs describe related but distinct aspects of alignment, future research must identify alignment goals for both LL and L1PA.

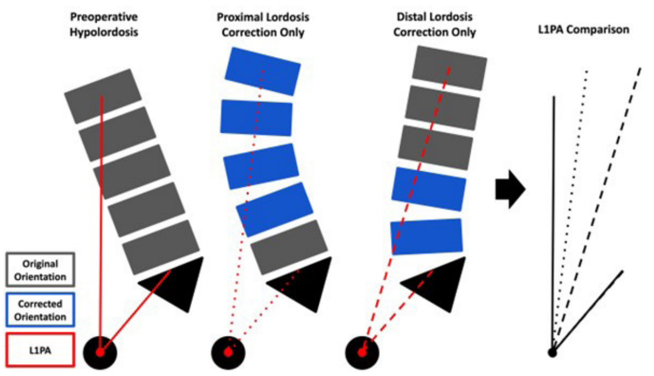


Figure. ΔDLL has a greater effect on ΔL1PA

70. A MULTIPURPOSE ADOLESCENT IDIOPATHIC SCOLIOSIS SPECIFIC SHORT MRI PROTOCOL: FEASIBILITY STUDY IN VOLUNTEERS

Yulia Shcherbakova, PhD; _Peter Lafranca, MD;_ Wouter Foppen, MD, PhD; Tijl van der Velden, PhD; René M. Castelein, MD, PhD; Keita Ito, MD, PhD; Tom Schlosser, MD, PhD; Peter R. Seevinck, PhD

Hypothesis
With a scoliosis-specific short MRI protocol, it is possible to visualize landmarks needed to detect early 3D anatomical changes, screen for neural axis abnormalities and perform surgical planning.

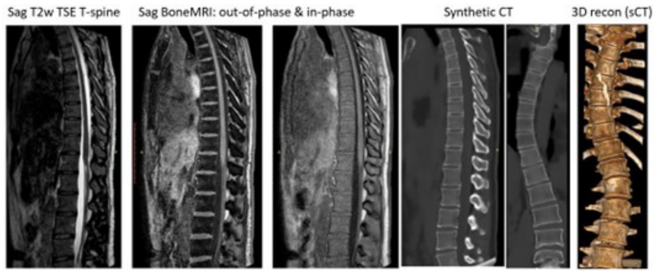
Design
Diagnostic validation study

Introduction
Scoliosis imaging requires ionizing radiation, especially when CT is required for 3D visualisation. Additional MRI is often obtained for neuraxial anatomy. Currently, MRI is not very suitable for visualizing 3D bony anatomy, but when combined with MRI-based synthetic CT (sCT), it has the potential to combine osseous and non-osseous information in one examination. We assess a scoliosis-specific, 14-min MRI protocol for its ability to detect early 3D patho-anatomical changes, screen for neural axis abnormalities, and perform surgical planning and navigation.

Methods
18 adult volunteers (mean 26 years-old) were scanned on 1.5T MR-scanner (3D T2wTSE and BoneMRI sequences) and based on the MRI, synthetic CT images were AI-generated. A predefined checklist of 8 questions on landmark identification (using lines and dots) and 10 Likert-based questions were used for assessment by three readers in an online tool for e-testing with 3D radiological images. Parameters included Cobb angles, rotation, torsion, segmental height, area and centroids of nucleus pulposus (NP) and discs (IVD). Precision (mean error of individual answers compared to group mean) and intra-class correlation coefficient (ICC) with 95% confidence interval (CI) were calculated.

Results
91% of Likert-based questions scored ≥4, indicating moderate to high confidence. Precision of line positioning was 0.6° (ICC=0.98, CI 0.98-0.99). Precision of 3D dot positioning was 1.0 mm (ICC=1.00, 1.00-1.00). Precision of vertebral and IVD height measurements was 0.4 mm (ICC=0.99, 0.99-1.00). Precision of sagittal area measurement was 8 mm2 (ICC = 0.55) for NP and 18 mm2 (ICC = 0.62) for IVD. Precision of centroid measurements for NP was 1.3 mm (ICC = 0.88-0.92) and for IVD 1.1 mm (ICC = 0.88-91).

Conclusion
This study shows that the short MRI protocol with synthetic CT reconstructions, has high precision and reliability for multiple scoliosis-specific purposes. It can be used for studies on scoliosis etiopathogenesis and for 3D assessments of spinal morphology. Future studies should explore the value of this radiation-free technique in children with severe scoliosis.



Examples of T2, BoneMRI and sCT reconstructions

71. INTRAOPERATIVE CT BASED PEDICLE SCREW NAVICATION IN PEDIATRIC SPINE DEFORMITY HAS MINIMAL IMPACT ON SCREW ACCURACY FOR AN EXPERIENCED SURGEON

Vishal Sarwahi, MD; Sayyida Hasan, BS; Keshin Visahan, BS; Katherine Eigo, BS; Aravind Patil, MD, BS; Anuj Gupta, MD; Effat Rahman, BS; David Essig, MD; Yungtai Lo, PhD; Jon-Paul P. DiMauro, MD; _Terry D. Amaral, MD_

Hypothesis
Intraoperative CT based navigation improves accuracy in pediatric spinal deformity surgeries.

Design
Retrospective case review

Introduction
Pedicle screw accuracy is an important safety goal in pediatric spine deformity surgery. Intraoperative CT guided navigation has a two-fold advantage of allowing screw insertion under navigation guidance and assessing accuracy after screw insertion. However, this entails modification of surgical workflow, which has potentially harmful effects such as increased surgical time, blood loss, and radiation exposure. This raises the question of the extent to which intraoperative CT navigation enhanc-

PODIUM PRESENTATION ABSTRACTS

es accuracy and its impact on surgical efficiency and outcomes.

Methods

533 pediatric patients with spine deformity undergoing surgery were reviewed. Patients whose surgeries utilized intraoperative CT navigation were compared to patients who underwent deformity surgery utilizing free hand technique. Borderline screws were screws that appeared to be breaching but were ultimately deemed acceptable. Demographic, radiographic, radiation exposure, and perioperative data was collected. Kruskal-Wallis and Fisher's exact test were performed.

Results

112 navigation patients (2218 screws) were compared to 421 patients (8269 screws) with pedicle screws placed freehand and confirmed on fluoroscopy. Demographic and radiographic variables were similar in both groups. Blood loss was similar between the groups, however, navigation patients had significantly longer surgical time ($p=0.01$) and higher radiation exposure ($p<0.001$). In the fluoroscopy group, 0 (0.0%) screws needed to be revised, 5 (0.2%) screws needed revision in the navigation group ($p<0.001$). In the fluoroscopy group, 20 (0.2%) screws were borderline, and 6 (1.4%) patients experienced transient signal loss. In the navigation group, 6 (0.3%) screws were borderline, and 4 (3.6%) patients experienced a transient signal loss. Length of stay and complication rates were similar between the groups.

Conclusion

Patients operated on using navigation for pedicle screw placement do not see an increase in safety or screw accuracy. However, the availability of navigation offers a potential to avoid screw misplacement and, for younger surgeons, could have significant benefits in terms of accuracy and time. Regardless of surgeon experience, it is still an additional mechanism for confirmation.

72. RADIOGRAPHIC ADAPTATION BETWEEN STANDING AND SITTING POSITIONS OF SUBJECTS WITH ADOLESCENT IDIOPATHIC SCOLIOSIS

Maria Karam; Emmanuelle Wakim; Maria Asmar; Abir Massaad, PhD; Mohammad I. Karam, PhD; Aren Joe Bizdikian, MD, MS; Georges El Haddad; Marc Boutros, BS; Marc Mrad; Gilles Prince, MD; Ibrahim Hamati; Guy Awad; Moustapha Rteil; Joe Azar; Nadim Freiha; Claudio Vergari, PhD; *Ismat Ghanem, MD, MS*; Rami Rachkidi, MD, MS; Ayman Assi, PhD

Hypothesis

Subjects with AIS utilize varied spinopelvic adaptation mechanisms between standing and sitting positions.

Design

Retrospective analysis of prospectively collected data.

Introduction

Routine evaluation of the spinal deformity of subjects with Adolescent Idiopathic Scoliosis (AIS) is based on standing radiographs. Assessing how subjects cope with different functional positions of daily life, such as the sitting position, is essential to better understand the underlying pathological processes. A better understanding of such adaptation mechanisms would provide insight on spinal flexibility.

Methods

43 primary AIS (40F) and 22 controls (12F) underwent bi-planar radiographs in both standing and sitting positions from which 3D spino-pelvic and global postural parameters were calculated. AIS subjects were grouped according to the Lenke classification. Skeletal changes between the 2 positions were compared between Lenke groups and controls.

Results

Subjects with AIS were divided into 2 groups: 29 Lenke 1 (Cobb=35±16°, 27F) and 14 Lenke 5 (Cobb=22±9°, 13F). The severity of the scoliotic deformity remained unchanged in both AIS groups between the standing and sitting positions. Adaptation strategies used by AIS subjects when transitioning from standing to sitting were similar to controls, notably increase in pelvic retroversion (PT: standing=9° vs. sitting=29°), reduction of lumbar lordosis (L1S1: 58 vs. 30°) and thoracic kyphosis (T4T12: 31 vs. 24°) while preserving their head over the pelvis (Sagittal ODHA: -2° vs. -4°). Although control subjects preserved T10L2 values when transitioning from standing to sitting (4°), the thoracolumbar junction of Lenke 1 and Lenke 5 subjects tended to increase in kyphosis (Lenke 1: -1 to 2°, Lenke 5: -4 to -1°; $p<0.001$ for both).

Conclusion

This study showed that both AIS Lenke 1 and Lenke 5 patients were able to acquire a normal sitting position similar to controls. The overall flattening of the spine in AIS subjects required a slight recruitment of the thoracolumbar junction for optimal adaptation to the seated position, without significantly affecting their sitting posture. Future work should investigate how adaptation strategies vary when transitioning from standing to sitting in subjects with AIS after spinal fusion.

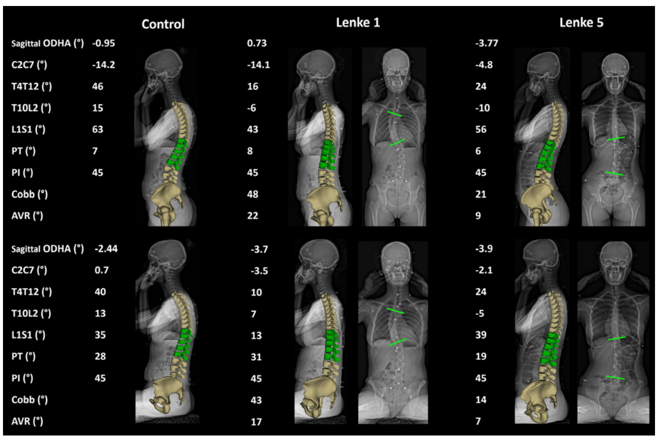


Figure 1: Examples of standing and sitting postures in controls, AIS Lenke 1 & 5.

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

73. PREVALENCE AND PROGNOSIS OF RIGHT SCAPULAR PAIN FOLLOWING SURGICAL TREATMENT OF ADOLESCENT IDIOPATHIC SCOLIOSIS: A PROSPECTIVE STUDY TO GUIDE PREOPERATIVE COUNSELLING

Antoine Dionne, BS; Julie Joncas, RN; Soraya Barchi, BSc; *Stefan Parent, MD, PhD*; Jean-Marc Mac-Thiong, MD, PhD

Hypothesis

The prevalence of right scapular pain is high following surgical treatment of adolescent idiopathic scoliosis (AIS), but it tends to resolve during follow-up 2 years after surgery.

Design

Prospective cohort study of 106 consecutive patients treated surgically for AIS at a single institution.

Introduction

Developing pain after surgical treatment of AIS can be devastating for some patients, particularly when they had no pain prior to surgery. Unfortunately, the prevalence and localization of postoperative pain has been poorly studied in this population, which complexifies the preoperative counselling by surgeons. The objective of this study is to report the prevalence, predictors and evolution of scapular pain pre- and postoperatively.

Methods

This prospective study included 106 patients undergoing posterior instrumentation and fusion for AIS. They were instructed to localize (drawing with a pen) the presence of pain anywhere on a human body pictogram preoperatively, as well as postoperatively 6 and 12 months after surgery. The presence of pain between the medial border of the scapula to the shoulder was defined as scapular pain. In addition to descriptive statistics pertaining to the incidence and evolution of post-operative scapular pain, inferential statistics were performed to identify factors associated with persisting de novo scapular pain 2 years after surgery.

Results

Of the 106 patients included in this study, 21 (19.8%) had right scapular pain pre-operatively. This improved at 2 years post-operatively with only 9 (8.5%) having persisting pain. Out of the 85 patients without pre-operative pain, 37 (43.5%) developed de novo post-operative pain, among which 29 (34.1%) had persisting pain 2 years post-operatively. Curve type and severity, pre-operative angle of trunk rotation, and fusion levels were not associated with the outcome.

Conclusion

AIS patients should be advised about the high risk (50%) of de novo right scapular pain after surgery, and nearly 80% of these patients will remain with persisting pain in the long term. Since there are no apparent predictive factors of this outcome, clinicians should carefully discuss this potential complication with patients before surgery. However, more than 50% of patients with pre-operative scapular pain will be pain-free post-operatively.

74. INCREASED MAIN THORACIC CURVE CORRECTION IS ASSOCIATED WITH WORSE POSTOP RADIOGRAPHIC SHOULDER BALANCE, ESPECIALLY IN LENKE 1A CURVES WITH BALANCED SHOULDERS PREOP

Matan Malka, BA; Ritt Givens, BS; Kevin Lu, MS; Emma Berube, MD; *Thomas M. Zervos, MD*; Stefan Parent, MD, PhD; Michael P. Kelly, MD; Lawrence G. Lenke, MD; Michael G. Vitale, MD, MPH; Harms Study Group; Benjamin D. Roye, MD, MPH

Hypothesis

Increased correction of main thoracic (MT) Cobb angle is associated with worse postop shoulder balance measured by radiographic shoulder height (RSH) in Lenke 1 AIS patients.

Design

Multicenter retrospective cohort

Introduction

Previous research associated significant correction of the main thoracic (MT) curve in AIS as a cause of post-operative left shoulder elevation, and recommended MT undercorrection. We reevaluated this relationship in a large registry-based cohort.

Methods

Inclusion criteria were Lenke 1 AIS patients (10-18yrs) undergoing primary fusion with 2-year follow-up. Pre and postop radiographic variables and SRS scores were collected. We categorized patients into three groups based on RSH change pre to postop: 1)RSH improvement>1cm 2)RSH stable(<1cm change) 3)RSH worse>1cm. Mean and standard deviations are reported for continuous variables, Kruskal-Wallis test assessed significant differences. Chi-square tests were used for categorical ones.

Results

775 patients met inclusion criteria and groups showed no difference in age or sex. At preop, Group 1 had worse RSH (2.3 vs 0.4cm p<0.001), larger MT (54° vs 51° p=0.001) and lumbar curves (36.5o vs 31.4o p<0.001), smaller upper thoracic (UT) curves (24.6° vs 27.1° p=0.005), and fewer lumbar A modifiers (45% vs 71% p <0.001) than Group 3. 2 years post-op, Group 3 had smaller MT curves (17.3° vs 20.7° p<0.001) and greater %correction of MT curves (66.3% vs 61.4% p<0.001) than Group 1. SRS-22 scores did not vary between groups at 2-years and did not correlate with RSH. Linear regression revealed no correlation between SRS-22 self-image and RSH or MT curve magnitude at two years in any group. For all patients, worse post-op RSH was predicted by lower pre-op RSH (ß= -0.08, p<0.002) and Lenke A modifiers (ß= -0.15, p<0.01).

Conclusion

Like previous work, Group 3 patients (worse postop shoulder balance) had more correction of their MT curves and larger UT curves. Yet it is difficult to apply the small magnitudes of these differences (3-5°) to clinical surgical decision making. However, our novel finding that Lenke 1A curves with low preop RSH (better balanced shoulders) are at highest risk for postop shoulder imbalance

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suggests modulating MT correction in this group may be most crucial. Continued work on finding a clinically relevant definition of shoulder imbalance is an important next step.

Table 1: Comparison between groups at preoperative and two-year timepoints.

		Group 1 (n=230)	Group 2 (n=415)	Group 3 (n=130)	P value
Preop:	Age	14.58±2.13	14.76±2.06	14.56±1.92	0.46
	Female n (%)	199 (86.5%)	350 (84.3%)	117 (90.0%)	0.53
	Lenke A n (%)	103 (44.8%)	227 (54.7%)	93 (71.5%)	**<0.001**
	Lenke B n (%)	55 (23.9%)	86 (20.7%)	20 (15.4%)	
	Lenke C n (%)	72 (31.3%)	101 (24.3%)	17 (13.1%)	
	Upper Thoracic Cobb (°)	24.62±8.10	25.68±6.50	27.13±6.51	**0.005**
	Main Thoracic Cobb (°)	54.23±9.37	51.77±8.64	51.46±8.38	**0.001**
	Lumbar Cobb (°)	36.53±9.68	34.09±9.38	31.42±8.38	**<0.001**
	RSH (cm)	2.28±0.90	0.83±0.60	0.40±0.55	**<0.001**
	SRS Pain	4.03±0.72	4.05±0.73	4.07±0.73	0.87
	SRS Self Image	3.30±0.72	3.41±0.68	3.48±0.59	**0.04**
	SRS Total	3.86±0.50	3.93±0.49	3.98±0.44	0.06
2 years	Upper Thoracic Cobb (°)	13.81±6.60	14.73±5.75	16.08±6.02	**0.003**
	Main Thoracic Cobb (°)	20.70±7.10	19.64±6.74	17.32±7.15	**<0.001**
	Lumbar Cobb (°)	16.19±8.06	14.36±8.36	10.86±7.85	**<0.001**
	% Correction Upper Thoracic Cobb	37.83±37.48	38.60±29.65	40.98±17.64	0.63
	% Correction Main Thoracic Cobb	61.41±13.06	61.36±13.28	66.31±13.03	**<0.001**
	% Correction Lumbar Cobb	55.69±29.31	55.41±29.88	66.17±22.88	**<0.001**
	RSH (cm)	0.41±0.45	0.81±0.58	2.08±1.43	**<0.001**
	SRS Pain	4.36±0.65	4.43±0.59	4.42±0.59	0.36
	SRS Self Image	4.44±0.54	4.46±0.54	4.44±0.53	0.92
	SRS Total	4.39±0.45	4.43±0.42	4.46±0.40	0.39

75. DO POSTOPERATIVE MEDIAL SHOULDER, LATERAL SHOULDER AND NECK IMBALANCE IMPROVE OVER TIME? AN ANALYSIS OF 120 LENKE 1 AND 2 ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS) PATIENTS WITH A MINIMUM OF 5-YEAR FOLLOW-UP

Chris Yin Wei Chan, MD, MSOrth; Weng Hong Chung, MD, MSOrth; Yuki Mihara, MD, PhD; Siti Mariam Mohamad, BSc; Chee Kidd Chiu, MBBS, MSOrth; Mun Keong Kwan, MBBS, MSOrth

Hypothesis
Postoperative lateral shoulder imbalance in Lenke 1 and 2 AIS would improve over time but not medial shoulder and neck imbalance.

Design
Retrospective study

Introduction
Shoulder and neck imbalance following AIS surgery is a cause of patients' dissatisfaction. However, the postoperative evolution of shoulder and neck imbalance over time is unclear.

Methods
We retrospectively reviewed 120 Lenke 1 and 2 AIS patients. "Medial shoulder balance (MSB)" was represented by T1 tilt and was defined as "balanced" (MB) when -3°≤T1 tilt≤3°. T1 tilt>3° was defined as Medial Shoulder Imbalanced Positive (MI+ve). T1 tilt<-3° was defined as MI-ve. "Lateral shoulder balance (LSB)" was represented by Clavicle angle (Cla-A) and was defined as "balanced" (LB) when -2°≤Cla-A≤2°. LI+ve was Cla-A>2°; LI-ve was Cla-A<-2°. Cervical axis (CA) represented "Neck Balance" and defined as "balanced" (NB) if -3°≤CA≤3°. NI+ve was CA>3° and NI-ve was CA<-3°. Shoulder and neck balance were compared at 6-month follow-up (FU) and at 5-year FU.

Results
At 6-month FU, 51.7% achieved MB, 35.8% had MI+ve and 12.5% reported MI-ve. Among the MB group, 87.1% remained MB at 5-year FU. 65.1% of patients with MI+ve remained MI+ve at 5-year FU. 86.7% MI-ve patients remained MI-ve at 5-year FU. For LSB, 68.3% achieved LB, 24.2% had LI+ve and 7.5% had LI-ve at 6-month FU. 72.4% of LI+ve patients achieved LB at 5-year FU. At 6-month FU, 65.8% achieved NB, 28.3% had NI+ve and 5.9% had NI-ve. 89.9% of patients who had NB remained NB at 5-year FU. However, 50% of those with NI+ve remained as NI+ve while the other half achieved NB at 5-year FU. Among patients with MI+ve and LI+ve who achieved good balance at final follow-up, there was a significant change in the distal disc angulation but not the T1-UIV angle.

Conclusion
At 5-year FU, most patients with MI+ve and MI-ve remained imbalanced. The majority of patients achieved LB regardless of the LSB pattern at 6-month FU. 50% of NI+ve patients remained NI+ve. Distal disc angulation led to improvement in the MSB/LSB. However, the T1-UIV angle remained relatively stable at 5 years follow-up.

76. ANTERIOR RELEASE IS NOT NEEDED TO RESTORE KYPHOSIS IN MODERATE AIS WITH HYPOKYPHOSIS

Craig R. Louer, MD; Jacquelyn S. Pennings, PhD; Maty Petcharaporn, BS; Arun R. Hariharan, MD; John S. Vorhies, MD; Michael P. Kelly, MD; Suken A. Shah, MD; Peter O. Newton, MD; Harms Study Group; Burt Yaszay, MD

Hypothesis
Posterior spine fusion (PSF) and PSF with Anterior Release (PSF+AR) have similar ability to correct most hypokyphosis deformities, but PSF+AR offers improved correction in the most severe cases.

Design
Retrospective review of prospective database

Introduction
Thoracic hypokyphosis is a common component of the typical three-dimensional deformity in AIS. In severe cases of hypokyphosis, the deformity can lead to pulmonary restriction as well as pathologic compensatory changes in the lumbar spine. While PSF alone is the most common approach to AIS, the addition of an anterior release (AR) can shorten the anterior column and potentially enable more kyphosis restoration.

Methods
A multicenter pediatric spine registry was queried for hypokyphotic (<10°) Lenke 1-4 AIS patients aged <20 years with >2-year surgical follow-up. Coronal curves were limited to <70°. Sagittal measures were converted to estimated 3D kyphosis by previously validated formula. Patients were grouped by treatment with PSF or PSF+AR. A linear mixed model was created to predict 2-year 3D kyphosis by treatment, while controlling for age, sex, pre-op 3D kyphosis, thoracic coronal deformity

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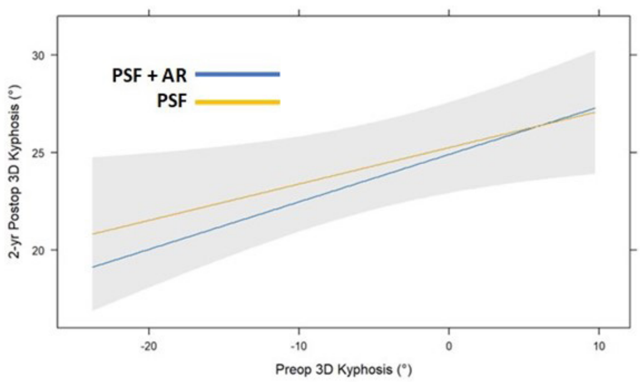
and flexibility, posterior column osteotomy use, rod size, rod material, surgery recency, and surgeon.

Results

1384 patients were included with 53 (3.8%) undergoing PSF+AR. PSF+AR group was younger (13.9 vs. 14.8yrs) with 36.5% open tri-radiates (vs. 7.2% in PSF). Groups had similar mean preop 3D kyphosis (-3.7° vs. -0.5°) and thoracic coronal deformity (54.6° vs. 55.0°). PSF-AR had similar 2-year 3D kyphosis (23.0° [95%CI 20.5-25.4°] vs. 23.3° [22.9-23.6°]) and correction (26.7° [23.3-29.9°] vs. 23.7° [23.3-24.2°]) to PSF. 71.7% of PSF+AR and 66.4% of PSF had restoration of TK above 20° at 2-years (p=0.42). When controlling for covariates, the model demonstrated no difference between approach (p=0.74) or interaction of approach and preop 3D kyphosis (Figure 1, p=0.51). Post-hoc power analysis showed adequate sample size to detect a difference of 5° between approaches. PSF+AR had longer surgical times (324 vs. 266 min, p<0.001) and a higher rate of 2-year complications (30.2% vs. 18.5%, p=0.033).

Conclusion

In AIS patients with coronal curve <70° and 3D hypokyphosis of 10° to -40°, treatment with PSF+AR did not improve 2-year sagittal correction more than PSF alone. Larger deformities in immature patients may still benefit from AR, but it is likely not warranted at this range.



77. A LARGE COMPARISON STUDY DEMONSTRATES LITTLE TO NO DIFFERENCE IN DEFORMITY CORRECTION WHEN USING PONTE OSTEOTOMIES FOR LENKE 1 AND 2 AIS CURVES

Daniel J. Sucato, MD, MS; Suken A. Shah, MD; Michael G. Vitale, MD, MPH; Amer FSamdani,MD; Peter O. Newton, MD; A. Noelle Larson, MD; Harms Study Group

Hypothesis

Ponte osteotomies do not provide clinically important improvement in deformity correction for patients with primary thoracic adolescent idiopathic scoliosis.

Design

Prospective multi-center

Introduction

The routine use of Ponte osteotomies in adolescent idiopathic scoliosis (AIS) surgery is controversial with conflicting data for deformity correction using 2D X-rays in small studies. Ultra-low dose slot scanning radiographs provide an opportunity to assess deformities in 3D. The objective of this study was to analyze the effectiveness of Ponte osteotomies to achieve improved deformity correction in AIS.

Methods

A prospectively-collected multicenter cohort evaluated consecutive patients treated for Lenke 1A and 2A AIS with pedicle screws with minimum 2-year follow-up. Patients with Ponte osteotomies (P group) were compared to patients without Ponte (NP group) for both 2D and 3D correction.

Results

There were 1403 (984 P, 419 NP) patients with 2D analysis, of which 328 (234 P, 94NP) had 3D data. There were no differences in age (13.7 vs 12.4 years) or gender between P and NP groups. Blood loss was greater (787.1 vs 678.4 cc, p<0.0001), surgical time was longer (286.9 vs 264.8 min, p=0.001) and the incidence of intraoperative neuromonitoring events was higher (7.9 vs 3.9%, p=0.02) in the P group. 2D Analysis: Preoperatively, the P group had larger thoracic coronal curves (56.4 vs 54.5°, p=0.001) but thoracic kyphosis was similar (20.9 vs 22.2°, p=0.06). At 2 years, there was no difference in thoracic coronal curve magnitude (18.8 vs 19.4°, p=0.5) or thoracic kyphosis (21.2 vs. 20.6°, p=0.2) between the P and NP groups. 3D Analysis: Preoperatively, the thoracic coronal curves were the same (55.7 vs. 55.0°, p=0.5), thoracic kyphosis was smaller in the P group (19.5 vs 22.9°, p=0.02) without differences in thoracic axial rotation (16.5 vs 15.8°, p=0.5). At 2 years there were smaller thoracic coronal curves for the P group (15.2 vs 17.9°, p=0.02) but similar thoracic kyphosis (25.0 vs 23.8°,p=0.3) and thoracic axial rotation (8.6 vs 8.8°, p=0.8).

Conclusion

There were no advantages identified to support the routine use of Ponte osteotomies in Lenke 1A and 2A curves for deformity correction, however limitations in understanding the specific indications for each patient may mask potential benefit in some cases.

78. IMPORTANCE OF THORACIC KYPHOSIS AND GLOBAL SAGITTAL PLANE RESTORATION IN THE SURGICAL TREATMENT OF AIS PATIENTS WITH PREOPERATIVE CERVICAL SAGITTAL MALALIGNMENT

Baris Peker, MD; Onur Levent Ulusoy, MD; Hamisi M. Mraja, MD; Ugur Yuzuguldu, MD; Bilge K. Yilmaz, MD; Halil Gok, MD; Emre Kurt, MD; Sepehr Asadollahmonfared, MD; Tunay Sanli, BE, MA; _Meric Enercan, MD;_ Selhan Karadereler, MD; Azmi Hamzaoglu, MD

Hypothesis

The restoration of physiologic thoracic kyphosis and sagittal alignment in the thoracolumbar and lumbar spine will improve postoperative cervical sagittal alignment in AIS pts with preoperative cervical malalignment.

Design

Retrospective

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

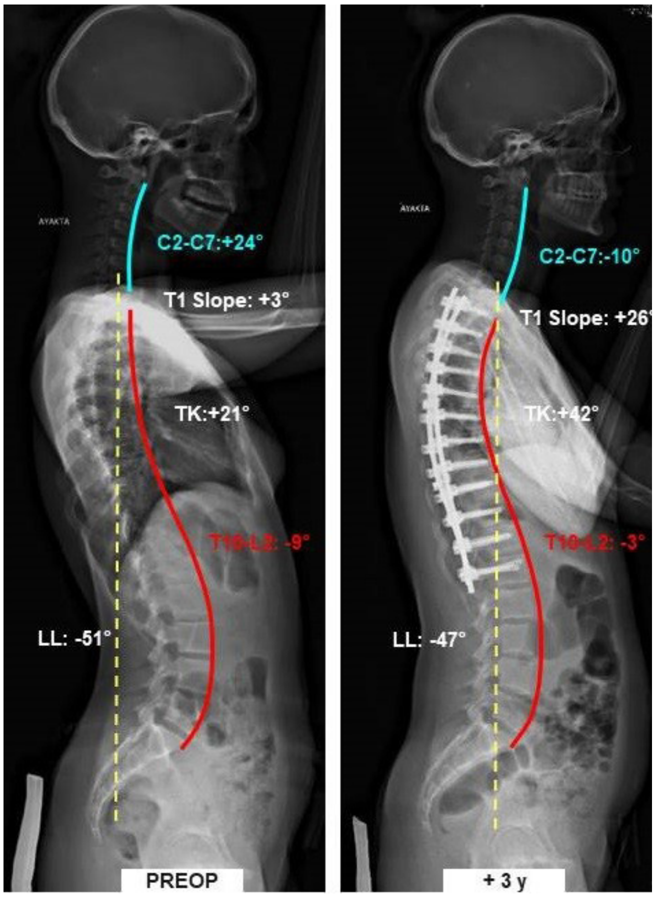
PODIUM PRESENTATION ABSTRACTS

Introduction
Restoration of the ideal sagittal alignment is essential in AIS deformity correction. Postop cervical sagittal alignment has been reported to be related to TK and global sagittal plane restoration following AIS surgery. The aim of the study is to evaluate the possible factors influencing the postop cervical sagittal alignment.

Methods
Among 253 AIS pts who underwent posterior-only surgery with all pedicle screw construct and had UIV between T2-T4 levels, 195(77%)pts with preop cervical sagittal malignment (sigmoid and kyphotic type) were included. Coronal and sagittal parameters were measured on preop and f/up x-rays. Cervical alignment was classified according to the Roussouly class.

Results
195 AIS pts with a mean age was 14.7 yrs and f/up was 6.3(2-9) yrs. Preop 89 pts had thoracic hypokyphosis(mean TK:11°). Preop 55 pts had thoracolumbar kyphosis and 29 pts had thoracolumbar lordosis. MT curve of 51° was corrected to 9.2°(82%) and TL/L of 43° was corrected to 9.7°(76%). Mean preop TK was improved from 25.4° to 35.5°. Mean T10-L2 kyphosis of 15° restored to 2.3°. Mean T10-L2 hyperlordosis of -12° restored to 2°. Mean preop C2-C7 was +12.2° was corrected to -5.1° and preop T1 slope improved from 11° to 21°. Cervical malignment improved in 155(79%). Among 155 pts, cervical alignment was completely restored to lordosis in 68(35%) pts and to a straight alignment in 87(65%)pts. ROC analysis showed that the restoration of TK >39.5° and T1 slope >23.5° correlated with postop cervical lordotic alignment(area=0.743). Additionally, changes in T10-L2 sagittal alignment were correlated with improvements in cervical lordotic alignment(r=0.531,p<0.01).

Conclusion
In AIS pts with preop cervical malalignment, the ideal cervical alignment restoration can be achieved by correcting abnormal thoracic hypokyphosis, thoracic lordosis, thoracolumbar kyphosis, thoracolumbar hyperlordosis, and restoring sagittal lumbar parameters. According to the study, among 253 AIS pts of 195(77%) pts who had preop cervical malalignment, cervical lordosis improved significantly when TK was restored to >39.5°, T1 slope was restored to >23.5°



79. THIRTY YEARS LATER: THE LINGERING EFFECTS OF ADOLESCENT IDIOPATHIC SCOLIOSIS SURGERY WITH THIRD GENERATION IMPLANTS ON QUALITY OF LIFE ‡

Antonia Matamalas, MD, PhD; Juan Bago, MD, PhD; Francisco Javier S. Perez-Grueso, MD; Lucía Moreno-Manzanaro, BS; Javier Pizones, MD, PhD; Carlos Villanueva Leal, MD, PhD; Susana Núñez Pereira, MD; Sleiman Haddad, MD, PhD, FRCS; Ferran Pellisé, MD, PhD

Hypothesis
Three decades post-surgery, patients treated with 3rd-generation implants for adolescent idiopathic scoliosis (AIS) report lower quality of life (QOL) than peers.

Design
Multicentric cross-sectional observational study.

Introduction
Surgery for AIS aims to eliminate traces of scoliosis, restoring normalcy. Long-term success with 3rd-gen implants is inadequately documented

Methods
We included AIS patients, operated during adolescence with CD or ISOLA instrumentation and ≥25 years of follow-up (FU). The clinical condition (status?) was assessed using the following self-perceived health-related instruments: numerical pain scale (NRS), ODI, SRS-22r, SF-36, and EQ-5D-5L questionnaires. For the NRS and SRS-22r, the reported "Patient Acceptable Symptom

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State" (PASS+) was used as the reference for normality. For the SF-36 and EQ-5D-5L, the patient cohort was compared with adjusted normative data. The standardized mean difference (SMD) was calculated as a measure of effect size (relevant if >0.7).

Results

Out of 226 eligible patients, 152 (67%) (87% female) participated in the study, after a mean FU of 29.6 (SD2.8; range 25-35) years. The mean age at surgery was 15 (1.9; 11-21) years and 45.1 (3.4; 36-55) years at FU. PASS+ status was achieved by 56.1%, 56.7%, and 55.5% of patients, on NRS, SRS-22 subtotal, and SRS-22-Self image scores, respectively. Mean NRS score was 3.3±2.9 with 56% of patients scoring ≤3. Mean ODI was 22.6± 16.9, with 56.8% of patients scoring ≤20. Significant differences were found between the patient cohort and normative values for the SF-36 physical component score (SF36-PC) (42.8 vs 50; p=0.0001), with a moderate effect size (SMD=0.6). No differences were observed for the SF-36 mental health score (SF36-MH). Patients' EQ-5D-5L score was significantly lower (0.8vs0.9; p=0.0001). The primary difference was observed in the pain question; 26.8% of patients compared with 82.5% of general population answered "I have no pain or disability" (p=0.0001).

Conclusion

Thirty years after surgery, individuals treated for AIS using 3rd-generation implants exhibit physical and mental health similar to the general population. Yet, the operated scoliotic group, on average, reports lower quality of life and increased pain. Surgery during adolescence has not fully restored normalcy in adulthood.

80. ENHANCED CARE DELIVERY AND PATIENT EXPERIENCES FOR KIDS WITH SCOLIOSIS: SMART DIGITAL STRATEGIES TO LINK PATIENTS AND CARE SERVICES ‡

J Paige Little, PhD; Sinduja Suresh, PhD; Maree T. Izatt, BPhy; Annabelle Stubbs, BEng; Addison Suhr, BSc; Simon Gatehouse, MD, FRCS; Robert D. Labrom, MD, FRCS; Geoffrey N. Askin, MD, FRCS

Hypothesis

Clinical measures of scoliosis trunk rotation show excellent agreement with digitally measured values from 3D models.

Design

Prospective cohort study

Introduction

We are developing new eHealth technology that will enable surgeons to undertake a 'virtual point-of-care' spinal healthcare appointment for paediatric spinal deformity patients located in rural and remote geographic regions. It uses interactive 3D virtual models of scoliosis patient anatomy captured by the parent with their smartphone at home. A critical step is validation of the predicted spinal deformity measurements.

Methods

Using our custom photogrammetry methodology we create 3D virtual models of the full body, while standing and in forward bend positions (Figure 1). The models are analysed using custom-code to evaluate torso deformity and measure angle of torso rotation (ATR), and then embedded within a new digital interface for use by the surgeon during eHealth appointments (Figure 1). ATR measured in forward bending is a key clinical deformity measurement for adolescent idiopathic scoliosis (AIS). To validate ATR measured from 3D models, 20 AIS patients were recruited (Ethics:LNR/21/QCHQ/75249) from our spinal orthopaedic clinic. Patients received their standard spinal healthcare appointment and in parallel, 3D models were created using photos captured on a smartphone. ATR was digitally measured from the bending models and compared with the clinically measured values (Spearman correlation, Mann-Whitney U test).

Results

ATR showed excellent positive correlation between clinically measured and 3D model-derived measurements (r=0.937, p<<0.05), with no significant difference between the two measures. Intra-rater variability (one user, three occasions) and inter-rater variability (three users, one occasion) showed mean ATR difference of 0.67 ± 0.6 degrees, and 0.49 ± 0.2 degrees.

Conclusion

Despite the abundance of smartphone-applications relating to paediatric scoliosis, there is currently no existing application that allows rural families to receive equitable access to healthcare from tertiary orthopaedic spine clinics in Australia. This technology will be pivotal in reducing departmental costs associated in facilitating orthopaedic surgeons to provide remote spine clinics.

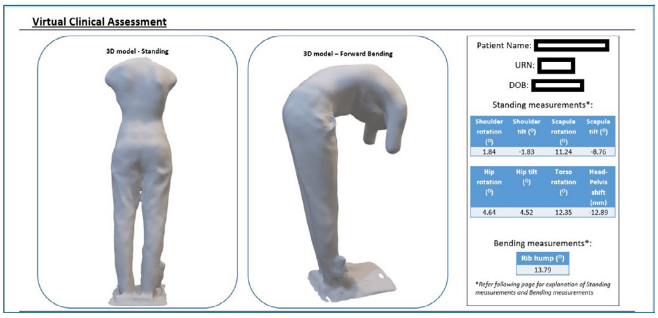

Figure-1: eHealth surgeon user interface. ATR shown as 'Bending measurement'

81. SERUM TITANIUM LEVELS REMAIN ELEVATED 6 YEARS AND BEYOND FROM SPINAL INSTRUMENTATION IN CHILDREN

Peter J. Cundy, MBBS; William J. Cundy, FRACS; Georgia Antoniou, BS

Hypothesis

That metal ion serum levels will persist in children following instrumented spinal fusion for adolescent idiopathic scoliosis

Design

34 of 56 participants from an earlier study returned for repeat testing for circulating metal ions at a minimum of 6 years from surgery.

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

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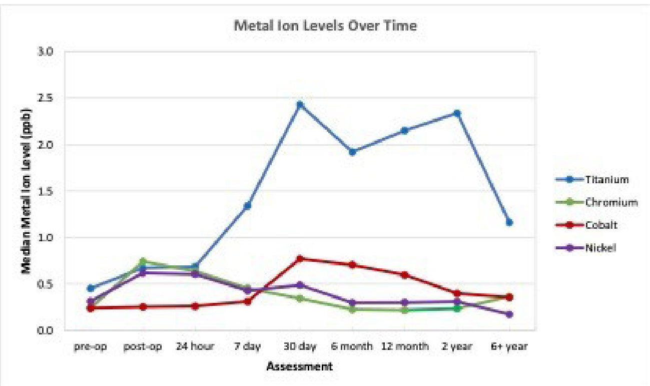
Introduction
Publications on metal ion levels after paediatric spine surgery have shown an immediate initial peak of most serum metal ion levels following surgery. Cobalt and chromium levels trend to baseline by 1 year post surgery, however titanium levels have been shown to remain elevated to 5 times baseline at a minimum 2 years. This persistence in raised titanium levels prompted a repeat study beyond 6 years from surgery.

Methods
34 of 56 participants from an earlier study returned for repeat testing for circulating metal ions, using high-resolution inductively coupled plasma mass spectrometry. To analyse differences in serum ion levels, linear regression models were used, with Generalised Estimating Equations (GEEs) to account for correlation due to repeated measurements. The use of GEEs also allowed the incorporation of incomplete data, so all participants were included in the models rather than only those who participated at 6 years.

Results
Median titanium levels at 6 years decreased significantly to 0.46 times that of 2-year levels (95% CI: 0.32-0.67, $p<0.001$) however they remained 2.40 times higher compared to the pre-surgery control levels (95% CI: 1.47-3.92, $p<0.001$). In comparison, median chromium levels at 6 years were significantly increased from 2 years (1.45 times, 95% CI: 1.05-2.01, $p = 0.024$), but were not significantly different to baseline (1.13 times, 95% CI 0.79-1.61, $p=0.509$). Cobalt levels at 6 years remained significantly higher than baseline (1.32 times, 95% CI 1.06-1.66, $p = 0.015$), but also decreased significantly compared to 2-year levels (0.76, 95% CI 0.64, 0.92, $p = 0.004$). Nickel levels at 6 years did not differ significantly from baseline or from 2-year levels.

Conclusion
Titanium remains elevated at beyond 6 years from spinal instrumentation in children. The effects on a person's health via deposition in solid organs including the brain, or on the offspring of persons with spinal instrumentation, remain unclear. Curiously, chromium levels increased at 6-year sampling in "all titanium" constructs which may be explained by metallurgical irregularities.



82. HOW DOES POSTERIOR FUSION AFFECTS MUSCLE ACTIVATION PATTERN IN ADOLESCENT IDIOPATHIC SCOLIOSIS: A WALKING EMG ANALYSIS

Bhavuk Garg, MS

Hypothesis
AIS and subsequent spinal fusion surgery changes the trunk and lower extremity muscle activity.

Design
prospective case control experimental

Introduction
This study assesses the impact of AIS and spinal fusion surgery on muscle activity during gait.

Methods
Five AIS patients (14.8 ± 1.7 years) and three age-matched healthy controls (15.1 ± 1.2 years) were recruited. Participants underwent 3D gait analysis using a BTS SMART DX-7000 motion capture system, AMTI force plates, and SMART DX100 EMG system . Surface EMG electrodes were bilaterally placed on the following muscles: Erector Spinae (ES), Iliocostalis, Gluteus Medius (GM), Biceps femoris (BF), Semimembranosus (SM), Gastrocnemius Lateralis (GL), Rectus Femoris (RF), Tibialis anterior (TA). EMG data were recorded during five overground walking trials at self-selected pace. The raw EMG data was filtered using a fourth-order Butterworth filter of 20 to 450 Hz with zero phase lag. Subsequently, the data was fully wave rectified. A double threshold method was used to detect muscle activation when the filtered TKEO-treated EMG signal exceeded 3% of its maximum amplitude and when the muscle was active for a period of at least 50 ms (Figure 1).

Results
Preop, AIS patients exhibited a significant increase ($p<0.05$) in muscle activity duration in the ES (52%), RF (56%), GM (59%) and SM (52%) compared to healthy subjects (31%; 34%; 40%; 36%, respectively). Ipsilateral side ES and RF were more activated than the contralateral side(15% and 18%, respectively). Postop, there was a significant reduction ($p < 0.05$) in muscle activity duration in ES (11%), RF (9%), and GM (12%) muscles compared to the preop.

Conclusion
AIS patients had prolonged and abnormal muscle activity, leading to inefficient gait patterns with higher energy demands. Spinal fusion surgery corrected the scoliotic deformity and reduced excessive electrical activity in lower extremity muscles. Future research should study the impact of surgical technique and rehabilitation on muscle activity in AIS patients.

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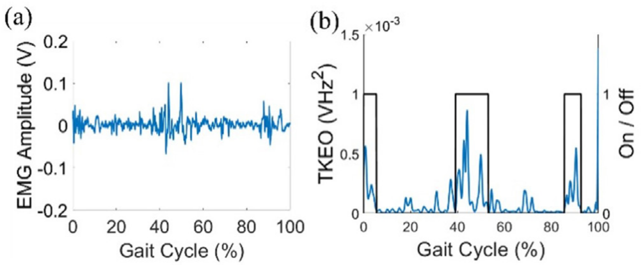

Figure 1: Processing of the EMG signal of the left Erector Spinae muscle recorded from a single participant (a) raw signal (b) detection of muscle activation from TKEO treated signal

83. AIS PATIENTS WITH DISTINCT LENKE TYPES ADOPT DIFFERENT KINEMATIC STRATEGIES DURING WALKING

Maria Asmar; Maria Karam; Emmanuelle Wakim; Abir Massaad, PhD; Mohammad I. Karam, PhD; Aren Joe Bizdikian, MD, MS; Georges El Haddad; Marc Boutros, BS; Marc Mrad; Gilles Prince, MD; Ibrahim Hamati; Guy Awad; Joe Azar; Moustapha Rteil; Nadim Freiha Claudio Vergari, PhD; Helene Pillet, PhD; Ismat Ghanem, MD, MS; *Rami Rachkidi, MD, MS*; Ayman Assi, PhD

Hypothesis
AIS Lenke 1 and Lenke 5 patients use different strategies and compensation mechanisms during walking.

Design
Retrospective analysis of prospectively collected data.

Introduction
Gait function requires meticulous coordination between the spine and adjacent segments. This can be affected in the setting of Adolescent Idiopathic Scoliosis (AIS) or after posterior spinal fusion, a procedure known to limit spine mobility and therefore affect movement. This study aims to investigate pre-operative kinematic strategies and compensation mechanisms in AIS during walking.

Methods
33 AIS: 10 AIS Lenke-5 (major Cobb: 26±7°), 23 AIS Lenke-1 patients (major Cobb: 40±13°) and 24 controls underwent biplanar X-rays with calculation of 3D radiographic spinopelvic parameters. 3D gait analysis was then performed, with the calculation of kinematic parameters of the head, trunk, pelvis, lower limbs, and spinal segments. Kinematic parameters were compared between groups.

Results
AIS Lenke 5 patients had a lumbar segment bending while walking: T12L3-L3L5 (5±8° vs. -2±7°) to the concave -right- side of the scoliotic curve. They walked with an increased pelvic axial mobility (18±7° vs. 13±4°) and internal rotation of the right foot (-2±7° vs. -11±8°; all $p<0.05$). In relation to their primary thoracic deformity, AIS Lenke 1 patients increased their thoracic & lumbar segment bending while walking: T3T6-T6T9 (-6±8° vs. 0±6° in controls) to the concave (left) side of the scoliosis and T12L3-L3L5 (9±13° vs. -2±7°) to the opposite side. However, they tend to reduce their lumbo-pelvic mobility (L3L5-Pelvis bending ROM=8±5° vs. 12±5°; all $p<0.05$; Fig.1).

Conclusion
AIS Lenke 5 patients seem to compensate at the lower limbs level due to the inherent stiffness in their scoliotic lumbar segment. In response to their lumbar bending, they tended to increase their pelvic axial mobility and to develop a homolateral internal foot rotation, ensuring a dynamic alignment during forward gait progression. AIS Lenke 1, by producing opposite bending movement at the thoracic and lumbar segments, tended to reduce lumbo-pelvic mobility and ensure coronal dynamic alignment. This further emphasizes the role of selective fusion in Lenke 1 patients in order to preserve adaptation mechanisms in the lumbar segment during gait.

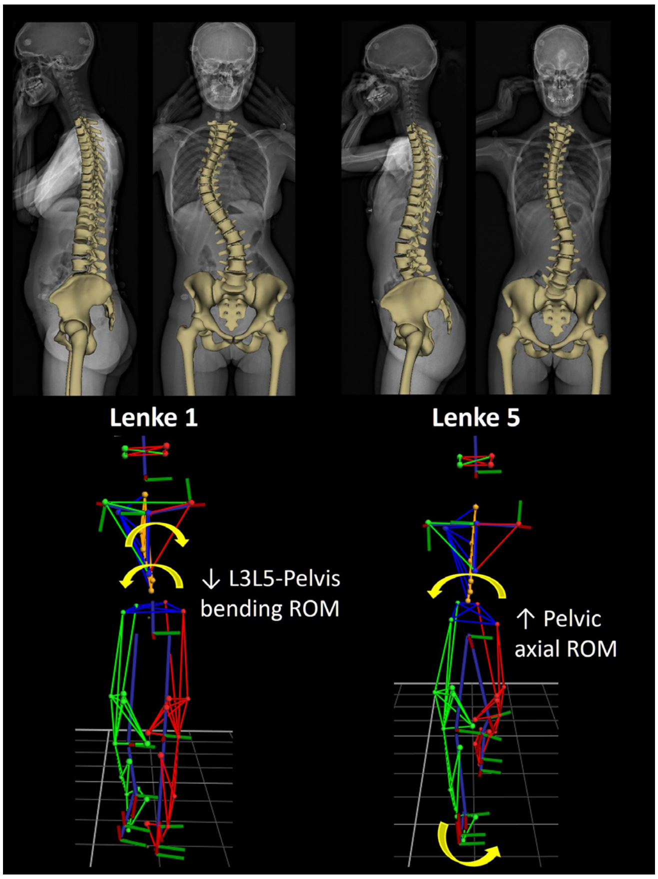

Fig.1: Illustration of kinematic strategies during walking in Lenke 1 and 5 AIS patients.

84. PATIENT'S PERCEIVED FLEXIBILITY AFTER A SPINAL FUSION

Vishal Sarwahi, MD; Katherine Eigo, BS; Sayyida Hasan, BS; Himanshu Rao, BS; Brittney Moncrieffe, BS; Kiara Thompson, BS; Hannah Travers, BS; Effat Rahman, BS; Sanjeev Suratwala, MD; Yungtai Lo, PhD; Terry D. Amaral, MD; Keshin Visahan, BS

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Hypothesis
Fusion level does not affect one's postop flexibility.

Design
Retrospective Cohort Study with Survey

Introduction
Spinal fusion has been associated with loss of functional flexibility in patients postoperatively. Furthermore, it is believed the more distal a fusion, the less flexible you become. However, recent literature is challenging this belief. The aim of this study is to assess a patient's perceived flexibility after a spinal fusion and determine if there is a correlation between level fused and flexibility.

Methods
This study included 311 participants, 287 AIS patients who underwent PSF between 2016-2022, and 24 non-operative control patients. Data was collected retrospectively through radiographic and chart review, as well as via phone or email. Out of 287 patients who were contacted, 253 had a working phone or email listed in the EHR. Among those, 159 patients responded to the survey (62.8% response rate). The survey asked various questions on flexibility such as toe-touch, trunk rotation, activity levels etc. Likert scale ranging from 1 (indicating severely limited flexibility and sedentary lifestyles) to 10 (representing high flexibility and activity levels).

Results
159 patients underwent PSF. 131 patients were fused to L3/L4, 28 were fused to T12/L1. Demographic data was similar between the two groups. Both L3/L4 patients and T12/L1 patients had an average 3.0-day LOS ($p = 0.90$). Preop self-assessed flexibility (L3/4: 7.0 vs T12/L1: 7.5 $p = 0.76$) and activity levels Likert scale results (7.0 vs 7.0, $p = 0.80$) were similar between groups. Postop, both groups had similar flexibility (6.0 vs 7.0, $p = 0.11$) and activity levels (6.5 vs 8.0, $p = 0.08$). Flexibility levels did not change between pre- and postop visit for L3/L4 ($p = 0.32$) or T12/L1 ($p = 0.87$) patients. L1+ patients were significantly less likely to be able to touch their toes both pre- and post-surgery and neither significantly changed after surgery. These groups were similar to the control group before and after surgery. L3/L4 patients returned to unrestricted gym and competitive sports at an average of 6.8 months and 7.0 months versus 6.3 months and 7.1 months for T12/L1 ($p = 0.48$, $p=0.35$).

Conclusion
Our study's findings suggest that adolescent's flexibility levels postop returned to the same level as they were preop and that fusion level did not affect flexibility. This is contrary to the common conception that fusion to L3/L4 restricts patients' flexibility.

85. PULMONARY FUNCTION IN PATIENTS WITH IDIOPATHIC SCOLIOSIS 40 YEARS AFTER DIAGNOSIS §

Lærke C. Ragborg, MD; Casper Dragsted, MD, PhD; Soren Ohrt-Nissen, MD, PhD; Jann Mortensen, MD, DMSc; Martin Gehrchen, MD, PhD; Benny T. Dahl, Md, PhD, DMSc

Hypothesis
To report the long-term pulmonary function (PF) in patients diagnosed with idiopathic scoliosis (IS) using extended pulmonary function testing (EPFT).

Design
Retrospective follow-up.

Introduction
Pulmonary function in patients with IS has been a topic of concern, with some reports of markedly decreased ventilatory function leading to disability and increased mortality in patients with severe IS. Only limited data is available concerning pulmonary function in adult patients with IS.

Methods
A total of 177 patients seen at our institution from 1972-1983 for a pediatric spinal deformity were included in the study. 91/129 eligible patients with IS (71%) partook in a clinical examination including radiographs, and 79/91 patients (87%) had EPFT performed. The EPFT values included forced vital capacity (FVC), forced expiratory volume in 1 sec (FEV1), FEV1/FVC ratio, vital capacity (VC), total lung capacity (TLC), residual volume (RV), RV/TLC, diffusion capacity of carbon monoxide (DLco), carbon monoxide transfer coefficient (KCO) and alveolar volume (VA). Results were expressed with z-scores derived from height and arm span normative data.

Results
Of 77 included patients, 76 (99%) were females with a mean age of 54.6±2.5 years. The mean follow-up time was 40.8±2.8 years. Forty-four had thoracic main curves, and 33 had TL/L main curves. We found no pulmonary impairment based on z-scores in the total cohort or between groups. Patients with main thoracic curves displayed significantly lower PF on mean absolute values and z-scores on FEV1, FVC, FEV1/FVC ratio, VC, TLC, and DLco compared with main TL/L curves. Patients with thoracic curves had significantly larger Cobb angles at follow-up; 52±17° vs. 40±22° (p-value <0.05) in the TL/L group. We found no linear association between thoracic Cobb angle and degree of pulmonary impairment assessed with DLco, TLC, and FVC. Comparison of pulmonary z-scores based on arm span data, differed significantly on FVC and TLC, with the arm span measurements showing lower z-scores (p-value <0.05).

Conclusion
Using EPFT, no pulmonary impairment could be demonstrated compared to the age-matched population 40 years after a diagnosis of IS. However, patients with thoracic curves had decreased PF compared to TL/L curves. Thus, when treated as current guidelines suggest, patients with IS can expect the same long-term pulmonary function as the general population.

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	Thoracic n=44	Thoracolumbar/Lumbar n=33	Total n=77	p-value
FEV1, L	2.4±0.5	2.7±0.5	2.5 ± 0.5	0.004*
FEV1, Z-score	-0.44±0.35	-0.23±0.30	-0.3 ± 0.3	0.005*
FVC, L	3.2±0.5	3.5±0.7	3.3 ± 0.6	0.021*
FVC, Z-score	-0.47±0.37	-0.29±0.40	-0.4 ± 0.4	0.040*
FEV1/FVC	0.8±0.1	0.8±0.1	0.8 ± 0.1	0.037*
FEV1/FVC, Z-score	-0.53±1.19	0.0±0.90	-0.3 ± 1.1	0.026*
TLC, L	5.1±0.7	5.5±0.8	5.2 ± 0.8	0.039*
TLC, Z-score	-0.42±0.55	-0.23±0.51	-0.3 ± 0.5	0.111
DLco, mmol/min/kPa	6.7±1.1	7.3±1.1	7.0 ± 1.1	0.031*
DLco, Z-score	-0.77±0.81	-0.37±1.00	-0.6 ± 0.9	0.063
KCO, mmol/min/kPa/L	1.5±0.2	1.5±0.2	1.5 ± 0.2	0.870
KCO, Z-score	0.00±1.21	0.03±1.20	0±1.2	0.876
VA, L	4.7±0.6	5.1±0.7	4.8±0.7	0.087
VA, Z-score	-0.80±0.91	-0.45±0.78	-0.6±0.9	0.085

Pulmonary function stratified on main curve

86. HALO-GRAVITY TRACTION PRIOR TO GROWING ROD INSERTION: WHICH CURVES CAN BENEFIT? §

Ambika Paulson, MD; Hui Nian, PhD; Jeffrey E. Martus, MD; John T. Smith, MD; Paul D. Sponseller, MD, MBA; John B. Emans, MD; *Michelle C. Welborn, MD*; Pediatric Spine Study Group; Craig R. Louer, MD

Hypothesis
Pre-index Halo-Gravity Traction (HGT) can lower the risk of complications for a subset of severe Early Onset Scoliosis (EOS) patients prior to growing rod (GR) insertion.

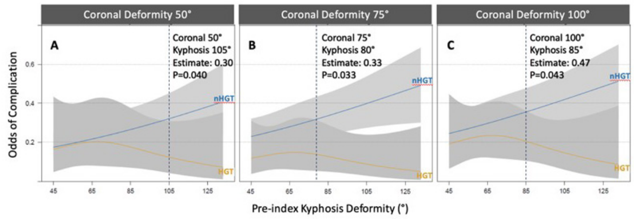
Design
Retrospective multicenter cohort

Introduction
HGT has poorly defined benefits in the EOS population with associated time and financial burdens. We sought to investigate the effect of pre-operative HGT treatment (vs. no HGT) on complications in EOS patients receiving GR surgery to identify curve severities where HGT offers benefit.

Methods
A multicenter pediatric spine registry was queried for EOS patients who have undergone TGR, VEPTR, or MCGR insertion with >2-year follow-up. Patients were grouped into HGT and "non-HGT" (nHGT) cohorts based on presence of HGT treatment prior to index GR surgery. Complications related to the device or procedure and requiring unplanned surgical treatment were the primary outcome. A multivariable regression model for 2-year complications included age, race, etiology, ambulatory status, weight, GR type, rod number, and pelvis attachment. For modeling, normal kyphosis values were set to 0, then re-adjusted for reporting results.

Results
1938 patients were included, of which 187 (9.6%) were treated with HGT. In unadjusted analysis, HGT had less 2-year complications (12% vs. 19%, p=0.037) than nHGT group. In the multivariate model, both baseline coronal (p=0.012) and sagittal (p=0.003) deformity significantly affected odds of complication with sagittal deformity having the strongest effect (Figure 1). With normal sagittal alignment, no severity of coronal deformity demonstrated benefit of HGT. However, when kyphosis >80°, scoliosis of 70°-90° treated with HGT demonstrated lower odds of complications (all p<0.05), with that range expanding at higher kyphosis severity.

Conclusion
Treatment with HGT prior to GR results in reduced odds of complications relative to non-HGT patients depending on severity of coronal and sagittal deformity. Patient-specific complication odds ratios will be of value for patients and surgeons weighing the burdens associated with HGT treatment.



Example plots with defined coronal deformity demonstrate a difference in complication odds between HGT and nHGT treatments as kyphosis increases. Threshold where statistical difference is reached is highlighted in each graph.

87. PNEUMONIA INDUCED MORTALITY AND RISK OF PNEUMONIA IN CHILDREN WITH CEREBRAL PALSY WITH SCOLIOSIS TREATED WITH AND WITHOUT SURGERY §

Matti Ahonen, MD, PhD; Ira Jeglinsky-Kankainen, PhD; Mika Gissler, PhD; Ilkka J. Helenius, MD, PhD

Hypothesis
We hypothesized that scoliosis surgery reduces incidence of pneumonia and pneumonia related mortality in individuals with CP and scoliosis.

Design
Retrospective national registry investigation.

Introduction
Scoliosis is common in children with cerebral palsy (CP). Scoliosis surgery in children with CP increases HRQoL and reduces caregiver burden, but effects of scoliosis surgery on incidence of pneumonia and pneumonia-related mortality remain obscure. The purpose of this study was to compare incidence of pneumonias and pneumonia-related mortality in scoliotic children with CP with and without spinal deformity surgery.

Methods
We identified 4571 children who had been diagnosed with CP between 1996 and 2022 from national registries, of these 474 children with CP had been diagnosed with scoliosis. Two hundred and thirty-six had not been operated and 238 were operated for scoliosis during the follow-up median 17.8 (IQR 11.7-25.7) and 23.0 (IQR 18.4-28.2) years, respectively. Associated co-morbidities, incidence of pneumonias and pneumonia-related

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PODIUM PRESENTATION ABSTRACTS

mortality were analyzed between groups. To compare groups and assess the impact of surgery, we established the index timepoints as the age at the diagnosis of scoliosis (12.1 years) for the non-surgical group and the age at surgery (12.9 years) for the surgical group.

Results

Children with CP and scoliosis with non-surgical and surgical treatment were diagnosed with scoliosis at the age of 12.1 and 12.5 years, respectively. Both groups had similar co-morbidities. During follow-up 47.9% in non-surgical and 54.2% in surgical group had been diagnosed with pneumonia. However, there was difference in cumulative incidence of pneumonia between groups before and after index timepoint. In non-surgically treated group, there was 192.8 hospitalizations for pneumonia before and 203.9 after the index timepoint for 1000 follow-up years (p=0.334). In surgically treated group there was 175.5 hospitalizations for pneumonia before and 121.5 after the surgery for 1000 follow-up years (p<0.001). During the follow-up pneumonia related mortality was higher in the non-surgically treated group than in the surgically treated group (n=22/236, 9.3% vs. n=8/238, 3.3%, p=0.008) (Fig. 1.).

Conclusion

These results indicate that surgical treatment of scoliosis in children with CP reduces incidence of pneumonia and pneumonia-related mortality.

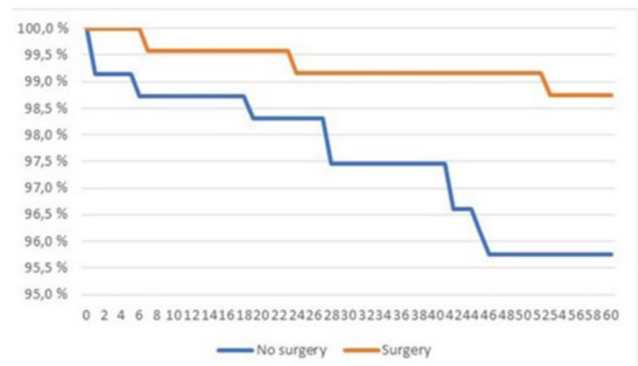

Fig.1 Observed mortality

88. LONG-TERM OUTCOMES OF OPERATIVE VERSUS NONOPERATIVE TREATMENT FOR ADULT SYMPTOMATIC LUMBAR SCOLIOSIS (ASLS): DURABILITY OF TREATMENT EFFECTS AND IMPACT OF RELATED SERIOUS ADVERSE EVENTS THROUGH 8-YEAR FOLLOW-UP § ‡

Justin S. Smith, MD, PhD; Michael P. Kelly, MD; Elizabeth L. Yanik, PhD; Christine Baldus, RN; Vy Pham, MD, MPH; David Ben-Israel, MD; Jon D. Lurie, MD, MS; Charles C. Edwards, MD; Steven D. Glassman, MD; Lawrence G. Lenke, MD; Oheneba Boachie-Adjei, MD; Jacob M. Buchowski, MD; Leah Y. Carreon, MD; Charles H. Crawford III, MD; Stephen J. Lewis, MD, FRCS(C); Tyler Koski, MD; Stefan Parent, MD, PhD; Virginie Lafage, PhD; Munish C. Gupta, MD; Han Jo Kim, MD; Christopher P. Ames, MD; Shay Bess, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Keith H. Bridwell, MD

Hypothesis

Treatment effects (TEs) favoring operative (op) over nonoperative (nonop) treatment for ASLS will deteriorate over 8-yr follow-up.

Design

Prospective multicenter study

Introduction

Long-term follow-up studies of op and nonop ASLS treatments are needed to assess benefits and durability.

Methods

The ASLS study is an NIH (2010-2017) and SRS (2017-present) sponsored multicenter prospective study to assess op vs nonop ASLS treatment, with randomized and observational treatment arms. Patients were 40-80 yrs with ASLS (Cobb >30° and ODI >20 or SRS-22 subscore <4.0 in pain, function and/or self-image). Op and nonop patients were compared using as-treated analysis, and the impact of related serious adverse events (SAEs) was assessed.

Results

The 286 ASLS patients enrolled (104 nonop, 182 op) had follow-up rates at 2, 5, and 8 yrs of 90% (256), 70% (199), and 72% (205), respectively. At 2 yrs, compared with nonop, op patients had greater improvement in SRS-22 (mean difference=0.57) and ODI (mean difference=-12.98) (p<0.001, Figure), with treatment effects (TEs) exceeding minimal detectable measurement difference (MDMD) for SRS-22 (0.4) and ODI (7). TEs at 5 yrs (SRS-22=0.58, ODI=-11.25, p<0.0001) and 8 yrs (SRS-22=0.74, ODI=-14.29, p<0.0001 for both) remained as favorable as 2-yr TEs. The SAE incidence rates for op patients at 2, 2-5, and 8 yrs were 20.5, 9.4, and 8.5 per 100 person-yrs, respectively. The majority of SAEs were revision surgeries. At the 2, 5, and 8 yr timepoints, there were 31, 34, and 23 revisions in 27, 32, and 20 patients, respectively. At 8 yrs, op patients with 1 SAE still had significant improvement, with TEs that exceeded MDMD (SRS-22=0.62, ODI=-9.5, p<0.0001, Figure). The 22 op patients with 2+ SAEs at 8 yrs had significant improvement of both SRS-22 (TE=0.49, p=0.0002) and ODI (TE=-6.0, p=0.0381) compared to nonop treatment, but only the SRS-22 TE exceeded MDMD.

Conclusion

Op treatment for ASLS provided significantly greater clinical improvement than nonop treatment at 2, 5 and 8 yr follow-up, with no deterioration. Patients in the op cohort with a related SAE maintained greater improvement than patients in the nonop cohort. These findings demonstrate long-term durability of surgical treatment for ASLS and may prove useful for patient counseling.

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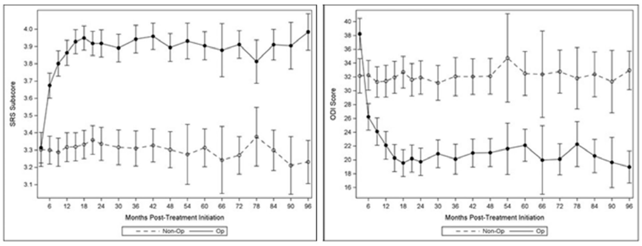


Comparison of primary outcomes on operatively treated adult symptomatic lumbar scoliosis patients with and without a related serious adverse event to non-operatively treated patients.*

	As Treated, Combined (Randomized + Observational) Cohort					
	2 Years		5 Years		8 Years	
	Mean Difference (95% CI)	P value	Mean Difference (95% CI)	P value	Mean Difference (95% CI)	P value
ODI						
Non-operative	Referent		Referent		Referent	
Operative with no SAE	-13.6 (-16.8, -10.4)	<0.0001	-11.4 (-15.6, -7.2)	<0.0001	-16.7 (-20.5, -12.9)	<0.0001
Operative with 1 SAE	-11.8 (-16.5, -7.2)	<0.0001	-10.8 (-15.9, -5.8)	<0.0001	-9.5 (-14.2, -4.7)	<0.0001
Operative with 2+ SAE	-0.3 (-6.5, 6.0)	0.9386	-3.9 (-10.9, 3.1)	0.2754	-6.0 (-11.6, -0.4)	0.0381
SRS subscore						
Non-operative	Referent		Referent		Referent	
Operative with no SAE	0.61 (0.48, 0.74)	<0.0001	0.63 (0.47, 0.79)	<0.0001	0.86 (0.69, 1.03)	<0.0001
Operative with 1 SAE	0.43 (0.24, 0.62)	<0.0001	0.56 (0.38, 0.75)	<0.0001	0.62 (0.41, 0.84)	<0.0001
Operative with 2+ SAE	0.18 (-0.08, 0.43)	0.1779	0.30 (0.04, 0.56)	0.0220	0.49 (0.23, 0.75)	0.0002

*CI = confidence interval; SRS = Scoliosis Research Society; SAE = serious adverse event (only those that are classified as Possibly/Probably/Definitely related); ODI = Oswestry Disability Index

89: ASSESSMENT OF MODERN IATROGENIC FLATBACK SYNDROME: NEARLY 70% OF SHORT LUMBAR FUSIONS HAD UNDERCORRECTION OF L4-S1 LORDOSIS §

Bassel G. Diebo, MD; Manjot Singh, BS; Mariah Balmaceno-Criss, BS; Mohammad Daher, BS; Lawrence G. Lenke, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; Stephen J. Lewis, MD, FRCS(C); Eric O. Klineberg, MD; Renaud Lafage, MS; Robert K. Eastlack, MD; Munish C. Gupta, MD; Gregory M. Mundis Jr., MD; Jeffrey L. Gum, MD; Kojo D. Hamilton, MD, FAANS; Richard Hostin, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Christopher I. Shaffrey, MD; Breton G. Line, BS; Praveen V. Mummaneni, MD, MBA; Pierce D. Nunley, MD; Justin S. Smith, MD, PhD; Jay D. Turner, MD; Frank J. Schwab, MD; Juan S. Uribe, MD; Shay Bess, MD; Virginie Lafage, PhD; Alan H. Daniels, MD; International Spine Study Group

Hypothesis
Iatrogenic adult spinal deformity (ASD) is commonly secondary to prior poorly aligned degenerative lumbar spinal fusion.

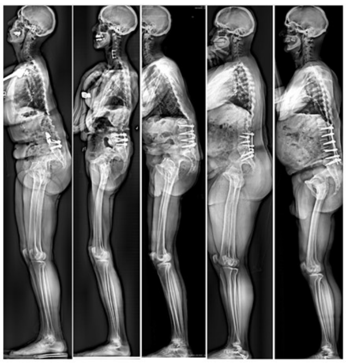
Design
Retrospective review of prospectively collected data.

Introduction
Revision spinal procedures in deformity patients are costly and invasive. However, the prevalence, modes of failure, and extent of deformity of iatrogenic ASD is unknown.

Methods
ASD patients with (IATROGENIC) and without (PRIMARY) prior spine surgery were included. IATROGENIC patients were prior short (L1-iliium) (IATROGENIC DEGEN) and long fusion (IATROGENIC DEFORMITY) constructs. DEGEN patients were further stratified into common modes of failure: implant, junctional, malalignment, and neurologic. Comparative analyses were performed on baseline demographics, spinopelvic alignment, offset from published segmental lordosis goals, patient-reported outcome measures (PROMs), and surgical procedures.

Results
Among 785 patients, 430 (55%) were PRIMARY, 181 (23%) were IATROGENIC DEFORMITY, and 174 (22%) were IATROGENIC DEGEN. DEGEN modes of failure included 27% implant, 40% junctional, 73% malalignment, and 28% neurologic. DEGEN patients were older (PRIMARY=60.6 vs DEGEN=66.3 years) and frailer (2.8 vs 4.4), and had worse baseline deformity (PT, PI-LL, SVA, L4-S1) and PROMs (NRS Back Pain, ODI, SRS-12 Total) compared to primary patients (all p<0.001). Segmental lordosis analysis revealed that 98/131 (75%) of SRS-Schwab type N patients were undercorrected, and only 12% were matched to L4-S1 goal (35-40 degrees). Likewise, 67/93 (72%) patients with L4-S1 spanning constructs, 19/21 (91%) patients with L1-L4 spanning constructs, and 10/11 (91%) patients with L1-S1/ilium spanning construct were undercorrected (Figure). DEGEN patients more often underwent 3-column osteotomies (12% vs 30%, p<0.001) and decompression (50% vs 62%, p=0.021), and had a higher Surgical Invasiveness Score (78.3 vs 87.8, p=0.006).

Conclusion
Nearly half of ASD surgeries were revision spinal fusions. Revisions were predominantly associated with sagittal malalignment with 72-91% being undercorrected to segmental lordosis goals, often at L4-S1. Revision patients underwent more invasive procedures, such as 3-column osteotomy. Further initiatives to optimize alignment are needed to avoid costly and invasive deformity corrections.



	PRIMARY (N=430)	REVISED (N=174)	P value
Spinopelvic Parameters			
PT (°)	23.0 (10.8)	28.0 (9.1)	**<0.001**
PI (°)	52.9 (12.6)	57.9 (13.9)	**<0.001**
TK (°)	-35.5 (21.3)	-30.1 (17.6)	**0.003**
LL (°)	39.4 (24.0)	28.3 (21.1)	**<0.001**
L1-L4 (°)	3.2 (20.1)	1.6 (18.7)	0.556
L4-S1 (°)	36.2 (15.2)	26.7 (13.0)	**<0.001**
PI-LL (°)	13.5 (22.0)	29.6 (18.5)	**<0.001**
SVA (mm)	50.8 (61.5)	106.3 (66.8)	**<0.001**
T1SPi (°)	-1.9 (5.9)	3.3 (6.7)	**<0.001**
Patient-Reported Outcome Measures			
NRS Back Pain	6.9 (2.4)	7.6 (2.0)	**<0.001**
ODI	41.0 (18.1)	50.5 (15.0)	**<0.001**
SRS-22 Total	2.9 (0.6)	2.7 (0.5)	**<0.001**

Figure 1. Preoperative imaging (left) and outcomes (right) for patients undergoing fusion with and without previous lumbosacral fusion.
Abbreviations: PT = Pelvic Tilt, PI = Pelvic Incidence, TK = Thoracic Kyphosis, LL = Lumbar Lordosis, L1-L4 = L1-L4 Lordosis, L4-S1 = L4-S1 Lordosis, PI-LL = Pelvic Incidence minus Lumbar Lordosis, SVA = Sagittal Vertical Axis, T1SPi = T1 SpinoPelvic Inclination, NRS = Numerical Rating Scale, ODI = Oswestry Disability Index, SRS-22 Total = Scoliosis Research Society 22-Item Total.

90. EXPLORING THE INDICATIONS, FAILURES, AND TREATMENT OF COMPLICATIONS AFTER A C2 TO PELVIS FUSION §

Nathan J. Lee, MD; Fthimnir Hassan, MPH; Ted Shi, BS; Anastasia Ferraro, BS; Chun Wai Hung, MD; Steven G. Roth, MD; Justin K. Scheer, MD; Zeeshan M. Sardar, MD; Joseph M. Lombardi, MD; Lawrence G. Lenke, MD; Ronald A. Lehman, MD

Hypothesis
Complications are high and often involve C2 or above

Design
Retrospective Single Center

Introduction
Fusions from the cervical spine to pelvis are relatively uncommon procedures. As a result, their indications and complications are not well-characterized in the current

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

literature. In the largest series on C2 to pelvis fusions, we seek to better elucidate the C2-related complications and treatments.

Methods

A single center series of patients who underwent a posterior spinal instrumented fusion from C2 to sacrum (2016-2023), both primary and revision cases, were included. Patient demographics, medical history, diagnosis, operative procedures, and complications were analyzed.

Results

A total of 37 patients underwent posterior spinal instrumented fusion from C2 to Ilium. The mean follow up was 1.9 years, mean age 56±19 years, 57% were female, and 38% had osteoporosis or osteopenia. Most patients had a prior fusion surgery 81% (N=30), which commonly included upper thoracic to sacrum (N=15) and cervical-thoracic (N=5) fusions. Most common reasons for C2 to Ilium constructs included proximal junctional kyphosis/failure (N=12), chin-on-chest deformity (N=5), and pseudarthrosis (N=5). The surgical complication rate was 46% (17/37), the revision surgery rate was 38% (14/37), and 3 patients required multiple revision surgeries after the C2 to pelvis construct. Reoperations commonly addressed C2-related fractures (N=6), wound complications (N=5), and pseudarthrosis unrelated to C2 (N=4). For those with C2 issues, surgery included either extension of fusion to Occiput (N=2) and C1 (N=4) or revision C2 (N=2). Four patients with radiographic C2 issues (i.e. partial screw pull-out) were treated non-operatively in a hard collar after appearing stable on repeat imaging.

Conclusion

This is the largest series of C2-ilium reconstructions with a mean follow-up of 2 years. The most common indication for surgery to C2 was PJK/F, followed by chin-on-chest deformity and pseudarthrosis. The surgical complication rate was 46%, and the revision rate was 38%. The most common reason for revision surgery was C2 related fractures and screw loosening, with 43% being extended to C1 or the occiput. Long constructs from C2-ilium carry a high complication rate and require frequent follow-up to assess for long term issues.

Patient #	Complications Per Patient	Related to C2 or Above?	Revision Surgery	Days After C2 to Pelvis Surgery
1	Instrumentation Failure/Pseudarthrosis	No	Revision Thoracic to Sacrum Fusion	1483
2	Instrumentation Failure/Pseudarthrosis	No	Revision Thoracic to Sacrum Fusion	1001
3	Instrumentation Failure/Pseudarthrosis	No	Revision Thoracic to Sacrum Fusion	343
4	Instrumentation Failure/Pseudarthrosis	No	Revision Thoracic to Sacrum Fusion + L3 PSO	882
5	Wound Complication	No	Irrigation & Debridement	14
6	Wound Complication	No	Irrigation & Debridement	464
7	Wound Complication	No	Irrigation & Debridement	57
8	Sagittal Imbalance	No	Revision Thoracic to Sacrum Fusion + L3 PSO	397
9	Falls due to Parkinsons. Complete Screw pullout C2-4 + Dens Fracture	Yes	ACDF C2-T1 + PCF C1-T4	298
10	Wound Complication	No	Irrigation & Debridement	31
	Dropped head syndrome w/o fall/trauma, Complete pullout screws b/l C2-5	Yes	ROI at C2-T9 with revision PSIF C1-T8	127
	Failure of C1-2 screws. C1 screw migrated cephalad into OC joint as well as a loose C3 screw	Yes	Revision fusion C1-T3	246
11	Wound Complication	No	Irrigation & Debridement	28
	Dens fracture after Fall	Yes	Revision with fusion C1-2	526
12	Dens fracture after Fall	Yes	Occiput to T4	210
13	Left C2 Pars Screw pullout without Fall	Yes	Revision C2-3	329
	Instrumentation Failure/Pseudarthrosis	Yes	ACDF C2-3 and C7-T1, Revision PSIF C2-T1	391
14	Dens fracture after Fall	Yes	Occiput to T4	28

Fig. 1

91.VITAMIN A DEFICIENCY INDUCES CONGENITAL VERTEBRAL MALFORMATION VIA RETINOIC ACID SIGNALING MEDIATED SCLEROTOME DYSPLASIA †

Xu'an Huang, MD; Yingxi Chen, PhD; Yuchang Zhou, PhD; Jiafeng Dai, MD; Yang Jiao, MD; Zhen Wang, MD; Haoyu Cai, MD; Junduo Zhao, MBBS; Heng Sun, MD; Bolun Qu, MD; Yizhen Huang, MD; Dahai Zhu, PhD; Yong Zhang, PhD; Jianxiong Shen, MD

Hypothesis

Vitamin A deficiency induces congenital vertebral malformation via inhibiting sclerotome differentiation. The inhibition of sclerotome differentiation is related to retinoic acid signaling pathway.

Design

Basic research

Introduction

Congenital vertebral malformations (CVMs) is a result of abnormal sclerotome development. Previous study has indicated that vitamin A deficiency (VAD) induced CVMs in rats. However, the phenotype observed through X-ray was indistinct and the mechanism was still unclear. In this study, 3D model of vertebral malformation was constructed and further pathogenesis of VAD induced CVMs was revealed.

Methods

Female rats were randomized into VAD group and control (CON) group. Female rats in VAD group were fed with vitamin A deficient AIN-93G diet for at least 2 weeks, while female rats in CON group were fed with vitamin A sufficient AIN-93G diet. After mating, embryos from gestational day (GD) 10.5 and GD12.5 were collected, and 2 weeks neonatal rats were euthanized in both groups. Micro-CT and X-ray were utilized to construct 3D model of vertebral malformation from 2 weeks neonatal rats. Whole mount in situ hybridization (WMISH) was applied to visualize the expression pattern of Pax1 and RALDH2 in GD10.5 and GD12.5 embryos. Combining laser captured microdissection, RNA-seq of sclerotome was proceed in GD12.5 embryo.

Results

Micro-CT and X-ray results showed the incidence of CVMs in neonatal rat was 32.65% (16/49) in VAD group and 0% (0/41) in CON group, all CVMs were butterfly vertebrae which was classified as failure of vertebral formation. In VAD group, WMISH result showed Pax1 was down-regulated in sclerotome at GD10.5 and RALDH2 was down-regulated in somite at GD10.5, while the expression pattern of Pax1 did not differ between two groups at GD12.5. RNA-seq result showed 1507 mRNAs were down-regulated and 596 mRNAs were up-regulated. Kyoto Encyclopedia of Genes and Genomes enrichment analysis showed down-regulated mRNAs were enriched to osteoclast differentiation.

Conclusion

VAD induces failure of vertebral formation via inhibition of sclerotome differentiation which is mediated by retinoic acid signaling pathway. Osteoclast differentiation

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may be a potential pathway associated with the pathogenesis of CVMs.

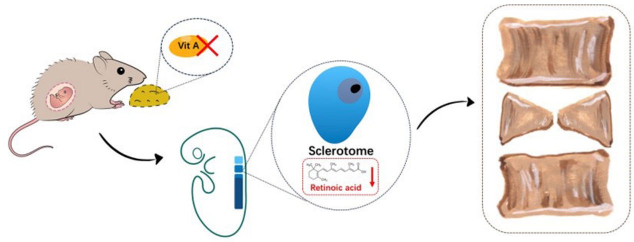

Figure 1: Schematic for vitamin A deficiency induces congenital vertebral malformation via retinoic acid signaling mediated sclerotome dysplasia.

92. EXPERIMENTAL STUDY ON THE ASYMMETRIC GROWTH OF VERTEBRAL GROWTH PLATE AND NEUROCENTRAL SYNCHONDROSIS MODULATED WITH MICROWAVE ABLATION UNDER CT-GUIDED FOR CORRECTING EARLY ONSET SCOLIOSIS IN IMMATURE PORCINE †

Jin Zhou, MD; Jingming Xie, MD; Yingsong Wang, MD; Zhi Zhao, MD; Tao Li, MD; Zhiyue Shi, MD; Ying Zhang, MD; Tingbiao Zhu, MD; Quan Li, MD; Ni Bi, MD

Hypothesis
MWA applied to the immature porcine EOS model's convex side's GP and NCS may cause asymmetrical vertebral growth, correcting spinal deformity.

Design
Prospective randomized controlled study.

Introduction
The GP and NCS play a crucial role in the imbalanced vertebral growth in the development of EOS. Existing therapeutic strategies have a dilemma in trauma and deformity correction. However, there is limited literature on minimally invasive interventions for EOS. The study investigated a less invasive treatment approach for early-onset scoliosis (EOS) by inducing asymmetrical growth of the spine. This was achieved by regulating the growth plate (GP) and neurocentral synchondrosis (NCS) on the convex side of the apical vertebrae of the immature porcine EOS model through microwave ablation (MWA).

Methods
To establish an EOS model, unilateral pedicle screw tethering was performed on eighteen 6-week-old pigs to induce a structured spinal curvature. The animals were allocated into three cohorts. The correction group involved eight pigs undergoing CT-guided MWA on the convex side's GP and NCS at the apical vertebra. The sham group was subjected to CT-guided needle puncture at the same-sided GP and NCS without MWA, and the control group entailed five pigs without any intervention. Follow-up entailed monthly spinal radiographs and axial CT imaging.

Results
One month after the spinal tethering procedure, the Cobb's angles were measured at 27.44±1.85° in the established EOS models. All subjects in the correction group demonstrated a reduction in Cobb's angle starting from the first month post-procedure of MWA, with a sustained decrease every subsequent month. In the treatment group, postoperative Cobb's angles were 15.91±1.92°, 12.01±1.97°, and 4.12±1.53° for the first, second, and third months, respectively. No significant reduction in Cobb's angles was observed in either the sham or control groups.

Conclusion
In immature porcine models of EOS, CT-guided unilateral MWA targeting the GP and NCS on the convex side of the apical vertebral has been demonstrated to induce asymmetrical growth of the vertebrae. This innovative application of MWA capitalizes on the differential growth inhibition on the convexity, achieving progressive correction of the scoliotic deformity.

93. EXAMINATION OF AN EPIGENETIC BIOMARKER FOR RISK STRATIFICATION IN ADULT SPINAL DEFORMITY SURGERIES †

Michael P. Kelly, MD; Lawrence G. Lenke, MD; Justin S. Smith, MD, PhD; Shay Bess, MD; Justin K. Scheer, MD; Breton G. Line, BS; Virginie Lafage, PhD; Renaud Lafage, MS; Eric O. Klineberg, MD; Ferran Pellisé, MD, PhD; Mitsuru Yagi, MD, PhD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; International Spine Study Group

Hypothesis
Increasing epigenetic age is associated with greater risk of poor outcomes in adult spinal deformity (ASD) surgeries.

Design
Post-hoc analysis

Introduction
Epigenetic (EPI) aging is associated with DNA-methylation and -demethylation and offers a measure of biological age distinct from chronological (CHRONO) age. This EPI age is more strongly related to morbidity and mortality in the general population than CHRONO. More accurate risk stratification methods are needed for ASD surgeries.

Methods
A multicenter ASD registry of patients undergoing complex reconstructions was queried. AE were captured prospectively and adjudicated by a surgeon panel. EPI age was calculated per Levine et al using albumin, creatinine, glucose, CRP, lymphocyte count, mean cell volume, red cell distribution width, alkaline phosphatase, white blood cell count, and CHRONO. Correlations validated the EPI clock in ASD. Logistic regression examined the relationship between EPI and risk of adverse AE including those requiring moderate/major intervention and neurologic complications. Pseudo-R2 (measure of model fit) compared models using CHRONO and EPI to estimate risk of AE.

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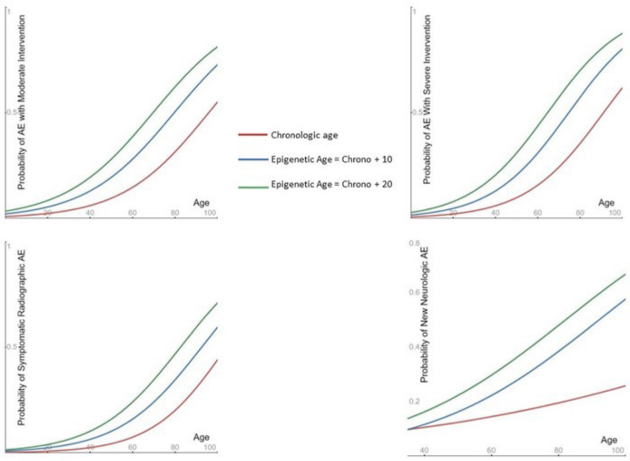
PODIUM PRESENTATION ABSTRACTS

Results
EPI lab data were available for 200 patients. Mean EPI was lower than CHRONO (EPI: 53.7±18.1, CHRONO: 61.1±15.4, p<.001, 95% CI: 6.3-8.5) Increasing CHRONO was associated with higher EPI (Coeff 1.05, p<.001). Overall, with an increasing EPI, there was an increase in risk of AE requiring moderate interventions (OR: 1.05, 95%CI: 1.02-1.08), major intervention (1.06,1.03-1.09), an increase in the risk of symptomatic radiographic AE (OR 1.05, 1.02-1.09) and an increase in risk of neurologic AE (OR 1.04, 1.01-1.07, FIG). Pseudo-R2 were higher for EPI in all four models.

Conclusion
Increasing EPI age is associated with increasing risks of (1) AE requiring major intervention, (2) symptomatic radiographic AE, (3) neurologic AE, with risks greater than estimated by CHRONO. This EPI biomarker may offer an opportunity for more precise risk estimation in ASD surgery. In addition, while chronologic age is linear, epigenetic age may be modifiable thereby offering an opportunity for risk modification prior to surgical intervention.



94. EFFICACY OF TOPICAL TXA IN REDUCING BLOOD LOSS AND TRANSFUSION RATES IN SPINE SURGERY: A DOUBLE-BLINDED RANDOMIZED CONTROLLED TRIAL †

Brett Kilb, MD; Shaina Sim, BS; Matthew McDermid, BS; Arvindera Ghag, MD; Robert H. Cho, MD; *Firoz Miyanji, MD*

Hypothesis
Topical TXA will not have a significant impact on blood loss and transfusion rates in spine surgery

Design
Blinded Randomized Controlled Trial

Introduction
Use of IV TXA in spine surgery to help reduce blood loss and transfusions is well-established,however,a paucity of data exists regarding its topical application in spine surgery.Our aim was to assess whether the application of topical TXA locally in addition to parenteral TXA has any additional benefit of reducing periop blood loss and transfusions in patients undergoing major spine surgery.

Methods
A double-blinded RCT was conducted in 59 patients. Patients randomized into the placebo group(PG)received standard intravenous TXA and epinephrine solution topically applied within the surgical incision prior to wound closure;whereas patients randomized into the experimental group(EG)received intravenous TXA and topical TXA solution.Demographic,preop,surgical,and postop data were collected.Study endpoints were compared using univariate methods,and the effect of topical TXA was analyzed using multivariable linear regression.

Results
PG consisted of 32 patients(82.8% idiopathic scoliosis;17.2% non-idiopathic/other),while EG consisted of 27 patients(69.6% idiopathic scoliosis;30.4% non-idiopathic/other).Preop major Cobb,diagnosis,BMI,preop Hb,preop hematocrit,OR time,length of fusion,and surgical approach did not significantly differ between groups.Mean total blood loss was 10.5+/-7.5cc/kg for PG and 12.5+/-7.9cc/kg for EG(p=0.38).Mean volume of autologous and allogeneic blood transfused was not significantly different between the groups(1.74+/-2.93cc/kg vs 3.17+/-4.7cc/kg;0.74+/-2.24cc/kg vs 1.7+/-4cc/kg;(p=0.23;p=0.35)).Major preop coronal Cobb,length of fusion,surgical approach,and non-idiopathic/other diagnosis had significant positive association with total blood loss (p<0.001);whereas only diagnosis of non-idiopathic scoliosis/other had a positive correlation with transfusion rates and volume on univariate analysis(p<0.001).Linear regression did not demonstrate any significant differences between groups for blood loss and transfusion rates.

Conclusion
In this double-blinded RCT the addition of topical TXA within the surgical wound did not display any significant advantage in reducing blood loss or transfusion rates and

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volume.Further exploration with a larger sample size may be necessary to formulate more conclusive findings.

Table

Basic Descriptives	ALL	PLACEBO (PG)	TOPICAL TXA (EG)	P-Value
Total Blood Loss(cc/kg)	11.4+/-7.7	10.5+/-7.5	12.5+/-7.9	0.38
Autologous Transfusion Volume(cc/kg)	2.4+/-3.9	1.74+/-2.9	3.17+/-4.7	0.23
Allogeneic Transfusion Volume(cc/kg)	1.2+/-3.1	0.74+/-2.2	1.7+/-4.0	0.35
Transfusion Rates; n (%)	21 (35.6%)	11 (34.4%)	10 (47%)	1
Preop Major Cobb (°)	62.3+/-17.1	63.2+/-17.2	60.9+/-17.4	0.67
OR Time (min)	283+/-75.9	278+/-68.8	289+/-85.2	0.66
Length of Fusion	11.7+/-3.3	11.5+/-3.0	12+/-3.7	0.64
Surgical Approach:				0.55
Posterior Only	38(64.4%)	23(71.9%)	15(55.6%)	
Anterior Only	10(16.9%)	5(15.6%)	5(18.5%)	
Anterior and Posterior	3(5.1%)	1(3.1%)	2(7.4%)	
Diagnosis				0.43
Idiopathic Scoliosis	40(76.9%)	24(82.2%)	16(69.9%)	
Non-Idiopathic/Other	12(23.1%)	5(17.2%)	7(30.4%)	
BMI	29.9+/-61.9	20.6+/-3.3	42.3+/-94.3	0.31
Preop Hb	132+/-27.3	127+/-34	138+/-12.3	0.13
Preop Hematocrit	0.41+/-0.03	0.41+/-0.03	0.42+/-0.04	0.35
Day 1 Hb	100+/-15.5	99.7+/-15	101+/-16.7	0.80
Day 3 Hb	96.7+/-16.4	96.2+/-15.7	97.6+/-17.8	0.80
Total Blood Loss Variables of Interest	**Univariate Analysis**		**Multivariate Analysis**	
	Beta	**P-Value**	**Beta**	**P-Value**
Topical TXA	2.1(-2.5,6.6)	0.38	2.7(-1.7,7.2)	0.2
Preop Major Cobb	0.3(0.2,0.4)	<0.001*	-0.03(-0.2,0.2)	0.8
OR Time	0.03(0.01,0.04)	0.19		
Length of Fusion	1.7(1.2,2,3)	<0.001*	0.3(-0.7,1.3)	0.6
Surgical Approach	16.5(10.3,22,8)	<0.001*	-6.9(-15,1.3)	0.1
Diagnosis	10.4(5.8,15.1)	<0.001*	4.6(-3.5,13)	0.3
BMI	0.01(-0.02,0.03)	0.67		
Preop Hb	0.15(-0.05,0.34)	0.14		
Preop Hematocrit	90.1(21.5,158.7)	0.01*	52(-14,117)	0.1
Day 1 Hb	-0.04(-0.19,0.1)	0.54		
Day 3 Hb	-0.1(-0.23,0.03)	0.15		
Transfusion Variables of Interest	**Univariate Analysis**		**Multivariate Analysis**	
	Beta	**P-Value**	**Beta**	**P-Value**
Topical TXA	2.6(-1.5,6.6)	0.22	2.7(-2.4,7.8)	0.3
Preop Major Cobb	0.2(0.1,0.4)	0.002*	-0.02(-0.2,0.2)	0.8
OR Time	0.01(-0.01,0.04)	0.36		
Length of Fusion	1.1(0.4,1.7)	0.003*	0.24(-0.7,1.2)	0.6
Surgical Approach	1.3(-8.6,11.3)	0.8		
Diagnosis	9.9(5.5,14.3)	<0.001*	12(1.8,22)	0.03*
BMI	0.01(-0.01,0.03)	0.46		
Preop Hb	0.1(-0.1,0.3)	0.21		
Preop Hematocrit	68.1(-1.1,137.3)	0.06		

95. RESIDUAL PELVIC COMPENSATION AFTER SPINAL RECONSTRUCTION: THE ROLE OF PSOAS SARCOPENIA

Chukwuebuka Achebe, BS; Han Jo Kim, MD; Takashi Hirase, MD, MPH; Myles Allen, MbChB; Robert Uzzo, MBA; Chad Z. Simon, BS; Tejas Subramanian, BS; Atahan Durbas, MD; Jung Mok, MD; Austin Kaidi, MD; Kasra Araghi, BS; Justin T. Samuel, BS; Cole Kwas, BS; Michael Mazzucco, BS; Samuel Adida, MS; Matthew E. Cunningham, MD, PhD; Francis C. Lovecchio, MD

Hypothesis
Psoas sarcopenia influences changes in pelvic tilt (PT) after adult spinal deformity (ASD) surgery

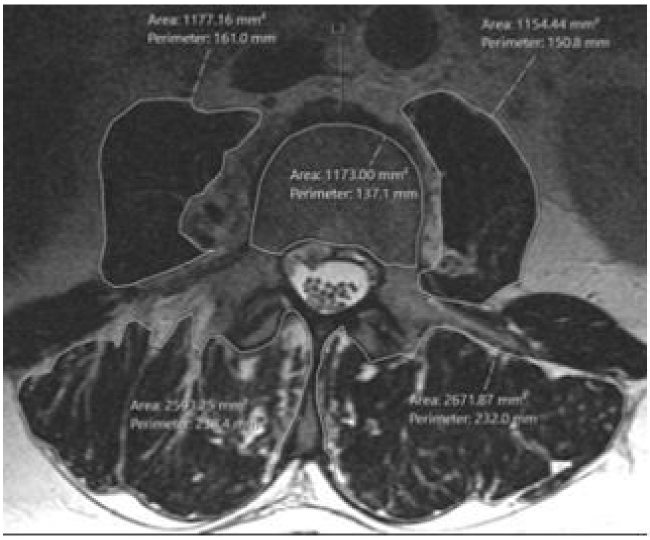
Design
Retrospective cohort study

Introduction
Normalization of compensatory mechanisms after ASD surgery may improve clinical and mechanical outcomes. Correction of pelvic retroversion may depend partially on the capacity of the psoas to antevert the pelvis. The relationship between preoperative psoas health and change in PT after ASD surgery has not been explored.

Methods
A retrospective cohort of patients who underwent ASD surgery at a single center was assessed (2013-2021, 5 or more levels of fusion to the pelvis). Sarcopenia was assessed quantitatively using normalized psoas (NTPA) and paralumbar (NTPL) cross-sectional area at L3 and L4, and qualitatively using Goutallier classification. Sex-specific quartiles were created for each muscle metric, those within the lowest quartile of each metric were classified as sarcopenic according to that metric. Multivariate linear regression models were created to control for race, age, sex, ASA Class, PI, and corrections in global (ΔT1PA) and regional alignment (ΔT4-T12, ΔL1-S1 and ΔL4-S1, 6 week value-baseline value). The primary outcome measure was the ΔPT from preop to 6 weeks postop (the closest postoperative timepoint to the baseline muscle health MRI).

Results
The study included 137 patients (47 males; 90 females; mean age 64.3 ± 9.64). The mean change in PT was -4.96° ± 8.16. Mean PI was 53.9° ± 11.7. Mean corrections were -5.28 ± 30.7 for L4-S1, -18 ± 16.5 for L1-S1 and -8.99 ± 9.97 for T1PA. Multivariate analysis revealed that NTPA L4 sarcopenia was associated with a 2.51° decrease in ΔPT (CI = -4.76 to -0.26, $p = 0.031$). Muscle health of the extensors (NTPL) was not associated with ΔPT. Increased ΔT1PA was also independently associated with increased ΔPT (β = 5.96°, CI = 4.71 to 7.21, $p < 0.001$). The overall model explained 72.7% of the variance in ΔPT (Adjusted R-squared = 0.695, $p < 0.001$).

Conclusion
While improvement in global alignment has the largest influence on ΔPT, psoas health also affects ΔPT, likely through its role in pelvic anteversion. Muscle imbalance in the lumbopelvic unit may play a role in ΔPT after ASD reconstruction.



Axial MRI showing measured muscle areas in a patient with psoas sarcopenia.

PODIUM PRESENTATION ABSTRACTS

96. MAINTAINING STABILITY AT THE LUMBOSACRAL-PELVIC REGION IN ADULT SPINAL DEFORMITY SURGERY WITHOUT SI JOINT FUSION: ARE FOUR PELVIC SCREWS SUPERIOR TO TWO PELVIC SCREWS?

Sarthak Mohanty, BS; *Stephen Stephan, MD*; Christopher Mikhail, MD; Andrew Platt, MD; Joshua Bakshesian, MD; Erik Lewerenz, BS; Fthimnir Hassan, MPH; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

Hypothesis
Dual, bilateral 4 pelvic screw fixation(4PvS) is more effective than single bilateral 2 pelvic screw fixation(2PvS) in reducing reoperation rates and screw breakage.

Design
Single-surgeon retrospective cohort.

Introduction
Up to 19% of adult spinal deformity(ASD) patients undergo revision surgery, often due to lumbosacral junction failures. This study compares 4PvS with 2PvS to improve stability at the lumbosacral junction.

Methods
ASD patients undergoing spinal fusion to the sacrum without SI fusion between 2015 and 2021 with at least two-year(2Y) follow-up were included. 4PvS was compared to 2PvS. Key outcomes included spinal implant-related reoperation, pelvic screw breakage, symptomatic screw reoperation, screw loosening/bending, L5-S1 pseudarthrosis, intraoperative adverse events, and PROs. Bias minimization was addressed using 4:1 propensity score matching(PSM) and inverse probability of treatment weighting(IPTW). Clinical outcomes were evaluated through conditional multivariable logistic regression.

Results
The study analyzed 406 patients(69% female, age 64.48, 22.41% osteoporotic), with an average of 12.85 total instrumented levels(TIL). Baseline demographic, alignment, and corrective techniques showed no significant differences in PSM and IPTW cohorts, with all variables having standardized differences below 0.15. In the 4:1 PSM cohort(228 2PvS matched to 57 4PvS), the 2Y reoperation rate was lower in the 4PvS group(3.51%) compared to the 2PvS group(10.53%, OR: 0.21, P=0.03). Pelvic screw breakage also favored 4PvS(3.51% vs. 9.21% in 2PvS, OR: 0.22, P=0.03). IPTW analysis showed a significant reduction in 2Y reoperation(10.45% vs. 1.18%, P=0.02) and screw breakage(8.72% vs. 1.18%, P=0.05) in the 4PvS group. Intraop complications were similar across groups: 16.37% in 2PvS vs. 12.5% in 4PvS(P=0.32). Dural tear(P=0.81) and neurologic deterioration(P=0.44) were comparable. No significant differences in baseline or 2Y PROs were observed. Two-year postoperative SRS Activity scores were 3.79(±0.09) for 2PvS vs. 3.57(±0.17) for 4PvS(P=0.27), and Pain scores were 3.7(±0.11) vs. 3.34(±0.21), respectively(P=0.15).

Conclusion
4PvS is superior to 2PvS in spinopelvic fixation for ASD patients, significantly reducing two-year implant-related reoperation and screw breakage rates, without increasing operative complications or adversely affecting PROs.

	Unmatched Cohort				*4:1 Propensity Score Matched Cohort*			
	Two Screw Pelvic Fixation [2PvS, n=349]	**Four Screw Pelvic Fixation** [4PvS, n=57]	**P Value (Unmatched)**	**Std. Difference (Unmatched)**	**Two Screw Pelvic Fixation** [2PvS], n=228	**Four Screw Pelvic Fixation** [4PvS, n=57]	**P Value (Matched)**	**Std. Difference (Matched)**
Patient Characteristics								
Age	64.1 (±0.56)	66.72 (±1.15)	0.0443	-0.257	66.29 (±0.59)	66.72 (±1.15)	0.7382	-0.049
Gender [Female]	234 (68.22%)	42 (73.68%)	0.3608		154 (67.54%)	42 (73.68%)	0.4263	
Edmonton Frailty Score	3.51 (±0.13)	3.32 (±0.33)	0.5819	0.079	3.33 (±0.16)	3.32 (±0.33)	0.9621	0.007
Osteoporosis	71 (20.7%)	20 (35.09%)	0.0168		64 (28.07%)	20 (35.09%)	0.3308	
Total Instrumented Levels (TIL)	12.64 (±0.21)	14.11 (±0.58)	0.0212	-0.368	13.89 (±0.33)	14.11 (±0.58)	0.7543	-0.043
Total Number of Osteotomies	5.66 (±0.25)	8.84 (±0.71)	<0.0001	-0.652	8.34 (±0.27)	8.84 (±0.71)	0.5115	-0.094
Three Column Osteotomy (3CO)	79 (23.03%)	12 (21.05%)	0.8654		43 (18.86%)	12 (21.05%)	>0.9999	
Max Coronal Cobb Angle	37.06 (±1.22)	35.63 (±3.15)	0.6732	0.065	36.46 (±1.56)	35.63 (±3.15)	0.8142	0.036
PI - LL	22.58 (±1.08)	19.85 (±2.79)	0.3641	0.139	21.09 (±1.36)	19.85 (±2.79)	0.6906	0.062
T1 Pelvic Angle [T1PA]	27.46 (±0.68)	25.38 (±1.72)	0.266	0.168	26.59 (±0.84)	25.38 (±1.72)	0.5316	0.097
Two- Year Clinical Outcomes								
Implant Related Reoperation	31 (9.04%)	2 (3.51%)	0.1896		24 (10.53%)	2 (3.51%)	0.0312	OR: 0.21 [0.04 to 0.99]
Pelvic Screw Breakage	26 (7.58%)	2 (3.51%)	0.2498		21 (9.21%)	2 (3.51%)	0.0349	OR: 0.22 [0.04 to 0.99]
Screw Bending or Loosening	16 (4.68%)	1 (1.79%)	-		9 (3.96%)	1 (1.79%)	-	
Operative Repair Pelvic Screw	15 (4.37%)	1 (1.75%)	-		9 (3.95%)	1 (1.75%)	-	
L5-S1 Pseudarthrosis	10 (2.92%)	1 (1.75%)	-		7 (3.07%)	1 (1.75%)	-	
Complications								
Intraoperative Complications	49 (14.37%)	7 (12.5%)	0.5567		37 (16.37%)	7 (12.5%)	0.3169	
Massive EBL	16 (4.66%)	2 (3.51%)	0.5129		13 (5.7%)	2 (3.51%)	0.1785	
Dural Tear	31 (9.04%)	7 (12.28%)	0.6636		23 (10.09%)	7 (12.28%)	0.8104	
Neurologic Deterioration	77 (22.58%)	12 (21.05%)	0.6708		54 (23.68%)	12 (21.05%)	0.4359	
Sensory Deficit	29 (8.45%)	3 (5.26%)	0.6629		16 (7.02%)	3 (5.26%)	0.5932	
Motor Deterioration	65 (19.06%)	10 (17.54%)	0.7576		45 (19.74%)	10 (17.54%)	0.5107	

97. DOES NORMALIZING T4-L1PA RELATIONSHIP IN LONG-SEGMENT FUSIONS INDEPENDENTLY REDUCE MECHANICAL COMPLICATIONS AND IMPROVE PATIENT REPORTED OUTCOMES?

Sarthak Mohanty, BS; Zeeshan M. Sardar, MD; *Michael P. Kelly, MD*; Josephine R. Coury, MD; Justin Reyes, MS; Fthimnir Hassan, MPH; Nathan J. Lee, MD; Justin K. Scheer, MD; Steven G. Roth, MD; Chun Wai Hung, MD; Joseph M. Lombardi, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

Hypothesis
Normalizing T4-L1PA reduces reoperations attributable to mechanical complications(MC) but does not impact PROs

Design
Retrospective cohort of ASD patients undergoing >6 level PSF

Introduction
Investigations in asymptomatic adults revealed harmonious T4-L1-Hip Axis, characterized by T4 pelvic angle(T4PA) within 4° of L1PA. Understanding the impact of L1PA/T4PA malalignment on MC and PROs is critical.

Methods
T4PA-L1PA mismatch was assessed at 6 weeks postop following deformity correction and patients were followed for 2Y thereafter. Key outcomes were MC, encompassing implant-related reoperations and reoperations for PJK/F alongside attainment of MCID for SRS and ODI PROs at 2Y postop. MCID thresholds were 0.4 for SRS scores and -11 for ODI. A multivariable logistic regression model investigated the association between(T4PA-L1PA)2 and MC, adjusting for comorbidities(CCI), preop alignment, UIV, pelvic fixation, and the correction magnitude. A polynomial logistic regression was employed to model the quadratic relationship between T4PA-L1PA and MC risk, with plots illustrating the probability of MC across the T4PA-L1PA spectrum. Logistic regression analyses investigated the relationship between(T4PA-L1PA)2 mismatch and MCID in PROs.

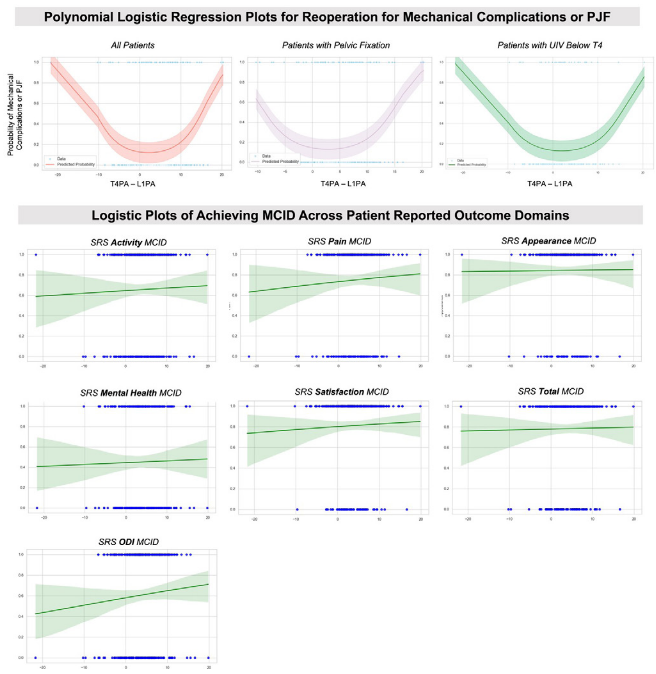
Results
427 patients with mean age 61.2(±0.7), 12.50(±0.2) instrumented levels, and 78.7% undergoing pelvic fixation were included. 66(15.5%) patients underwent MC-related reoperations. Univariate analysis revealed higher CCI(OR=1.3,p=0.001), increased (T4PA-L1PA)2 (OR=1.01,p<0.001), lower preop TK(OR=0.99,p=0.021),

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

increased ΔPI-LL(OR=1.01,p=0.037), and ΔT-4PA(OR=1.03,p=0.029) were associated with higher odds of MC. In the multivariable model(AUC=0.72,p<0.001), higher CCI(OR=1.21,p=0.029),pelvic fixation(OR=2.78,p=0.022), and greater (T4PA-L1PA)2(OR=1.01,p<0.001) were independent predictors of MC. The probability of MC across T4PA-L1PA values indicated that both over- and under-correction are associated with MC. (T4PA-L1PA)2 was not associated with achieving MCID in SRS activity(p=0.635), pain(p=0.444), appearance(p=0.800), mental health(p=0.800), satisfaction(p=0.189), and ODI(p=0.472).

Conclusion

Aligning T4-L1PA mismatch within normative ranges mitigates mechanical complications but does not significantly influence attainment of MCID. This suggests that mechanical complications are driven by alignment, while PROs may be multifactorial.



98. IS CORTICAL BREACH AT THE UPPER INSTRUMENTED VERTEBRA ASSOCIATED WITH INCREASED RISK OF PROXIMAL JUNCTIONAL KYPHOSIS?

Samuel K. Ezeonu, BA; Juan D. Rodriguez-Rivera, BS; Nicholas S. Vollano, BS, MBS; Alyssa E. Capasso, BS; Constance Maglaras, PhD; Tina Raman, MD; *Themistocles S. Protopsaltis, MD*

Hypothesis

Cortical breach at the UIV increases the risk of proximal junctional kyphosis (PJK) following surgery.

Design

Single center retrospective cohort study

Introduction

While some studies have suggested that pedicle screw trajectory at the upper instrumented vertebra (UIV) is associated with PJK, it is unknown if screw cortical breach is also a significant risk factor.

Methods

Patients ≥ 18 years of age undergoing surgery with 5 ≥ levels fused were placed into PJK and no-PJK cohorts based on a clinical diagnosis of PJK documented by the operating surgeon within two years. Placement and trajectory of pedicle screws at the UIV were assessed at the first postoperative radiographic and CT-imaging. Medial or lateral breach was categorized if screw breach was ≥ 2 mm on either respective side of the pedicle tract at the UIV. Endplate breach was classified if any part of the screw tip surpassed the superior endplate at the UIV. Pedicle screw trajectory (UIV-PVA) was measured as the mean of the two angles between the UIV superior endplate and both UIV pedicle screws: Positive sign for UIV-PVA indicates cranially-directed screw, and negative sign indicates caudally-directed screw. T-tests, X2, and logistic regression were used for analyses of patient and radiographic outcomes.

Results

88 patients were included (mean age 66 yr, 64% female). 38 patients demonstrated a clinical diagnosis of PJK (43%). There was a significantly greater percentage of patients with history of diabetes in the PJK group (p<0.05). No differences were observed between the groups in UIV location or baseline and postoperative radiographic parameters. While no difference was seen in rates of medial or lateral breach, incidence of endplate breach at the UIV was found to be significantly higher in the PJK group (p<0.001). Patients in the PJK group also demonstrated significantly higher rate of cranially-directed screw trajectory at the UIV compared with non-PJK patients (p=0.003). Multivariate regression for variables p<.05, revealed endplate breach at the UIV as an independent predictor of PJK development (OR = 3.953, CI 1.17-13.39; p=0.027).

Conclusion

Pedicle screw endplate breach at the UIV contributed to a 3.95-fold increased risk for development of PJK. This data highlights the critical importance of screw trajectory and positioning at the UIV in minimizing risk for PJK.

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

PODIUM PRESENTATION ABSTRACTS

Table 1: Patient and Radiographic Analysis Comparing Patients Who Did Not Develop PJK Versus Those Who Did Develop PJK

		NoPJK (N=58)	PJK (N=30)	p-value
Patient and Surgical Factors	Age	64.77±10.11	67.60±7.52	0.182
	Gender (%F)	59.60%	73.30%	0.254
	BMI	28.86±5.51	28.94±6.27	0.947
	Smoking	7.00%	0.00%	0.294
	Diabetes	5.30%	23.30%	**0.028**
	UIV location			0.389
	Upper Thoracic (T1-T5)	36.20%	26.70%	
	Mid Thoracic (T6-T9)	12.10%	6.70%	
	Thoracolumbar (T10-T12)	51.70%	66.70%	
	Levels Fused	10.05±3.17	9.63±3.34	0.576
	3CO performed?	14.00%	6.70%	0.483
	Pelvic Fixation	80.70%	90.00%	0.363
Radiographic Analysis				
Preoperative	SVA (cm)	7.29±6.88	5.46±4.14	0.183
	TPA°	27.01±11.86	27.58±10.72	0.843
	PI °	54.61±12.77	58.82±12.68	0.195
	TK°	31.69±21.65	35.87±18.18	0.417
	PI-LL°	23.01±22.83	22.67±16.71	0.949
	PT°	26.35±9.61	29.57±10.38	0.201
Postoperative	SVA (cm)	3.75±5.00	4.12±3.80	0.787
	TPA°	19.02±9.52	24.15±9.12	0.066
	PI °	54.19±13.74	59.89±17.38	0.142
	TK°	42.24±10.56	43.85±12.57	0.626
	PI-LL°	7.42±14.29	12.03±12.02	0.220
	PT°	23.19±11.63	27.38±9.94	0.174
UIV Screw Analysis	Medial Breach	7 (12.1%)	7 (23.3%)	0.221
	Lateral Breach	10 (17.2%)	1 (3.3%)	0.089
	Endplate Breach	8 (14.0%)	15 (50.0%)	**<0.001**
	UIV-PVA°	0.32±5.79	4.47± 6.45	**0.003**

99. COMPARISON OF ELDERLY PATIENTS WITH SPINAL DEFORMITY FUSED FROM THE UPPER VERSUS THE LOWER THORACIC/THORACOLUMBAR SPINE TO THE SACRUM. PROSPECTIVE EVALUATION OF ELDERLY DEFORMITY SURGERY (PEEDS) STUDY

Zeeshan M. Sardar, MD; Roy Miller, MS; Scott Zuckerman, MD, MPH; Stephen J. Lewis, MD, FRCS(C); Marinus de Kleuver, MD; Yong Qiu, PhD; Yukihiro Matsuyama, MD, PhD; Lawrence G. Lenke, MD; Ahmet Alanay, MD; Ferran Pellisé, MD, PhD; Kenneth M. Cheung, MD, MBBS, FRCS; Maarten Spruit, MD; David W. Polly, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Michael P. Kelly, MD; Benny T. Dahl, MD, PhD, DMSc; Sigurd H. Berven, MD

Hypothesis
We hypothesized that patients fused to the Upper Thoracic (UT) spine would demonstrate more severe preoperative deformity, increased early complications but similar long term reoperation probability

Design
Prospectice, Multicenter, Observational study

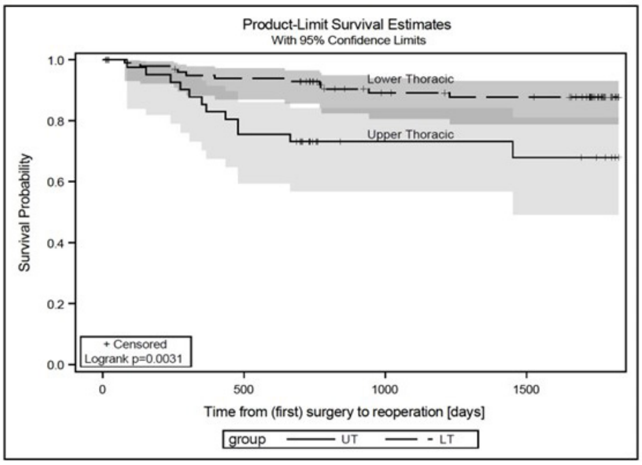
Introduction
In adult spinal deformity (ASD) surgery, choosing the upper instrumented vertebra (UIV) between the upper thoracic (UT) or lower thoracic/thoracolumbar (LT) spine is critical to balancing the risk of periop surgical morbidity with durable long-term outcomes. This study compares outcomes of elderly patients fused to the sacrum from UT vs. LT

Methods
ASD patients (age 60+) undergoing fusion to the sacrum were divided into UT (UIV T1-T7) and LT (UIV T8-L2) groups and were followed up for 5 years. We compared demographics, radiographic parameters, perioperative outcomes, reoperation probability, and patients-reported outcome metrics (PROMs).

Results
145 ASD patients (80% females; mean age 68.0±5.4) were included (UT: 42, LT: 103). Although there was no significant difference in operative times, the UT group had higher estimated blood loss (EBL) than the LT group (2163.4cc vs. 1569.8cc; p=.01). Both groups had similar postop complication rates 40.5% vs. 40.8%. Preoperatively, the UT group had higher thoracic kyphosis (TK) (p<.05), higher thoracolumbar kyphosis angle (TLA) (p<.001), and higher distal lordosis (p=.006). At 5 year follow up, UT group demonstrated lower SVA of 33.1mm vs.65.3mm (p=.05) even though preop SVA was similar. The rate of radiographic PJK was not different. However, the probability of reoperation after 5 years was higher in the UT group (32.1% vs. 12.27%; p=0.003). Implant failure was the most common reason for reoperation (UT: 47%, LT: 28%). Junctional pathology accounted for 10% and 14% of reoperations in the UT and LT groups respectively. PROMs were similar at baseline and significantly improved postop in both groups.

Conclusion
The UT group had greater thoracic/thoracolumbar kyphosis, and higher EBL versus the LT group. The UT group maintained a lower SVA at final follow-up but had a higher reoperation probability. Surprisingly, implant failure was the most common cause of revision in both cohorts. Complication rates and PJK rates were similar. Importantly, both groups showed significant improvement in postop PROMs at all visits

Figure 01: Kaplan-Meier curve for reoperations 5 years postop



100. UPPER INSTRUMENTED VERTEBRA PEDICLE SCREW LOOSENING FOLLOWING COMPLEX ADULT SPINAL DEFORMITY SURGERY: INCIDENCE AND OUTCOME ANALYSIS OF 147 CASES

John D. Arena, MD; Yohannes Ghenbot, MD; Connor Wathen, MD; Gabrielle Santangelo, MD; Mert Marcel Dagli, MD; Joshua L. Golubovsky, MD; Ben Gu, MD; Dominick Macaluso, PhD; Jang Yoon, MD, MSc; William C. Welch, MD; Ali Ozturk, MD

Hypothesis
The development of pedicle screw loosening following surgery for adult spinal deformity (ASD) is associated with increased odds of eventual hardware revision surgery.

Design
Retrospective cohort study

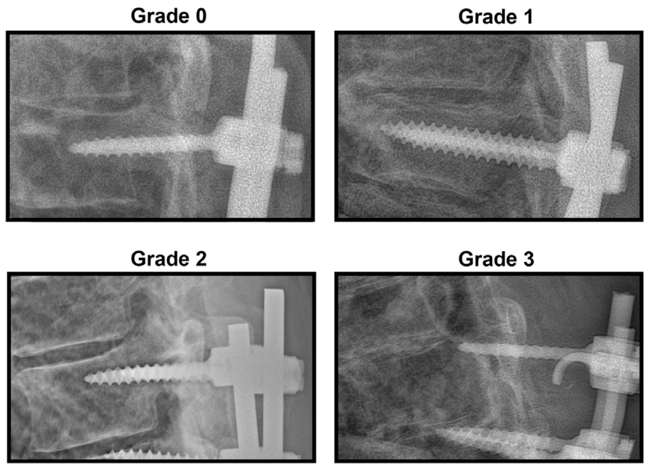
Introduction
ASD is a debilitating condition which is increasing in prevalence as the population ages. Surgical correction of ASD may confer considerable improvement in quality of life, however, there exists a high rate of hardware complication which can be challenging to predict. Hardware integrity and alignment are frequently followed with standing radiographs, where pedicle screw loosening may be incidentally identified, the clinical significance of which is often unclear.

Methods
A single-institution retrospective cohort of 147 patients (69% female, mean age 63.7) who underwent long-segment fusion for ASD was reviewed. Patients with minimum two-year follow-up (mean 4.1 years) and with follow-up standing radiographs were included. Upper instrumented vertebra (UIV) pedicle screws were graded on radiographs for evidence of loosening as: 0=no loosening, 1=positive radiolucency within screw threads, 2=positive radiolucency around screw threads, 3=screw dislodgement (Figure 1). T-Test and logistic regression analyses were performed.

Results
109 cases (74.1%) demonstrated no loosening, 26 (17.7%) Grade 1 loosening, 9 (6.1%) Grade 2, and 3 (2.0%) Grade 3. No baseline patient characteristics or surgical construct features significantly differed between patients with and without High Grade (Grade 2/3) UIV loosening (all p>0.05). High Grade UIV loosening was associated with significantly increased odds of eventual hardware revision surgery (Odds Ratio 9.29, p=0.002), including specifically surgery for proximal junctional kyphosis (Odds Ratio 9.18, p=0.015). Among patients with PROMIS scores (n=88), those requiring hardware revision reported worse Pain Interference (p=0.003) and Physical Function (p=0.031). Patients with High Grade UIV Loosening trended toward higher Oswestry Disability Index (n=27) scores (44.7 vs 34.8, p=0.263).

Conclusion
Whereas Grade 1 UIV pedicle screw loosening may be a benign incidental finding, High Grade loosening is associated with significantly increased odds of hardware revision surgery, including PJK. High Grade loosening may also be associated with worse patient-reported disability. High Grade loosening warrants increased attention in follow-up.

Figure 1. UIV Pedicle Screw Loosening Grades



101. PROXIMAL JUNCTIONAL DEGENERATION AND FAILURE: A NOVEL CLASSIFICATION AND CLINICAL IMPLICATIONS

Riza Mert Cetik, MD; Steven D. Glassman, MD; John R. Dimar, II, MD; Mitchell J. Campbell, MD; Mladen Djurasovic, MD; Charles H. Crawford III, MD; Jeffrey L. Gum, MD; Kirk Owens, MD; Kathryn McCarthy Mullooly, MD; Leah Y. Carreon, MD

Hypothesis
Varying mechanisms of proximal junctional degeneration or failure demonstrate different clinical characteristics and revision rates.

Design
Retrospective review

Introduction
Proximal junctional degeneration after spinal fusion is often identified as PJK/PJF. Existing classifications are descriptive, but not necessarily correlated with mechanism or clinical course.

Methods
Patients with posterior fusion of ≥3 levels and upper instrumented level (UIV) at or distal to T8, with minimum 2-year follow-up were identified from a single center database. Demographic, surgical and radiographic variables were recorded. The proposed classification system identified 4 patterns: Type 1: symmetrical collapse involving multiple levels cranial to the UIV, Type 2: single level adjacent level collapse with bony erosion ± screw penetration into disc space, Type 3: fracture, and Type 4: spondylolisthesis (Figure). Radiographic and clinical findings, and rates of progression were compared between different types of proximal junctional degeneration.

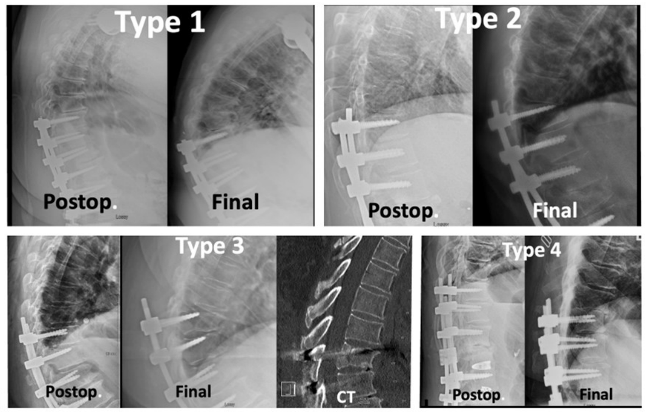
Results
150 patients were included (mean age 65.1 years and follow-up 3.2 years). 92 (61%) patients developed degenerative changes in the proximal junctional region, and

PODIUM PRESENTATION ABSTRACTS

were classified as Type 1 (32, 21%), Type 2 (15,10%), Type 3 (22, 15%) and Type 4 (12, 8%). All results in parentheses are for types 1,2,3 and 4, respectively. Greater preop SVA was associated with Types 3 and 4 (61±47, 97±121, 136±41, 155±15, p=0.019), greater preop PI-LL mismatch with Type 4 (23±14, 23±22, 22±16, 40±21, p=0.05) and greater postop thoracic kyphosis with Types 2 and 3 (33±12, 47±9, 48±12, 36±13, p=0.049). Mean time to revision was shorter for Type 3 cases (1.9, 2.1, 0.9, 2.1 years, p=0.004). Rates for PJK were 31%, 67%, 46% and 33% (p=0.125), for revision were 63%, 73%, 73% and 83% (p=0.564) and for neurologic deficit were 9%, 20%, 32% and 17% (p=0.221).

Conclusion

This novel comprehensive classification system defines different modes of degeneration at the proximal junction, without reliance on angular definitions of PJK/PJF. Different types have different clinical courses (fractures have significantly shorter time to revision). Pre/postop radiographic characteristics are associated with specific types of failure (i.e. spondylolisthesis had the highest preop SVA). Future studies with larger sample sizes are needed to validate this novel classification.



102. RISK OF UPPER INSTRUMENTED VERTEBRA FRACTURE IN ADULT SPINAL DEFORMITY SURGERY ASSOCIATED WITH INSERTION OF OVERSIZED SCREWS RELATIVE TO PEDICLE WIDTH

Shin Oe, MD; Yu Yamato, MD, PhD; Tomohiko Hasegawa, MD, PhD; Go Yoshida, MD, PhD; Tomohiro Banno, MD, PhD; Hideyuki Arima, MD, PhD; Koichiro Ide, MD; Tomohiro Yamada, MD; Yuh Watanabe, MD; Kenta Kurosu, MD; Yukihiro Matsuyama, MD, PhD

Hypothesis

If the pedicle width at the upper instrumented vertebra (UIV) is smaller than the diameter of the pedicle screw, there is an increased likelihood of an upper instrumented vertebra fracture (UIVF).

Design

Retrospective cohort study

Introduction

The etiology of UIVF in adult spinal deformity (ASD) surgery is complex and involves multiple factors. Individual variability in pedicle width is a contributing factor, and when screws with a diameter exceeding the pedicle width are inserted into the UIV, there exists a potential risk of UIVF attributable to pedicle fractures induced by screw placement. The objective of this research is to examine the occurrence of UIVF in cases where the screw diameter within the UIV surpasses the width of the pedicles.

Methods

The research comprised 322 individuals who underwent ASD surgery, with a follow-up period exceeding 2 years. The UIV was positioned cephalad to the T10 vertebra, utilizing 5.5 mm screws. Preoperative CT scans measured pedicle width in the UIV, classifying individuals with pedicle widths below 5.5 mm as the N group and those with widths equal to or exceeding 5.5 mm as the W group.

Results

Among the participants, 264 individuals were categorized in the N group, while 58 were in the W group, with an average age of 68 years in both cohorts. The average pedicle width on both sides measured 4.0 mm in the N group and 6.2 mm in the W group. The incidence of UIVF was found to be 26% in the N group compared to 14% in the W group (P=0.046). In the N group, UIVF cases were distributed across T2 (1 case), T3 (1 case), T4 (18 cases), T5 (22 cases), T6 (11 cases), T7 (11 cases), T8 (29 cases), T9 (92 cases), T10 (79 cases). Conversely, in the W group, UIVF occurred at T5 (1 case), T8 (4 cases), T9 (13 cases), and T10 (40 cases). Notably, within the N group, the incidence of UIVF was 22.7% (48/211 cases) for those with UIV located at T7-10, compared to 39.6% (21/53 cases) for cases with UIV at T2-6.

Conclusion

A pedicle width smaller than the screw diameter is regarded as a contributing factor to UIVF. Special attention is warranted, especially when the UIV is positioned cephalad, as pedicle width tends to be narrower in such cases. In instances where the pedicle width is less than the screw diameter, careful consideration should be given to either reducing the screw diameter or employing alternative devices such as hooks.

103. BEYOND KYPHOSIS: MODES OF FAILURE AT THE PROXIMAL JUNCTION IN ADULT SPINAL DEFORMITY

Virginie Lafage, PhD; Ayman Mohamed, MD; Christopher Katchis, MD; Alan H. Daniels, MD; Bassel G. Diebo, MD; Christopher P. Ames, MD; Shay Bess, MD; Douglas C. Burton, MD; Robert K. Eastlack, MD; Munish C. Gupta, MD; Richard Hostin, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Eric O. Klineberg, MD; Gregory M. Mundis Jr., MD; David O. Okonkwo, MD, PhD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Renaud Lafage, MS; Frank J. Schwab, MD; International Spine Study Group

Hypothesis

Modes of junctional failure are more diverse than just a kyphotic change.

Design

Retrospective analysis of prospective registry.

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Introduction
Proximal segment disease in adult spinal deformity (ASD) surgery has been historically evaluated as a kyphotic change and is well known as Proximal Junctional Kyphosis (PJK). Junctional diseases such as endplate fracture, spinal canal stenosis, disc herniation, soft tissue failure, spondylolisthesis, and instrumentation failure without kyphosis, therefore, are overlooked.

Methods
Database entries and radiographs of 185 ASD patients with radiographic PJK (Lovecchio's criteria) or those who underwent revision surgery with proximal extension were reviewed by three independent readers. The readers qualitatively reported the type of failure in the junction zone using free text. After standardizing text descriptions, patterns of junctional issues were categorized, and the location of the failure was reported in relation to the last instrumented vertebra.

Results
Among the 1506 enrolled patients, 185 (12.3%) had severe junctional issues (67.5 yo, 86.5%F) after an upper thoracic (UT) to Pelvis (36.2%) or lower thoracic (LT) to pelvis (57.3%) surgery. Failure patterns included focal bony elements, focal soft tissues, or diffuse degeneration (Table). Focal bony vertebral body failure occurred in 122 (66%) patients, with a vertical collapse of the vertebra in 18 (9.7%) and angular collapse in 99 (53.5%), along with endplate fractures in 111 (60%). Focal soft tissue failure occurred in 120 (64.9%) patients, with a vertical disc collapse in 39 (21.1%), a kyphotic disc in 53 (29.2%), and spondylolisthesis in 34 (18.4%). Finally, 41 patients (22.2%) developed generalized degeneration across several levels. Median times to failure are reported in the Table. Patients with a LT UIV tended to have a higher rate of angular bony failure (55.7%), while those with lumbar UIV tended to have a higher rate of "non-angular" failures (58.3%).

Conclusion
Postoperative proximal junctional disease following ASD surgery is not always simply kyphosis. This study revealed three distinct modes of failure at the junction (vertebral failure, disc failure, junctional degeneration), with 25% of patients presenting with non-kyphotic junctional disease. Those modes not only varied in radiographic presentation, but also in their median time to onset from the index surgery.

	N (Rate%)	Time to Failure in days
Vertebral Failure	122 (66%)	284 [46 to 647]
Vertebral Collapse	18 (9.7%)	369 [47 to 904]
UIV-1	0 (0%)	
UIV	**15 (8.1%)**	384 [45 to 946]
UIV+1	4 (2.2%)	
Vertebral Wedge	99 (53.5%)	248 [46 to 430]
UIV-1	2 (1.1%)	
UIV	**82 (44.3%)**	90 [43 to 422]
UIV+1	15 (8.1%)	304 [49 to 762]
UIV+2	3 (1.6%)	
UIV+3	1 (0.5%)	
Vertebral endplate fracture	111 (60%)	248 [45 to 457]
UIV-1	1 (0.5%)	
UIV	**100 (54.1%)**	215 [44 to 450]
UIV+1	8 (4.3%)	
UIV+2	1 (0.5%)	
UIV+3	1 (0.5%)	
Disc Failure	120 (64.9%)	384 [74 to 787]
Disc Collapse / DDD	39 (21.1%)	383 [363 to 751]
UIV / UIV+1	**39 (21.1%)**	383 [363 to 751]
UIV+1 / UIV+2	1 (0.5%)	
Disc Kyphotic	54 (29.2%)	370 [63 to 761]
UIV / UIV+1	**54 (29.2%)**	370 [63 to 761]
UIV+1 / UIV+2	1 (0.5%)	
Spondylolisthesis	34 (18.4%)	378 [89 to 728]
UIV-1 / UIV	1 (0.5%)	
UIV / UIV+1	**30 (16.2%)**	373 [89 to 534]
UIV+1 / UIV+2	3 (1.6%)	
Junctional Degeneration	41 (22.2%)	730 [315 to 1140]

104. SAFETY OF CERVICAL PEDICLE SCREW NAVIGATION BASED ON AI-GENERATED, MRI-BASED SYNTHETIC-CT VERSUS CT

Peter Lafranca, MD; Yorck Rommelspacher, MD, PhD; Sander Muijs, MD, PhD; Sebastian Walter, MD, PhD; Tijl van der Velden, PhD; René M. Castelein, MD, PhD; Keita Ito, MD, PhD; Peter R. Seevinck, PhD; _Tom Schlosser, MD, PhD_

Hypothesis
MRI-based synthetic-CT (sCT) spinal navigation is non-inferior to CT for the safety of cervical pedicle screw placement.

Design
Investigator-initiated experimental safety study, supported by a Scoliosis Research Society grant.

Introduction
Application of pedicle screw placement in the cervical spine may lead to critical complications due to the surrounding neurovascular structures. Several solutions for navigated cervical pedicle screw placement are available and all these navigation systems require pre- and/or intra-operative 3D CT, C or O-arm imaging. Especially in young patients, it is important to minimize the exposures to ionizing radiation. MRI based synthetic CT is a novel method to visualize osseous structures with a CT-like contrast without the use of any ionizing radiation. This experimental study aims to test the safety of MRI-based sCT spinal navigation by assessing whether this is non-inferior to CT for cervical pedicle screw placement.

Methods
5 cadavers were scanned with CT and with BoneMRI. From the BoneMRI sequences, AI-generated sCT scans

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

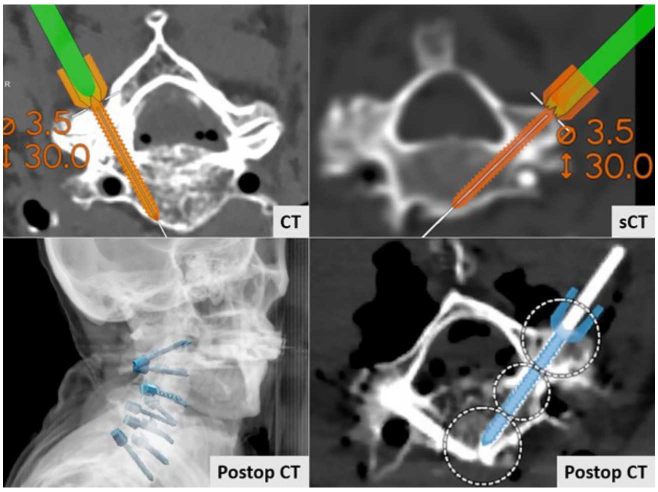
were made. Four spine surgeons performed surface matching and navigated k-wire placement from levels C2 to C7 bilaterally. Randomization for CT vs sCT, surgeon, and side was performed with a 1:1 ratio. A postoperative CT was acquired and 3.5mm virtual screws were simulated on the k-wires. Medial and lateral breaches were verified by an independent researcher. Breach rate was assessed using the Gertzbein-Robbins classification, with grade A and B as a satisfactory screw position.

Results

In total 60 k-wires were placed, 3 wires (1 CT-, 2 sCT-guided) were excluded due to complete wire dislocation during transport. Of the 29 CT-navigated screws, 23 were grade A, 5 grade B and 1 was grade C. Thus, 97% were within the pedicle or <2mm exceeding the pedicle cortex. Of the 28 sCT navigation screws, 23 were grade A and 5 grade B, giving in 100% of the cases satisfactory screw positions.

Conclusion

Radiation-free, MRI-based synthetic CT is non-inferior to conventional CT for surface matching and navigated cervical pedicle screw placement.



Screenshot of intraoperative screw planning on CT, sCT and postoperative screenshot of the virtual screws placed over k-wires.

105. THE GAP BETWEEN SURGEON GOAL AND ACHIEVED SAGITTAL ALIGNMENT IN ADULT CERVICAL SPINAL DEFORMITY (CSD) SURGERY

Justin S. Smith, MD, PhD; David Ben-Israel, MD; Michael P. Kelly, MD; Virginie Lafage, PhD; Renaud Lafage, MS; Eric O. Klineberg, MD; Han Jo Kim, MD; Breton G. Line, BS; Themistocles S. Protopsaltis, MD; Peter G. Passias, MD; Robert K. Eastlack, MD; Gregory M. Mundis Jr., MD; K. Daniel Riew, MD; Khaled M. Kebaish, MD; Paul Park, MD; Munish C. Gupta, MD; Jeffrey L. Gum, MD; Alan H. Daniels, MD; Bassel G. Diebo, MD; Justin K. Scheer, MD; Richard Hostin, MD; Alex Soroceanu, MD, FRCS(C), MPH; Kojo D. Hamilton, MD, FAANS; Thomas J. Buell, MD; Stephen J. Lewis, MD, FRCS(C); Lawrence G. Lenke, MD; Jeffrey Mullin, MD; Frank J. Schwab, MD; Douglas C. Burton, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Shay Bess, MD; International Spine Study Group

Hypothesis

Preop sagittal alignment goals are not consistently achieved following CSD surgery.

Design

Multicenter, prospective cohort

Introduction

Malalignment following CSD surgery can negatively impact outcomes and increase mechanical complications. Despite increasing ability to preoperatively plan alignment goals, it remains unclear whether preop goals are achieved with surgery.

Methods

Adult CSD patients were enrolled based on radiographic criteria. Surgeons documented alignment goals prior to surgery, including C2-C7 sagittal vertical axis (SVA), C2-C7 sagittal Cobb angle, T1 slope-cervical lordosis (TS-CL), and C7-S1 SVA. Goals were compared with achieved alignment (6 wks) and parameter mean and SD were calculated for the offset (achieved-goal). Goal alignment was achieved if the offset was within +/-1 SD of the goal.

Results

The 88 enrolled patients had a mean age of 64 years (SD=13) and 51% were women. Mean anterior and posterior instrumented levels were 3.5 (SD=1.0) and 10.6 (SD=4.5), respectively, and 20% had a PSO or VCR. Mean (SD) offsets (achieved-goal) were: C2-C7 SVA=8.3 mm (21.1), C2-C7 sagittal Cobb=4.8° (13.5), TS-CL=10.9° (16.2), and C7-S1 SVA=8.2 mm (43.1). Goals were achieved for C2-C7 SVA, C2-C7 sagittal Cobb, TS-CL, C7-S1 SVA, and all 4 parameters in 52.3%, 62.5%, 39.1%, 53.2%, and 10.2% of cases, respectively. On regression analysis: goal C2-C7 SVA was more likely to be achieved in women (OR=2.772, 95% CI=1.168-6.576, p=0.021); no factors were associated with achievement of goal C2-C7 sagittal Cobb; goal TS-CL was more likely to be achieved with greater baseline C7-S1 SVA (OR=1.016, 95%CI=1.004-1.028, p=0.010) and lower baseline TS-CL (OR=0.959, 95%CI=0.926-0.993, p=0.018); goal C7-S1 SVA was more likely to be achieved with greater baseline TK (OR=1.036, 95%CI=1.007-1.066, p=0.013) and use of PACS/equiv for surgical planning (OR=2.885, 95%CI=1.041-7.994, p=0.042) and was less likely to be achieved with a diagnosis of osteoporosis (OR=0.254, 95%CI=0.078-0.833, p=0.024); goal alignment for all 4 parameters was more likely to be achieved in women (OR=9.081, 95%CI=1.084-76.058, p=0.042).

Conclusion

Surgeons failed to achieve goal alignment of each sagittal parameter in ~50% of adult CSD patients and achieved goal alignment for all 4 parameters assessed in only 10.2% of cases. Further advancements are needed to enable more consistent translation of preop alignment goals to the operating room.

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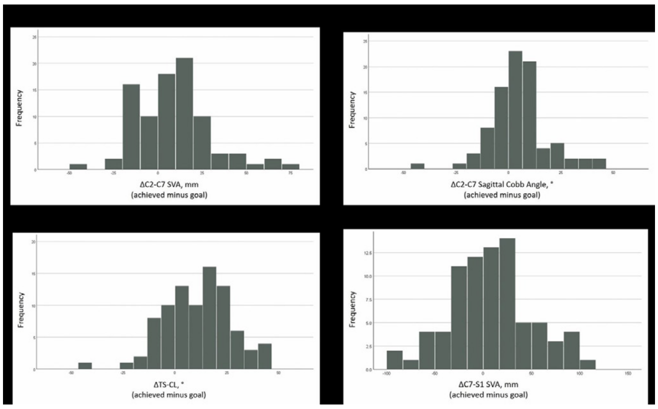


106. COMPLICATIONS, MORBIDITY, AND MORTALITY FOLLOWING CORRECTIVE SURGERY FOR CERVICAL DEFORMITY AMONG GERIATRIC COHORTS

Andrew Kim, BS; Yesha Parekh, MD; Wesley M. Durand, MD; Shay Bess, MD; Douglas C. Burton, MD; Jeffrey L. Gum, MD; Munish C. Gupta, MD; Richard Hostin, MD; Khaled M. Kebaish, MD; Michael P. Kelly, MD; Han Jo Kim, MD; Eric O. Klineberg, MD; Virginie Lafage, PhD; Gregory M. Mundis Jr., MD; Paul Park, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; K. Daniel Riew, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Christopher P. Ames, MD; Sang Hun Lee, MD; International Spine Study Group

Hypothesis
Complication, morbidity and mortality rates following cervical deformity (CD) surgery may be higher in older populations than younger cohorts.

Design
A retrospective review of a prospective, multicenter CD database.

Introduction
Corrective surgery for CD is challenging due to high risk of complications, and morbidity as well as technical difficulties. This is the first study to analyze complication rates among different geriatric CD cohorts.

Methods
This is a retrospective review of a prospective, multicenter CD database. Operative CD patients with clinical and health-related quality of life (HRQL) data were included. Patients were divided into 3 cohorts, >75 vs. <75, >70 vs. <70, and >65 vs. <65 years of age. Demographics, HRQLs, surgical characteristics, and complications (medical, surgical, neurological, revision surgery, mortality) were compared using Welch's t-test and chi-square analysis. Logistic regression was performed to assess the impact of patient demographics.

Results
A total of 278 CD patients (mean age 62.6 years) were analyzed. Number of levels fused, estimated blood loss, operative time, and length of showed no difference within the >65, >70, and >75 years of age cohorts (p > 0.05). The number of patients with complication were 53.6:56.8% in the <65: >65 years group, 56.2:52% in the <70: >70 years group, and 54.1:61.1% in the <75: >75 years group. Among complication types, patients >65 years of age had higher rates of instrumentation complications (p=0.049), and patients >75 years had higher rates of dysphonia (p=0.026) and musculoskeletal complications (p<0.001). Logistic regression revealed age had no impact on complication or revision surgery rates (p>0.05). History of osteoporosis was found to be a significant predictor of revision surgery, with odds of revision surgery increasing by 3.56 times (OR = 3.56, 95% CI [1.17, 10.89], p=0.026).

Conclusion
The present study demonstrates high complication rates following corrective surgery for CD more than 50% regardless of age criteria. There are no differences in surgical characteristics, major complication rates, revision surgery and mortality when comparing patients among geriatric cohorts with different criteria including 65, 70 and 75 years old. Understanding high complication and morbidity risks associated with different ages will be important when discussing corrective surgery for CD in geriatric patients.

	Analysis 1			Analysis 2			Analysis 3		
	<65 years (n = 153)	>65 years (n = 125)	p value	<70 years (n = 201)	>70 years (n = 77)	p value	<75 years (n = 242)	>75 years (n = 36)	p value
Patient Characteristics									
Age, years	54.59 ± 8.29	72.41 ± 5.10	**<0.001**	57.72 ± 9.17	75.34 ± 4.30	**<0.001**	60.18 ± 9.99	78.93 ± 3.54	**<0.001**
Female Sex	99 (64.71%)	60 (48.00%)	**0.005**	126 (62.69%)	33 (42.86%)	**0.003**	146 (60.33%)	13 (36.11%)	**<0.001**
History of Osteoporosis	19 (12.75%)	34 (29.06%)	**0.001**	30 (15.38%)	23 (32.39%)	**0.002**	41 (17.75%)	12 (34.29%)	**0.022**
Surgical Characteristics									
Number of Levels Fused	9.71 ± 4.16	10.95 ± 4.67	0.102	10.01 ± 4.28	10.94 ± 4.79	0.302	10.09 ± 4.36	11.58 ± 4.74	0.260
EBL, cc	678.29 ± 777.56	946.12 ± 1,524.02	0.098	746.41 ± 1,225.94	924.92 ± 927.72	0.224	787.13 ± 1,203.49	825.86 ± 738.39	0.809
Operative Time, mins	369.25 ± 195.41	381.08 ± 199.46	0.639	371.18 ± 205.08	383.34 ± 171.31	0.642	378.52 ± 202.46	341.31 ± 144.70	0.223
Length of stay, days	5.85 ± 4.13	16.00 ± 57.37	0.278	12.58 ± 49.69	7.50 ± 7.25	0.473	11.27 ± 43.78	8.38 ± 10.09	0.634
No. of Patients with a Complication	82 (53.59%)	71 (56.80%)	0.593	113 (56.22%)	40 (51.95%)	0.522	131 (54.13%)	22 (61.11%)	0.432
Total Complications	155	143		215	83		245	53	
Cardiopulmonary	22	19	0.849	28	13	0.894	30	11	0.073
Dysphagia	9	12	0.350	17	4	0.591	18	3	0.627
Dysphonia	2	3	0.224	3	2	0.315	3	2	**0.026**
Infection/Wound	17	12	0.775	20	9	0.713	23	6	0.106
Instrumentation	6	12	**0.049**	12	6	0.367	16	2	0.956
Intraoperative	7	7	0.930	10	4	0.800	13	1	0.563
Musculoskeletal	3	4	0.512	3	4	0.078	3	4	**<0.001**
Neurologic	30	30	0.196	44	16	0.937	51	9	0.400
Radiographic	12	14	0.477	18	8	0.679	22	4	0.627
Revision Surgery	23 (15.03%)	20 (16.00%)	0.824	30 (14.93%)	13 (16.88%)	0.163	38(15.70%)	5 (13.89%)	0.779
Mortality	0 (0.00%)	1 (0.80%)	0.450	1 (0.50%)	0 (0.00%)	0.723	1 (0.41%)	0 (0.00%)	0.871
HRQLs									
NRS Back (Baseline)	5.96 ± 2.93	5.09 ± 3.09	**0.022**	5.79 ± 2.98	5.01 ± 3.11	0.071	5.82 ± 2.92	3.97 ± 3.25	**0.003**
NRS Back (6-Week)	5.36 ± 2.98	4.34 ± 3.51	0.175	4.78 ± 3.13	5.04 ± 3.65	0.762	4.91 ± 3.22	4.50 ± 3.75	0.749
NRS Neck (Baseline)	7.43 ± 2.35	6.08 ± 2.80	**<0.001**	7.24 ± 2.41	5.75 ± 2.93	**<0.001**	7.08 ± 2.50	5.23 ± 3.02	**0.001**
NRS Neck (6-Week)	5.73 ± 3.20	4.84 ± 3.18	0.226	5.29 ± 3.24	5.30 ± 3.20	0.987	5.43 ± 3.19	4.45 ± 3.33	0.380
NDI (Baseline)	54.64 ± 17.36	41.21 ± 17.57	**<0.001**	52.33 ± 18.03	38.89 ± 16.78	**<0.001**	50.43 ± 18.21	37.24 ± 17.75	**<0.001**
NDI (6-Week)	47.71 ± 2.82	44.17 ± 3.68	0.449	47.71 ± 20.95	44.17 ± 17.65	0.449	47.97 ± 19.99	37.80 ± 18.51	0.134
mJOA (Baseline)	13.62 ± 2.86	14.01 ± 2.57	0.298	13.62 ± 2.86	14.01 ± 2.57	0.298	13.71 ± 2.85	13.82 ± 2.42	0.810
mJOA(6-Week)	14.48 ± 2.48	14.33 ± 2.72	0.811	14.48 ± 2.48	14.33 ± 2.72	0.811	14.31 ± 2.57	15.08 ± 2.40	0.312

*Values presented as mean ± standard deviation or count (percent of total); *EBL* = estimated blood loss; *HRQL* = health-related quality of life; *NRS* = numeric pain rating scale; *NDI* = neck disability index; *mJOA* = modified Japanese Orthopaedic Association score

Table 1. Comparing patient characteristics, surgical characteristics, complication rates, and HRQLs by age group

	Odds Ratio	Standard Error	p value	95% Confidence Interval	
Any Complication	1.006	0.011	0.601	0.985	1.027
Cardiopulmonary	1.016	0.018	0.378	0.981	1.052
Dysphagia	1.014	0.023	0.528	0.971	1.069
Dysphonia	1.083	0.060	0.152	0.971	1.208
Infection/Wound	1.006	0.019	0.753	0.970	1.043
Instrumentation	1.044	0.027	0.092	0.993	1.098
Intraoperative	1.017	0.027	0.527	0.966	1.070
Musculoskeletal	1.032	0.038	0.388	0.960	1.110
Neurologic	1.016	0.014	0.242	0.989	1.044
Radiographic	1.023	0.022	0.286	0.981	1.067
Revision Surgery	1.014	0.015	0.358	0.984	1.045
Mortality	1.068	0.114	0.536	0.867	1.316

Table 2. Logistic regression assessing the impact of age on postoperative complications

107. RELATIONSHIP BETWEEN GLOBAL SAGITTAL ALIGNMENT AFTER ADOLESCENT IDIOPATHIC SCOLIOSIS SURGERY AND THE EVOLUTION OF SAGITTAL CERVICAL ALIGNMENT 10 YEARS POST-INTERVENTION

Laura Telleria, MD; Juan Carlos Gutierrez-Gomez, MD; Irene Zarcos, MD; Paloma Martinez-Ureña, MD; Miguel Angel Castrillo, MD, PhD; Javier Cobo, MD, PhD; Alejandro Gomez-Rice, MD, PhD

Hypothesis
Postoperative alignment of the thoracolumbar region following surgery for Adolescent Idiopathic Scoliosis (AIS) may serve as a determinant for the 10-year evolution of sagittal cervical alignment.

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

PODIUM PRESENTATION ABSTRACTS

Design
Single center retrospective radiographic analysis.

Introduction
Few studies have assessed the correlation between global sagittal alignment after adolescent idiopathic scoliosis (AIS) surgery and reciprocal changes in the cervical spine, and none with long-term follow-up.

Methods
Patients were retrieve from prospective database of 120 patients who underwent AIS surgery. Patients included in the study had a 10-year radiological follow-up, comprising lateral standing radiographs taken 3 months post-surgery and at the 10-year post-surgical follow-up. Cervical sagittal alignment was evaluated by measuring T1 tilt, the C2-C7 angle, and C2-C7 sagittal vertical axis (SVA). Continuous quantitative variables are presented as median and interquartile range. Statistical analysis was performed using SPSS software (IBM), version 21.

Results
A total of 43 patients were included (35 females, 8 males) with a median age of 15 years (13; 18). The distribution of curves according to Lenke classification was: 25 type 1, 7 type 2, 7 type 3, 2 type 4, 1 type 5, and 1 type 6. Postoperative Gap score 4 (2; 6). Postoperative Global tilt 15º (9.2; 26). In the entire sample, sagittal cervical alignment parameters remained stable 10 years after surgery. A subanalysis of poorly aligned patients post-surgery revealed that patients with a GAP Score > 6 experienced a greater increase in cervical lordosis (p=0.029). Due to this increased cervical lordosis, poorly aligned patients maintained a similar C2-C7 sagittal vertical axis to better-aligned patients (table)

Conclusion
Poor postoperative alignment is associated with a compensatory increase in cervical lordosis 10 years after AIS intervention.

	Patients with GAP Score <6	Patients with GAP Score ≥6	p-Value
Angle C2-C7 at 3 months	8.4 (4.5; 16)	12.05 (7.2; 15.80)	0.331
T1 Tilt at 3 months	17.5 (11.6;23.6)	17.9 (9.5; 24)	0.766
C2-C7 Sagittal Vertical Axis (C2-C7 SVA) at 3 months (cm)	2.02 (1.2; 3.1)	2.2 (1.23; 3.5)	0.979
Angle C2-C7 at 10 years	9.5 (3.4; 14)	16 (10.25; 27.10)	**0.029** *
T1 Tilt at 10 years	18 (11.1; 26.6)	23.9 (17.8; 31.6)	0.108
C2-C7 Sagittal Vertical Axis (C2-C7 SVA) at 10 years (cm)	2 (1.4; 2.8)	2.5 (1.6; 3.5)	0.209

Data expressed as median (interquartile range).

Radiographic cervical alignment evolution after surgery.

108. RELEASE OF STERNOCLEIDOMASTOID MUSCLE SURGERY FOR NEGLECTED CONGENITAL MUSCULAR TORTICOLLIS IMPROVES GLOBAL SPINAL ALIGNMENT

Haruki Funao, MD, PhD; Ryo Mizukoshi, MD; Nao Otomo, MD; Norihiro Isogai, MD, PhD; Mitsuru Yagi, MD, PhD

Hypothesis
Release of sternocleidomastoid muscle could improve global spinal alignment in adult patients with neglected congenital muscular torticollis.

Design
Retrospective study

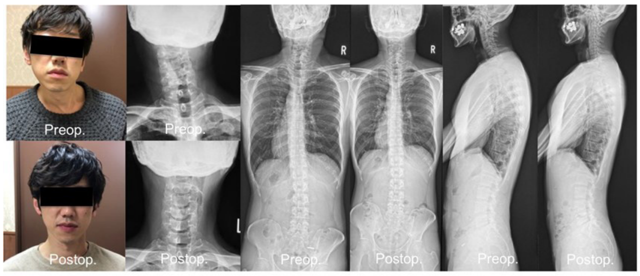
Introduction
Congenital muscular torticollis (CMT) is generally diagnosed in infancy, and most of the cases heal spontaneously or with conservative treatment. Although residual CMTs are treated by surgery before school age, they are rarely left behind resulting in neglected CMT. Surgical outcome of sternocleidomastoid muscle (SCM) release for adult neglected CMT still remains unclear, because it is an extremely rare disease condition. To date, there was no study investigating the impact of SCM release on coronal and sagittal spinal alignments in adult patients with neglected CMT.

Methods
The inclusion criteria were as follows: the diagnosis of neglected CMT was confirmed by physical examination and imaging studies; symptomatic CMT that required surgical treatment; and age at surgery was over 20 years old. Radiographic parameters were evaluated including: cervicomandibular angle (CMA) for head tilt; thoracic scoliotic curve; clavicle angle; central sacral vertical line (CSVL); and C2–7 sagittal vertical axis (C2–7 SVA). The modified Cheng and Tang scoring system is used for quantifying clinical outcomes. This system consists of rotational deficits, side flexion deficits, craniofacial symmetry, scar, band, head tilt, appearance, and function, with 17 to 21 points being excellent, 12 to 16 points good, 7 to 11 points fair, and 6 or less points poor.

Results
Twenty consecutive patients with adult neglected CMT (average age 36.2 years) were enrolled. All patients improved in appearance complaints after surgery. CMA significantly improved from 14.9° preoperatively to 4.1° postoperatively (p<0.01). Thoracic scoliotic curve significantly decreased from 11.4° to 7.7° (p<0.05), clavicle angle significantly improved from 2.3° to 1.2° (p<0.01), CSVL significantly decreased from 13.0 mm to 6.1 mm (p<0.05), and C2–7 SVA significantly decreased from 30.3 mm to 19.0 mm (p<0.01). According to the modified Cheng and Tang scoring system, 9 patients were classified as excellent and 11 patients as good.

Conclusion
Global spinal alignment significantly improved after SCM release, and clinical outcome was favorable in adult patients with neglected CMT.

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant



Appearance and Radiograph

109. CLINICAL, RADIOGRAPHIC, AND MRI FINDINGS GUIDE SURGICAL DECISION-MAKING IN SKELETAL DYSPLASIA CERVICAL INSTABILITY

Bryan Menapace, MD; William G. Mackenzie, MD; Jeffrey Campbell, MD; Colleen Ditro, RN, DNP, CPNP; Kenneth J. Rogers, PhD; W.G. Stuart Mackenzie, MD

Hypothesis

Clinical, radiographic findings differ in their surgical decision-making utility .

Design

Retrospective Case Control

Introduction

Cervical spine (CS) atlantoaxial instability (AAI) is seen in collagen type 2 (COL2) mutations and mucopolysaccharidosis (MPS) skeletal dysplasias (SKD). Evaluation includes history, physical, flexion/extension (F/E) x-rays (XR), and F/E magnetic resonance imaging (MRI).

Methods

Medical record query (2007-2024) for SKD with CS imaging. Inclusion criteria: COL2 or MPS diagnosis, pediatric orthopaedic surgeon history and exam, CS F/E XR, and CS F/E MRI. Patient demographics, history, and clinical exam findings were recorded. XR measures included dens morphology, anterior atlanto-dens interval (AADI), and posterior ADI (PADI). MRI measures included cord diameter (CD),dens-C1 space available for the cord (SAC), and myelomalacia. Patients were followed to surgery, and, for nonoperative, until dens officiation at 2 years. Statistical analysis defined significance p≤0.05.

Results

547 SKD patients were identified. After inclusion criteria, there were 51/78 COL2 and 35/70 MPS. Patients were separated into COL2 and MPS, subdivided by surgical (S) versus nonsurgical (NS). Results in Table 1. For COL2 patients, demographics were similar between S and NS, with the exception being lower S age. There were no differences in the history. S patients were more likely to have hyperreflexia. On XR, S patients more frequently had os or hypoplastic odontoids and change in F/E AADI and PADI. On MRI, S patients showed greater change in F/E SAC and relatively tighter CD:SAC, along with myelomalacia. For MPS patients, demographics were similar between S and NS. S patients were more likely to report paresthesias and diminished ambulation. S patients demonstrated weakness, hyperreflexia, and upgoing Babinski. XR and MRI imaging findings for MPS were similar to those for COL2, where differences included odontoid shape, AADI, PADI, SAC change, CD:SAC, and myelomalacia. Of the surgical patients, 100% (21) received at least C1 decompression and C1-C2 fusion.

Conclusion

This series on COL2 and MPS found clinical history was largely unreliable, but the presence of myelopathic exams was notable. F/E XR indicated instability. Therefore, in the setting of abnormalities on exam and/or XR, a F/E MRI provides critical data, notably myelomalacia, indicating surgery.

		COL2			MPS		
		Nonoperative	Surgery	P-value	Nonoperative	Surgery	P-value
Demographics	Diagnosis	62% SED	78% SED	0.6621	71% Morquio	83% Morquio	0.2751
	Race	79% white	89% white	0.6609	65% white	67% white	0.4117
	Gender (% female)	50%	67%	0.3734	35%	67%	0.0665
	Age (yr)	8.56	3.99	0.0310*	9.75	10.81	0.6476
History	Neck Pain (%)	2.38%	11.11%	0.2290	0.00%	0.00%	N/A
	Weakness (%)	9.52%	22.22%	0.2926	5.88%	5.56%	0.9680
	Paresthesias (%)	4.76%	0.00%	0.5139	5.88%	33.33%	0.0437*
	Decreased ambulation (%)	4.76%	11.11%	0.4726	11.76%	38.89%	0.0698
	Comorbidities (#)	0.64	0.78	0.7098	0.65	0.61	0.9057
Physical	UE strength	4.95	5.00	0.5757	4.86	4.47	0.0705
	LE Strength	4.92	4.83	0.4987	4.88	4.47	0.0253*
	UE reflex	1.99	2.50	0.0115*	2.00	2.38	0.0846
	LE reflex	2.07	2.64	0.0061**	2.03	2.58	0.0247*
	Babinski (%)	12.50%	16.67%	0.7834	0.00%	27.78%	0.0183*
	Clonus (%)	2.56%	0.00%	0.6767	11.76%	33.33%	0.1366
XR	Odontoid Type	55% normal	22% normal	0.0005***	65% hypo	44% hypo	0.0375*
	ADI neu (mm)	2.36	2.49	0.8934	0.84	0.73	0.8965
	ADI flex (mm)	3.31	5.23	0.0508	2.21	2.92	0.3824
	ADI ext (mm)	0.03	-1.23	0.2523	-1.04	-3.02	0.0556
	ADI change F-Ex (mm)	3.28	6.46	0.0031**	3.25	5.93	0.0124*
	PADI neu (mm)	13.69	6.50	0.0020**	15.95	12.31	0.0090**
	PADI flex (mm)	12.71	2.87	0.0000***	13.92	10.34	0.0098**
	PADI ext (mm)	15.68	10.11	0.0112*	17.07	15.19	0.1841
	PADI change F-Ex (mm)	-2.98	-7.23	0.0000***	-3.15	-4.85	0.0940
MRI	cord diameter (mm)	6.93	6.12	0.0238*	7.17	7.24	0.8582
	SAC neu (mm)	9.24	7.37	0.0161*	8.75	6.26	0.0000***
	SAC flex (mm)	8.81	5.82	0.0001***	8.60	5.83	0.0000***
	SAC ext (mm)	9.37	7.75	0.0453*	9.18	6.89	0.0004***
	SAC change (mm)	-0.56	-1.93	0.0026**	-0.58	-1.06	0.1721
	CD:SAC (%)	77.71%	90.35%	0.1033	83.31%	120.14%	0.0000***
	Myelomalacia (%)	16.67%	77.78%	0.0001***	5.88%	50.00%	0.0029**

COL2 and MPS, S vs NS, means and p-values

110. THE EFFECT OF THE SPRING DISTRACTION SYSTEM ON VERTEBRAL BODIES AND INTERVERTEBRAL DISCS IN PATIENTS WITH EARLY ONSET SCOLIOSIS

Casper S. Tabeling, MD; Peter Lafranca, MD; Justin V. Lemans, MD; Keita Ito, MD, PhD; Tom P. Schlösser, MD, PhD; René M. Castelein, MD, PhD; Moyo C. Kruyt, MD, PhD

Hypothesis

The height of vertebral bodies and intervertebral discs will increase during spring distraction treatment (SDS) of early onset scoliosis (EOS).

Design

A retrospective cohort study.

Introduction

A challenge in treating patients with EOS is to correct the spinal deformity, while allowing for growth. Current techniques involve intermittent distractions or passive growth guidance. Intermittent distraction and limited motion have shown to negatively affected the develop-

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

ment of IVDs, possibly due to stress shielding and autofusion. The SDS utilizes a compressed spring placed around conventional rods to provide continuous distraction. The aim of this study was to quantify the effect of SDS on the height of VBs and IVDs partially within and outside the construct (i.e., adjacent to the distal anchor).

Methods

All EOS patients treated with SDS with a minimum of 2 years follow-up were reviewed. For all patients with a distal anchor between T12 and L4, the height of the VBs and IVDs within and proximal and distal adjacent to the distal anchor were measured on the direct postoperative and 2-year postoperative calibrated biplanar full spine radiographs. VB and IVD height changes were assessed and compared between three groups: Within growing system (DIV+2, DIV+1; IVD 1-3), within anchor (INS 1, INS 2; IVD 4) and in the uninstrumented part of the spine (DIV -1, DIV -2; IVD 5-7) (Fig. 1) using a one-way ANOVA.

Results

28 patients (mean age 8.4±2.4 years) were included. After two years follow-up, the VB height increased in all groups: 10% Within distraction, 9% Instrumented and 8% Outside distraction. IVD height decreased within as well as outside the construct; Within distraction 10%, Instrumented 15% and Outside distraction 5% (p=0.04).

Conclusion

While the SDS promotes spinal growth of the VBs, the IVD height in the evaluated segment seems to decrease over time. This was most apparent in the instrumented anchor, but also present within the distracted segment and outside the construct. Compared to healthy children where IVD height is basically stable, this generalized decrease in disc height is remarkable and the consequence remains to be investigated.

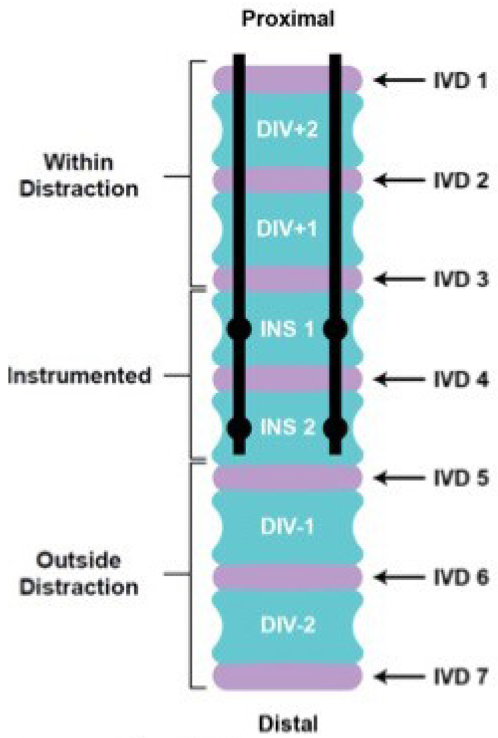


Figure 1. Evaluated levels
Two VBs and three IVDs within the growing system (within distraction or DIV+2/DIV+1). Two VBs and one IVD within the distal anchor (instrumented or INS). Two VBs and three IVDs distal to the distraction construct (outside distraction or DIV-1/DIV-2).

111. MACHINE LEARNING BASED PREDICTORS FOR UNPLANNED RETURN TO THE OPERATING ROOM IN EARLY ONSET SCOLIOSIS TREATED WITH MAGNETICALLY CONTROLLED GROWING RODS

Bahar Shahidi, PhD; Hazem Elsebaie, MD, FRCS; Fernando Rios, MD; Pearce B. Haldeman, BS; Bailee Monjazeb, BS; William Kerr, BS; Peter O. Newton, MD; *Gregory M. Mundis Jr., MD*; Pediatric Spine Study Group; Behrooz A. Akbarnia, MD

Hypothesis

Proximal anchor configuration will predict unplanned return to the operating room (UPROR) in children with early onset scoliosis (EOS) treated with magnetically controlled growing rods (MCGR).

Design

A retrospective cohort study from prospectively collected data in an international multicenter EOS database.

Introduction

MCGR is commonly used as a distraction-based technique for surgical treatment of progressive EOS. UPROR is common and is often a result of implant related complications (IRC). Proximal anchor configurations significantly impact the risk of IRC and failure; however variability is great, and consensus on optimal configurations has not been established. Our purpose was to identify risk factors for UPROR after MCGR implantation using a machine learning (ML) analytic technique.

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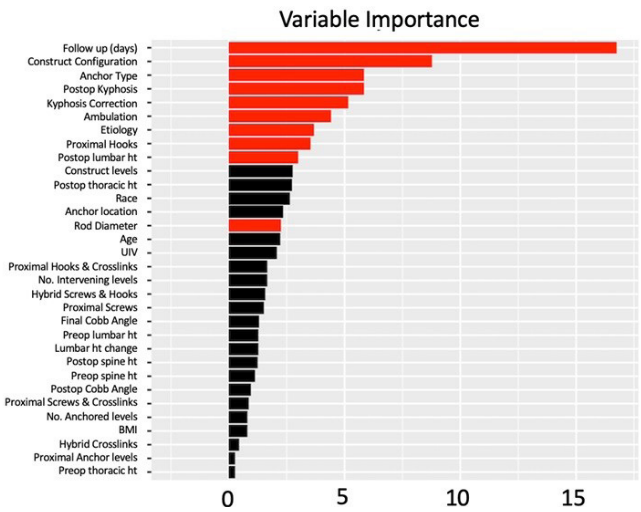
Methods
Data from patients who had undergone MCGR for EOS, with a 2-yr follow up were included. Only patients under 10 years, primary surgery and with dual rods were included. The primary outcome was UPROR as determined by radiographic evidence of implant change between post op and follow up. Proximal construct configurations and demographic characteristics were included as predictors. An unbiased ML-based Random Forest model was implemented, with 2/3rds of the sample utilized for training, and the remaining 1/3rd for validation.

Results
388 patients met the inclusion criteria, and 67(17.3%) experienced UPROR. Model accuracy for predicting UPROR was 69.1%(Sensitivity=0.58; Specificity=0.89). 10 variables significantly increased UPROR risk; longer duration of follow up (p=0.01), the use of hook-only anchors (p=0.01), greater post-operative sagittal kyphosis (p=0.01), smaller change in sagittal kyphosis with surgery (p=0.01), preoperative non-ambulatory status (p=0.02), congenital etiology (p=0.02), lower post-operative lumbar height (p=0.03), and a smaller average rod diameter (p=0.049).

Conclusion
Using an ML-based prediction model, we found that non-ambulatory patients, longer follow-up, congenital EOS, all-hooks proximal anchors, smaller rods, greater postoperative kyphosis, and less intraoperative kyphosis correction are risk factors for UPROR.



ML-based variable importance rankings. Significant variables are in red, with greater magnitudes indicating greater importance.

112. DOCUMENTING THE VARIATION OF PROXIMAL FOUNDATION CONSTRUCT AND THEIR CORRELATION WITH UNPLANNED RETURN TO THE OPERATING ROOM IN CHILDREN WITH MAGNETICALLY CONTROLLED GROWING RODS

Bahar Shahidi, PhD; Fernando Rios, MD; Hazem Elsebaie, MD, FRCS; Bailee Monjazeb, BS; William Kerr, BS; Joshua M. Pahys, MD; Steven W. Hwang, MD; Amer F. Samdani, MD; Lindsay M. Andras, MD; Matthew E. Oetgen, MD; Peter O. Newton, MD; Burt Yaszay, MD; Peter F. Sturm, MD; Michael G. Vitale, MD, MPH; Paul D. Sponseller, MD, MBA; Gregory M. Mundis Jr., MD; *Behrooz A. Akbarnia, MD*; Pediatric Spine Study Group

Hypothesis
Proximal construct configuration is an important factor affecting the outcomes of MCGR. We hypothesize that the most commonly utilized configurations are the most protective against UPROR.

Design
Retrospective Cohort Study.

Introduction
The evolution of MCGR has led to modifications in the configuration of the proximal construct to decrease the incidence of implant related complications (IRC) and revision surgeries. However, there is no data characterizing the performance of the most used configurations reducing risk of complications.

Methods
487 patients were identified from an international multicenter EOS database. Inclusion criteria: EOS patients, primary dual MCGR, complete radiographs, and minimum of 2 year follow up. 76 patients had incomplete x-rays, 5 had apical fusions, and 18 had inconclusive complications, leaving 388 patients for review. A digital spine template was created to document UIV; number of levels; number, type, and location of anchors; as well as implant configuration. First available postoperative and latest follow-up radiographs were reviewed by 2 senior surgeons and 2 spine fellows. UPROR due to IRC was defined as any change in proximal anchors between the post-operative and final follow up radiographs.

Results
The most common proximal construct configuration: UIV at T2 (50.0%) with 17.5% UPROR, followed by T3 (34.0%) with 12.1% UPROR; number of levels was 3 (57.1%) with 16.8% UPROR, and 2 (26.0%) with 17.0% UPROR; number of proximal anchors was 6 (49.9%) with 14.1% UPROR, and 4 (27.0%) with 18.3% UPROR. The most common anchors were all screws (42.0%) with 9.9% UPROR, and all hooks (26.4%) with 31.4% UPROR (P<0.001). The most common construct with the lowest rate of UPROR was a UIV at T2, with 6 anchors (all screws) across 3 levels (42 cases), with a 0% UPROR.

Conclusion
Proximal anchor configuration impacts the incidence of UPROR due to IRC in MCGR. UIV at T2 and T3 compared to T4, and the use of all screws or combination of screws and hooks compared to all hooks were associated with a

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PODIUM PRESENTATION ABSTRACTS

lower UPROR rate. The most common construct configuration was T3 UIV, 3 levels, 6 anchors, all screws. The use of a combination of 6 anchors (screws or screws and hooks) across 3 levels with an UIV at T2 or T3 were associated with a lower UPROR rate.

Construct Configurations	No UPROR	UPROR
T1 UIV, 2 lvls, 4 anchors; Screws	9 (90%)	1 (10%)
T2 UIV, 2 lvls, 4 anchors; Screws	24 (82.8%)	5 (17.2%)
T2 UIV, 3 lvls, 6 anchors; Screws	42 (100%)	0 (0%)
T2 UIV, 3 lvls, 6 anchors; Hooks	12 (60%)	8 (40%)
T2 UIV, 3 lvls, 6 anchors; Screws/Hooks	20 (90.9%)	2 (9.1%)
T2 UIV, 4 lvls, 8 anchors; Hooks	4 (80%)	1 (20%)
T2 UIV, 4 lvls, 8 anchors; Screws/Crosslinks	6 (100%)	0 (0%)
T2 UIV, 4 lvls, 8 anchors; Screws/Hooks/Crosslinks	5 (62.5%)	3 (37.5%)
T3 UIV, 2 lvls, 4 anchors; Screws	23 (85.1%)	4 (14.8%)
T3 UIV, 2 lvls, 4 anchors; Hooks	3 (50%)	3 (50%)
T3 UIV, 3 lvls, 6 anchors; Screws	25 (100%)	0 (0%)
T3 UIV, 3 lvls, 6 anchors; Hooks	22 (78.5%)	6 (21.4%)
T3 UIV, 3 lvls, 6 anchors; Screws/Hooks	9 (100%)	0 (0%)
T3 UIV, 3 lvls, 6 anchors; Screws/Crosslinks	4 (80%)	1 (20%)
T3 UIV. 4 lvls, 8 anchors; Screws/Crosslinks	5 (100%)	0 (0%)
T4 UIV, 2 lvls, 4 anchors; Screws	3 (60%)	2 (40%)

Number (%) of cases for each configuration according to UPROR status.

113. IS EARLY ONSET SCOLIOSIS IMMUNE TO QUALITY IMPROVEMENT? COMPLICATION DATA ANALYSIS VIA THE MODIFIED CLAVIEN-DINDO-SINK CLASSIFICATION

Lucas Hauth, BS; Margaret Bowen, BS; Patrick J. Cahill, MD; John M. Flynn, MD; Benjamin D. Roye, MD, MPH; Selina C. Poon, MD; Michael J. Heffernan, MD; Sumeet Garg, MD; Pediatric Spine Study Group; Jason B. Anari, MD

Hypothesis
EOS complication severity will decrease over the 15-year study period in response to best practice guidelines & quality improvement projects.

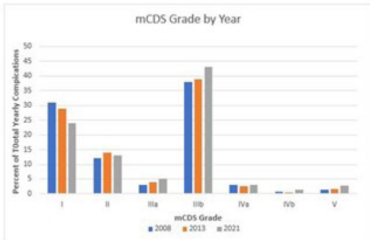
Design
Retrospective review of a prospectively collected database.

Introduction
Early onset scoliosis (EOS) is well known to have a complication rate significantly greater than other pediatric spine deformities, as highlighted by the landmark article from Bess et al in 2010. Advancements such as the magnetically controlled growing rod and quality improvement projects/best practice guidelines have provided surgeons and patients with hope at minimizing complications during EOS treatment. Quantifying complication severity in an EOS database over time will allow for assessment of the progress made at improving EOS patient care.

Methods
A prospectively collected pediatric spine deformity database was queried for all complications in patients with EOS from the years 2008, 2013, and 2021 (15, 10, and 2 years from study initiation in 2023). Data provided for each complication included type (GI, hardware-related, cardiac, neurologic, pulmonary, etc.), clinical course, whether the complication changed clinical course, and outcome. Complications were rated independently by two evaluators using the modified Clavien-Dindo-Sink (mCDS) complication classification system.

Results
A total of 1153 complications were obtained from 2008 (288), 2013 (504), and 2021 (361). The most common complications over all three years were grade IIIb (40%) and grade I (28%). This breakdown of complications was consistent in each year. The incidence of grade IIIb complications increased slightly over time from 38% in 2008 to 43% in 2021, coupled with a decrease in grade I complications (31% in 2008 to 24% in 2021), but neither of these trends were statistically significant (p=0.64 and p=0.33, respectively). All other complication sub-groups did not change more than 2 percentage points across the study period (3 to 5%).

Conclusion
The complication profile in EOS across a multicenter database has not changed over the last 15 years. Approximately 40% of EOS complications required surgical or procedural intervention in 2008, 2013, and 2021.



mCDS Grade	2008 N (%)	2013 N (%)	2021 N (%)
I	90 (31)	144 (29)	88 (24)
II	35 (12)	69 (14)	48 (13)
IIIa	8 (3)	20 (4)	18 (5)
IIIb	111 (38)	198 (39)	157 (43)
IVa	9 (3)	13 (3)	12 (3)
IVb	2 (<1)	2 (<1)	5 (1)
V	4 (1)	8 (2)	10 (3)

Figure 1. Distribution of mCDS-rated complications by year.

114. GROWTH GUIDANCE SURGERY: PREDICTORS OF OPTIMAL VS SUBOPTIMAL PERFORMERS

William G. Elnemer, BS; Myung-Jin Cha, BS; Gregory Benes, BS; Lindsay M. Andras, MD; Behrooz A. Akbarnia, MD; David B. Bumpass, MD; Scott J. Luhmann, MD; Richard E. McCarthy, MD; Pediatric Spine Study Group; Paul D. Sponseller, MD, MBA

Hypothesis
Patients with S-shaped curves will have greater rates of reoperation and decreased linear spinal growth.

Design
Retrospective Multicenter Cohort Study.

Introduction
Growth Guidance surgery (GGS) aims to correct a child's spinal deformity while allowing continued growth. Our study aims to determine predictors of best candidates.

Methods
Patients who underwent GGS and had a minimum follow-up of 2 years were reviewed. Radiographs were evaluated preoperatively, at 1st postoperative erect, and

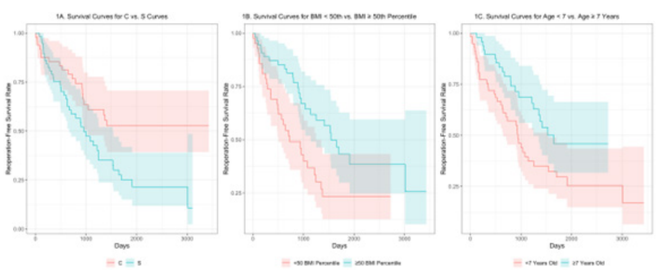
latest available follow-up. Multivariate regression model assessed the effects of pre-operative major cobb, kyphosis, BMI percentile, age at surgery, and other pre-operative characteristics on the following outcomes: 1) percent of initial curve correction, 2) curve progression after surgery per year, 3) unplanned GGS-related reoperation, 4) T1-T12 height gain/year from 1st postoperative erect to final available follow-up.

Results

Included were 105 children; average follow-up was 4.8±2.4 years. Scoliosis etiologies included neuromuscular (n=36; 34%), syndromic (n=31; 30%), idiopathic (n=30; 29%), and congenital (n=8; 8%). Average preoperative, 1st postoperative erect, and latest follow-up major curves measured 69°, 32°, and 49°, respectively. Average T1-S1 postoperative height gain/year was 7±9 mm and overall T1-S1 height gain was 24±35 mm. Forty-eight (46%) patients had C-shaped and 57 (54%) had S-shaped curves; 59 (56%) patients underwent ≥1 GGS-related reoperation. Multivariable Cox-proportional hazard test revealed age <7 years (HR=2.08, P = 0.021) and S-shaped curves (HR=2.33, P=0.014) were associated with ≥1 reoperation. Multivariable linear regression revealed idiopathic etiologies (ß=4.1 mm/year, P=0.026) and age <6.5 years (ß=4.5 mm/year, P=0.012) were associated with increased T1-T12 length gain/year. Preoperative major curve cobb angle was not significantly associated with any outcome measure. A reoperation-free survival rate of 50% corresponded to 3.5 years. Kaplan-Meier reoperation-free survival graphs for curve shape, BMI, and age are shown in Figure 1A, B, and C.

Conclusion

GGS instrumentation in patients younger than 7 years and those with S-shaped curves were associated with GGS-related reoperations. Despite younger age being associated with likely complications, this procedure still benefits these children and provides significant curve correction while allowing growth.



115. RISK OF PROXIMAL JUNCTIONAL KYPHOSIS AFTER REVISION OF GROWING ROD CONSTRUCTS

Chidebelum Nnake, BS; Alondra Concepción-González, BA; Matan Malka, BA; Ritt Givens, BS; Simon Blanchard, BS; Ron El-Hawary, MD; Michael G. Vitale, MD, MPH; Pediatric Spine Study Group; Benjamin D. Roye, MD, MPH

Hypothesis

Patients converted from rib- to spine-based cranial anchors (RTS) have a higher risk of PJK two years post-revision compared to those revised to rib-based anchors (RTR). Revising the upper instrumented vertebra (UIV) to the same level increases the risk of PJK at two years post-revision compared to revising to a higher level.

Design

Multicenter retrospective cohort

Introduction

For early onset scoliosis (EOS) patients with growth-friendly implants, posterior distraction is a known contributor to proximal junctional kyphosis (PJK). Rib-based proximal fixation is thought to potentially reduce the risk of PJK. The effect of revising proximal rib-based implants to rib vs spine-based implants on PJK has not yet been investigated.

Methods

In this retrospective cohort study of EOS patients with rib-based growing constructs undergoing revision surgery with a minimum 2-year follow-up, we assessed pre-revision, post-revision, and 2-year follow-up radiographs. We excluded patients lacking lateral X-rays and attachment data and conducted descriptive analyses.

Results

280 subjects were included, average age 7.2 years at revision with RTS patients slightly older (8.6y vs 7.2y), and 51% female. At 2 years, 32% of all patients developed PJK. This risk was higher in RTS patients compared to RTR patients (42.8% vs 30.2%, p=0.09). RTS patients had a greater pre-revision total spine height (p=0.02), greater post-revision sagittal kyphosis (p=0.04), a more negative 2-year sagittal balance (p=0.01) and trended to have more males (p=0.08) compared to RTR; all these factors were associated with a greater risk of PJK. There was no difference in risk at 2 years of developing PJK among patients revised to a higher level compared to those revised to same level (33.3% vs 30.9%, p=0.74).

Conclusion

32% of all subjects developed PJK at 2-year follow-up. The risk of PJK in RTS patients was 40% higher than in RTR patients. While this did not reach statistical significance to the 0.05 level, due to the associations of risk established by literature and replicated in this study, we believe these results to be clinically significant. We intend to re-evaluate this population in the future as more data becomes available. With no demonstrated risk in revision levels, it is worth considering revising fewer levels to maintain flexibility in these growing rods.

Table 1. Pertinent Findings of Those Undergoing Revision Surgery

	RTS	RTR	p-value
2-Year PJK Risk	42.8%	30.2%	0.09
Age	8.57± 3.34	7.15± 3.61	0.03
Pre-Revision Total (T1-S1) height (cm)	29.24± 5.33	26.92± 5.51	0.02
Post-Revision Sagittal Kyphosis	54.75± 16.79	46.55± 22.66	0.04
2-Year Sagittal Balance (mm)	-5.62±34.46	11.55± 37.55	0.01
Gender	M: 22 F:13	M: 115 F: 130	0.08
	Higher Level	**Same Level**	**p-value**
2-Year PJK Risk	33.3%	30.9%	0.74

Pertinent Findings of Those Undergoing Revision Surgery

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

PODIUM PRESENTATION ABSTRACTS

116. OSTEOTOMIES AT THE TIME OF GRADUATION SURGERY: HOW MUCH DO WE GET FROM THEM?

Tyler Tetreault, MD; Tiffany N. Phan, BA; Tishya Wren, PhD; Michael J. Heffernan, MD; John B. Emans, MD; Lawrence I. Karlin, MD; Amer F. Samdani, MD; Michael G. Vitale, MD, MPH; Pediatric Spine Study Group; Lindsay M. Andras, MD

Hypothesis
Posterior column osteotomies (PCO) at time of conversion to fusion from growing rod instrumentation result in minimal additional correction.

Design
Retrospective Multicenter

Introduction
Increasing spinal rigidity following treatment of EOS with growing rod instrumentation can limit curve correction during conversion to definitive spinal fusion. PCO are often employed to improve flexibility, but this technique's efficacy has not been studied. Our purpose was to determine if PCO at conversion to definitive fusion in EOS graduates impacts outcomes.

Methods
Patients from a multicenter database undergoing growing rod instrumentation conversion to definitive fusion were grouped by those that did or did not have PCO. Patients with inadequate radiographs, <2 years of follow-up, or three-column osteotomies at time of fusion were excluded.

Results
832 EOS patients who underwent conversion to definitive fusion met inclusion criteria. 175 (21%) patients had PCOs and 663 (79%) did not. Mean age at index surgery was younger (6.6 vs. 7.4 years, p =0.0009) and duration of growing instrumentation was greater (6.2 vs. 5.5 years, p=0.009) in the PCO group. Prior to fusion, curve magnitude was similar between groups (PCO=61.9 degrees, NoPCO=59.3 degrees, p=0.18). For the PCO group, on average 4.4 osteotomies (range:1-12) were performed. EBL (PCO=820cc vs NoPCO=752cc, p<0.01) and surgical time (PCO=403 min vs NoPCO=349 min, p<0.01) were greater in the PCO group. Postoperatively, mean major curve magnitude and curve correction were similar between groups (mean correction PCO=16.6, NoPCO=14.4 degrees, p=0.19). However, accounting for preoperative curve magnitude, there was a relationship between number of PCOs and curve correction (p=0.04). Mean correction was 14.2 degrees with 1-4 osteotomies, 19.0 degrees with 5-8 osteotomies, and 23.9 degrees with 9-12 osteotomies. Mean correction per osteotomy was 4.5 degrees. There was no relationship between degrees of correction per osteotomy and duration of instrumentation prior to fusion (p=0.12). Postoperative complications at 2 years were similar between groups (PCO=25% vs NoPCO=27%, p=0.63).

Conclusion
EOS graduates achieve minimal correction at time of conversion regardless of whether PCOs were performed. PCOs were associated with increased EBL and operative time, but similar complication rate. More PCOs resulted in more correction, though less than that anticipated in a previously uninstrumented spine.

117. LESSONS LEARNED AFTER 20 YEARS OF USING VEPTR IN EARLY ONSET SCOLIOSIS

Norman Ramirez, MD; Alexandra Claudio-Marcano, MD; John T. Smith, MD; John B. Emans, MD; Amer F. Samdani, MD; Mark A. Erickson, MD; John M. Flynn, MD; Norberto J. Torres-Lugo, MD; Gerardo Olivella, MD; Pediatric Spine Study Group

Hypothesis
VEPTR's objectives were not fully achieved.

Design
Retrospective.

Introduction
The use of Vertical Expandable Prosthetic Titanium Rib (VEPTR) for treating early onset scoliosis (EOS) has markedly declined. At the verge of the VEPTR era, we assessed 20 years of outcomes to evaluate this device's effectiveness.

Methods
We examined demographic and radiographic parameters, pulmonary function tests (PFT), 24–Items EOS Questionnaire (EOSQ-24) findings, and complications of all EOS patients from the Pediatric Spine Study Group database who were treated initially with VEPTR and followed-up for at least five-years.

Results
A total of 447 patients with a mean age of 4.24 years; 51.0% male were included. Fifty percent had congenital scoliosis, followed by neuromuscular (27.5%), syndromic (11.9%), and idiopathic etiologies (10.3%). Of these, 213 patients had at least one comorbidity. Thoracic insufficiency syndrome was the most common comorbidity. Five years after the initial surgery, 237 patients continued with VEPTR, 186 were fusioned, and 24 required hardware removal. Mean body mass index changed from 16.40Kg/m2 to 17.42Kg/m2 (P<0.001). Preoperative coronal Cobb angle went from 66.94° to 56.71° (P<0.001). Preoperative sagittal Cobb angle went from 46.73° to 53.95° (P<0.001). The T1-S1 spine height increased from 232.99mm to 297.54mm (P<0.001), T1-T12 height went from 141.63mm to 188.33mm (P<0.001), and L1-S1 height went from 90.56mm to 109.63mm (P<0.001). During the follow-up, 82 patients underwent PFT. Forced vital capacity diminished from 61.92% to 46.84% (P<0.001). Forced expiratory volume in one second decreased from 85.53 to 47.98 (P=0.004). EOSQ-24 scores (N=238) changed from 71.92 to 73.17 (P=0.328). Seventy-two percent of patients had post-operative complications (336/447). Evaluation between all EOS categories showed better results in congenital scoliosis.

Conclusion
We present the most extensive sample of VEPTR utilization in the literature. VEPTR's objectives were to improve

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Meeting Information
Meeting Agenda
Abstracts
Industry Workshops
Disclosures
Author Index
About SRS

coronal deformity, stimulate spine growth, and hold respiratory function deterioration. Our results show that the first two objectives were achieved. However, it could not prevent worsening of respiratory function or improve HRQoL. Although we acknowledge the limitations of analyzing limited PFT/EOSQ data, it is important to highlight the trend observed in both parameters. Due to high complication rates, we should continue to seek treatment alternatives for EOS.

118. LONG-TERM SURGICAL OUTCOMES AND OPERATIVE TIMING ANALYSIS IN ONE-STAGE POSTERIOR LUMBOSACRAL HEMIVERTEBRA RESECTION: A MINIMUM 2-YEAR FOLLOW-UP STUDY

Qianyu Zhuang, MD; Zhuosong Bai, MD; Haoran Zhang, MD; Yuechuan Zhang, PhD; Xiangjie Yin, MD; Yunze Han, MD; Yiqiao Zhang, MD; Jianguo T. Zhang, MD

Hypothesis

In the surgical management of lumbosacral hemivertebrae (LSHV), the timing of posterior hemivertebra resection with short-segmental fusion significantly influences surgical outcomes. We hypothesized that early surgery (≤6 years old) would yield better results in terms of radiographic and clinical outcomes compared to late surgery (>6 years old).

Design

Retrospective review of prospective database.

Introduction

LSHV is a complex and unique congenital spinal deformity characterized by early severe trunk imbalance and progressive compensatory curve. Previous studies have proved the efficiency of posterior LSHV resection. However, there is still controversy regarding the optimal timing for the surgical intervention of LSHV with few studies comparing the surgical outcomes in patients of different age groups.

Methods

From 2002 to 2022, a consecutive series of 58 LSHV patients treated by posterior LSHV resection with short segmental fusion were investigated retrospectively, with a 7.5-year average follow-up period (ranging from 2.0 to 19.5 years). Patients were stratified into two groups based on the timing of surgery: Group Early-surgery (≤6 years old) and Group Late-surgery (>6 years old). Radiographic assessments included pre- and postoperative measurements of main scoliosis, compensatory scoliosis, trunk shift, and sagittal balance parameters. Operative data, peri-operative complications and SRS-22 questionnaires were also collected.

Results

Compared to Group Late-surgery, Group Early-surgery exhibited a lower intraoperative blood loss (P<0.01), higher final main curve correction rate (P=0.037), smaller post-op compensatory curve (P=0.031), higher sagittal vertical axis correction rates at immediate post-op (P=0.045) and last follow-up (P=0.027), and lower implant failure complications incidence (P<0.01).

Conclusion

This study proved for the first time that early surgical intervention in LSHV patients can achieve better correction outcomes, while reducing blood loss and postoperative complications in a large-scale cohort at long-term follow-up.

Outcomes	Group Early-surgery (≤6 years old, n=27)		Group Late-surgery (>6 years old, n=31)		P-value
	Mean	SD	Mean	SD	
Intraoperative blood loss (ml)	206.7	142.4	548.5	474.4	<0.01*
Operating time (h)	3.5	1	3.9	1	0.173
Main curve					
pre (°)	27.6	7.1	26.6	7	0.767
post (°)	7.7	4.7	8.4	5	0.585
correction%	0.71	0.19	0.68	0.18	0.464
last follow (°)	8.2	4.9	10.4	5.5	0.177
correction%	0.7	0.18	0.61	0.18	0.037*
Compensatory curve					
pre (°)	16.4	7	18.2	10.5	0.72
post (°)	5.4	3	8	6	0.031*
correction%	0.62	0.26	0.5	0.38	0.095
last follow (°)	6.3	4.7	8.4	8.3	0.201
correction%	0.55	0.34	0.52	0.28	0.304
Trunk shift (mm)					
pre	25.4	17.1	16.9	8.7	0.088
post	9.6	5.1	8	7.6	0.059
last follow	12.4	9.1	12.4	11.4	0.755
SVA (mm)					
pre	36.1	27.2	23	17	0.023*
Post correction%	-0.33	2.74	-1.48	3.84	0.045*
Last follow correction%	0.23	0.75	-1.15	3.14	0.027*
PI-LL (°)					
pre	15.2	11.2	13.9	11.2	0.702
post	8.8	7.2	10.6	9.2	0.64
last follow	8.2	7.9	11.2	8.9	0.18
LL					
pre	37.2	15.5	35.7	14.2	0.7
post	33.9	8.3	36.6	10.5	0.286
last follow	41.8	8.2	36.9	10.9	0.06
Segmental Lordosis					
pre	14.8	7.3	13	7.9	0.378
post	14.9	8.4	14.6	8.3	0.899
last follow	15.7	8.2	14.3	7.2	0.492

Complications	Group Early-surgery (≤6 years old, n=27)	Group Late-surgery (>6 years old, n=31)	P-value
Neurological Impairment	8/27	5/31	0.362
Implant failure	1/27	3/31	0.006*
Infection	0/27	2/31	0.534

Comparison of surgical outcomes between Group Early-surgery and Group Late-surgery

119. FLEXIBLE POSTERIOR VERTEBRAL TETHERING FOR THE MANAGEMENT OF SCHEUERMANN'S KYPHOSIS(SK): CORRECTION BY USING GROWTH MODULATION

Mehmet Aydogan, MD; *Tuna Pehlivanoglu, MD;* Yigit Erdag, MD; Umut D. Akturk, MD; Abdulhalim Akar, MD

Hypothesis

Gradual correction of the kyphotic deformity together with vertebral wedging could be acquired as a result of posterior vertebral tethering (PVT),which induces a growth arrest on posterior portion of vertebral growth plates by compression,while accelerating growth on anterior portion of growth plates by distraction.

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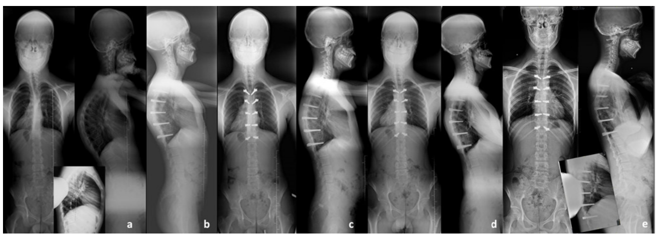
Design
Prospective Case series

Introduction
The present study was intended to present the minimum 3 years' results of flexible posterior vertebral tethering(PVT) applied to 10 skeletally immature patients with SK to question,if it could be an alternative to fusion, similar to VBT, which was proposed as an alternative to fusion in AIS patients.

Methods
Ten skeletally immature patients with radiographically confirmed SK, who had flexible (minimum 35%) kyphotic curves (T2-T12), were included. A decision to proceed with PVT was based on curve progression within the brace, and/or persistent pain, and/or unacceptable cosmetic concerns of the patient/caregivers, and/or non-compliance within the brace. It was discussed with the patients and their families, that PVT may yield to additional future surgeries.

Results
Patients had an average age of 13.1 (11-15) and an average follow-up duration of 47.6 months (36-60). Posterior vertebral tethering (PVT) was undertaken to all patients by utilizing Wiltse approach and placing monoaxial pedicle screws intermittently. At the final follow-up: mean pre-operative thoracic kyphosis and lumbar lordosis improved from 73.6 – 45.7 to 34.7 - 32.1(p<0.001). A gradual correction was noted.Mean sagittal vertical axis (-15 to -3.2), vertebral wedge angle (14.1 to 6.1) and total SRS-22 scores (3.6 to 4.8) improved significantly (p<0.001). A fulcrum lateral X-ray obtained at the latest follow-up, showed that the tethered levels remained mobile as confirmed clinically.

Conclusion
This study, for the first time in the literature, concluded,that as a result of growth modulation applied to skeletally immature patients with SK,flexible PVT was detected to yield gradual correction of the thoracic kyphosis by reverting the pathological vertebral wedging process, while keeping the mobility of the tethered segments in addition to successful clinical-functional results.The successful results of the present study questioned the role of the PVT as a viable alternative to fusion in skeletally immature patients with SK.



13yo M. TK:81-43-38-36-32. Flexibility:44%.

120. OUTCOMES OF PEDIATRIC AND YOUNG ADULT KYPHOTIC DEFORMITIES TREATED WITH VERTEBRAL COLUMN RESECTIONS AT AN SRS-OUTREACH SITE IN WEST AFRICA WITH 5-YEAR FOLLOW-UP

Kwadwo Poku Yankey, MD; Derrick Owusu Nyantakyi, MPH; Arthur Sackeyfio, MD; Jessie Rapoza, MS; Irene A. Wulff, MD; Oheneba Boachie-Adjei, MD; Kushagra Verma, MD, MS; Liliane Luu, BS

Hypothesis
VCR allows for excellent sagittal correction, but with known risks of intra and post-operative complications.

Design
Retrospective analysis of prospectively collected data

Introduction
Vertebral column resection (VCR) offers the potential for drastic improvements in sagittal balance but complication risks remain high and should be managed carefully. This study provides an updated outcome analysis of VCRs performed at an SRS-Outreach site in west Africa.

Methods
Twenty patients with severe sagittal deformities underwent VCR at the FOCOS hospital in west Africa between 2013 and 2018. Follow-up included five-year outcomes. Sagittal radiographic parameters and SRS-22 scores were analyzed to compare preoperative and postoperative outcomes via paired t-tests.

Results
39 patients (age 16 ± 3.7) underwent surgery with VCR and 20 returned for 5-year follow up (51%). Three patients underwent a 1-level VCR, seven 2-level VCRs, ten 3-level VCRs, and one 4-level VCR. Comparison of mean radiographic parameters depict a significant improvement in T2-T5 kyphosis (–4.3˚ to 6.7˚, P=0.016), T5-T12 kyphosis (68.9˚ to 37.8˚, P=0.02), and L1-S1 lordosis (69.5˚ to 43.2˚, P=0.003). Mean SRS-22 scores depicted significant improvement in all categories: pain (3.1 to 4.6, P=1.5E-6), self-image (2.3 to 3.8, P=2.3E-4), general function (3.1 to 4.5, P=1.04E-6), mental health (3.3 to 4.4, P=6.7E-5), satisfaction (3.3 to 4.5, P=0.028), and total (3.0 to 4.4, P=2.1E-6). Mean estimated blood loss was 1918 ± 859 mL and mean operating time was 337 ± 100 minutes. 12 patients had intraoperative complications, including 1 dural tear, 1 pleural tear, and 12 neuromonitoring changes that improved with corrective maneuvers. One patient experienced a postoperative neurologic complication. Re-operation rate was 20%.

Conclusion
Here, VCRs performed on pediatric populations with severe sagittal deformities in an outreach setting produced generally favorable outcomes in both sagittal radiographic parameters and SRS-22 scores. Although a 60% complication rate was observed, a majority were intra-operative neuromonitoring changes and resolved without lasting neurological affects.

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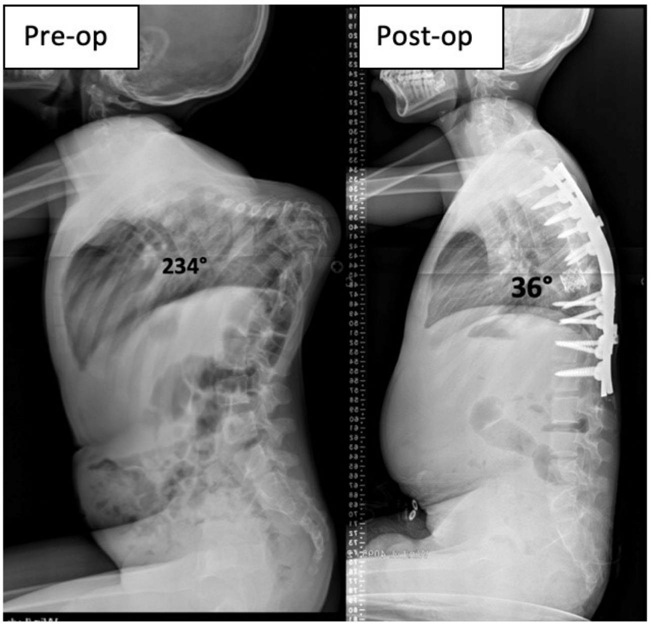


Figure 1: Radiographic images of case example.

121. DIAGNOSTIC CHALLENGES AND CONSEQUENCES OF NEONATAL VERTEBRAL OSTEOMYELITIS: A CASE SERIES

Talissa O. Generoso, MD; Rubens Furlan Neto, MD; Luca E. Cordeiro, MD; Luiz Müller Avila, MD; Carlos A. Aguiar, MD; *Luis E. Munhoz da Rocha, MD*

Hypothesis
Patients with neonatal vertebral osteomyelitis often present in late childhood with acute-angle kyphosis, which may be mistakenly identified as congenital, thereby perpetuating the undiagnosed vertebral infection.

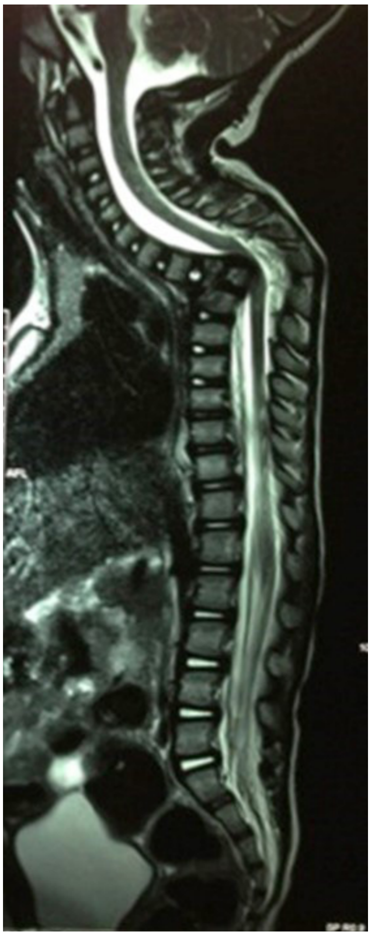
Design
Retrospective case series.

Introduction
Neonatal vertebral osteomyelitis is a rare condition, with limited descriptions in the literature primarily comprising case reports. Diagnosis within this age group proves challenging due to subtle clinical and laboratory findings, such as axial pain during breastfeeding, leading to a heightened risk of diagnostic errors, including misdiagnoses as meningitis, and subsequent treatment delays. This context fosters disease progression, resulting in the development of severe spinal deformities characterized by the destruction and collapse of affected vertebrae, posing a significant risk of neurological compromise. This study aims to enhance awareness of this challenging diagnosis, empowering healthcare professionals to recognize early signs and symptoms and provide optimal treatment for affected children.

Methods
A retrospective case series was conducted by analyzing medical records and images within the past 15 years at a tertiary pediatric hospital in Brazil.

Results
This study comprised 10 cases of neonatal osteomyelitis initially undiagnosed, presenting late for orthopedic evaluation due to severe kyphosis. All were either premature or had experienced a prolonged hospital stay as newborns, with at least 20 days spent in the ICU. Upon initial assessment, all patients had involvement of at least two vertebral bodies, acute angle kyphosis in the thoracic spine, spinal canal stenosis, and varying degrees of spinal cord compression. Four patients displayed signs of neurological compromise. Surgical intervention was required for all patients, with only one receiving treatment during the acute phase while hospitalized for sepsis.

Conclusion
Early diagnosis of vertebral osteomyelitis in neonates can alter the course of the disease and patient outcomes. Awareness of this diagnosis is essential, especially in cases with a history of bacteremia and ICU admission, providing swift and aggressive treatment, preventing extensive bone destruction and neurological compromise. Surgical treatment with decompression and spinal stabilization should be considered early in cases with signs of vertebral instability.



Severe acute kyphosis with neurological compromise in a 2yo patient.

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PODIUM PRESENTATION ABSTRACTS

122. POSTERIOR CORRECTIVE SURGERY FOR TYPE II CONGENITAL KYPHOSIS: SRS-SCHWAB GRADE 4 OSTEOTOMY OR VERTEBRAL COLUMN RESECTION?

Yong Qiu, PhD; Hongru Ma, MD; Benlong Shi, PhD; *Zezhang Zhu, PhD*

Hypothesis

Both SRS-Schwab Grade 4 osteotomy and vertebral column resection (VCR) are effective in surgical correction of congenital kyphosis if selected based on proper indications.

Design

Retrospective comparative study.

Introduction

The rigid nature of anterior or circumferential failure of segmentation in type II CK rendered indispensably radical and risky corrective surgery, raising the question on how to trade-off between safety and effectivity regarding the selection of surgical techniques. Bothe VCR and SRS-Schwab Grade 4 osteotomy were reported to be effective in surgical correction of CK, the optimal strategy in selection of the two techniques were not proposed.

Methods

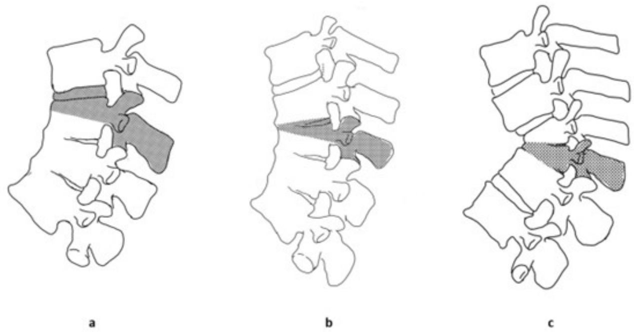
Type II CK patients undergoing vertebral column resection (VCR) in our center from January 2015 to January 2020 were included in Group 1, and those undergoing SRS-Schwab Grade 4 osteotomy during the same period were enrolled in Group 2. The radiographic parameters, clinical outcomes, and quality-of-life measures at pre-operation, post-operation and follow-up were compared between groups.

Results

A total of 31 patients (19 patients in Group 1 and 12 patients in Group 2) with an average age of 16.3±10.4 years were recruited. Similar correction of segmental kyphosis was observed between groups (51.1±17.6º in Group 1 and 48.4±19.8º in Group 2, p=0.694). Group 1 had significantly longer operation time (365.9±81.2 vs.221.4±78.9, p<0.001) and more estimated blood loss (975.2±275.8 ml vs. 725.9±204.3 ml, p=0.011) as compared to Group 2. Significant improvement of SRS-22 Self Image, Function and Satisfaction domains was observed in both groups during follow-up. The SRS-22 measurements were similar between groups at the latest follow-up. Alert event of intraoperative sensory and motor evoked potential (SEP and MEP) monitoring was observed in 1 patient of Group 2. Both groups had 1 transient post operative neurological deficit respectively. The incidence of peri- and post-operative complications was higher in Group 1 but not statistically different.

Conclusion

Both VCR and SRS-Schwab Grade 4 osteotomy, if selected properly, could provide satisfying radiographic and clinical outcome in type II CK patients during a minimum of 2 years follow-up. Compared to SRS-Schwab Grade 4 osteotomy, patients undergoing VCR procedure might have longer operation time, more blood loss and higher incidence of peri- and post-operative complications.



123. DECISION OF PEDICLE SUBTRACTION OSTEOTOMY VERTEBRA IN SURGICAL CORRECTION FOR ANKYLOSING SPONDYLITIS WITH THORACOLUMBAR KYPHOSIS

Yong-Chan Kim, MD, PhD; Tae-Hoon Kim, MD, PhD; Young-Jik Lee, MD; Sung-Min Kim, MD; *XiongJie Li, MD*; Romeo II G. Galapon, MD; Min-Gyu Kim, MD

Hypothesis

'Kim's apex' is useful when determining the apex in Ankylosing spondylitis (AS) patients with thoracolumbar kyphosis, and performing pedicle subtraction osteotomy (PSO) using it can achieve better surgical outcomes.

Design

A retrospective study

Introduction

PSO can effectively correct AS patients with thoracolumbar kyphosis, but the choice of location remains controversial. This study aims to provide a method for the decision of the apical vertebra as the site for PSO in corrective surgery for AS with thoracolumbar kyphosis.

Methods

235 AS patients with thoracolumbar kyphosis who underwent PSO from 2009 to 2021 were retrospectively enrolled in this study. 'Kim's apex vertebra' was defined as the farthest vertebra from a line drawn from the center of the T10 vertebral body to the midpoint of the S1 upper endplate and 229 patients whose apex was located at each of T12, L1, or L2 were finally analyzed. We divided all patients into two groups. Group A (n=144) underwent PSO at the KA vertebra, while Group B (n=85) underwent PSO at a different level. Demographic and radiologic data, including sagittal spinopelvic parameters, were collected. An additional analysis was performed on patients with the same KA vertebra.

Results

The distribution of patients based on KA were T12 (28,12.2%), L1 (119,51.9%), and L2 (82,35.9%), respectively. The correction of sagittal vertical axis (SVA, 101.0±48.5 mm vs 82.0±53.8 mm, p=0.010), global kyphosis (GK, 31.6±10.0° vs 26.4±10.5°, p=0.005), and thoracolumbar kyphosis (TLK, 29.4±10.2° vs 24.2±12.9°, p=0.012) in group A was significantly greater than in group B, and there was no difference in the correction of thoracic kyphosis (TK), lumbar lordosis (LL), and pelvic incidence (PI) between the two groups. On further analysis, Group A showed greater correction in TK (26.2±13.7° vs 4.5±20.1°, p=0.013) for patients with T12 as the KA, greater improve-

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ments in SVA (101.5±44.2° vs 73.4±48.7°, p=0.020), GK (30.6±11.0° vs 26.0±10.4°, p=0.046), and TLK (32.6±7.8° vs 26.7±9.9°, p=0.012) for those with L1 as the KA, and significant correction in TLK (30.0±6.3° vs 4.3±19.5°, p=0.008) for patients with L2 as the KA, compared to Group B.

Conclusion

PSO at the apical vertebra provides a greater degree of correction of sagittal imbalance. Our proposed method, the KA is easily reproducible for determining the apex level in AS patients with thoracolumbar kyphosis.

124. SELECTION OF PROXIMAL FUSION LEVEL IN OSTEOPOROTIC VERTEBRAL COMPRESSION FRACTURE WITH SPINAL KYPHOSIS: THE GUIDENCE OF HOUNSFIELD UNIT

Junyu Li, MD; Yiqiao Zhang, MD; Ben Wang, MD; Xueshi Tian, MD; Zhuoran Sun, MD; Yongqiang Wang, MD; Miao Yu, MD; Weishi Li, MD; Yan Zeng, MD

Hypothesis

Upper maximal vertebra (UMV) and upper sagittal reverse vertebra (USRV) can help to select the fusion level and decrease the incidence of adjacent segment degeneration (ASD) and proximal junctional kyphosis (PJK).

Design

Retrospective analysis

Introduction

The selection of the upper instrumented vertebra (UIV) in Osteoporotic Vertebral Compression Fracture (OVCF) has been proven to be related to postoperative complications. For the first time, we defined the upper maximal vertebra (UMV) as the vertebra above the compressed section that had a higher Hounsfield Unit (HU) value than two vertebrae proximal to the fracture level. The upper sagittal reverse vertebra (USRV) was defined as the first vertebra that presented opposite HU value distribution from the anterior to posterior part of the vertebra compared to proximal vertebrae. In accordance with previous studies, we believe that the UMV and USRV might play an important role in the biomechanical stability of the spine.

Methods

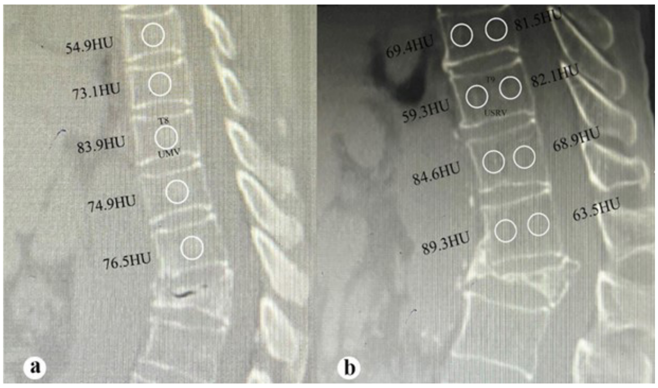
This clinical research included 70 continuous OVCF patients (14 males and 56 females) with a mean age of 63.24 ± 7.83 years and mean follow-up of 48.13 ± 20.22 months. Whole spine CT were performed for each patient. The patients were divided into groups according to whether their UIV was below the UMV or USRV. The incidence of ASD and PJK was evaluated in each subgroup.

Results

The average HU value of all patients was 80.88 ± 39.84. All sagittal parameters improved significantly after operation and at follow-up. For UMV, the UIV of 25 OVCF patients was located on the UMV, while that of 45 patients was not. There was a significant difference in the rates of ASD (p=0.003) and PJK (p=0.010) between the 2 groups. 55 patients (78.57%) were identified to have USRV. The UIV of 16 patients was located on the USRV while that of 39 patients was not. There was a significant difference in the rate of ASD between the two groups (p=0.010).

Conclusion

HU values should be considered in the selection of UIV. Locating UIV on UMV decreases the incidence of PJK and ASD, and taking USRV into the fusion level reduces the occurrence of ASD.



The definition of the UMV and the USRV

125. OPPORTUNISTIC MONITORING OF BONE MINERAL DENSITY USING A STEREORADIOGRAPHY DUAL ENERGY SYSTEM

Saba Pasha, PhD; Russell Chow; Darryl Lau, MD; *Christopher I. Shaffrey, MD*; Tyler Koski, MD

Hypothesis

Bone mineral density (BMD) of lumbar, calculated with a stereoradiography dual energy system and DXA, are significantly correlated.

Design

Cadaveric study

Introduction

While the role of several spinal radiographic measurements on patients' spinal health, surgical planning, and outcome prediction has been investigated, the role of BMD values in treatment of spinal condition is not well documented. A hindering factor in systematically including BMD in patients' clinical care is additional imaging requirements, increasing operational burden and insurance policies associated with increased costs. A BMD measurement technology integrated in clinical a radiography system can alleviate this shortcoming.

Methods

A total of 36 adult cadaveric torsos were scanned twice with a low dose stereoradiography system and once with DXA. An automated segmentation method identified vertebral bodies in the radiography system, while a technician manually adjusted the pre-determined boundary of the vertebrae in DXA. Stereoradiography frontal (L1-L4) BMD value in mono (only PA view) and bi-plane images (both PA and lateral images) and DXA images were calculated for both systems and compared statistically. The repeatability of the BMD measured in the stereoradiography system was evaluated.

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PODIUM PRESENTATION ABSTRACTS

Results
22 male and 14 female specimens were included. A total of 222 vertebral bodies were segmented. A significant correlation was observed for both mono- and bi-plane acquisition modes compared to DXA scans, R2=0.92 and R2=0.90, p<0.05, respectively (Fig. 1). ANOVA analysis for repeatability assessment resulted in F=0.001 and p=0.977, showing no statistically significant differences between the repeated measurements. The mean and standard deviation of the differences between repeated BMD values measured in the stereoradiography system were 0.001 (g/cm2) and 0.058 (g/cm2) respectively.

Conclusion
The dual energy stereoradiography system offers opportunistic monitoring of BMD as part of routine clinical evaluation of spine. The BMD measurements of the stereoradiography system were strongly comparable to the DXA BMD measurements. The repeatability of the stereoradiography system showed minimal differences between multiple measurements of the same dataset.

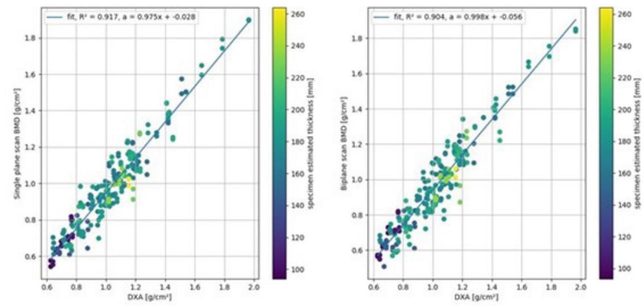

Fig. 1- The correlation between the BMD measured at all levels between DXA and stereoradiography mono- and bi-plane scans.

126. AI-POWERED 3D RECONSTRUCTIONS FROM STEREO-RADIOGRAPHS: IS 3D READY FOR PRIMETIME

Justin Dufresne; Rachelle Imbeault; Lulu Zhou, PhD; Marjolaine Roy-Beaudry, MSc; Thierry Cresson, PhD; Stefan Parent, MD, PhD

Hypothesis
Our hypothesis is that the newly developed AI-powered software can generate accurate 3D spine reconstructions with significantly improved efficiency compared to the previous generation semi-automatic software.

Design
Retrospective cohort data

Introduction
3D reconstructions of the spine have been used for over 30 years mainly in a research environment. The main limitation to their clinical use has been access to rapid and accurate 3D reconstructions. This study assesses the accuracy and reliability of a newly developed AI-powered software for generating 3D spine reconstructions from 2D X-ray images, focusing on idiopathic scoliosis.

Methods
The study initially focuses on validating the accuracy of the AI-powered software by comparing 85 automatic reconstructions with those performed using a semi-automatic tool, which has undergone third-party verification for reliability and accuracy. Clinical parameters, including Cobb angle, thoracic kyphosis, lumbar lordosis, pelvic tilt, and plane of maximal deformity, are assessed. Following validation, the study shifts to creating a robust database by generating 1000 reconstructions using the validated automatic software. Exclusion criteria involve patients who have undergone surgery for scoliosis. Radiographs were sourced from a specialized center's research image database spanning the years 2014 to 2018.

Results
Mean differences were observed for thoracic kyphosis (3.86°±3.6), lumbar lordosis (3.85°± 3.8), pelvic tilt (1.74°±2.1), plane of maximal deformity (6.14°±6.1) and Cobb angle (4.77°±5.2). Strong positive correlation coefficients were found (r = 0.93 for thoracic kyphosis, 0.91 for lordosis, 0.93 for pelvic tilt, 0.89 for max plan and 0.71 for Cobb angle). Notably, the AI-powered software reduced the time required for a single 3D reconstruction to 2.13 minutes, demonstrating significant efficiency gains compared to the semi-automatic software, which took approximately 75 minutes per reconstruction.

Conclusion
This study confirms the precision of 3D spine reconstructions produced by the AI software for database creation, highlighting the successful automation of a large-scale dataset. The implementation of this AI-powered software for rapid database generation provides a unique opportunity to systematically investigate and provides an efficient method to make 3D reconstruction available in the clinical setting.

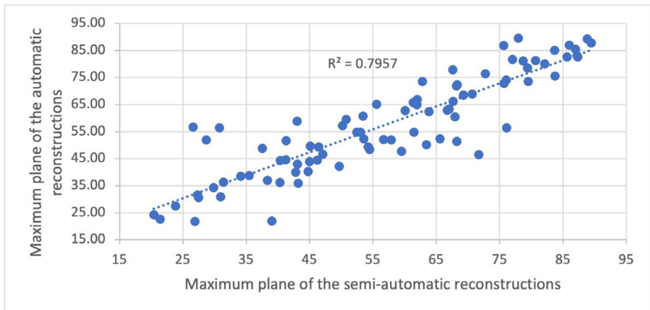

Figure 1 : Distribution of the different maximum plane angles

127. NOVEL TRIZONAL MEMBRANE FOR BONE GENERATION IN A RABBIT POSTEROLATERAL SPINE FUSION MODEL

Takashi Hirase, MPH; Ava Brozovich, MD; Austin Q. Nguyen, MD; Enrica De Rosa, MS; Comron Saifi, MD; Francesca Taraballi, PhD; Weiner K. Bradley, MD

Hypothesis
The biomimetic osteoinductive/osteoconductive collagen-based 3ZM is an effective scaffold for bone genera-

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

tion in a rabbit orthotopic posterolateral spine fusion model. We hypothesize this scaffold may have the potential to be utilized as an effective tool for spinal fusion.

Design

The osteoinductive and osteoconductive potential of the 3ZM was evaluated using a preclinical rabbit posterolateral fusion model. Suturability was also assessed.

Introduction

This study aimed to investigate a new biomimetic osteoinductive collagen-based trizonal membrane (3ZM) that exhibits molecular mimicry with human periosteum to be used alone as a scaffold for bone generation in a rabbit spinal fusion model. This first phase was aimed at (a) demonstrating the ability to form bone in this milieu and (b) to verify suturability of the material for use in fusions.

Methods

3ZM was fabricated using type I collagen from bovine tendon in GMP-like condition. A rabbit posterolateral spine fusion model was used to evaluate the osteoinductive and osteoconductive potential of the 3ZM. 3ZM was implanted within the bilateral lumbar paraspinal musculature of eight New Zealand white rabbits. The suturability of the 3ZM was investigated using 3-0 PDS sutures. Bone formation was assessed at 3, 6, and 9 weeks using computer tomography (CT) bone quantification analysis. The implanted 3ZM was explanted at 9 weeks and histological analysis was performed to evaluate for de novo bone formation.

Results

The 3ZM demonstrated excellent suturability affording fixation in the intertransverse process interval. Successful de novo trabecular bone formation was observed at 3, 6, and 9 weeks via CT bone quantification. The mean de novo trabecular bone formation at 3, 6, and 9 weeks were 6140.6 ± 636.6 mm3, 2236.0 ± 1149.5 mm3, and 2913.2 ± 910.0 mm3 respectively. The mean de novo cortical bone formation at 3, 6, and 9 weeks were 3892.1 ± 423.0 mm3, 3753.3 ± 725.4 mm3, and 3776.4 ± 836.3 mm3 respectively.

Conclusion

The biomimetic osteoinductive/osteoconductive collagen-based 3ZM is an effective material for bone generation in a rabbit orthotopic posterolateral spine fusion model. Additional in vivo and clinical trials will be required to further determine the efficacy and safety of this product in the clinical setting.

128. A TRANSCRIPTOMIC ASSESSMENTS OF PULMONARY DEVELOPMENT BASED ON PORCINE MODEL OF EARLY-ONSET SCOLIOSIS COMBINED WITH THORACIC INSUFFICIENCY SYNDROME TREATED BY A NOVEL GROWTH-FRIENDLY DEVICE

Ying Zhang, MD; Jingming Xie, MD; Yingsong Wang, MD; Zhiyue Shi, MD; Quan Li, MD; Tao Li, MD; Ni Bi, MD; Zhi Zhao, MD; Jin Zhou, MD

Hypothesis

There were differentially expressed mRNAs (DE-mRNAs) that may be key regulatory genes of pulmonary hypoplasia treated with NGFD in EOS + TIS.

Design

A comparative study with large animal model of EOS+TIS treated with NGFD and transcriptome analysis.

Introduction

EOS+TIS demonstrated with pulmonary hypoplasia. However, there is little study on the outcomes based on large animal models for evaluating pulmonary development of EOS+TIS treated with NGFD in therapeutic studies and basic research at the transcriptomic level.

Methods

Two groups (treatment and model groups) were set up in this study (6 Yorkshire pigs in each group). Imaging studies, pathological analysis, RNA sequencing, bioinformatics analysis of lung tissue were performed.

Results

Implantation of NGFD increased body weight, body length, and TLV and decreased the θs and θk for EOS+TIS model. It also ameliorated the EOS+TIS-induced thickening of the alveolar wall, increase in alveolar spaces, and decrease in alveolar number and diameter. In lung tissue, a total of 790 novel growth-friendly system-associated DEGs were identified, and they were mainly involved in the regulation of immune, inflammatory, calcium transport and vascular development. Among these DEGs, BDKRB1, THBS1, DUSP1, IDO1, and SPINK5 were hub genes, and their differential expression was consistent with RNA-seq results in lung tissues.

Conclusion

Scoliosis and pulmonary hypoplasia of EOS+TIS model treated by NGFD have been alleviated. We also reveal the molecular mechanism of improvement of pulmonary hypoplasia. These findings will provide a solid theoretical foundation for future applications of novel growth-friendly system in clinical therapy.

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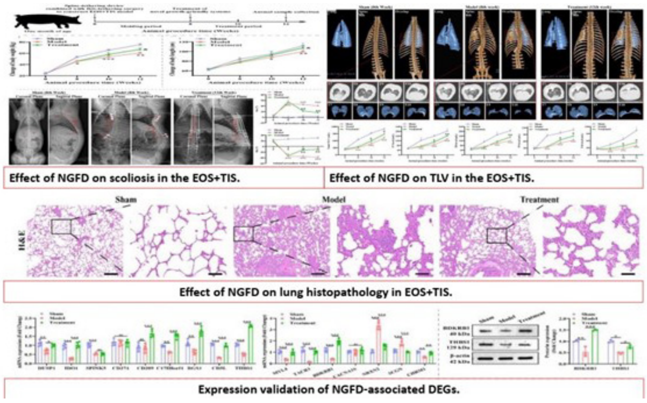


porcine model of early-onset scoliosis combined with thoracic insufficiency syndrome treated by a novel growth-friendly device

129. TETHERING OF KYPHOTIC DEFORMITIES IN THE HYPERKYPHOTIC PORCINE MODEL: INSIGHTS FOR ALL VERTEBRAL GROWTH MODULATION

Matthew A. Halanski, MD; Cameron Jeffers, BS; David M. Bennett, MD; Brittney Kokinos, MS; Susan Hamman, MD; Ellen Leiferman, DVM; Max Twedt, BS; James Sypherd; Thomas Crenshaw, PhD

Hypothesis
Posterior vertebral tethering can be used to correct deformities through growth modulation in the hyperkyphotic porcine model.

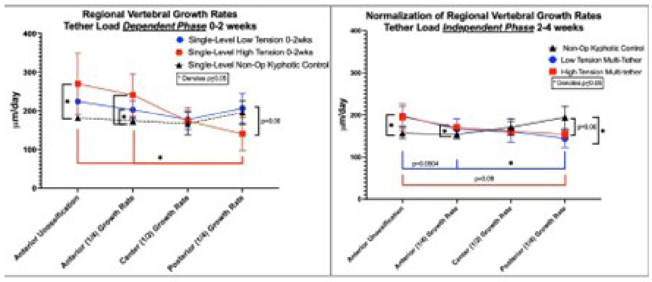
Design
Prospective Cohort

Introduction
Growth modulation has been used in coronal plane deformities, this study evaluates vertebral tethering to correct kyphotic deformities.

Methods
70 piglets were divided into non-operative (N=23) and operative cohorts (N=47). Piglets underwent vertebral periosteal resection (N=6), Disc pressure testing (N=21), Distraction-based (N=4) or High (N=4) and Low (N=4) tension single level posterior tethering, and multi-level High (N=4) or Low (N=4) tension posterior tethering. Digital radiographs were used to measure Cobb angles and regional vertebral growth rates were measured using pulsed fluorochrome labeling using a custom Matlab image analysis program used to measure distance between the labels.

Results
Apical disc pressures decreased with increasing tether load and this was significant in the control spines (99+25 vs 61+39 kPa, p=0.02). Periosteal resection of the vertebra did not accelerate vertebral growth. At two-weeks, distraction-based and high-tension single level tethering resulted in significantly greater growth modulation (28+14%, 53+43%) than lower tether tension (-1+15% p=0.03). Higher tension resulted in increased (241+54 vs 157+12um/d, p=0.04) anterior and decreased (141+43, 198+ 38 um/d, p=0.001) posterior growth rates compared to internal physeal controls. No differences between the initial (17+10°, 18+/-4°, p=0.9) or final (15+6°, 12+8°, p=0.7) apical Cobb angles were found. Growth modulation was normalized at 2-4 weeks (p=0.6) between the low (14+11%) and high (10+10%) tensioned tethers. Serial Cobb measurements paralleled growth rate findings in the multi-tether cohorts. A significantly lower instrumented Cobb angle was found in the high-tension cohort (11.3+14° vs. 32+6° p=0.04) at week one, however after the initial 2 weeks, mean slopes (degree kyphosis/week) normalized becoming very similar between cohorts (-9.7 vs -10.4).

Conclusion
(1) The hyperkyphotic pig model can be used to study vertebral growth modulation. (2) Sagittal deformities can be corrected by growth modulation. (3) Vertebral growth modulation, in the flexible spine, appears to be biphasic with an initial phase that is tether load dependent that later transitions into a tether load independent phase.



130. ZEBRAFISH PRE-CLINICAL MODELS IMPLICATE OXIDATIVE STRESS-INDUCED INTERVERTEBRAL EXTRACELLULAR MATRIX DEFECTS IN ADOLESCENT IDIOPATHIC SCOLIOSIS, AND IDENTIFY ELEVATED SPINE STIFFNESS AS A PROGNOSTIC BIOMARKER

Josh Gopaul, BS; Patrick Pumputis; Ran Xu; Jenica VanGennip, PhD; Nikan Fakhari, PhD; Jerome Baranger, PhD; David E. Lebel, MD, PhD; Olivier Villemain, MD, PhD; *Brian Ciruna, PhD*

Hypothesis
Increased spine stiffness drives AIS

Design
prospective interventional

Introduction
Patient exome/genome sequencing and mouse functional studies have associated genetic variants in musculoskeletal collagen and cartilaginous extracellular matrix (ECM) defects with a fraction of adolescent idiopathic scoliosis (AIS) cases. However, GWAS meta-analyses estimate that >95% of total genetic variance underlying AIS remains to be discovered. As the biology of AIS remains poorly understood, there are no prognostic biomarkers and treatment options remain limited to restrictive bracing and corrective surgery. Using zebrafish models of AIS, we discovered that oxidative stress and

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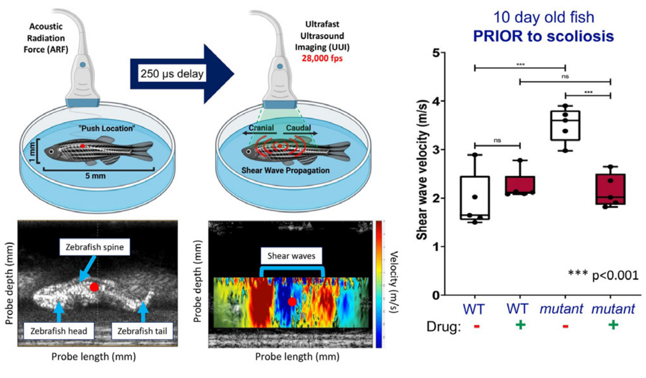
pro-inflammatory signals in the spinal cord, which develop because of cerebrospinal fluid homeostasis defects, are necessary and sufficient to drive spine curvature. Indeed, antioxidant and immunomodulating drugs can efficiently block scoliosis onset and severe progression in fish models. Although this provides proof-of-principle that AIS might be managed therapeutically, uncertainties regarding downstream mechanism and their link to human disease pose a barrier to clinical translation.

Methods
Zebrafish genetics, electron microscopy, shear wave elastography, pharmacological intervention

Results
Here, we demonstrate that oxidative stress in fish AIS models induces an unfolded protein response that is associated with collagenous ECM defects within developing intervertebral spine segments. Using shear wave elastography (SWE), we show that zebrafish scoliotic spines are consequently stiffer than healthy controls - a property also reported for intervertebral discs in human AIS patients. Remarkably, animals are significantly stiffer prior to scoliosis onset and increasing axial stiffness positively correlates with curve severity, suggesting a causal role for elevated stiffness in AIS. Finally, we demonstrate that antioxidant drugs known to suppress scoliosis also reduce spine stiffness to normal levels, providing a possible mechanistic link between oxidative stress and connective tissue/intervertebral defects identified in both fish and human AIS studies.

Conclusion
As SWE is non-invasive and widely applied in the clinic, tissue stiffness may translate into a valuable prognostic biomarker and therapeutic target for AIS.



131. MACHINE LEARNING CLUSTERING OF PREOPERATIVE FITNESS AND ITS PROGNOSTIC VALUE FOLLOWING DEFORMITY CORRECTION

Sarthak Mohanty, BS; *Fthimnir Hassan, MPH*; Larae Klarenbeek-Mitchell, PT, DPT, OCS; David Ruderman, PT, DPT; Eric Schaum, PT, DPT; Erik Lewerenz, BS; Zeeshan M. Sardar, MD; Joseph M. Lombardi, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

Hypothesis
Phenotypes based on functional fitness assessment preoperatively prognosticate medical complications following ASD correction.

Design
Retrospective

Introduction
Preop rehabilitation preceding ASD correction is associated with less postop disability. The impact of preop fitness on patients' presentation and subsequent outcomes remains unclear.

Methods
Included patients underwent PSF≥8 levels and had sagittal deformity[PI-LL≥20°, T1PA≥20°, or C7SVA ≥4 cm]. Preoperative fitness was prospectively assessed through 6-Minute Walk Test(6MWT) and the Timed Sit-to-Stand Test. Fuzzy K-means machine learning clustering algorithm categorized patients into three fitness-based clusters: Deconditioned, Intermediate, and Strongly Conditioned. Primary outcome was 90-day(90D) medical readmission. Secondary outcomes included the length of stay(LOS) and intra-op complications. Exploratory analysis compared ODI sub-domains in 75 patients with baseline and two-year ODI. Clusters were compared using Tukey's post-hoc test following ANOVA with data presented as: [worst vs intermediate vs best fitness, P-value(ANOVA or Chi-Square)].

Results
108 patients, 32 Deconditioned, 40 Intermediate, 32 Strongly Conditioned, were included. Age(P=0.1923), gender (P=0.5543), instrumented levels(P=0.9714), pelvic fixation(P=0.1397), preop T1PA(P=0.9470), and C7 SVA(P=0.4893) were comparable across cohorts. Patients with the best conditioning had the shortest sit to stand time(12.7 vs 11.5 vs 8.9;P=0.0035), highest speed during 6MWT(1.23 vs 1.69 vs 2.15 m/s;P=0.0103) and walked the farthest(1331.1 vs 1659.95 vs 1771.22;P<0.0001). While LOS was similar(6.44 vs 6.95 vs 6.11 days;P=0.2697), intra-op complication rates decreased with increasing fitness levels(50% vs 25% vs 11.11%, p=0.0015). 90D medical readmissions were lowest among patients with the best preop conditioning(37.5% vs 18.18% vs 11.11%; p=0.0014). In the exploratory analysis, preop ODI was significantly better with improved fitness(43.83 vs 34.0 vs 26.0;P<0.0001) with significant differences in all ODI domains aside from sleeping and standing. Two-year ODI scores were superior in patients with best baseline fitness(23 vs 25.4 vs 12.5;P=0.0005).

Conclusion
Baseline fitness profiling in ASD patients offers predictive value for perioperative complications. Better preop fitness is associated with lower intra-op complication rates, lower early readmissions, and better two-year ODI scores.

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	Deconditioned *Worst Fitness* [N=32]	Intermediate *Medium Fitness* [N=40]	Strong *Best Fitness* [N=36]	Worst vs. Best Fitness	Best vs. Medium Fitness	Worst vs. Medium Fitness
Demographics and Baseline Alignment						
Demographics						
Age	58.56 (1.44)	55.45 (1.3)	56.3 (0.85)	0.1812	0.5826	0.1122
Gender [Male]	6 (18.75)	8 (20)	4 (11.11)	0.5543		
ASA Score	1.92 (0.1)	1.88 (0.07)	1.73 (0.16)	0.3335	0.3943	0.766
Total Instrumented Levels (TIL)	13.69 (0.62)	13.45 (0.7)	13.56 (0.75)	0.8927	0.9181	0.8004
Pelvic Fixation [Pelvic]	30 (93.75)	36 (90)	28 (77.78)	0.1397		
Baseline Alignment						
Pelvic Incidence [PI]	55.53 (5.33)	62.5 (4.87)	64.93 (3.93)	0.1644	0.6997	0.3401
PI - LL	28.67 (5.34)	27.49 (4.11)	28 (4.51)	0.9241	0.934	0.8622
T1 Pelvic Angle [T1PA]	28.35 (3.91)	27.78 (3.8)	29.49 (3.67)	0.8332	0.749	0.9178
C7 Sagittal Vertical Axis	5.9 (1.6)	4.73 (0.9)	3.82 (1.11)	0.292	0.5307	0.5264
Baseline Functional Testing						
6 Minute Walk Test						
Systolic Resting Blood Pressure(BP)	130.63 (1.9)	126 (1.88)	119.78 (1.27)	<0.0001	0.0079	0.0881
Diastolic Resting BP	81.31 (1.2)	80.35 (1.6)	77.89 (1.11)	0.0401	0.2104	0.632
Sit to Stand Test - Seconds	12.71 (0.82)	11.5 (0.92)	8.9 (0.5)	0.0002	0.0159	0.3308
Gait Speed During 6 Min Walk (m/s)	1.23 (0.06)	1.69 (0.2)	2.15 (0.27)	0.0019	0.1769	0.028
6 Min. Walk Test(6MWT) Distance	1331.06 (65.59)	1659.95 (38.39)	1771.22 (35.34)	<0.0001	0.0363	<0.0001
6 Min. Walk Test(6MWT) Heart Rate(HR)	112.5 (2.91)	102.18 (3.57)	120.33 (3.22)	0.0756	0.0003	0.0286
6 Min. Walk Test(6MWT) HR - 1min	101 (2.5)	98.95 (3.81)	107.56 (3.06)	0.1021	0.0824	0.6542
6 Min. Walk Test(6MWT) HR - 2min	92.75 (2.6)	91.9 (3.59)	102.89 (2.72)	0.0089	0.0171	0.8485
Primary Outcome						
Perioperative Complications						
Length of Hospital Stay	6.44 (0.34)	6.95 (0.41)	6.11 (0.36)	0.5098	0.1285	0.3367
Intraoperative Complication	16 (50)	10 (25)	4 (11.11)	0.0015		
90-Day Readmission	12 (37.5)	4 (18.18)	2 (11.11)	0.0014		
Exploratory Outcome						
Baseline, Preoperative Functional Scores						
Pain Intensity	2.67 (0.34)	1.53 (0.22)	1.75 (0.28)	0.0443	0.5414	0.0084
Personal Care (Washing, Dressing, etc.)	1.42 (0.22)	0.76 (0.15)	0.38 (0.09)	<0.0001	0.0309	0.0178
Lifting	2.75 (0.27)	2.71 (0.2)	2 (0.2)	0.0312	0.0144	0.8956
Walking	2.33 (0.13)	1.35 (0.15)	1 (0.22)	<0.0001	0.1864	<0.0001
Sitting	1.75 (0.17)	1.82 (0.16)	1 (0.16)	0.0022	0.0005	0.7566
Standing	2.75 (0.24)	2.65 (0.19)	2.5 (0.22)	0.4488	0.6133	0.739
Sleeping	1.58 (0.3)	0.94 (0.18)	0.88 (0.17)	0.0463	0.7904	0.0758
Employment/Homemaking	1.75 (0.19)	1.82 (0.15)	1.38 (0.09)	0.0655	0.0121	0.7642
Social life	2.58 (0.28)	2.06 (0.16)	1.25 (0.17)	0.0002	0.0012	0.1093
Traveling	2.33 (0.3)	1.35 (0.12)	0.88 (0.11)	<0.0001	0.004	0.0047
ODI score	43.83 (3.61)	34 (2.13)	26 (1.41)	<0.0001	0.0027	0.0243
Two-Year, Functional Scores						
Pain Intensity	1.63 (0.32)	1.7 (0.24)	0.03 (0.03)	<0.0001	<0.0001	0.8524
Personal Care (Washing, Dressing, etc.)	0.63 (0.18)	0.6 (0.11)	0.06 (0.04)	0.0039	<0.0001	0.9045
Lifting	2.25 (0.27)	2.2 (0.21)	1.75 (0.23)	0.1624	0.1585	0.8836
Walking	1 (0.27)	0.9 (0.15)	0.25 (0.08)	0.0112	0.0003	0.7475
Sitting	0.75 (0.12)	1.2 (0.12)	0.75 (0.15)	>0.9999	0.0217	0.0095
Standing	1.63 (0.22)	1.5 (0.23)	1.06 (0.04)	0.0158	0.0652	0.6945
Sleeping	0.38 (0.18)	0.7 (0.16)	1 (0.13)	0.006	0.1479	0.1804
Employment/Homemaking	1.38 (0.28)	1.3 (0.22)	0.5 (0.09)	0.0055	0.0012	0.8337
Social life	1.25 (0.17)	1.6 (0.19)	0.5 (0.09)	0.0004	<0.0001	0.1812
Traveling	0.63 (0.09)	1 (0.16)	0.5 (0.09)	0.3212	0.0085	0.044
ODI score	23 (3.08)	25.4 (2.65)	12.5 (1.2)	0.0029	<0.0001	0.5567

132. INSIGHTS FROM WEARABLE BIOMETRICS AFTER ASD SURGERY: DOES WEARABLE BIOMETRIC DATA (WBD) CORRELATE TO COMPLICATIONS AND 30-DAY READMISSION BETTER THAN TRADITIONAL PROS?

Rohit Bhan, MD, MS; Salim Yakdan, MD, MSCI; Jacob Greenberg, MD; *Brian J. Neuman, MD*;

Hypothesis
Patients with greater mobility captured by wearable biometric data (WBD) will have a less complicated post-operative-course.

Design
Prospective

Introduction
ASD surgery has been shown to provide substantial long-term benefit to patients, however many patients ask about short-term recovery in the 4-6 weeks after surgery. Traditional PROs have failed to reliably predict post-operative course, with studies showing inconsistent results. This may reflect PROs capturing a single moment in time, whereas pain, function, and activity are dynamic processes. WBD, including motion trackers like Fitbit, provide a more comprehensive picture of physical activity. We evaluated the relationship between WBD, PROMIS Physical Function, and postoperative course after ASD surgery.

Methods
ASD patients were enrolled at their preoperative visit. PROMIS scores were collected and patients were provided a Fitbit to wear prior to surgery. Preoperatively, various activity metrics were recorded for a minimum of 1 week. Perioperative course and complications were recorded for 30 days after discharge, such as reoperation, DVT, dehiscence, infection, and others. Parametric and non-parametric analyses were performed to assess significance.

Results
23 ASD patients were enrolled. Average fusions levels were 10.4 (SD = 3.6), all patients were fused to pelvis. 8 received all-posterior surgery and 15 received anterior-posterior surgery. 8 patients (35%) experienced perioperative complications and 3 (13%) patients were readmitted within 30-days of discharge. Patients with greater activity measured by WBD were less likely to experience complications. Between complication and non-complication groups, number of steps per activity bout was 44.5 and 81.0 (p=0.017), active time per bout was 1.78 and 2.59 (p=0.028), and number of steps per minute of activity was 23.5 and 29.1 (p=0.028) respectively (Figure 1). No difference was found for Physical Function between complication groups (p=0.104).

Conclusion
Increased preoperative activity determined by Wearable Biometric Data was associated with decreased complications, however no relationship was found with self-reported activity questionnaires. These preliminary findings suggests that WBD is superior to traditional PROs in assessing activity levels and may have utility in predicting perioperative course.

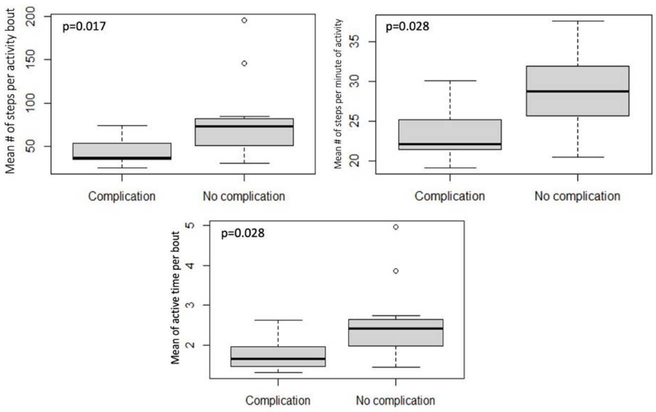

Figure 1: Box and whisker plots of activity measures in patients with and without complications

133. COMPUTER-AIDED PLANNING OF SURGICAL FUSION LEVEL FOR ADOLESCENT IDIOPATHIC SCOLIOSIS BASED ON DEEP LEARNING MODELS

Zhong He, MD; Wu-Jun Li, PhD; Neng Lu, MS; Xiaodong Qin, PhD; Yi Chen, MD; Zhen Liu, PhD; Xipu Chen, MD; Yong Qiu, PhD; *Zezhang Zhu, PhD*; Xiaodong Qin, PhD

Hypothesis
Our advanced deep learning system will revolutionize surgical fusion level decisions in AIS treatment by accurately detecting and segmenting vertebrae in X-ray images. Its multi-module approach is expected to surpass current methods in precision, potentially improving surgical outcomes and minimizing complications.

Design
Retrospective study.

Introduction
This study aims to develop a deep learning system which achieves the target detection and instance segmentation of vertebrae in adolescent idiopathic scoliosis (AIS),

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assisting spine surgeons in choosing the optimal surgical fusion levels to improve the correction effect of scoliosis.

Methods
This automatic system consists of the following modules: preprocessing module, deep learning network module, target detection module, instance segmentation module, and calculation module for surgical confidence. The system concatenates coarse-grained results of instance segmentation with the original X-ray image as input for the target detection network, recognizing whether the target vertebra needs to be fused by extracting multi-scale features from X-ray images. Surgical confidence is further refined with prior knowledge. A total of 1079 AIS patients who underwent posterior corrective surgery and were followed up for more than 2 years postoperatively were included for model training and internal testing.

Results
According to internal test results, the accuracy of our proposed method for surgical levels prediction is 0.840, with a recall rate of 0.942. The mAP50 of the instance segmentation mask is 0.945, and mAP50-95 is 0.563. The mAP50 for the target detection box of our method is 0.951, and mAP50-95 is 0.690. We compared the performance of seven other mainstream algorithms: the mAP50 of instance segmentation masks ranged from 0.870 to 0.929, and mAP50-95 ranged from 0.485 to 0.569; the mAP50 for target detection boxes ranged from 0.885 to 0.935, and mAP50-95 ranged from 0.542 to 0.678.

Conclusion
We propose an automatic method to determine AIS surgical fusion levels. Compared to current algorithms, it demonstrates SOTA (State-of-the-Art) performance. Our method is the first computer-assisted prediction system for AIS surgical fusion level based on instance segmentation and target detection. This proposed system can simultaneously extract semantic and instance features from spine X-ray images and effectively assess the correction range.

134. DISTRIBUTION OF CURVE FLEXIBILITY IN IDIOPATHIC SCOLIOSIS - A DESCRIPTIVE STUDY

Simon Blanchard, BS; Matan Malka, BA; Ritt Givens, BS; Michael G. Vitale, MD, MPH; Benjamin D. Roye, MD, MPH

Hypothesis
Curve flexibility in adolescent idiopathic scoliosis (AIS) would be normally distributed and would correlate with patient characteristics such as body mass index (BMI), curve pattern and skeletal maturity.

Design
Multicenter retrospective cohort.

Introduction
Curve flexibility is an important variable for AIS outcomes. This study sought to determine the distribution of flexibility in a multi-center AIS cohort and investigate associated characteristics.

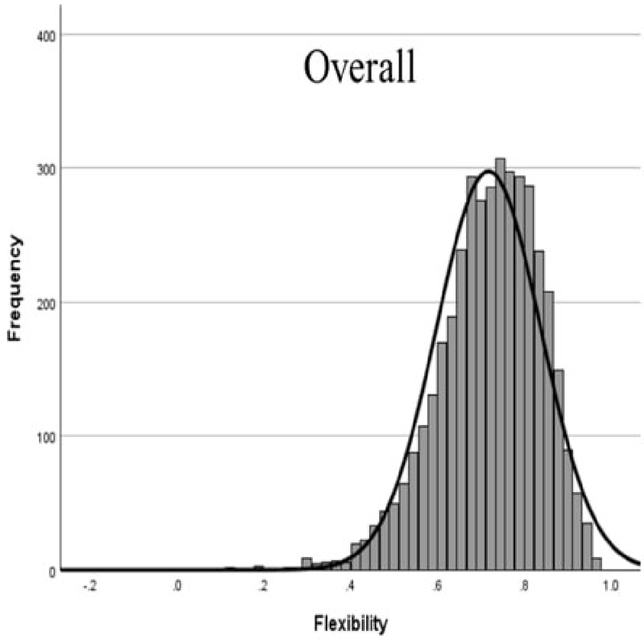
Methods
Surgical AIS patients enrolled in Harms Study Group (HSG) center were included. Flexibility was measured using lateral bending radiographs. The distribution was graphed using SPSS, and the relationship between flexibility and other parameters was assessed using t and chi square tests. Pearson's R was used for regression analysis.

Results
4,574 patients (mean age: 14.5±2.2 years, 80.5% Female) met inclusion criteria. Mean flexibility was 72.0±11.6%. Both primary thoracic (Lenke 1+2, N=2895) and primary lumbar curves (Lenke 5+6, N=1030) followed a normal distribution. Mean thoracic curve flexibility was significantly higher than primary lumbar curve flexibility (71.4% vs 68.98%, $p<0.001$). Flexibility was inversely correlated with both higher age ($p=0.002$) and increased skeletal maturity ($p=0.003$). Patients who were a healthy weight had more flexible curves than those who were overweight ($p = 0.019$). Interestingly, and unanticipated, better SRS22 and SRS24 scores were associated with lower flexibility ($p<0.03$, $p<0.01$). Not associated with curve flexibility were sex ($p=0.124$), weight ($p=0.536$), and height ($p=0.121$). Surprisingly, thoracic curves were more flexible than lumbar curves ($p<0.001$). Increased BMI was associated with decreased flexibility in thoracic curves ($p<0.001$), but not with lumbar curves ($p=0.963$). Additionally for thoracic curves, those with a lumbar A modifier were significantly more flexible than B ($p<0.001$) and C ($p<0.001$) types. For sagittal parameters, normo-kyphotic and hypo-kyphotic curves were more flexible than hyperkyphotic curves ($p=0.001$).

Conclusion
This study describes a normal distribution of flexibility in a large population of surgical AIS patients. It also confirms previously described relationships between flexibility and various patient characteristics (age, maturity, BMI) with a significantly larger sample size than previous studies, as well as describing several new factors that correlate with curve flexibility.

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

PODIUM PRESENTATION ABSTRACTS



Flexibility Distribution

135. ASSOCIATION BETWEEN LOWER BONE MINERAL DENSITY AND INCREASED COBB ANGLE IN ADOLESCENT IDIOPATHIC SCOLIOSIS

Takahiro Shibata, MD, PhD; Kazuki Takeda, MD, PhD; Satoshi Suzuki, MD, PhD; Toshiki Okubo, MD, PhD; Masahiro Ozaki, MD, PhD; Osahiko Tsuji, MD, PhD; Narihito Nagoshi, MD, PhD; Morio Matsumoto, MD, PhD; Masaya Nakamura, MD, PhD; Kota Watanabe, MD, PhD

Hypothesis
Bone mineral density (BMD) is associated with the curve severity of adolescent idiopathic scoliosis (AIS).

Design
A retrospective study of 348 surgically treated AIS patients.

Introduction
Few studies have examined the relationship between curve severity and BMD in large cohort. In this study, we investigated the relationship between preoperative BMD and anthropometric and radiographic parameters in AIS patients who underwent surgery.

Methods
A total of 501 AIS patients (54 males, 447 females) who underwent posterior corrective fusion were retrospectively reviewed. Skeletal maturity was assessed by Risser grade, and 348 patients (44 males, 304 females) who reached Risser grade 4 or 5 were selected from the population for study. Proximal femur BMD were assessed using dual-energy X-ray absorptiometry (DEXA). All patients were classified into normal (N group; Z-score>1) or low (L group; Z-score≦1) BMD group. Preoperative radiographic parameters (Cobb angle, C2-7 angle, TK, LL) were compared between the two groups. Furthermore, based on the Lenke classification, radiographic parameters were compared between the two groups in each curve type. Multiple regression analysis was conducted to identify the independent risk factors of curve severity. Correlation analysis of the Z-scores of BMD with BMI and Cobb angle was also conducted.

Results
Of the 348 patients, 242 (70%) were in the N group and 106 (30%) in the L group. BMI was 19.6±2.3 kg/m2 in the N group and 17.9±1.9 kg/m2 in the L group. The Cobb angle was significantly larger in the L group (59.3±11.8°) compared to the N group (51.4±9.1°; p<0.01), with no significant differences in sagittal parameters. 189 (54%) were classified as Lenke type 1 and 78 (22%) as Lenke type 5, with significantly larger Cobb angle in the L group for both curve types. Multiple regression analysis revealed that Z-scores of BMD was the independent factor significantly related to the magnitude of the Cobb angle (B=-0.33, p<0.01). There was a significant positive correlation between Z-score of BMD and BMI (r=0.41, p<0.01) and a significant negative correlation between Z-score of BMD and Cobb angle (r=-0.37, p<0.01).

Conclusion
AIS patient with lower BMD had significantly larger Cobb angles, suggesting an association between low BMD and increased AIS severity. This underscores the potential need for early BMD screening and therapeutic interventions in AIS patients.

136. DEVELOPMENT OF SCOLIVIEW: AN ARTIFICIAL INTELLIGENCE TOOL FOR THE AUTOMATED AND REPRODUCIBLE CALCULATION OF COBB ANGLES

Germán Casabó-Vallés, MS; Gisselle Pérez-Machado, PhD; *Rosa M. Egea-Gámez, MD, PhD*; Judit Sánchez-Raya, MD, PhD; Inmaculada Vilalta-Vidal, MD; Pedro Rubio Belmar, MD, PhD; Judith Salat, PhD; María Gallán, MD; Carles Fabres-Martin, MD; Paloma Bas Hermida, MD; Carmen Martínez-González, MD; Juan Bago, MD, PhD; Marta Gómez, MD; Miquel Bovea, MS; Rafael Gonzalez-Diaz, MD, PhD; Rocio Garcia-Garcia, MS; Amalia Capilla, PhD; Eva García-López, PhD; José Luis García-Giménez, PhD; Teresa Bas, MD, PhD; Salvador Mena, PhD

Hypothesis
Inter-observer variability in Cobb angle(s) calculation is the main cause of diagnosis uncertainty in Adolescent Idiopathic Scoliosis (AIS). Developing an Artificial Intelligence (AI) tool capable of processing any provided anteroposterior spine x-ray image and estimating its Cobb angle(s) without human intervention will provide robust and precise values to support better clinical decision-making.

Design
Multicentre, ambispective

Introduction
AIS is an abnormal lateral curvature of the spine with an unknown cause that affects 3% of the pediatric population worldwide. The gold standard diagnostic test involves manually measuring the spinal column deviation by determining the Cobb angle on a full spine X-ray image. This measurement involves a subjective interpre-

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tation of vertebrae position that increases the risk of Cobb angle(s) miscalculation.

Methods

First, we collected 500 full spine X-ray images from patients under 17 years old with Cobb angles from mild to severe from four reference hospitals in Spain. Each image was anonymized and measured by 3 independent surgeons who annotated the region corresponding to the spine and measured the Cobb angles. In total, we collected 1500 measurements for analysis and AI model training. We have developed a deep learning pipeline featuring two specialized AI models, both based on Convolutional Neural Networks (CNNs). The first model is designed to detect the spine's curvature from X-ray images, providing a preliminary analysis of spinal alignment. The second model advances this analysis by identifying individual vertebrae and accurately estimating the Cobb angles, offering detailed insights into the specific curves of the spine.

Results

Our preliminary analysis, which was conducted on an image subset representing 85% of our image data, reveals that in 88% of the cases, the deviation in Cobb angle measurement by our AI model is less than 5 degrees when compared with the mean of the measurements made by experienced clinicians. These promising initial findings lay a solid foundation for a more in-depth analysis.

Conclusion

We anticipate that our tool ScoliVIEW will be capable of processing any provided anteroposterior spine x-ray image and estimate its Cobb angle(s). Moreover, our tool will be embedded in a web application designed to be fast, simple and intuitive for use by both specialized surgeons and non-specialized clinicians.

137. IMPROVEMENT IN AXIAL ROTATION WITH BRACING REDUCES RISK OF CURVE PROGRESSION IN PATIENTS WITH ADOLESCENT IDIOPATHIC SCOLIOSIS

Michael Fields, MD, BS; Christina C. Rymond, BA; Ritt Givens, BS; Matan Malka, BA; Matthew Simhon, MD; Hiroko Matsumoto, PhD; Gerard F. Marciano, MD; Afrain Z. Boby, MS, BS; Benjamin D. Roye, MD, MPH; *Michael G. Vitale, MD, MPH*

Hypothesis

Pre-brace axial vertebral rotation (AVR) as well as in-brace correction of AVR correlate with progression of Cobb Angle in patients with Adolescent Idiopathic Scoliosis (AIS).

Design

Single-center retrospective cohort.

Introduction

While in-brace coronal plane correction is commonly used as a proxy for brace efficacy, emerging evidence supports the importance of three-dimensional (3D) in brace correction for AIS patients. This study investigated the relationship between axial plane parameters and treatment failure in patients undergoing brace treatment for AIS.

Methods

AIS patients (Sanders 1-5) undergoing Rigo Chêneau bracing at a single institution were included. AVR was determined by utilizing pre-brace and in-brace (3D) spinal reconstructions based on biplanar low dose EOS® radiographs. The primary outcome was treatment failure defined as coronal curve progression >5°. Minimum follow-up was two years.

Results

75 patients (61/75, 81% female) were included in the final cohort. Mean age at bracing initiation was 12.8±1.3 years and patients had a pre-brace major curve of 31.0°± 6.5°. Twenty-five (33%) patients experienced curve progression >5°, and 18 of these 25 required surgical intervention. Patients who progressed had larger in-brace absolute AVR than those who did not progress (5.8°±4.1° vs. 9.9°±7.6°, p=0.003), but also larger initial coronal curve measures. The magnitude of in-brace AVR did not appear to be associated with treatment failure after adjusting for pre-brace major curve (Hazard Ratio (HR): 0.99, 95% Confidence Interval (CI): 0.94-1.05, p=0.833). However, patients with improvement of AVR with bracing had an 85% risk reduction in treatment failure versus those without improvement (HR: 0.15, 95% CI: 0.02-1.13, p=0.066), after adjusting for pre-brace major coronal curve, at final follow-up, 42/50 (84%) patients who did not progress had a Sanders ≥7.

Conclusion

While absolute in-brace rotation was not an independent predictor of curve progression (due to its correlation with curve magnitude), improved in-brace AVR was a significant predictor of curve progression. This study is the first step toward investigating the interplay between three-dimensional parameters, skeletal maturity, compliance, and brace efficacy, setting the stage for an ongoing prospective multicenter study.

Table 1. Baseline characteristics of treatment failure vs. treatment success group

		Treatment Failure		
		No (N=50)	Yes (N=25)	P-Value
Age an Initiation of Bracing (age; mean ± SD)		12.9 ± 1.3	12.5 ± 1.4	0.171
Gender (N (%))	Female	42 (84%)	19 (76%)	0.402
	Male	8 (16%)	6 (24%)	
Sanders Stage (N (%))	2	4 (8%)	6 (24%)	0.097
	3	30 (60%)	11 (44%)	
	4	9 (18%)	7 (28%)	
	5	7 (14%)	1 (4%)	
CORONAL PLANE				
Pre-Brace Major Curve (°; mean ± SD)		28.4 ± 5.2	36.3 ± 5.9	<0.001
In-Brace Major Curve (°; mean ± SD)		16.2 ± 5.8	25.3 ± 7.4	<0.001
Pre to In-Brace Major Curve Correction (°; mean ± SD)		12.2 ± 6.5	11.0 ± 6.2	0.434
In-brace C7-CSVL (cm; mean ± SD)		13.0 ± 10.0	20 ± 15	0.017
In-brace Pelvic Obliquity (°; mean ± SD)		5.0 ± 3.7	5.3 ± 2.8	0.732
AXIAL PLANE				
|In-brace Major Curve Axial Rotation| (°; mean ± SD)		5.8 ± 4.1	9.9 ± 7.6	0.003

Table 1. Baseline characteristics of treatment failure vs. treatment success group

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

PODIUM PRESENTATION ABSTRACTS

138. SOCIOECONOMIC DISPARITY LIMITS OPPORTUNITY FOR CONSERVATIVE MANAGEMENT OF ADOLESCENT IDIOPATHIC SCOLIOSIS

Jennifer A. Dermott, BSc(PT), MSc; Liisa Jaakkimainen, MD, PhD; Teresa To, PhD; Maryse Bouchard, MD, FRCS(C); Andrew Howard, MD, MS; David E. Lebel, MD, PhD

Hypothesis
Socioeconomic status (SES) and healthcare utilization impacts timing of adolescent idiopathic scoliosis (AIS) presentation in public healthcare.

Design
Retrospective case-control

Introduction
Brace treatment minimizes risk of scoliosis progression to surgical range; however, many AIS patients present too late to be considered an ideal brace candidate, contributing to a higher than necessary surgical burden. This study evaluates the association of SES and public healthcare utilization with late AIS presentation to a spine specialist. Late presentation is defined as a Cobb angle ≥50° or >40° and ≤Risser 2.

Methods
All AIS patients aged 10-18 years, seen for initial consultation in a single tertiary care spine program between 2014-21 were linked to provincial health administrative databases. Linked data included: age, sex, body mass index (BMI), Cobb angle, and Risser score. Material deprivation, an area-level poverty index, and individual-level immigration data were proxies for SES. Utilization of health services in the 5 years before presentation was represented by physician outpatient visits stratified by specialty and annual health exams. A comparative analysis was conducted between youth referred late/not late. Variables that increased the probability of late presentation and adjusted odds ratios (OR) were significant at p<0.001.

Results
In total 2732 AIS patients (82% female) were included, average age 14.1 (±1.7, 10.0-17.9), mean Cobb angle 37.6° (±14.4, 10-95°) and BMI 20.4 kg/m2(±5.2, 12.2-54.5). The volume of late referrals was 27% (n=728). A significantly higher proportion of the late cohort were Risser 0-1, in the most materially deprived quintile (Q5), had no annual health exams, and had not seen a paediatrician (Table 1). The probability of presenting late increased with deprivation (Q1=0.22 vs Q5=0.34, OR 1.66) and decreased when the primary care provider was a paediatrician versus a general practitioner (from 0.35 to 0.13, OR 0.3), and with regular annual health exams (0=0.32 vs 5=0.11, OR=0.37).

Conclusion
Lower SES and healthcare utilization both increase the probability of late AIS presentation, limiting opportunities for conservative management. Those having regular annual health exams were least likely to present late, suggesting a possible role for routine screening for scoliosis within a public health care system.

	Entire Cohort (n=2732)	Not Late (n=2004)	Late (n=728)	p=value
PATIENT CHARACTERISTICS				
Age (y), mean ± SD	14.1 ± 1.7	14.2 ± 1.7	13.8 ± 1.6	<0.001
Sex, n (%)				0.3892
Female	2236 (82)	1632 (81)	604 (80)	
Male	496 (18)	372 (19)	124 (20)	
BMI, median (IQR)	19.4 (17.4 to 21.9)	19.2 (17.1 to 21.3)	19.5 (16.8 to 22.2)	0.778
Risser, n (%)				<0.001
0	659 (24)	443 (22)	216 (30)*	
1	240 (9)	149 (7)	91 (13)*	
2	203 (7)	120 (6)	83 (11)	
3	250 (9)	191 (10)	59 (8)†	
4	1052 (39)	832 (42)	220 (30)†	
5	328 (12)	269 (13)	59 (8)†	
SOCIOECONOMIC STATUS				
Immigrant (Y), n (%)	244 (9)	176 (8)	68 (9)	0.6991
Material Deprivation, n (%)				<0.001
Quintile 1 (lowest deprivation)	744 (27)	586 (29)	158 (22)†	
2	706 (26)	526 (26)	180 (25)	
3	513 (19)	364 (18)	149 (20)	
4	416 (15)	295 (15)	121 (17)	
Quintile 5 (highest deprivation)	346 (13)	230 (11)	116 (16)*	
missing	7	3	4	
HEALTHCARE UTILIZATION				
Physician outpatient visits, Median (IQR)	15 (9 to 23)	115 (7.5 to 22.5)	13 (6 to 20)	<0.001
Physician specialty, n (%)				<0.001
Pediatrics	233 (8)	203 (10)	30 (4)†	
Family/General Practice	868 (32)	567 (28)	301 (42)*	
Annual Exams, n (%)				<0.001
0	1314 (48)	875 (44)†	439 (60)*	
1	609 (23)	458 (23)	151 (21)	
2	329 (12)	273 (14)	56 (8)†	
3	240 (9)	196 (10)	44 (6)†	
4	154 (6)	128 (6)	26 (4)†	
5	86 (3)	74 (4)	12 (2)†	
ED Visit (Y), n (%)	1382 (51)	1005 (50)	377 (50)	0.4759

† lower than expected frequency * higher than expected frequency

Table 1

139. EFFECTS OF SCHROTH SCOLIOSIS SPECIFIC EXERCISE IN ADOLESCENT IDIOPATHIC SCOLIOSIS - A PROSPECTIVE, RANDOMIZED CLINICAL TRIAL

Kenny Y. Kwan, MD; Lee Yin Goh, MS; Aldous CS Cheng, BS; Anjaly Saseendran, BS

Hypothesis
Schroth Scoliosis Specific Exercise (SSE) during bracing is more effective than bracing alone in reducing curve progression.

Design
Prospective, randomized, assessor- and statistician-blind clinical trial.

Introduction
The role of Schroth SSE in patients with adolescent idiopathic scoliosis (AIS) who are at high risk of curve progression is controversial. This study was conducted to determine the effectiveness of Schroth SSE during bracing compared with bracing alone in reducing curve progression in AIS at skeletal maturity, according to the SRS-SOSORT criteria.

Methods
This institutional review board approved study (NCT03305185) was conducted in a single centre. Patients diagnosed with AIS who fulfilled the SRS criteria for bracing were randomized to receive Schroth SSE in conjunction with bracing (Group A) or bracing alone (Group B). Power analysis showed that 110 patients were needed to detect a 29% difference in curve control rates (deterioration of Cobb>=6deg) between the 2 groups, and an attrition rate of 15%. Follow-up was performed at 3

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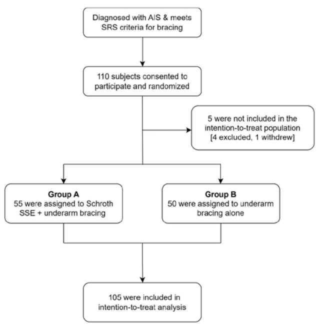
months, 6 months, 12 months and annually until skeletal maturity. Data and EOS imagings were collected and analysed by blinded assessors and statistician.

Results

There was no difference in age, gender, pretreatment curve magnitude or stage of skeletal maturity between the 2 groups. There was no significant difference in brace compliance between the 2 groups (12.2±6.1 hr vs 13.0±6.7 h, p=0.51, 95% CI -3.5-1.7). The overall SSE compliance was assessed by: (1) mean number of days of exercise per week (4.2±1.9); (2) mean therapy attendance (88.0±15.8%); and (3) mean objective score by therapist (80.2±22.3%). At skeletal maturity, 23.5% of patients progressed ≥6o in Group A vs. 31.1% in Group B (p=0.49, 95% CI 0.3-1.9). 9.8% of patients in Group A reached the surgical threshold (Cobb ≥50o) vs. 13.3% in Group B (p=0.75, 95% CI 0.2-3). There was no significant difference between the 2 groups in any of the patient-reported outcome scores (SRS-7, EQ-5D-5L, TAPS and NRS). No serious adverse events occurred in both groups.

Conclusion

In AIS patients who were at high risk of curve progression, this prospective randomized clinical study showed that Schroth SSE during bracing did not reduce curve progression rate nor rate of progression to the surgical threshold compared with bracing alone.



Primary Efficacy Analysis (ITT Population)

	Experimental	Control
Improved/ Unchanged (Cobb angle change ≤ 6°)	39 (76.5%)	31 (68.9%)
Progressed (Cobb angle change >6°)	12 (23.5%)	14 (31.1%)
Total	51	45

p=0.4918; 95% confidence interval: 0.2490, 1.8524; odds ratio 0.6841 (Fisher's Exact test)

Surgical Threshold Proportion (ITT Population)

Cobb angle ≥50°	**Experimental**	**Control**
Surgical Threshold Proportion	5/51 (9.80%)	6/45 (13.33%)

Remarks: Total number of subjects is the number of subjects who had non-missing value in all visits.

Patient-reported Outcome Measures (SRS-7, EQ-5D-5L, TAPS and NRS) for Both Groups (ITT Population)

Variable	Group	Baseline	Last visit	Changes from Baseline to Last visit	w	*p* value	R (rank biserial)
SRS-7	A	4.00 (0.51)	3.96 (0.48)	0.156 (1.12)	774	0.9569	-0.01
	B	3.82 (0.36)	3.80 (0.54)	1.11E-16 (0.65)			
EQ-5D-5L (Index value)	A	0.94 (0.11)	0.95 (0.09)	0.05 (0.23)	807.5	0.7863	0.04
	B	0.94 (0.09)	0.94 (0.09)	-0.001 (0.13)			
EQ VAS	A	84.63 (11.56)	84.23 (15.39)	4.31 (23.82)	771.5	0.9371	0.04
	B	79.22 (16.72)	83.35 (12.63)	5.63 (21.90)			
TAPS	A	3.84 (0.66)	3.94 (0.42)	0.35 (1.23)	872	0.3646	0.12
	B	3.77 (0.58)	3.77 (0.52)	0.03 (0.67)			
NRS	A	0.42 (0.88)	0.44 (1.39)	0.08 (1.09)	726.5	0.547	-0.07
	B	0.47 (1.15)	0.71 (1.28)	0.21 (1.58)			

Group A = SSE + Bracing, Group B = Bracing alone. W = Mann-Whitney U test, significant level at 0.05.
SRS-7 = Scoliosis Research Society-7 questionnaire; mean score 5= best, 1= worst.
EQ-5D-5L = EQ-5D-5 level; lower index value = better QoL.
EQ-VAS = EQ Visual Analogue Scale; as a measure of self-rated health status, 100 = best, 0 = worst.
TAPS = Trunk Appearance Perception Scale; 1 = greatest deformity, 5 = smallest deformity.
NRS = Numeric Rating Scale, higher the scoring indicated higher level of pain experienced.
Values are expressed as mean and SD.

140. RAPID RESPONSE DURING SPINAL DEFORMITY SURGERY CAN SUCCESSFULLY SAVE SPINAL CORD FUNCTION USING INTRAOPERATIVE MONITORING

Munish C. Gupta, MD; Alekos A. Theologis, MD; Ganesh Swamy, MD, PhD; Go Yoshida, MD, PhD; Michael P. Kelly, MD; Thorsten Jentzsch, MSc; Samuel Strantzas, MSc, DABNM; Saumyajit Basu, MS(Orth), DNB(Orth), FRCSEd; Kenny Y. Kwan, MD; Justin S. Smith, MD, PhD; Ferran Pellisé, MD, PhD; So Kato, MD, PhD; Zeeshan M. Sardar, MD; Christopher P. Ames, MD; Kristen E. Jones, MD, FAANS; Anastasios Charalampidis, MD; Brett Rocos, MD, FRCS; Lawrence G. Lenke, MD; Stephen J. Lewis, MD, FRCS(C)

Hypothesis

Intra-operative neuromonitoring (IONM) is used in spinal deformity surgery to detect changes in neural function which can be reversed with rapid response to prevent neural deficits.

Design

Prospective

Introduction

IONM is used in spinal surgery to detect changes in neural function to prevent neural deficits. We assessed the use of IONM and rapid response in preventing neurologic deficits during complex cord-level deformity surgeries.

Methods

20 centers prospectively collected data on pts. undergoing surgery. We included ages 10-80 yrs., neuro intact, Cobb>80° or spinal osteotomy with EMG, SSEP, and MEP and detailed neuro exams. IONM changes with amplitude loss of >50% in SSEP or MEP from baseline or sustained EMG activity lasting >10 seconds. Types and rates of IONM alerts and intra-operative responses were assessed.

Results

349 pts. with 16% having alerts. Ave. age 23.4±17.2 yrs., F (77.2%) primary surgery (82.5%) for scoliosis (77.2%) or kyphosis (24.6%) a posterior-only (99.4%; mean levels 12.2±3.3). Osteotomies 93% [PCO (type 2)-43, PSO (type 3/4)–5, VCR (type 5/6)–10]. The pts. with alerts had larger Cobb (73.4° v. 61.3°; p=0.008) and deformity angular ratios (DAR) (11.0 vs. 8.3; p<0.001). There were 81 alerts with 1-alert (71.2%), 2-alerts (19.3%) and 3-alerts (19.3%). MEP alerts (76.5%; unilateral-53.2%; bilateral-46.8%). Combined MEP+SSEP alerts in 17.5%. Events before the alert were release/osteotomy (57.9%), correction/rod placement (21.1%), and instrumentation placement (18.4%). Osteotomy/release was the common cause of unilateral IONM alerts and rod placement/correction was for bilateral IONM alerts. Rapid response (i.e., anesthesia, rod and/or implant) reversed 80% of the IONM changes. There were 25.0% new neurological deficits, 21.4% root dysfunction (LEMS decrease), and 5.8% had sensory dysfunction. Nerve roots deficits in 4.9% of patients without alerts (i.e., false negatives). No spinal cord syndrome occurred without alerts (cord-level false negative).

PODIUM PRESENTATION ABSTRACTS

Conclusion
MEP changes occur more commonly in patients with larger Cobb and DARs. The majority (80%) of alerts can be reversed with rapid response. There were no false negatives for cord syndromes, but 4.9% false negative rate in detecting nerve root level deficits highlighting the need for more sensitive detection modalities for nerve root function.

141. THE EFFECT OF INTRAVENOUS INFUSION OF LIDOCAINE ON INTRAOPERATIVE NEUROPHYSIOLOGICAL MONITORING DURING ADOLESCENT IDIOPATHIC SCOLIOSIS SURGERY

Mohd Shahnaz Hasan, MBBS; Chong Huey Nee, MBBS; Lee Zheng-Yii, PhD; *Chee Kidd Chiu, MBBS, MSOrth*; Chris Yin Wei Chan, MD, MSOrth; Mun Keong Kwan, MBBS, MSOrth; Siti Nadzrah Yunus, MBBS

Hypothesis
Intravenous (IV) lidocaine used as an analgesic adjunct perioperatively to reduce opioid consumption has an effect on intraoperative neurophysiological monitoring (IONM).

Design
Retrospective study

Introduction
Intravenous (IV) lidocaine is increasingly used as an analgesic adjunct to reduce opioid consumption but studies evaluating its effect on intraoperative neurophysiological monitoring (IONM) is limited. The aim of this study is to evaluate the effect of IV lidocaine on both somatosensory evoked potential (SSEP) and motor evoked potential (MEP) in adolescent idiopathic scoliosis (AIS) surgery.

Methods
We performed a retrospective analysis of 115 patients from 2020 to 2023. All patients received total intravenous anaesthesia (TIVA). 59 patients who received IV lidocaine (Lidocaine group) was given 1.5 mg/kg bolus at induction followed by 2 mg/kg/hour infusion until wound closure. The data from these patients was matched to 56 patients who did not receive lidocaine. 2 neurophysiologists reviewed the SSEP and MEP recordings. Measurements were obtained at different time points: T0 at pre-operative baseline, T1 at 10 minutes post induction and T2 at wound closure.

Results
Demographic data was similar between the groups. There were no differences in the MAP, HR, temperature, and depth of anesthesia. The MEP amplitudes over the right tibialis anterior and bilateral abductor hallucis were significantly lower at both T1 and T2 time points in the Lidocaine group. MEP latency was similar between the 2 groups. For SSEP, significant reduction of bilateral cortical amplitudes and significantly prolonged left cortical latency were noted at T1 and T2 time points in the Lidocaine group. ($p<0.05$ were considered significant for all measurements)

Conclusion
IV lidocaine infusion given as an analgesic adjunct during TIVA in AIS surgery caused a significant reduction in SSEP and MEP amplitudes and an increase in SSEP latency. Future randomised controlled trial should be performed to confirm the above findings.

142. INTENSIVE REHABILITATIVE TREATMENT FOR AIS PATIENTS WITH A MAJOR CURVE OF 40-60° WHO REFUSED SURGERY

Tianyuan Zhang, PhD; Wenyuan Sui, MD; Yaolong Deng, MD; Huang Zifang, MD, PhD; Junlin Yang, MD, PhD

Hypothesis
This study introduced the protocol of intensive rehabilitative treatment comprising of bracing management and physiotherapeutic scoliosis-specific exercises (PSSE) and evaluated its effectiveness in AIS patients with a major curve of 40-60° who refuse surgery.

Design
A prospective cohort study.

Introduction
Current guidelines for brace management of AIS are mostly recommended for curves between 25° to 40°. For curves >40°, surgery is often considered since bracing may be less effective. However, there are still some patients and families who refuse operation. Therefore, further research is necessary to determine optimal bracing management in this group.

Methods
10-18 years old AIS patients having 40-60°curves and a Risser grade of 0-3, but firmly refusing surgery were eligible. A total of 82 patients were recruited. The primary outcome was defined as "success" when the main curve was below 50° upon reaching skeletal maturity, and "failure" if otherwise. The secondary outcome was defined as improved (>5° reduction), unchanged (≤5° change) or progressed (>5° increase) based on the evolution of the main curve. The per protocol (PP) and intent to treat (ITT) analyses were performed to quantify success rates, while the dropouts were considered as failures. Risk factors associated with bracing failure were identified and a receiver operating characteristic (ROC) curve was used to determine the cut-off value.

Results
A total of 77 patients completed the treatment, while 5 dropped out. The average main curve was 47.40±5.93° at baseline and 38.56±11.85° at last follow-up ($P<0.001$). Our management was successful in 83% and 78% of patients based on the PP and ITT analyses, respectively. When compared with the curve magnitude at baseline, 65% patients improved, 30% remained unchanged, and 5% progressed when using a 5° threshold. Univariate comparison and logistic regression analysis demonstrated that patients with successful outcomes had a significantly smaller baseline curve, larger Risser Stage, and larger in-brace correction (IBC) rate.

Conclusion
For AIS patients with 40-60° curves who refused surgery, our intensive bracing management along with PSSE was practical and effective, achieving success in 78% of

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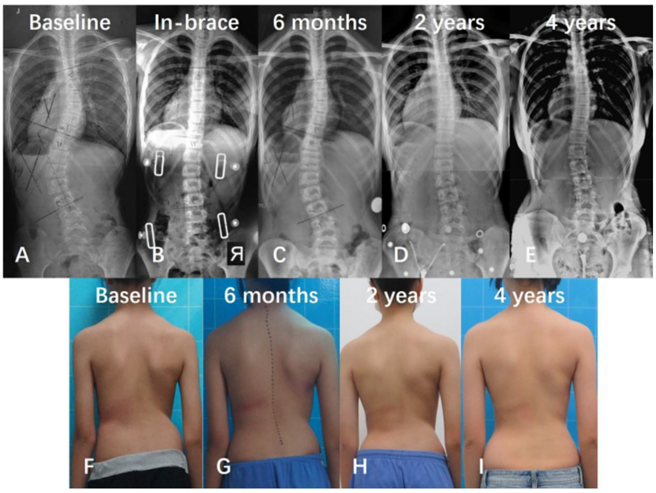
patients based on an ITT analysis. A larger baseline curve, smaller Risser Stage, and smaller IBC rate were associated with treatment failure.



An AIS case with lumbar curve of 50°

143. OPTIMAL SELECTION OF LOWER INSTRUMENTED VERTEBRA CAN MINIMIZE DISTAL JUNCTIONAL KYPHOSIS AFTER POSTERIOR SPINAL FUSION FOR THORACIC ADOLESCENT IDIOPATHIC SCOLIOSIS

Yusuke Hori, MD, PhD; Akira Matsumura, MD, PhD; Takashi Namikawa, MD, PhD; Norihiro Isogai, MD, PhD; Luiz Silva, MD; Burak Kaymaz, MD; Petya Yorgova, MS; Peter G. Gabos, MD; Nicholas D. Fletcher, MD; Michael P. Kelly, MD; Harry L. Shufflebarger, MD; Peter O. Newton, MD; Burt Yaszay, MD; Paul D. Sponseller, MD, MBA; Baron S. Lonner, MD; Amer F. Samdani, MD; Firoz Miyanji, MD; Harms Study Group; Suken A. Shah, MD

Hypothesis
Utilizing sagittal stable vertebra (SSV) and preoperative distal junctional angle (DJA) can provide the optimal selection of the lowest instrumented vertebra (LIV) to prevent distal junctional kyphosis (DJK).

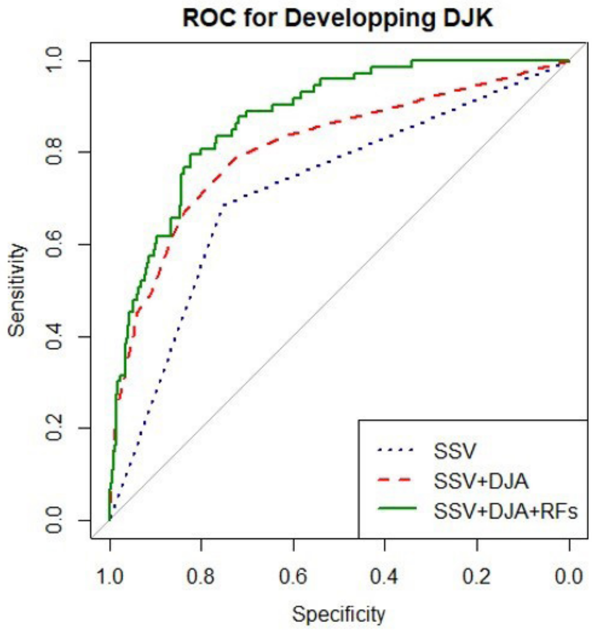
Design
A retrospective cohort study of a prospectively collected multicenter database

Introduction
While including the SSV may minimize DJK following posterior spinal fusion (PSF) for AIS, relying solely on the SSV criteria can necessitate more extensive fusion. As LIV moves distally, a patient's motion, function, and chance of reoperation may all be negatively affected.

Methods
This study included patients with Lenke 1 or 2 curves who underwent thoracic PSF (defined as LIV≤ L1), and the development of DJK (DJA≥10°) was evaluated two years postoperatively. Preoperative DJA was measured between LIV and LIV+1, consistent with the postoperative measurements, and categorized into three groups: neutral/lordosis (≤0°), slight kyphosis (1° to 4°), and significant kyphosis (≥5°). Multiple logistic regression model identified risk factors for developing DJK. The DeLong's test compared the area under the curve (AUC) from different ROC curves to assess DJK predictive accuracy between models.

Results
Out of 1,034 patients, 86 (8%) developed DJK at two years postoperatively. Risk factors identified for DJK include preoperative DJA categories of slight kyphosis (adjusted odds ratio (aOR): 2.65) and significant kyphosis (aOR: 6.63); LIV at SSV-2 or higher (aOR: 4.09); a UIV of T2 or above (aOR: 3.39) ; lumbar modifiers B (aOR: 2.91) and C (aOR: 2.70); and larger T5-12 kyphosis (aOR: 1.04). Incorporating preoperative DJA and SSV-1 for LIV selection enhanced DJK prediction accuracy over solely considering SSV inclusion (AUC = 0.81 vs 0.72, p<0.001) (see Figure). Furthermore, a multivariate model with risk factors achieved the highest AUC (0.87). Patients with DJK experienced a worsening of T10-L2 kyphosis and increased upper lumbar lordosis over time, without affecting the SRS-22 quality of life score.

Conclusion
To prevent DJK, PSF should end below preoperative kyphosis and no more proximal than SSV-1 in patients with thoracic AIS, particularly for high-risk cases. DJK led to worsened regional thoracolumbar alignment at two-year follow-up.



ROC for developing DJK with different prediction models. RFs: risk factors.

144. IS NEXT-DAY DISCHARGE AFTER POSTERIOR SPINAL FUSION FOR ADOLESCENT IDIOPATHIC SCOLIOSIS SAFE?

Alyssa Barre, MD; Andrew Kirk, MD; Vincent Prusick, MD; Ryan D. Muchow, MD; Caitlin Conley, PhD, Vishwas R. Talwakar, MD

Hypothesis
We hypothesized that next-day discharge after posterior spinal fusion for adolescent idiopathic scoliosis would not result in an increase in emergency department visits or hospital readmissions.

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Design
Retrospective cohort study

Introduction
While the implementation of post-operative protocols and improvements in pain control have decreased the length of stay following scoliosis surgery, adolescents are typically hospitalized for several days after posterior spinal instrumented fusion (PSF). The purpose of this study was to determine if next-day discharge after PSF for adolescent idiopathic scoliosis (AIS) was associated with an increase in emergency department (ED) visits or hospital readmissions. The secondary purpose was to examine peri-operative factors associated with next-day discharge.

Methods
We performed a retrospective study of all patients who underwent PSF for AIS at a single institution from 2017 to 2022. One hundred eleven patients were included. We compared patients based on post-operative length of stay with an early discharge group consisting of those who discharged on the first post-operative day (POD1) (n = 40) and a late discharge group consisting of those who discharged after POD1 (n = 71). We documented post-operative ED visits within 30 days and hospital readmissions within 90 days, in addition to peri-operative variables.

Results
Forty patients (36%) discharged on POD1. There was one (2.5%) ED visit and two (5%) readmissions in the early discharge group and three (4.2%) ED visits and two (2.8%) readmissions in the late discharge group (p = 0.64 and 0.55, respectively). Patients in whom intravenous methadone was used intra-operatively were more likely to discharge POD1 (p = 0.02). There were no other significant differences in peri-operative variables between the two groups including: BMI, distance from home to hospital, magnitude of main curve, curve flexibility, number of levels fused, estimated blood loss, implant density, operative time, or post-operative pain scores.

Conclusion
Over one-third of patients discharged on POD1 after PSF for AIS. There was no statistically significant difference in ED visits or hospital readmissions among the early discharge group. Next-day discharge after PSF for AIS is safe for some patients. Further research may help identify patients prior to surgery who are likely to discharge on POD1.

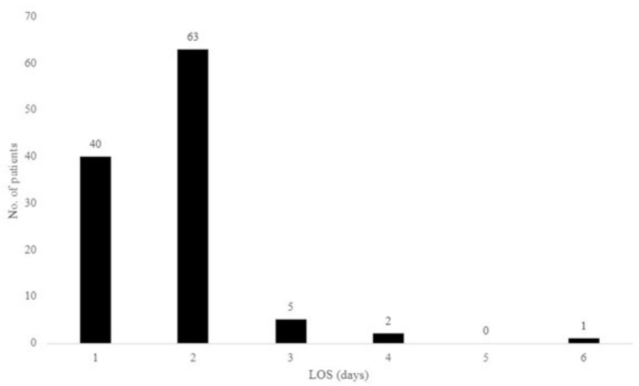

Figure 1: Bar chart depicting the length of stay (LOS).

145. LOCAL WOUND INFILTRATION REDUCES ACUTE POSTOPERATIVE OPIOID REQUIREMENTS IN ADOLESCENT IDIOPATHIC SCOLIOSIS ‡

Craig M. Birch, MD; Sydney Lee, BS; K. Mikayla Flowers Zachos, MA; Grant D. Hogue, MD; M. Timothy Hresko, MD; Shanika De Silva, PhD; Daniel Hedequist, MD

Hypothesis
Local wound infiltration will result in reduction of opioid use in the first 24 hours following posterior spinal fusion (PSF) in Adolescent Idiopathic Scoliosis (AIS) patients compared to the placebo group.

Design
Double-blind randomized controlled trial (RCT)

Introduction
Local wound infiltration is a non-narcotic method of acute pain management following surgical intervention. This RCT aimed to determine the impact of wound infiltration with 0.25% bupivacaine with epinephrine, compared to a placebo of equal volume injectable saline, on pain and opioid consumption during the first 24 hours postoperatively in patients with AIS undergoing PSF.

Methods
AIS patients, ages 10-17 years old, undergoing PSF were randomized to receive intraoperative wound infiltration with 0.25% Bupivacaine+epinephrine (treatment) or saline (placebo). Postoperatively, patients rated their pain using an 11-point numeric rating scale, 0 to 10. Inpatient pain scores and opioid administration were extracted from medical records. Four 6-hour intervals were created to assess average pain scores and total opioids administered during the first 24 hours. Linear mixed models were used to analyze differences between treatment groups in pain scores and opioid consumption over time.

Results
57 patients were included (mean age 14.9 years, mean BMI 21.3): 27 randomized to the treatment group and 30 to placebo. Patients were predominantly female (75%), White (86%), and non-Hispanic (86%). There was no statistically significant difference in pain between treatment groups during the 24-hour postoperative period, however pain did decrease across time for the entire cohort by approximately 1 point per interval (Figure A). Patients in the treatment group consumed significantly less opioids during the first 24 hours, with the placebo group receiving an average estimated 6 MME/kg more compared to the treatment group (Figure B, p=0.05). Difference at Interval 1 was most notable with average 36.1 MME/kg in placebo group compared to 26.0 MME/kg in the treatment group. Opioid consumption decreased over time, with Interval 4 showing a significant reduction compared to the Interval 1, demonstrating an estimated mean decrease of 13 MME/kg (p<0.001).

Conclusion
Local anesthetic injection of 0.25% bupivacaine with epinephrine can effectively decrease postoperative opioid consumption in AIS patients in the first 24 hours, without compromising pain control.

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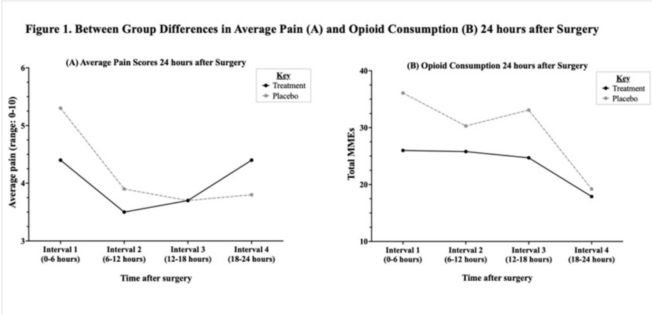

146. OUTCOMES OF REVISION SURGERIES FOLLOWING INDEX ANTERIOR VERTEBRAL BODY TETHERING

Cleopatra Nehme, BS; Amer F. Samdani, MD; Joshua M. Pahys, MD; Taemin Oh, MD; Jessica Steindler, BA; Sarah Nice, BS; Kaitlin Kirk, BS; Amanda Stutman, BS; Camille Brown, BS; Natalie Williams, BS; Steven W. Hwang, MD

Hypothesis
Revision aVBT (rVBT) can be a successful salvage procedure following index aVBT.

Design
Retrospective single-center study

Introduction
Anterior vertebral body tethering (aVBT) is an alternative to treat scoliosis, but the need for revision surgeries remains a concern. This study aims to assess the outcomes and characteristics of patients undergoing successful revision surgeries.

Methods
We reviewed all patients who underwent revision surgery following aVBT with idiopathic scoliosis and at least 2 years of follow-up. We divided patients into 4 groups: fusion, tether release, retethering, and miscellaneous. Baseline and follow-up demographic and radiographic measures were compared across the groups. Success was defined as no additional surgeries after revision and the largest Cobb <35° at last follow-up.

Results
87/388 (22%) patients underwent revision surgery [36 (9%) fusion, 28 (7%) rVBT, 17 (4%) release, 2 (2%) miscellaneous]. The mean age at index aVBT was 12.4 ± 1.5 years (91% female) and 56.3 ± 21.4 months of follow-up. The mean preoperative thoracic and lumbar Cobb angles were 55.8 ± 11.5° and 37.5 ± 13.2°, respectively. As expected, the tether release group was less skeletally mature, had smaller curves, were more flexible, and had greater correction of first erect (p<0.05) (Table). At revision surgery, they also had less EBL and shorter OR times (p<0.05). Comparatively, the fusion group had larger curves on first erect, larger Cobb angles at revision surgery, and greater EBL at revision surgery (p<0.05). Within the tether release group, 82% had successful outcomes compared to 61% the rVBT group and 100% in the fusion group. The tether release group had a mean of 44.6 ± 20.2 months of follow-up following revision, compared to 31.0 ± 21.1 and 10.6 ± 11.7 months for rVBT and fusion, respectively. When comparing successful to unsuccessful rVBT patients, most variables were not significantly different: mean index age, revision age, curve size, flexibility, first erect correction (p>0.05). The follow-up was longer in the unsuccessful group (41 vs. 25 months, p<0.01). Patients who were skeletally less mature had a trend towards greater success (p=0.08).

Conclusion
Our results suggest that 39% of rVBT, 18% of tether release, and 0% fusion revision surgeries after aVBT are unsuccessful and may require more surgery. rVBT may be more successful in less skeletally mature patients.

	Revision Surgery Type			p value		
	Retethering (rVBT)	Tether Release/Removal (TR)	Fusion	TR vs rVBT	TR vs Fusion	Fusion vs rVBT
Age at Index Procedure (Years)	12.1 ± 1.6	12.5 ± 1.6	12.7 ± 1.4	0.45	0.75	0.17
PreOp Thoracic Cobb Angle (Degrees)	57.3 ± 10.2	44.1 ± 11.1	60.3 ± 8.7	<0.05	<0.05	0.22
PreOp Lumbar Cobb Angle (Degrees)	40.5 ± 14.7	29.5 ± 13.2	39.0 ± 10.5	<0.05	<0.05	0.65
PreOp Sanders (Median)	3	3	3	0.99	0.75	0.28
PreOp Risser (Median)	0	0	0	0.63	0.76	0.36
PreOp Open Triradiate	21 (75.0%)	14 (58.9%)	12 (70.6%)	0.56	<0.05	<0.05
FE Thoracic Cobb Angle (Degrees)	31.8 ± 9.5	20.7 ± 9.0	38.6 ± 9.6	<0.05	<0.05	<0.05
FE Lumbar Cobb Angle (Degrees)	20.5 ± 11.6	14.2 ± 8.3	23.3 ± 10.9	0.05	<0.05	0.35
Latest Thoracic Cobb Angle (Degrees)	27.0 ± 13.8	17.5 ± 12.0	17.2 ± 16.1	<0.05	0.99	<0.05
Latest Lumbar Cobb Angle (Degrees)	16.5 ± 11.1	17.7 ± 10.1	14.9 ± 11.5	0.72	0.38	0.58
Months from Index to Revision	25.8 ± 12.5	22.3 ± 10.2	44.0 ± 16.5	0.32	<0.05	<0.05
Months from Revision to Latest Follow-Up	31.0 ± 21.1	44.6 ± 20.2	10.6 ± 11.7	<0.05	<0.05	<0.05

147. OUTCOMES OF ANTERIOR VERSUS POSTERIOR GROWTH MODULATION SURGERY FOR ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS)

Glenys Poon, MBBS, MRCS; Leok-Lim Lau, FRCS; Hee-Kit Wong, FRCS; Gabriel KP Liu, MD

Hypothesis
There is no outcome difference between anterior and posterior growth modulation devices in treatment of AIS

Design
Prospective cohort study.

Introduction
Anterior growth modulation via vertebral body tethering (VBT) is well described. However studies on posterior growth modulation via posterior dynamic fixation(PDF) are limited with no direct comparison of anterior to posterior growth modulation devices.

Methods
A prospective review of all Lenke 1 patients undergoing selective thoracic growth modulation procedures for AIS. Patient demographics, surgical, clinical and radiological data was collected.

Results
7 patients underwent a VBT and 12 underwent a PDF. Patients were followed up across a mean duration of 32.4±12.6 months. There was no significant difference in baseline gender, age, Risser and preoperative lumbar curve between cohorts. Preoperative main thoracic (MT) curve size was lower in the VBT group at 37.9±6.0 deg as compared to the PDF group at 49.1±6.99 deg. There was a shorter length of stay in PDF patients at 3.5±0.5 days as compared to AVT patients who stayed for 4.8±0.4 days. (p<0.001) but no difference in blood loss and operative duration. All VBT patient had a chest tube and overnight

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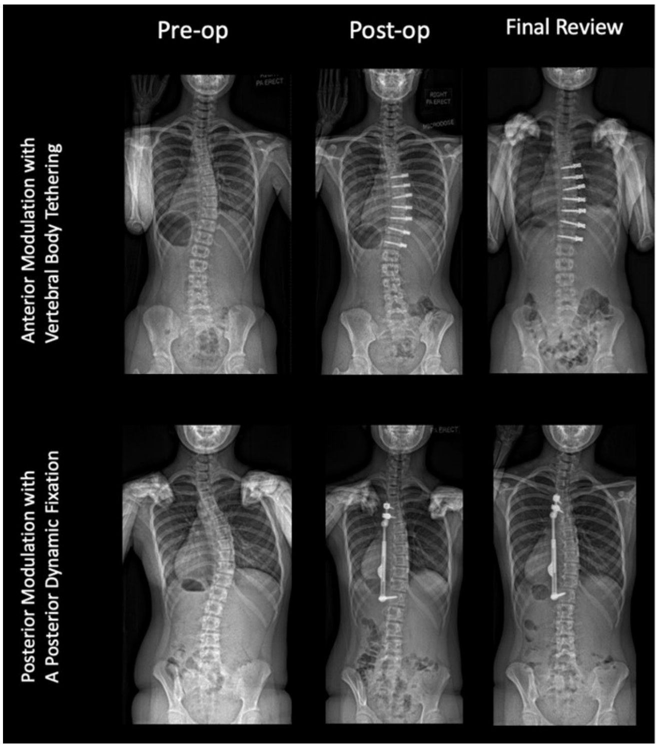
ICU stay post op. Immediate post op the PDF group had better main thoracic(MT) curve correction at 20.0±10.0 deg(60.1±18.2%) as compared to 22.0±7.3 deg(42.5±12.2%)(p=0.016) in the VBT group. However by final follow up the VBT group trended towards better curve maintenance with a size of 22.0±12.7 deg and a 0.0±7.4 deg change in curvature whereas the PDF had a final curve of 26.5±12.3deg and a -7.0±9.8 deg change in curvature(p=0.061). The compensatory lumbar correction likewise showed greater correction in the PDF group at 17.6±9.7 deg(45.7±15.8%) as compared to the VBT group at 21.3±10.0 deg(25.1±17.2%). By final follow up there was no difference in curvature between groups. There was higher incidence of implant breakage in the VBT(n=3) as compared to the PDF(n=0)(p=0.013). However there was no difference in re-operations or loss of curve correction. Overall there was no difference in patient reported outcome scores.

Conclusion

Early review suggests an advantage of the PDF in terms of length of stay, avoidance of ICU stay and initial correction power. However there was no difference in outcomes on mid to long term follow up.



Radiographs of patients who underwent VBT (top) and PDF (bottom).

148. WHEN IS GROWTH THE GREATEST? SPINE AND TOTAL BODY GROWTH IN IDIOPATHIC SCOLIOSIS THROUGH SANDERS MATURATION STAGES 2, 3A, 3B, AND 4

Yusuke Hori, MD, PhD; Bryan Menapace, MD; Norihiro Isogai, MD, PhD; Sadettin Cifti, MD; Burak Kaymaz, MD; Luiz Silva, MD; Kenneth J. Rogers, PhD; Petya Yorgova, MS; Peter G. Gabos, MD; *Suken A. Shah, MD*

Hypothesis

Different Sanders Maturation Stages (SMS) are characterized by variations in spine and total body growth rates, which have obvious implications for treatment

Design

Single-center, retrospective, case-control, longitudinal study

Introduction

SMS 2,3 and 4 represent periods of rapid growth and are key indicators for growth modulation surgery of the spine and lower extremity. The purpose of this study was to evaluate spine and total body growth through SMS 2, 3A, 3B, and 4 and correlate with scoliosis progression.

Methods

This study evaluated consecutive patients with idiopathic scoliosis staged SMS 2-4. T1-S1 spine height, total body height, and curve magnitude were measured at each visit. Spine and total height velocity as well as curve progression rate were assessed between baseline and follow-up visits. For those followed to skeletal maturity, overall height gain and scoliosis progression were assessed. To adjust for height loss due to scoliosis, spine and total body height were corrected for curve magnitude using validated formulae. Kruskal-Wallis test and multivariate linear regression models were employed to determine the influence of SMS on height growth and scoliosis progression.

Results

517 patients (68% female) with 566 hand radiographs and 1,492 spinal X-ray images were included. Spine height velocity peaked during SMS 3A and was approximately 1.4 times that of stage 2, 1.5 times that of stage 3B, and 1.8 times that of stage 4 (see image). SMS 2 and 3A had comparable total body height velocities, both greater than SMS 3B and 4 (see image). Curve progression rates were consistent across SMSs. Among those followed to skeletal maturity, patients at SMS 2 exhibited the highest growth remaining and the greatest potential for scoliosis progression.

Conclusion

This study demonstrated that peak spine growth occurred at SMS 3A, while total body height exhibited its fastest growth during SMS 2 and 3A. These patients exhibit greater potential for height growth and scoliosis progression. These findings are critical for optimizing the timing of interventions in growth modulation surgery and scoliosis treatment strategies.

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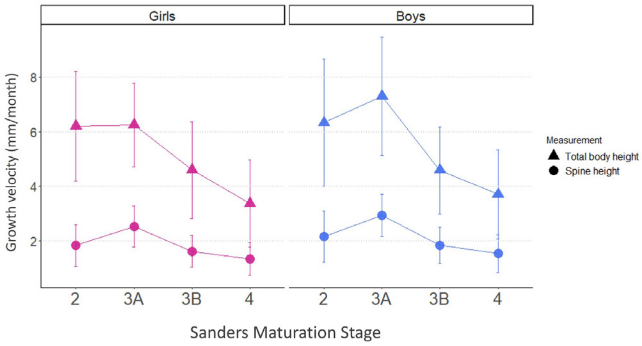

Growth velocity in spine and total body height through Sanders Maturation Stage 2, 3A, 3B, and 4. Dots indicate the mean value and error bars indicate standard deviation.

149. WHICH COMPLICATIONS IMPACT SATISFACTION AMONG PATIENTS WITH ADULT SPINAL DEFORMITY (ASD)?

Kojo D. Hamilton, MD, FAANS; Rohit P. Kumar, BA; Nitin Agarwal, MD; Lawrence G. Lenke, MD; Peter G. Passias, MD; Eric O. Klineberg, MD; Virginie Lafage, PhD; Shay Bess, MD; Justin S. Smith, MD, PhD; Jeffrey L. Gum, MD; Renaud Lafage, MS; Jeffrey Mullin, MD; Michael P. Kelly, MD; Bassel G. Diebo, MD; Thomas J. Buell, MD; Justin K. Scheer, MD; Breton G. Line, BS; Han Jo Kim, MD; Khaled M. Kebaish, MD; Raj S. Lavadi, MBBS; Robert K. Eastlack, MD; Alan H. Daniels, MD; Alex Soroceanu, MD, FRCS(C), MPH; Gregory M. Mundis Jr., MD; Richard Hostin, MD; Themistocles S. Protopsaltis, MD; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; International Spine Study Group

Hypothesis
Neurological complications result in lower satisfaction compared to those that are mechanical or treatable in nature.

Design
Multicenter, prospective cohort

Introduction
Surgical management of ASD has a well-cited complication profile. Of note, a subset of patients who experience a perioperative complication still express post-surgical satisfaction. This study strives to identify the characteristics of complications that influence levels of satisfaction.

Methods
Data was obtained from a multicenter cohort of patients with ASD, who developed postoperative complications within two years of follow-up. Satisfaction was determined by the SRS-22 satisfaction subscore. Demographic and spinopelvic parameters at baseline and two years were recorded. Complication-related variables included latency, frequency, subcategory, and severity (high = major/requiring reoperation and low = minor). The associations between the variables were evaluated with multiple linear regression. Post hoc analysis was conducted of the complication profiles significantly related to satisfaction (p-value < 0.05).

Results
Of the initial 795 patients meeting inclusion criteria, 533 (67.0 %) had at least one complication. The demographic, spinopelvic, and satisfaction parameters are shown in Table 1. On regression, patients with implant-related (β = 0.39, p = 0.006) and infection-related (β = 0.42, p = 0.017) complications were associated with greater satisfaction at two years. Complication frequency was negatively associated with satisfaction at two years (β = -0.14, p = 0.018). Among patients who had an infectious complication, those who developed sepsis were more likely to have worse satisfaction at two years (β = -1.66, p = 0.047). The subcategory of neurologic or implant-related complication was not associated with satisfaction at two years.

Conclusion
Greater complication frequency, likely due to the cumulative effect of multiple complications on recovery, yields poor long-term satisfaction. Patients with implant-related or infectious complications tended to have better long-term satisfaction compared to patients with other categories of complications. Likely, sustaining an adverse event with a permanent deficit yields poorer satisfaction, when compared with recoverable adverse events.

Table 1.

	All complications (n = 533)	Surgical neurologic complications only (n = 109)	Implant-related complications only (n=120)	Infectious complications only (n=63)
Age	62.0 ± 12.7 (range 19.8 – 86.6)	62.5 ± 11.7 (range 24.0 – 82.1)	60.6 ± 11.6 (range 20.0 – 79.0)	62.0 ± 11.9 (range 30.2 – 84.3)
Female (%)	417 (78.2)	83 (76.1)	89 (74.1)	52 (82.5)
BMI	28.4 ± 5.8	29.5 ± 6.1	29.0 ± 6.0	30.7 ± 6.7
CCI	2.0 ± 1.8	2.4 ± 0.6	2.0 ± 1.7	2.1 ± 1.7
ASA score	2.5 ± 0.6	2.4 ± 0.6	2.4 ± 0.6	2.5 ± 0.6
Osteoporosis (%)	100 (18.8)	22 (20.2)	17 (14.2)	12 (19.0)
Depression at baseline	130 (24.3)	24 (22.0)	38 (31.7)	11 (17.5)
Depression at two years	75 (14.1)	14 (12.8)	22 (18.3)	4 (6.3)
PI-LL at baseline	19.6 ± 21.4	17.6 ± 20.3	22.9 ± 24.6	25.0 ± 19.9
SVA at baseline (mm)	79.1 ± 73.2	69.9 ± 72.5	91.1 ± 82.2	99.2 ± 76.8
PI-LL at two-years	5.5 ± 15.6	5.3 ± 16.4	10.1 ± 16.8	8.5 ± 12.3
SVA at two-years (mm)	38.8 ± 55.4	46.7 ± 57.9	55.8 ± 53.9	49.1 ± 62.5
Satisfaction				
SRS-22 satisfaction at baseline	2.7 ± 1.0	2.7 ± 1.1	2.8 ± 1.1	2.8 ± 0.9
SRS-22 satisfaction at two years	4.1 ± 1.0	3.9 ± 1.0	4.1 ± 1.0	4.2 ± 0.9

Complication categories		Neurologic complications		Implant-related complications		Infectious complications	
Adverse Event (%)	228 (42.3)	Peroneal nerve palsy (%)	0 (0)	Rod breakage (%)	56 (46.7)	Deep infection (%)	20 (31.7)
Cardiopulmonary (%)	88 (16.5)	Epidural hematoma (%)	1 (0.9)	Screw breakage (%)	16 (13.3)	Clostridium difficile infection (%)	1 (1.6)
Gastrointestinal (%)	56 (10.5)	Femoral neuralgia (%)	2 (1.8)	Screw loose (%)	11 (9.2)	Superficial infection (%)	11 (17.5)
Implant (%)	120 (22.5)	Motor deficit (%)	37 (33.9)	Painful Implant (%)	11 (9.2)	Sepsis (%)	7 (11.1)
Infection (%)	63 (11.8)	Nerve root injury (%)	1 (1.8)	Prominence (%)	8 (6.7)	Pneumonia (%)	10 (15.9)
Neurologic (%)	132 (24.8)	Radiculopathy (%)	52 (47.7)	Interbody dislocation (%)	5 (4.2)	Urinary tract infection (%)	23 (36.5)
Operative (%)	133 (25.0)	Myelopathy (%)	7 (6.4)	Screw medial breach (%)	9 (7.5)	Other infection (%)	5 (7.9)
Radiographic (%)	142 (26.6)	Bowel or bladder deficit (%)	4 (3.7)	Screw vascular impingement (%)	0 (0)		
Renal (%)	8 (1.5)	Sensory deficit (%)	14 (12.8)	Loose dislocation (%)	12 (10)		
Wound (%)	23 (4.3)			Rod dislocation (%)	2 (1.7)		
				Screw nerve impingement (%)	3 (2.5)		

150. PERIOPERATIVE INFECTION PROPHYLAXIS WITH VANCOMYCIN IS A SIGNIFICANT RISK FACTOR FOR DEEP SURGICAL SITE INFECTION IN SPINE SURGERY

Gregory Kazarian, MD; Francis C. Lovecchio, MD; Jung Mok, MD; Yusef Jordan, MD; Mitchell A. Johnson, BS; Takashi Hirase, MD, MPH; Han Jo Kim, MD

Hypothesis
We hypothesize that perioperative use of vancomycin for infection prophylaxis increases the risk of infection compared to cefazolin in primary spine surgery.

Design
This study was a single-center multi-surgeon retrospective review of all patients undergoing primary cervicotho-

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

racic, thoracolumbar, lumbar, or lumbosacral discectomy, decompression, or fusion surgery from an institutional registry.

Introduction

Perioperative infection prophylaxis with cefazolin is an important preventative measure for infection in spine surgery. However, the relative efficacy of alternative regimens is poorly understood.

Methods

Postoperative infection was defined by the combination of three criteria: irrigation and debridement within 3 months of the index procedure, clinical suspicion for infection, and positive intraoperative cultures. Microbiology records for all infections were reviewed to assess the infectious organism and organism susceptibilities. Univariate and multivariate analyses were performed.

Results

A total of 10,122 patients met the inclusion criteria for this study. The overall incidence of infection was 0.78%, with an incidence of 0.73% in patients who received cefazolin and 2.03% in patients who received vancomycin (OR 2.83, 95% CI 1.35-5.91, p-0.004). Use of IV vancomycin (OR 2.83, 95% CI 1.35-5.91, p=0.006), BMI (MD 1.56, 95% CI 0.32-2.79, p=0.014), presence of a fusion (OR 1.62, 95% CI 1.04-2.52, p=0.033), and operative time (MD 42.04, 95% CI 16.88-67.21, p=0.001) were significant risk factors in the univariate analysis. In the multivariate analysis, only non-cefazolin antibiotics (OR 2.48, 95% CI 1.18-5.22, p=0.017) and BMI (MD 1.56, 95% CI 0.32-2.79, p=0.026) remained significant independent risk factors. Neither IV antibiotic regimen nor topical vancomycin significantly impacted Gram type, organism type, or antibiotic resistance (p>0.05). The most common reason for antibiosis with vancomycin was a penicillin allergy (75.0%).

Conclusion

Perioperative prophylactic antibiosis with IV vancomycin leads to a roughly 2.5-times higher risk of infection compared to IV cefazolin when controlled for other risk factors in primary spine surgery. We recommend the routine use of IV cefazolin for infection prophylaxis, and caution against the elective use of alternative regimens like IV vancomycin unless clinically warranted.

	OR	95% CI Lower bound	95% CI Upper bound	p-Value
Vancomycin	2.48	1.18	5.22	0.017*
IV Steroid Intraoperatively	1.84	0.45	7.53	0.399
IV Steroid Postoperatively	1.22	0.74	2.03	0.442
Topical Vancomycin	1.09	0.68	1.75	0.719
Fusion	1.06	0.62	1.84	0.825
Sex (Male)	0.80	0.51	1.26	0.329
Topical Steroid Intraoperatively	0.60	0.14	2.45	0.473
Location (Lumbar)	0.35	0.12	1.02	0.053
	MD	95% CI Lower bound	95% CI Upper bound	p-Value
BMI	1.56	0.32	2.79	0.026*
OR Duration	42.04	16.88	67.21	0.089
Age	0.27	-3.67	3.11	0.756

Table 1: Multivariate Logistic Regression Assessing Risk Factors for Infection. BMI = body-mass index; OR duration = operating room duration; OR = odds ration; CI = confidence interval; * = indicates statistical significance

151. SPINE SHAPE VS ALIGNMENT: WHICH DETERMINES THE BEST OUTCOMES IN ADULT SPINAL DEFORMITY?

Nicholas S. Vollano, BS, MBS; *Themistocles S. Protopsaltis, MD*; Renaud Lafage, MS; Alex Soroceanu, MD, FRCS(C), MPH; Jeffrey L. Gum, MD; Munish C. Gupta, MD; Lawrence G. Lenke, MD; Kojo D. Hamilton, MD, FAANS; Justin S. Smith, MD, PhD; Robert K. Eastlack, MD; Gregory M. Mundis Jr., MD; Han Jo Kim, MD; Richard Hostin, MD; Khaled M. Kebaish, MD; Bassel G. Diebo, MD; Alan H. Daniels, MD; Eric O. Klineberg, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; Christopher I. Shaffrey, MD; Frank J. Schwab, MD; Shay Bess, MD; Virginie Lafage, PhD; International Spine Study Group

Hypothesis

Alignment and spine shape are important for optimizing outcomes in adult spinal deformity (ASD) patients.

Design

Retrospective analysis of prospective multicenter databases.

Introduction

Overcorrected patients experience more proximal junctional kyphosis (PJK) than those functionally aligned or undercorrected, in ASD surgery. In addition, previous studies identified that PJK patients have a more posteriorly translated spine shape than non-PJK patients. This study analyses combinations of alignment and spine shape with respect to severe PJK, proximal junctional failure (PJF) and health-related quality of life (HRQL) outcomes.

Methods

Patients with fusions to the pelvis and above T11 were included. Linear regression was performed to predict T10PA using age-normative short form-36 physical component scores (PCS) and pelvic incidence (PI) for each patient. Functional alignment was defined as postoperative alignment within a 10o window around the predicted T10PA. Linear regression modeling was also used to assess normative spine shape associating T10PA, L1PA, L4PA and PI in asymptomatic subjects. Normative spine shape was defined as postoperative alignment within 6-degree regional windows of predicted lumbar and thoracolumbar shape. Patients were grouped based on alignment and spine shape. The frequency of severe PJK, PJF, and HRQL outcomes were compared between groups.

Results

751 patients were included (Age: 63.7 ± 9.4; BMI: 28.4 ± 5.9; 79.2% female). Mean HRQL outcomes improved significantly for all groups with surgery (p<0.05) but there was no difference in HRQL improvement between the groups. The malaligned/poor spine shape group had the highest frequency of severe PJK and PJF by 2 years (27.6% and 18.1%, respectively), whereas the functional alignment/normative spine shape group had the lowest (13.3% and 7.7%, respectively), all p<0.05. Multinomial regression revealed a higher odds of severe PJK (2.48, CI:

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1.37-4.50; p=0.003) and PJF (2.65, CI: 1.29-5.47; p=0.008) by 2 years in the malaligned/poor spine shape group compared to the functional alignment/normative shape group. No differences in frequency of revision for PJK were observed.

Conclusion

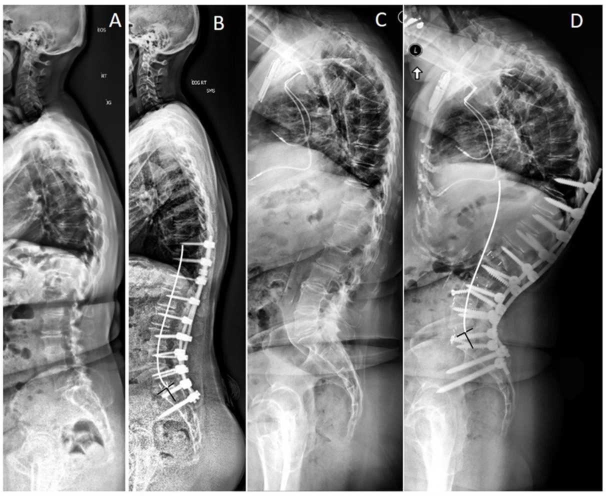
Normative spine shape with functional alignment is associated with lower frequency and lower odds of severe PJK and PJF, emphasizing the importance of assessing both shape and alignment in deformity corrections.

Table 1. Comparison of baseline information and mechanical complications between malaligned vs functional T10PA radiographic alignment and poor vs normative T10-L1, L1-L4 spine shape groups.

Total (N=751)	Malaligned & Poor Spine Shape n=105	Malaligned & Normative Spine Shape n=331	Functional Alignment & Poor Spine Shape n=120	Functional Alignment & Normative Spine Shape n=195	p-value
Gender (% Female)	**83.7%**	**83.7%**	**72.5%**	**73.2%**	**0.005**
Age (years)	64.4 +9.4	64.2 ±9.7	63.0 ±9.0	62.8 ±9.4	0.292
Body Mass Index (kg/m²)	**27.7* ±5.6**	**27.2^ ±5.3**	**30.1'~ ±6.2**	**29.8'~ ±6.4**	**<0.001**
Charlson Comorbidity Index	1.9 ±1.7	1.9 ±1.7	2.0 ±1.7	2.0 ±1.7	0.789
1 year					
sPJK by 1 year	**25 (23.8%)**	**65 (19.6%)**	**14 (11.7%)**	**21 (10.8%)**	**0.005**
PJF by 1 year	**18 (17.1%)**	**41 (12.4%**	**8 (6.7%)**	**13 (6.7%)**	**0.012**
2 years					
sPJK by 2 years	**29 (27.6%)**	**71 (21.5%)**	**19 (15.8%)**	**26 (13.3%)**	**0.012**
PJF by 2 years	**19 (18.1%)**	**48 (14.5%)**	**10 (8.3%)**	**15 (7.7%)**	**0.016**
Revision for PJK	9 (8.6%)	19 (5.7%)	6 (5.0%)	7 (3.6%)	0.335
Rod Breakage	20 (19.0%)	36 (10.9%)	22 (18.3%)	23 (11.8%)	0.054
Revision for Rod Breakage	8 (6.7%)	18 (5.4%)	12 (10.0%)	10 (5.1%)	0.296
Any mechanical complication[t]	**47 (44.8%)**	**96 (29.0%)**	**39 (32.5%)**	**46 (23.6%)**	**0.002**

[t] Any mechanical complication is defined as having severe PJK by 2 years or rod breakage or pseudarthrosis.

PJA - proximal junctional angle; sPJK - severe proximal junctional kyphosis (≥ 20° change and proximal junctional angle ≥ 20°); PJF - proximal junction failure, defined as undergoing revision for PJK before 2-year visit or having a proximal junctional angle >28° and change in PJA > 22°



T10PA= 17.0° T10PA= 16.2° Functional T10PA = 14.3° T10PA= 3.6° T10PA= -6.0° Functional T10PA = 7.7°

Figure 1. Preoperative (A) and Postoperative (B) radiographs of a patient with functional alignment/normative spine shape. Preoperative (C) and Postoperative (D) radiographs of a malaligned/poor spine shape patient who developed PJK. Normative spine shape is represented by the white line.

152. PROXIMAL JUNCTIONAL KYPHOSIS AFTER PROPHYLACTIC TETHERS IN ADULT SPINAL DEFORMITY: INCIDENCE, MECHANISM AND RISK FACTORS FOR PROXIMAL JUNCTIONAL FAILURE

Francis C. Lovecchio, MD; Takashi Hirase, MD, MPH; Michael Mazzucco, BS; Virginie Lafage, PhD; Renaud Lafage, MS; Frank J. Schwab, MD; Shay Bess, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Gregory M. Mundis Jr., MD; Bassel G. Diebo, MD; Robert K. Eastlack, MD; Eric O. Klineberg, MD; Han Jo Kim, MD; International Spine Study Group

Hypothesis

Observational analysis of incidence, mechanism, and risk factors for proximal junctional complications in tethered ASD patients

Design

Retrospective cohort study

Introduction

Posterior tethers at the upper instrumented vertebrae (UIV) may reduce PJK after adult spinal deformity (ASD) surgery. PJK and PJF in tethered patients is not well understood.

Methods

Patients who underwent posterior tethering for PJK prophylaxis were pulled from two multicenter ASD datasets with pre-defined inclusion criteria and fusion >4 levels to S1. Surgeries were performed from 2013-2022 with min f/u of 1-2 yrs. PJK was defined as UIV/UIV+2 PJA of 10 and Δ10. PJF was defined as revision within the f/u period or UIV/UIV+2 PJA of 28 and Δ22. Tether techniques were surgeon-dependent. Radiographs were reviewed for PJF mechanism by a spine surgeon. Adjusted analyses controlling for the proximal level tethered, comorbidities, surgical factors, and alignment were conducted to determine independent associations.

Results

A total of 302 patients met inclusion criteria, with a mean f/u 1.5 yrs. PJK and PJF rates were 46% (n=139) and 9.2% (n=28), respectively. 163 patients had specific placement of tether level data (54% were to UIV+2, 45% UIV+1, and 1% UIV+3). On adjusted analysis, prior fusion (OR 0.32 [0.12-0.77], p=0.01), #interbody fusion (2.27 [1.14-5.33], p=0.03), supplemental rod (4.82 [1.90- 13.3], p<0.01), and proximal level tethered (2.55 [1.07-6.67], p=0.04) were associated with PJK. BMI (1.20 [1.08-1.36], p<0.01), osteoporosis (9.44 [2.18-50.1], p<0.01), preop PT (1.10 [1.01-1.22], p=0.03), preop C7PL (0.98 [0.96-0.99], p=0.01), and change in T4PA (1.16 [1.06-1.29], p<0.01) were associated with PJF. In the PJF cohort, screws were used at the UIV in 93% of cases. Failure modes included UIV superior endplate fracture (54%, 93% lower thoracic [LT] UIV), disc degeneration with increased distance across the interspinous processes (ISP) (18%, all UT UIV), UIV screw pullout (11%), UIV+1/+2 compression fractures (7.1%), and disc degeneration without increased distance across the ISP (10%).

Conclusion

PJF occurred via bony mechanisms in the LT spine and through soft-tissue mechanisms in the UT spine. Risk factors and mechanisms for PJF in tethered patients are similar to reported risk factors in non-tethered patients.

153. POSTOPERATIVE THORACIC KYPHOSIS MORPHOLOGY FOLLOWING ADULT SPINAL DEFORMITY SURGERY: AN ANALYSIS OF FUSED AND UNFUSED SEGMENTS

Renaud Lafage, MS; Jonathan C. Elysee, BS; Alan H. Daniels, MD; Bassel G. Diebo, MD; Christopher Katchis, MD; Christopher P. Ames, MD; Shay Bess, MD; Douglas C. Burton, MD; Robert K. Eastlack, MD; Munish C. Gupta, MD; Richard Hostin, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Eric O. Klineberg, MD; Gregory M. Mundis Jr.,

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MD; David O. Okonkwo, MD, PhD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Frank J. Schwab, MD; Virginie Lafage, PhD; International Spine Study Group

Hypothesis

This study aimed to quantify iatrogenic and reciprocal changes in TK between pre and post-surgery and identify influencing parameters, assess the maintenance of unfused thoracic curvature between early and 2-year follow-up, and identify parameters affecting proximal failure.

Design

Retrospective analysis of prospective data

Introduction

Predicting postoperative changes in thoracic kyphosis (TK) and reciprocal changes in the unfused thoracic spine is challenging in adult spinal deformity (ASD) surgery.

Methods

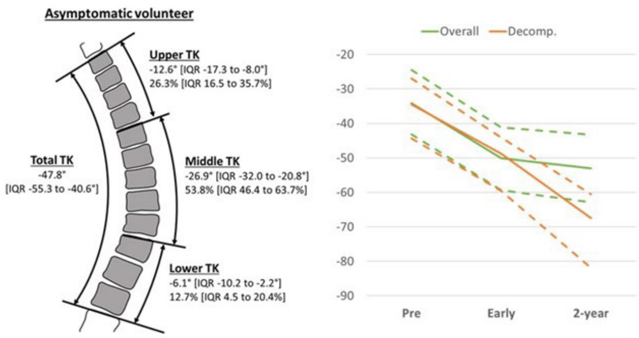
362 ASD patients treated with posterior instrumentation from T9-11 to the pelvis, with a minimum 2-year follow-up were included. After reporting TK values and distribution vs normative data (Figure), multilinear hierarchical regression was used to investigate post-operative lumbar parameters associated with reciprocal thoracic changes. The rate of thoracic failure was reported, and logistic regression was used to investigate associated risk factors.

Results

In this cohort (65±9 yo, 73.5% female), the pre-op T1-T12 TK (median 34°) was normal for 59.7% and hypo-kyphotic for 39.3% of patients. At 6 weeks, TK normalized for 79.1% of hypo-kyphotic patients and deteriorated for 11.7% of normo-kyphotic patients. The post-op TK increase (+7° across T5-10 and across T10-L1) was significantly associated with an increase in L1-S1 lordosis ($p<0.001$) and a decrease in L4-S1 lordosis ($p<0.012$) (r-square 0.69). From 6 weeks to 2 years, 9.1% experienced TK decompensation >15° and 9.4% a proximal extension due to junctional issues (collectively coined “thoracic failures” = 17.1%). Multivariate analysis showed early post-op thoracic alignment was a significant predictor of 2-year thoracic failure based on T10-L1 <15° and T5-T10 contribution to TK < 38%.

Conclusion

Following ASD surgery with the UIV at T9-T11, deviations in thoracic kyphosis within non-fused segments increase the likelihood of revision surgery. Despite achieving TK normalization in most cases, postoperative spinal shape often strays from the norm. Accurate postoperative thoracic kyphosis estimation is possible with preoperative alignment and lumbar correction. A two-year failure trend is associated with early postoperative lower kyphosis and the distribution of thoracic curvature, emphasizing the importance of meticulous preoperative planning.



154. IDENTIFYING RISK OF PROXIMAL JUNCTIONAL KYPHOSIS PRIOR TO CHOOSING UPPER INSTRUMENTED VERTEBRA

<u>*Jeffrey M. Hills, MD*</u>; Han Jo Kim, MD; Lawrence G. Lenke, MD; Justin S. Smith, MD, PhD; Shay Bess, MD; Breton G. Line, BS; Virginie Lafage, PhD; Renaud Lafage, MS; Eric O. Klineberg, MD; Jeffrey L. Gum, MD; Khaled M. Kebaish, MD; Gregory M. Mundis Jr., MD; Alex Soroceanu, MD, FRCS(C), MPH; Richard Hostin, MD; Themistocles S. Protopsaltis, MD; Kojo D. Hamilton, MD, FAANS; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; Michael P. Kelly, MD; International Spine Study Group

Hypothesis

Preoperative cervicothoracic sagittal alignment is associated with risk of PJK after long fusions, and the risk is dependent on UIV region (higher risk with lower thoracic(LT UIV vs upper thoracic(UT UIV))

Design

Retrospective Cohort

Introduction

Surgical alignment is an important PJK risk factor, but malalignment in the unfused spine increase risk despite achieving instrumented alignment goals. Some cases of PJK may represent high risk UIV selection. We aimed to determine if PJK risk was associated with preoperative cervicothoracic malalignment, and if the risk depended on UIV region.

Methods

A multi-center, prospective ASD registry was queried to identify patients instrumented to the sacrum with a UIV in the UT or LT spine, without prior fusion >4 levels, and minimum 2yr radiographic follow-up. Primary outcome was PJK (>20 change or failure) within 2 years. A multivariable logistic regression model examined the risk of PJK by UIV region, preoperative C2-T9PA mismatch (Fig 1A), age, sex, pelvic incidence and tested for an interaction between preoperative C2-T9PA mismatch and UIV region. Adjusted absolute risk reduction (ARR) and number needed to be exposed (to upper thoracic UIV) to benefit 1 (NNEB) was computed.

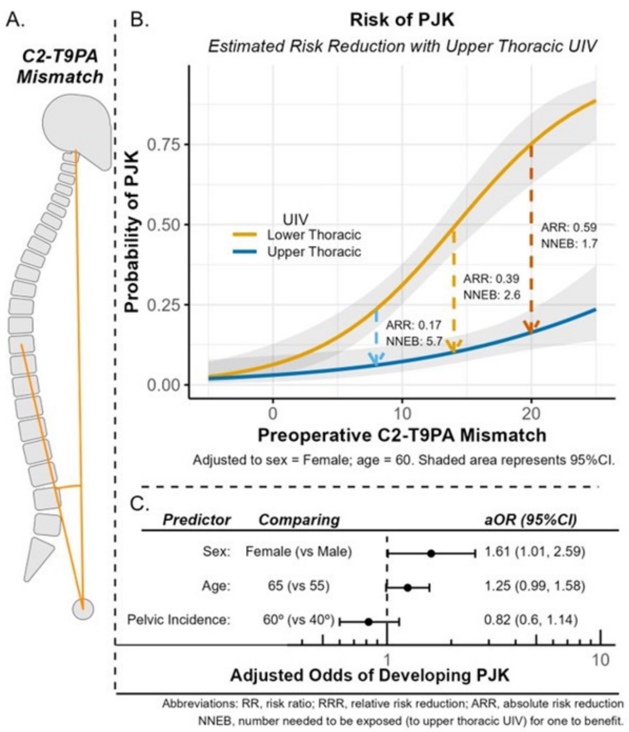
Results

627 patients across 20 centers were included, with a median age 66 (IQR, 59, 70), 483 (77%) females, 380 (61%) with a LT and 247 (39%) with an UT UIV. PJK developed in

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

149 (39%) patients with a LT, and 30 (12%) patients with an UT UIV. A significant interaction between UIV and preoperative C2-T9PA mismatch was observed (P=.03), indicating the risk of PJK associated with preoperative C2-T9PA mismatch depended on the UIV. With a preoperative C2-T9PA mismatch of 14°, an UT UIV had an adjusted ARR of 39% and NNEB was 2.6 (Fig 1B). Females had an aOR of 1.6 (P=.047) for developing PJK (Fig 1C).

Conclusion
Higher preoperative C2-T9PA mismatch (cervical/thoracic kyphosis) was associated with higher risk of PJK and depended on the UIV. An UT UIV for patients with high preoperative C2-T9PA mismatch may lower the risk of PJK.



A) C2-T9PA Mismatch. B) Probability of PJK due to higher preoperative C2-T9PA mismatch depended on UIV region. C) Adjusted odds of PJK was significantly higher in females.

155. HIP RANGE OF MOTION PREDICTS OUTCOMES FOLLOWING SPINAL FUSION SURGERY IN ADULT SPINAL DEFORMITY PATIENTS

Shane Burch, MD; Andrew Sawires, MD

Hypothesis
Hip range of motion predicts global and disease specific patient reported outcome scores (PROS) following spinal fusion surgery.

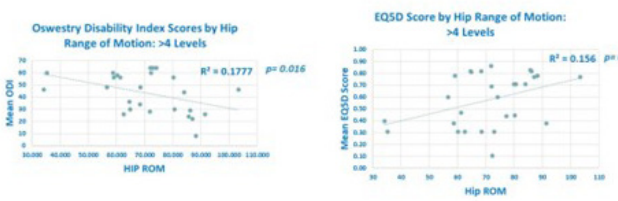
Design
Non-randomized prospective study.

Introduction
ADLs include reaching the ground, tie shoes, and perineal care. After spinal fusion surgery patients lose spinal motion and must rely on other joints compensate.

Methods
A 3D motion capture system (Motion Analysis, Petaluma CA) with standardized spine and appendicular marker sets was used to capture motion of the spine and appendicular skeleton through a flexion and extension and sit to stand cycle. Patients who had undergone 1- 3 levels, 4-8 levels or > 8 level fusions were captured during a flexion / extension and sit-to-stand maneuver and compared to back pain patients without fusions and to healthy control subjects. Standardized radiographic parameters (PI, PT, SVA, LL and TK) and PROMS (EQ5D, ODI and NRS) were measured for each group and compared. Correlation coefficients were derived between hip ROM in the sagittal plane and PROMS. A radial based neural network algorithm was employed to model hip ROM to predict ODI scores <40 and EQ5D scores >0.7 in each cohort.

Results
67 patients (49 females) with average age of 65.4 years and follow up time of 25.9 months were enrolled along with 8 controls. (>8 levels fused: n= 11, 4-8 level fused: n=13, 1-3 levels fused: n=15 and 0 levels fused n=10). No difference in sagittal alignment parameters (mean PI°-LL°=6.01°) was observed between groups. PRO scores were: EQ5D (mean =0.575, SD ,225, range 0.101-0.860), ODI (mean = 41.08, SD 17.3, range 10-72) and NRS scores (mean = 5.35, SD 2.8, range 0-10) p.0.05 between groups. Mean ROM of the TL spine in controls (59°) and greater than all fusion groups, p<0.05). No difference in mean hip ROM between fusion groups was identified (p=>0.05).Hip ROM during flexion / extension was moderately correlated to EQ5D (R^2=0.156, p=0.019) and ODI (R^2=0.178, p=0.016) in patients with >8 levels fused. The neural networks model predicted 87.5% ODI outcomes correctly with an AUROC of 0.795 while the same model predicted 68.8% of EQ5D scores of >0.7 with an AUROCC of 0.728

Conclusion
Hip ROM predicts PROM scores in adult degenerative scoliosis patients following spinal fusion surgery. Those with limited hip ROM prior to spinal fusion surgery may benefit less than those with greater hip ROM.



Hip ROM Predicts Spinal PROMS

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PODIUM PRESENTATION ABSTRACTS

156. INCREASED POSTERIOR PINCER MIGHT INCREASE THE RISK OF HIP OSTEOARTHRITIS IN ADULT SPINAL DEFORMITY WITH HIGH PELVIC RETROVERSION

Elena Jaber, MS; Rami Rachkidi, MD, MS; Abir Massaad, PhD; Ali Rteil, MS; Elma Ayoub, MS; Maria Saadé, MS; Celine Chaaya, MS; Elio Mekhael, BS; Nabil Nassim, BS; Rami Rhayem, BS; Mohammad I. Karam, PhD; Ismat Ghanem, MD, MS; Virginie Lafage, PhD; Wafa Skalli, PhD; Ayman Assi, PhD

Hypothesis
Posterior femoro-acetabular impingement might increase the risk of hip osteoarthritis in ASD with high pelvic retroversion.

Design
Retrospective analysis of prospectively collected data.

Introduction
Pelvic retroversion is a primary compensatory mechanism in patients with adult spinal deformity (ASD). These patients are known to have a higher risk of developing hip osteoarthritis (HOA), which may be due to alterations in acetabular orientation. This study aims to investigate possible alterations in acetabular orientation in ASD patients with increased PT.

Methods
121 ASD patients and 32 controls underwent biplanar X-rays in standing position with calculation of 3D spinopelvic and acetabular parameters: tilt, anteversion, abduction, anterior coverage and posterior coverage. Hip osteoarthritis (HOA) grade was determined according to Kellgren and Lawrence. PT adjusted to PI was calculated in the control group (adj.PT=0.37*PI-7°) then patients with high adjusted PT (>2SD in controls) were grouped as ASD-HighPT, otherwise as ASD-NormPT. Spinopelvic and acetabular parameters were compared between groups.

Results
42 patients were categorized as ASD-HighPT and 79 as ASD-NormPT (PT= 31 vs 13°, $p<0.001$). ASD-HighPT had a decreased lumbar lordosis (L1S1=33 vs 63°) and a decompensated sagittal alignment (SVA=75 vs 10mm, both $p<0.001$). ASD-HighPT showed an increased acetabular tilt (38 vs 25°), anteversion (27 vs 19°), abduction (61 vs 56°), posterior coverage (103 vs 97°), and decreased anterior coverage (50 vs 56°), compared to ASD-NormPT (all $p<0.001$). ASD-HighPT had an increased grade of HOA (median: 2 vs 1, $p=0.003$). ASD-NormPT had normal acetabular orientation. PT was positively correlated to acetabular tilt ($r=0.74$), anteversion ($r=0.68$), abduction ($r=0.64$), posterior coverage ($r=0.57$), and negatively correlated to anterior coverage ($r=-0.47$, all $p<0.05$).

Conclusion
ASD patients with increased pelvic retroversion are subject to increase their acetabular tilt, anteversion, and abduction leading to an increased posterior coverage and a decreased anterior coverage. These alterations, characteristic of a posterior pincer type of femoro-acetabular impingement, may contribute to the heightened risk of HOA development in ASD patients.

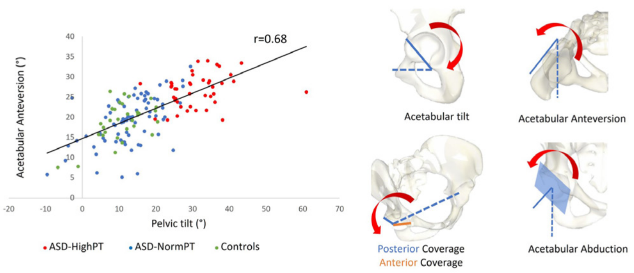

Fig 1: Correlation between acetabular anteversion and PT.

157. PATTERNS AND PREDICTORS OF MECHANICAL COMPLICATIONS FOLLOWING 3-COLUMN OSTEOTOMIES FOR CORRECTION OF ADULT THORACOLUMBAR SPINAL DEFORMITY WITH 2 YEARS OF FOLLOW UP

Winward Choy, MD; Jaemin A. Kim, Research Assistant; Terry Nguyen, Research Assistant; Tony Catalan, BS; Austin Lui, MS; Ping-Yeh Chiu, MD; David Mazur-Hart, MD; Aaron J. Clark, MD; Vedat Deviren, MD; Christopher P. Ames, MD

Hypothesis
Rates of mechanical failure following 3 column osteotomies for adult thoracolumbar spinal deformity have decreased with the advent of new surgical techniques

Design
retrospective study

Introduction
Correction of fixed thoracolumbar adult spinal deformities (ASD) may require three column osteotomies to restore adequate spinal alignment. However, mechanical complications (MC) remain significant following ASD surgery. We report the outcomes of patients with thoracolumbar deformities undergoing 3-column osteotomies.

Methods
Consecutive patients who underwent 3-column osteotomies from 2006 to 2021 performed by the senior author were identified. Those with a minimum of 2 years of clinical and radiographic follow up were included. Main outcome comprised MC, defined by rod fracture, proximal junctional failure (PJF)/distal junctional failure (DJF), or other implant related complications. Univariate and multivariate analysis of clinical, radiographic and operative features was used to identify predictive factors.

Results
253 patients follow up were included. Mean age was 63 years, 36.8% of patients were male, 71.9% of patients had a previous fusion. Mean number of levels fused was 12.5. The most common site of the 3-column osteotomy was at L3 in 30.8% and L4 in 33.2% of patients. 13.8% of patients were smokers. Mean follow up was 38 months. Rates of MC were 59.3% and overall reoperation rate was 31.7%. The most common types of MC were rod fracture (32.5%), pseudoarthrosis (21.4%) and proximal junctional failure (10.7%). Reoperation was required in 52% of all MC. Rates of rod fracture and PJF have significantly decreased in the last 5 years of the series. Only half of MC occurred within 2 years

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of index operation, and rate of mechanical complications increases with length of follow up. On multivariate analysis, ligamentoplasty and use of multi-rod constructs were correlated with decreased rates of MC.

Conclusion

Mechanical complications following 3-column osteotomy are significant, and require long term follow up for detection. However, advancements in surgical techniques have significantly decreased rates of MC.

158. ADJACENT SEGMENT DISEASE (ADSD) AFTER SPINAL FUSION IN THE UK BIOBANK (UKB)

Rohit Bhan, MD, MS; Vy Pham, MD, MPH; Elizabeth L. Yanik, PhD; Brian J. Neuman, MD

Hypothesis

The rate of AdSD in the cervical or lumbar spine will be less than 3% annually after primary fusion.

Design

Cohort Study

Introduction

The prevalence of symptomatic spinal disease requiring fusion is increasing with an aging population. Patients are counseled there is a 3% annual risk of additional surgery due to AdSD, though this may not account for advances in surgical technique. The UKB is a large population-based cohort of 500,000 deidentified people, with in-depth genetic and non-genetic information, as well as linked hospital records. The database is regularly updated and includes >20 years of hospital records. We investigated the rate of AdSD after primary cervical and lumbar fusion in the UKB cohort, as well as risk factors that may contribute.

Methods

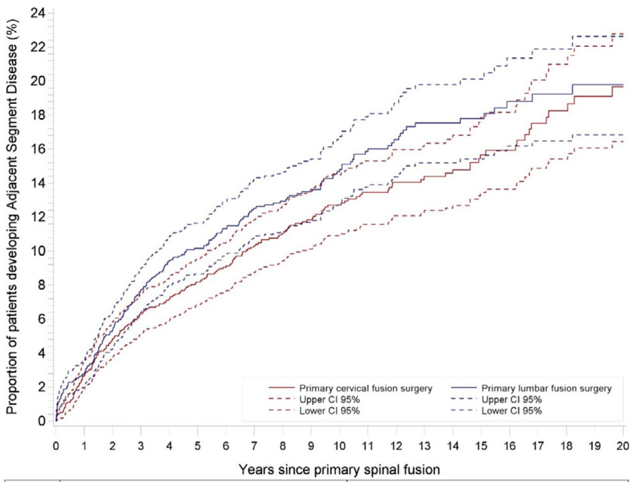
UKB patients that underwent primary cervical or lumbar fusion were identified using OPCS-4 codes. AdSD was defined as subsequent fusion, revision, or decompression within the same spinal region as their primary surgery. Associations with risk factors were assessed using Cox regression.

Results

3487 patients underwent primary fusion in the cervical (N=1732) or lumbar (N=1755) spine. 211 (12.1%) cervical and 230 (13.1%) lumbar patients were revised for AdSD. 5-year cumulative incidence for cervical and lumbar spine revision surgery was 8.19% and 10.16%. 20-year cumulative incidence for revision cervical and lumbar spine surgery was 19.67% and 19.79% respectively, amounting to an annual risk of ~1%. Unemployed/Retired status achieved significance as a risk factor for AdSD in univariate (p=0.011) and multivariate analysis (p=0.0063). BMI, Age, Gender, Race, Tobacco Use, area deprivation, and Osteoporosis were not significant in univariate or multivariate models.

Conclusion

Our findings suggest the rate of AdSD in the cervical and lumbar spine is lower than previously reported, roughly 1% annually, with about half of the revisions occurring within the first 5 years. Occupational status as Unemployed/Retired was found to increase risk of developing AdSD, suggesting that decreased work activity may be indicative of greater disability and disease burden. The first 5 years has a higher rate of AdSD compared to the next 15 years. There may be underlying risk factors that account for the increased early rate of AdSD, such as genetic variation, spine characteristics, surgical factors, and medical comorbidities.



Year since primary spinal fusion	For primary cervical fusion surgery				For primary lumbar fusion surgery			
	Survival Probability (%)	95% CI for Survival Probability	Cumulative Incidence (%)	95% CI for Cumulative Incidence	Survival Probability (%)	95% CI for Survival Probability	Cumulative Incidence (%)	95% CI for Cumulative Incidence
5	91.81	90.46-93.17	8.19	6.83-9.54	89.84	88.36-91.34	10.16	8.66-11.64
10	87.28	85.52-89.09	12.72	10.91-14.48	85.33	83.42-87.28	14.67	12.72-16.58
15	84.32	82.14-86.56	15.68	13.44-17.86	82.20	79.88-84.59	17.80	15.41-20.12
20	80.33	77.23-83.56	19.67	16.44-22.77	80.21	77.36-83.16	19.79	16.84-22.64

Cumulative incidence of revision for cervical (red) and lumbar (blue) AdSD over time.

159. DOES STRATEGY DERIVED FROM THE GHAILANE-GILLE CLASSIFICATION FOR DEGENERATIVE SPONDYLOLISTHESIS OF THE LUMBAR SPINE AFFECT SURGICAL OUTCOME: A MATCH-MISMATCH STUDY

Soufiane Ghailane, MD; Houssam Bouloussa, MD, MS; Matthieu Campana, MD; Jean Etienne Castelain, MD; Olivier Gille, MD, PhD; Vincent Challier, MD

Hypothesis

Restoring sagittal alignment (SA) when treating degenerative spondylolisthesis of the lumbar spine (DSLS) yields better clinical and radiographic results. Ghailane and Gille proposed treatment guidelines (TG) according to their classification based on SA. Objective: To investigate whether adherence to TG affects surgical outcome in DSLS.

Design

Retrospective match-mismatch study

Introduction

DSLS is a common cause of low back pain, leg pain, neurogenic claudication and sagittal imbalance. Numerous studies highlighted the impact of SA on surgical outcome. A validated a DSLS classification based on SA was proposed. TG were the following: Type 1 requires a segmental strategy consisting of treating the spondylolisthesis level with decompression with dynamic stabilization or fusion. Type 2 and 3 require regional or global correction to address associated spinal deformity.

Methods

Patients treated for DSLS, who underwent surgical treatment from September 2021 to May 2023 in our institution were retrospectively reviewed. Radiographic measurements, clinical data and health-related quality of life scores, including Oswestry index (ODI), Visual Analogue Scale (VAS) for pain, were recorded preoperatively, and postoperatively with a minimum 1 year follow-up. Patients were divided in two groups according to TG: the first group is a match (TG followed), the second group is a mismatch (rule-breaker). Patients' satisfaction, complications were recorded. Normality and heteroskedasticity of data were assessed with the Shapiro-Wilk test. The difference between the two groups were assessed using Mann-whiteney, Fischer's exact tests.

Results

Eighty-four patients were enrolled. Among them, 67 were in the Match group and 18 in the Mismatch Group. Table 1 summarizes the main results. No difference was found between the groups regarding L-VAS, R-VAS or ODI. The perioperative complication rate was 0% and 25 % (2 dural tear, 1 mechanical failure, acute lung edema) in patients for match and mismatch group p=0.003). Median values of satisfaction score were 72.5% (IQR 33.25) for TG-followed and 50.0% (IQR 35.0) for rule-breaker (p=0.008).

Conclusion

Restoring satisfactory alignment following the Ghailane-Gille Classification TG seems to decrease intraoperative complications and improves patients' satisfaction.

Variable	Match	Mismatch	p-Value
	N = 65	N = 17	
Gender			0.757
M	16 (24.62%)	5 (29.41%)	
W	49 (75.38%)	12 (70.59%)	
Age	69.29 (± 9.62)	70.29 (± 11.99)	0.731
Pre L-VAS	7.31 (± 1.88)	7.18 (± 2.04)	0.806
Pre R-VAS	7.22 (± 1.81)	7.24 (± 2.31)	0.541
Pre ODI	41.63 (± 15.81)	41.71 (± 13.7)	0.986
Classification Ghailane-Gille Preop			0.752
1A	16 (26.23%)	7 (43.75%)	
1B	7 (11.48%)	1 (6.25%)	
2A	2 (3.28%)	0 (0.0%)	
2B	1 (1.64%)	0 (0.0%)	
3	35 (57.38%)	8 (50.0%)	
DSLS Level(s)			>0.999
L3L4	10 (15.39%)	2 (11.76%)	
L4L5	51 (78.46%)	15 (88.24%)	
L4S1	1 (1.54%)	0 (0.0%)	
L5S1	3 (4.62%)	0 (0.0%)	
Perioperative Complication			**0.003**
Yes	0 (0.0%)	4 (25.0%)	
No	50 (100.0%)	12 (75.0%)	
Surgical satisfaction score	70.36 (± 18.79)	53.94 (± 23.88)	**0.008**
Are you satisfied with the results of your surgery?			**<0.001**
Dissatisfied	0 (0.0%)	14 (87.5%)	
I don't know	1 (1.64%)	0 (0.0%)	
Satisfied	42 (68.85%)	0 (0.0%)	
Very satisfied	18 (29.51%)	2 (12.5%)	
Given your results, would you do this surgery again?			**<0.001**
Certainly	47 (77.05%)	2 (12.5%)	
Certainly not	0 (0.0%)	13 (81.25%)	
Certainly	13 (21.31%)	1 (6.25%)	
I don't know	1 (1.64%)	0 (0.0%)	
Given the results of your surgery, would you recommend this surgery to a family member or friend?			**<0.001**
Certainly	47 (77.05%)	3 (18.75%)	
Certainly not	0 (0.0%)	12 (75.0%)	
Certainly	14 (22.95%)	1 (6.25%)	
Post L-VAS (1YFU)	4.91 (± 2.81)	3.67 (± 3.16)	0.267
Post R-VAS (1YFU)	3.78 (± 2.9)	3.11 (± 3.62)	0.503
Post-ODI (1YFU)	23.59 (± 17.58)	20.44 (± 14.59)	0.682

Main Results

160. CONTEMPORARY GUIDELINES FOR ACETABULAR POSITIONING IN HIP ARTHROPLASTY MAY JEOPARDIZE HIP DISLOCATION FOR SELECT ASD PATIENTS

Marc Boutros, BS; Mohammad Daher, BS; Ayman Assi, PhD; Gilles Prince, MD; Mohammad I. Karam, PhD; Christopher P. Ames, MD; Shay Bess, MD; Alan H. Daniels, MD; Munish C. Gupta, MD; Richard Hostin, MD; Michael P. Kelly, MD; Han Jo Kim, MD; Eric O. Klineberg, MD; Lawrence G. Lenke, MD; Pierce D. Nunley, MD; Peter G. Passias, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Renaud Lafage, MS; *Bassel G. Diebo, MD*; Virginie Lafage, PhD; International Spine Study Group

Hypothesis

The conventional Lewinnek safe zone does not apply to adult spinal deformity (ASD) patients with high pelvic tilt (PT).

Design

Retrospective analysis of prospectively collected data.

Introduction

Lewinnek et al. defined a safe zone for cup inclination (40° ± 10°) and anteversion (15° ± 10°) to reduce dislocations after total hip arthroplasty (THA). Despite the Lewinnek safe zone being respected, higher rates of prosthetic dislocation are found in ASD patients undergoing THA. This study aims to investigate if ASD patients with high PT need a specific safe zone for acetabular positioning.

Methods

ASD patients with moderate to severe sagittal deformity underwent full-body xrays and a detailed 3D reconstruction of the pelvis and lower limbs in standing position pre-op. The PI-adjusted PT was calculated using Vialle et al formula (adj.PT=0.37*PI-7°) and patients with PT> adj. PT were grouped as HighPT, otherwise as NormPT. Spino-pelvic, 3D acetabular parameters were compared between the groups. PT offset from adj.PT was calculated. The number of patients falling outside the Lewinnek safe zone between the 4 quartiles of PT offset was compared. The relationship between PT and acetabular parameters was assessed with linear regression.

Results

132 patients were included (HighPT:86, NormPT:46) with no differences in age, sex, comorbidities, and hip OA grades between the groups. HighPT had higher PI-LL (32.1, 12.4°), SVA (79.7, 59.0 mm), T1PA (31.2, 19.5°), SFA (209.1, 199.3°), pelvic Shift (50.3, 17.2 mm), GSA (7.6, 4.5°), and L4-S1 lordosis (26.2, 34.5°; all p<0.05). HighPT had higher acetabular abduction (60.5, 58.4°), acetabular anteversion (23.4, 20.1°), acetabular tilt (36.5, 29.8°) and posterior coverage (102.6, 98.6°, all p<0.05).The % of patients falling outside of the anteversion safe zone increased with PT offset (Q1:32%, Q2:47, Q3:57, Q4:75%, p=0.003) without being significant for abduction. The equation to determine acetabular anteversion in function of PT was derived: 16.582 + 0.215*PT (SE:6) (Figure). Anteversion of 21, 23, 25, 27 was associated with PT of 20, 30, 40 and 50°.

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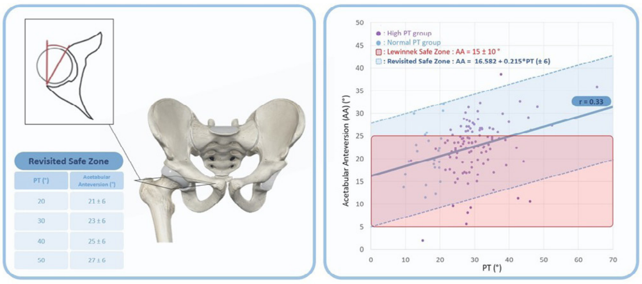
Conclusion

This is the first study to investigate impact of severe spinal deformity on pelvic tilt and acetabular anteversion in native hips. It also proposes an equation to calculate safe zone for acetabular component position and establishes thresholds of PT adjusted acetabular anteversion (Figure).



161. COMPARISON OF REOPERATION RATES FOR ANTERIOR CERVICAL DISCECTOMY AND FUSION AND CERVICAL DISC ARTHROPLASTY: A RETROSPECTIVE COHORT STUDY FROM A MULTICENTER HEALTHCARE SYSTEM

Samir AlSalek, BS; Richard N. Chang, PhD; *Shayan U. Rahman, MD;* Harsimran S. Brara, MD; Daniel Hirt, MD; Heather A. Prentice, PhD; Jessica Harris, MS; Maya Harary, MD; Hunter G. Richards, BS; Azim N. Laiwalla, MD; Kern H. Guppy, MD, PhD

Hypothesis

There is no difference in all-cause reoperation rates between ACDF and CDA.

Design

multi-center, multi-surgeon retrospective cohort

Introduction

Cervical degenerative disc disease (DDD) has historically been treated with ACDF. Anterior Cervical Discectomy and Fusion (ACDF) is associated with favorable clinical outcomes but may increase the risk of adjacent segment disease (ASD) and subsequent reoperation. Cervical disc arthroplasty (CDA) was introduced as an alternative technique to preserve cervical mobility and reduce the risk of ASD. Few prior studies have evaluated the long-term outcomes of ACDF compared to CDA in large patient cohorts. We sought to compare these two techniques with regard to all-cause reoperation.

Methods

A retrospective cohort study using data from a US-based multicenter healthcare system's Spine Registry identified a propensity score-matched cohort (3:1, ACDF vs CDA) of adult patients (>18 years) with cervical DDD who had primary ACDF or CDA between levels C3 and C7 (2009-2022). Patients were followed until validated reoperation, membership termination, death, or end of study. Cox-proportional hazards regression was used to evaluate reoperation rates. 10-year crude cumulative incidence rates were calculated.

Results

The original cohort consisted of 5,830 patients. 2,286 ACDF patients were propensity-score matched to 762 CDA patients. The average age was 48.3 years (SD ±7.9), and average follow-up was 6.5 years (SD ±4.0). For CDA versus ACDF, we found a 10-year reoperation rate of 8.9% versus 12.4%; ASD rate of 5.7% vs 9.3% and implant failure 2.8% vs 0.2%. In regression analysis, no difference in all-cause reoperation risk was observed for CDA compared to ACDF (HR=0.79, 95% CI=0.60-1.05); a lower risk of ASD was found in the CDA group (HR=0.72, 95% CI=0.54-0.96), however, there was a higher risk of implant failure (HR=13.85, 95% CI=4.70-40.84).

Conclusion

In a large, matched cohort, CDA was associated with a 30% reduction in operative ASD, but a significantly higher rate of implant failure compared to ACDF. No difference in all-cause reoperation rates was observed between the two techniques.

162. DEEP LEARNING CLASSIFICATION OF PEDIATRIC SPINAL RADIOGRAPHS

Kellen Mulford, PhD; Christina M. Regan, BS; Julia Todderud, BA; Charles P. Nolte; Zachariah W. Pinter, MD; Cody C. Wyles, MD; Bardia Khosravi, MD; Pouria Rouzrokh, MD; Hilal Maradit Kremers, MD; *A. Noelle Larson, MD*

Hypothesis

We hypothesize that this deep learning classifier will correctly identify patient radiographs with a high degree of accuracy.

Design

Development of a computer vision model to identify pediatric spine radiographs for development of an automated image classifier.

Introduction

Large imaging registries frequently rely on DICOM header information for entering new images into the registry which is unreliable or alternatively manual data entry which is labor-intensive and comparatively slow. Artificial intelligence and deep learning methods particularly suited for the analysis and classification of unstructured data, such as medical images, may provide fast and accurate methods for classifying incoming images.

Methods

Anterior-posterior (AP) and lateral spine radiographs were extracted from a single center for patients with confirmed scoliosis diagnoses over the last 20 years, for a total of 13,398 images (7777 AP images, 5621 lateral). Radiographs were manually classified into ten categories including in-brace, out-of-brace, fusion, growing rod, non-fusion surgeries (2 preop and 3 postop each for AP/lateral). The images were split into training, validation, and testing sets in a 70:15:15 proportional split. A deep learning classifier using the EfficientNet B6 architecture with pretrained weights was trained on the images. Hyperparameters and model architecture were tuned with the validation set. Final performance metrics were calculated on the test set, including accuracy, positive predictive value as defined by precision, recall, and F1 score (the harmonic mean of precision and recall).

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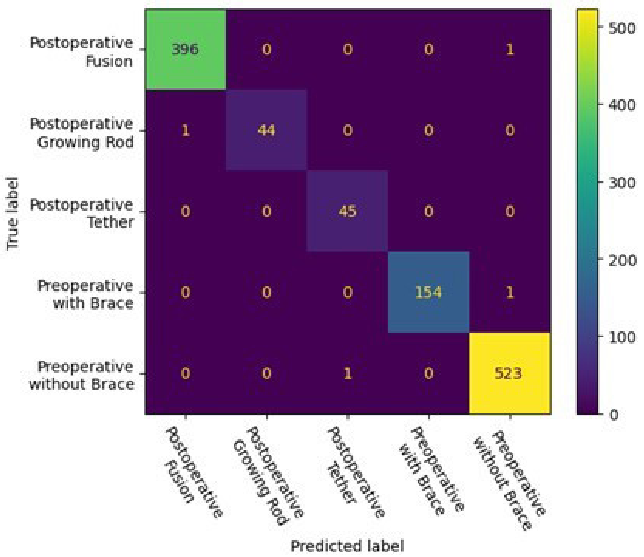
PODIUM PRESENTATION ABSTRACTS

Results

The trained classifiers had nearly perfect performance with an overall accuracy of 1.00 on 1166 AP images in the test set, and 1.00 on 843 lateral images in the test set. Precision ranged from 0.98 to 1.00 in the AP images, and from 0.91 to 1.00 on the lateral images. Performance was higher on the more common classes in the dataset, while the lower performance was observed on classes with fewer than 100 images in the dataset.

Conclusion

A deep learning convolutional neural network classifier was trained to a high degree of accuracy to distinguish between 10 categories pre- and postoperative spine radiographs of children with scoliosis. These models represent an important step in developing automated classification for large, labeled imaging registries.



AP classifier confusion matrix analyzing predicted versus true labeling.

163. PROMIS AND ODI TOOLS: CLINICALLY USEFUL PREDICTORS OF ABNORMAL MRIS IN PEDIATRIC BACK PAIN?

Devan J. Devkumar, BSA; Karina A. Zapata, PhD, PT, DPT; Chan-Hee Jo, PhD; Brandon A. Ramo, MD

Hypothesis

Patient-Reported Outcomes Measurements Information System (PROMIS) and Oswestry Disability Index (ODI) tools may help predict abnormal MRIs in adolescents with back pain.

Design

Retrospective case series

Introduction

Back pain is growing in prevalence in adolescents, and MRIs are increasingly ordered to elucidate an underlying cause which can strain resource utilization. The usefulness of patient reported outcome measures (PROMs) to help providers determine whether to order an MRI is unknown.

Methods

Retrospective review of 300 children (100M, 200F) ages 5-18 years, presenting with caregiver-reported back pain, who underwent spine MRIs, and who had completed 1) the PROMIS Pediatric Computer Adapted Test Pain Interference, Mobility, and Anxiety measures, 2) the 9-item ODI, and 3) back pain intensity on a scale of 0-5, from April 2021 to June 2023. Patients were excluded if they had non-idiopathic scoliosis, previous spinal surgeries, or specifically neck pain. PROMs were compared in both normal MRIs and abnormal MRIs (defined by presence of correlative and/or causative findings) with Mann-Whitney tests and logistic regression analyses. PROMIS and ODI score thresholds were determined with abnormal MRIs via ROC analyses.

Results

174 children had normal MRIs (59%) and 126 had abnormal MRIs. Average overall scores were PROMIS Mobility mild severity (41.3±8.7), PROMIS Pain Interference moderate severity (57.5±8.4), PROMIS Anxiety within functional limits (47.1±10.9), ODI Percentage moderate disability (25.0±16.8), and back pain intensity 1.7±1.1 out of 5. Lower PROMIS Mobility scores (OR 0.951; 95%CI 0.923-0.978) and higher ODI Percentage (OR 1.015; 95% CI 1.001-1.029) were associated with abnormal MRI findings. There were no associations between PROMIS Anxiety, PROMIS Pain Interference, and pain intensity with abnormal MRI findings (Table). A PROMIS Mobility threshold of 40.5 (AUC=0.64) and ODI Percentage of 21.1 (AUC=0.58) were associated with abnormal MRIs.

Conclusion

"What you see is more important than what you hear": Decreased mobility and increased disability are more indicative of abnormal MRI findings than pain interference and intensity. While AUC for PROMIS mobility and ODI scores were not strong, they still reflect positive results. In conjunction with a thorough history and physical exam, PROMIS Mobility and ODI tools may aid clinical decision making on the utility of MRIs in pediatric back pain.

	MRI Findings						
PROM	Normal* (n=174)	Abnormal Spine (Causative + Correlative, n=122)	p-value: Normal vs. Abnormal spine	Spine Causative (n=94)	p-value: Normal vs. Spine Causative	Spine Correlative (n=28)	p-value: Normal vs. Spine Correlative
PROMIS Mobility	42.8 ± 8.6	39.2 ± 8.7	**0.001***	39.3 ± 9.0	**<0.001***	38.7 ± 7.8	**0.014***
PROMIS Pain Interference	56.9 ± 8.7	58.3 ± 7.8	0.13	58.3 ± 8.1	0.15	58.2 ± 6.8	0.43
PROMIS Anxiety	47.7 ± 11.4	46.3 ± 10.2	0.40	46.9 ± 10.1	0.73	44.4 ± 10.5	0.17
ODI Percentage	23.3 ± 16.5	27.4 ± 17.1	**0.015***	27.6 ± 17.2	**0.018***	26.8 ± 17.0	0.24
Pain Intensity	1.6 ± 1.1	1.8 ± 1.2	0.32	1.8 ± 1.2	0.21	1.6 ± 1.0	0.90

*$P < 0.05$. MRI was considered normal if either no findings (n=158), incidental findings of the spine (i.e. hemangioma, n=5), or incidental findings of the non-spine regions (i.e. kidney cyst, n=11). Abnormal spine findings (n=122) included findings causative (i.e. disc herniation, n=94) or correlative (i.e. Schmorl's node, n=28) with back pain. Abnormal non-spinal findings (n=4) included findings causative (i.e. pancreatitis) or correlative (ovarian cyst).

164. HEMIVERTEBRA RESECTION IN CHILDREN BELOW 3-YEARS-OF-AGE: SAFETY PROFILE, CLINICAL AND RADIOGRAPHIC OUTCOMES

Bing Wui Ng, MD; Altug Yucekul, MD; Nuri Demirci; Yilmaz Kilic, MD; Feyzi Kilic, MD; Aynur Kaval; Elif Gizem Carus, MS; Tais Zulemyan, MSc; Caglar Yilgor, MD; Ahmet Alanay, MD

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Hypothesis
Hemivertebra resection before age 3 is safe and efficient

Design
Retrospective chart review

Introduction
Controversy exists regarding the most suitable age for hemivertebrae resection. Yet, the consensus would be to treat this congenital defect before compensatory scoliosis sets in, which ultimately results in a fixed deformity. Main concerns with early surgery include the unknown neurotoxic effects of anesthetics on the developing brain, difficulties in neuromonitoring, small sized fragile pedicles, less secure fixation and extensive bleeding. This study evaluates the safety, clinical and radiological outcomes of patients with hemivertebra operated on before age 3 with a minimum 2-years of follow-up.

Methods
Demographic and radiographic data were retrospectively analyzed. Coronal and sagittal curve magnitudes and balance were measured. Correction rates, complications, intraoperative blood loss, duration of surgery and length of hospital stay were collected. Descriptive analyses were performed. Surgical technique included type-3 hemivertebra resection, use of navigation for pedicle screws and multi-rod (3-4) constructs performed by a specialized pediatric neuro-ortho surgical team.

Results
14 patients who had undergone 18 hemivertebrectomies with minimum 2-years follow-up were included. Mean age at surgery was 29 (11-35) months. Mean follow-up was 64.6 (24-121) months. Mean preoperative segmental Cobb angle of the hemivertebra and C7PL-CSVL distance was 31.2°±7.4° and 11.4mm±8.9mm, respectively. Mean postoperative segmental Cobb angle was 4.0°±3.3°. Mean segmental Cobb angle at the latest follow-up was 5.1°±6.1°, resulting in an average correction rate of 85.1%±15.2%. Mean C7PL-CSVL at the latest follow-up was 16.4mm±12.8mm. Median intraoperative estimated blood loss was 175 (75-600) and operative time was 250 (180-480) mins per hemivertebra; and length of hospital stay was 4 (3-6) days. There was one patient with recurrent wound dehiscence necessitating implant removal 2 years after surgery, and one patient had superficial wound infection. None of the patients had implant failure and all multi-rod instrumented patients used only brace as external support.

Conclusion
Hemivertebra resection in patients under age 3 results in low complication rates and provides favorable outcomes. Use of navigation, multi-rod constructs and specialized teams contribute to the procedure's safety in this age group.

165. TRENDS IN BLOOD LOSS AND TRANSFUSION IN PATIENTS WITH CEREBRAL PALSY UNDERGOING POSTERIOR SPINAL FUSION FOR NEUROMUSCULAR SCOLIOSIS

Terrence G. Ishmael, MBBS; Steven W. Hwang, MD; Joshua M. Pahys, MD; Suken A. Shah, MD; Paul D. Sponseller, MD, MBA; Peter O. Newton, MD; Nicholas D. Fletcher, MD; Amer F. Samdani, MD; Harms Study Group; Tracey P. Bastrom, MA

Hypothesis
EBVL and transfusion of RBCs and cell saver blood in PSF for patients with CP has decreased from 2008-2020.

Design
Retrospective review of prospective multicenter registry of patients with CP undergoing PSF.

Introduction
Spinal deformity is common in patients with cerebral palsy (CP). These patients undergo long surgical procedures with a high complication rate, such as bleeding requiring transfusion. Changes in surgical and anesthesia techniques have reduced blood loss in recent years, and we aimed to evaluate recent trends.

Methods
We performed a retrospective review of a prospective multicenter registry of patients with CP (GMFCS IV & V only) who had posterior spinal fusion (PSF) and a minimum 2-year follow-up. Baseline characteristics (demographics, functional status, and deformity measures) were evaluated. Operative approach and outcomes evaluated included estimated blood volume loss (EBVL), allogenic blood transfusion, cell saver transfusion, and use of tranexamic acid (TXA).

Results
333 patients (23% GMFCS IV and 77% GMFCS V) met inclusion criteria. Between 2008-2020, there was an overall decrease in EBVL with Spearman's rho value of -0.444 ($p<0.001$). CART analysis divided patients into two groups: 2008-2012 (n=157) and 2013-2020 (n=176). There were no significant differences in curve characteristics and patient demographics except that there were 82% GMFCS V in Group 1 vs. 73% in Group 2 ($p=0.037$). There was no difference in curve magnitude between the groups ($p=0.776$), percent correction ($p=0.662$), surgical time ($p=0.565$) or the rate of fusion to the pelvis ($p=0.182$). There was a decrease in cell saver transfusion (431cc vs. 319cc, $p=0.004$), decrease in transfusion of RBCs (1012cc vs. 599cc, $p<0.001$) and an increase in the use of TXA ($p<0.001$). There were also fewer anterior releases performed ($p=0.003$), fewer days spent intubated ($p<0.001$), and no difference in length of stay ($p=0.107$) or occurrence of infections ($p=0.735$).

Conclusion
Between 2008–2020, there was a decrease in EBVL and transfusion of cell saver blood and allogenic blood after PSF for patients with CP. There was also an increase in the use of TXA, decrease in the use of anterior releases, and fewer days spent intubated. The overall decrease in EBVL over time may be associated with routine use of

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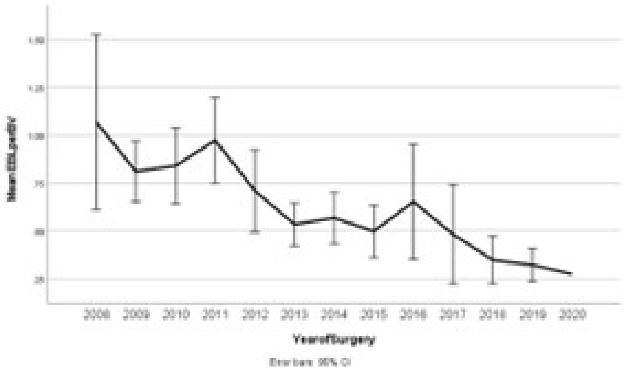
TXA, decrease in anterior releases, and practice changes in anesthesia.



rs -0.444 p<0.001

166. TRENDS IN READMISSION RATES AFTER SPINAL FUSION FOR NEUROMUSCULAR SCOLIOSIS: A 12-YEAR RETROSPECTIVE ANALYSIS

Aladine A. Elsamadicy, MD; James Cross; Joshua M. Pahys, MD; Amer F. Samdani, MD; Paul D. Sponseller, MD, MBA; Suken A. Shah, MD; Peter O. Newton, MD; Firoz Miyanji, MD; Harms Study Group; *Steven W. Hwang, MD*

Hypothesis
Length of stay, estimated blood loss, and and readmission rates have improved for CP patients undergoing fusions
over time.

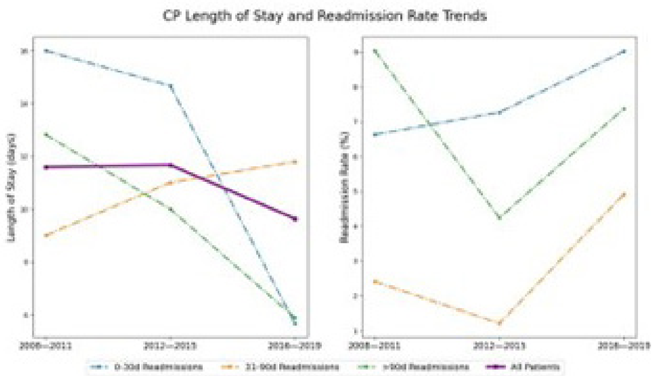
Design
Retrospective review of a prospectively collected multicenter database

Introduction
The aim of this study was to investigate the longitudinal trend in hospital readmission rates for patients with CP undergoing spinal fusion.

Methods
We queried a database for CP patients who underwent a fusion (2008-2019) from 19 centers. Patients were categorized in 4-year increments: 2008-2011; 2012-2015; 2016-2019. Readmission rates were categorized as: 0-30 vs. 31-90 vs. >90 day readmissions (with a 5.5-year cut-off post discharge to limit excessive weighting of the earlier years). Length of hospital stay (LOS) after index case and hospital readmission rates were the primary outcomes of this study.

Results
There were 453 patients included in the study, with n=166 in 2008-2011, n=165 in 2012-2015, and n=122 in 2016-2019. There were no significant differences in age at time of surgery (p=0.825). Majority of patients were GMFCS Level V (78.1% vs. 63.6% vs. 72.9%, p=0.024). There was no significant difference in the use of intra-op halo traction (p=0.669). There was a significant decrease in mean EBL in the later years (1983 mL vs. 1313 mL vs. 972 mL, p<0.001), with a decreasing trend in average operative times over the years (410 min vs. 413 min vs. 374 min, p=0.063). The mean LOS was not significantly different over time, respectively (11.6 days vs. 11.7 days vs. 9.6 days, p=0.164). Readmission rates within 30 days, 31-90 days, and >90 days have been similar over the years (2008-2011: 6.6%, 4.2%, 11.4% vs. 2012-2015: 7.3%, 1.8%, 6.7% vs. 2016-2019: 9.0%, 4.9%, 9.8%; p=0.741, p=0.311, p=0.315, respectively). There were no significant differences in the driver of readmissions (p=0.76), with the most common being surgical site/incision, gastrointestinal, and instrumentation complications (2008-2011: 7.2%%, 3.0%, 1.8% vs. 2012-2015: 5.5%, 3.0%, 1.2% vs. 2016-2019: 8.2%, 3.3%, 4.1%, respectively).

Conclusion
Our study suggests there have been improvements in the care of CP patients undergoing surgical intervention over time (EBL and OR time). However, readmission rates and the drivers of readmission have not improved. Further studies are necessary to better understand and identify risk factors for early and late readmissions to begin reducing these rates.



167. MULTICENTER ASSESSMENT OF CLOSURE TECHNIQUE FOR REDUCING SHORT-TERM WOUND COMPLICATIONS IN PEDIATRIC NEUROMUSCULAR SCOLIOSIS

Jason Z. Amaral, BS; McKenna C. Noe, BS; Rebecca Schultz, BS; Tristen N. Taylor, BS; Kennedy Morey, BS, ATC; John T. Anderson, MD; Richard Schwend, MD; *Brian G. Smith, MD*

Hypothesis
We hypothesized that plastic closure would decrease the rate of short-term complications after spinal fusion with pelvic fixation in pediatric neuromuscular scoliosis.

Design
Retrospective Comparative

Introduction
This study evaluates plastic multilayered closure (PMC) for preventing infections and improving wound healing in children with neuromuscular scoliosis (NMS) undergoing spinal fusion and pelvic fixation. It compares the rates of surgical site infection (SSI), wound complications, and unplanned reoperations between PMC and orthopedic closure (OC) techniques.

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Methods

This study analyzed NMS patients undergoing spinal fusion and pelvic fixation from 2018-2023 at two institutions using distinct closure techniques: PMC and OC. It examined demographics, surgical details, reoperation rates, and complications between the groups. SSI was defined as deep infection within 90 days post-operation, following CDC guidelines. Exclusions were patients over 18 years, those undergoing revision surgeries, and those with growth constructs. The minimum follow-up was 90 days.

Results

Of 156 patients (average age 13.5 years, 57% female), 79 underwent OC and 77 PMC. No significant differences in age, sex, blood loss, or transfusion rates were observed between groups (P>0.05). The average BMI was higher in the PMC group (19.1 vs. 17.6, P=0.008). OC procedures were shorter on average, taking 5.7 hours compared to 7.6 hours for PMC (P<0.001). Drains were placed in all PMC cases (vs. 28% of OC, P<0.001), with 25% of PMC patients discharged with a drain. SSI incidence did not significantly differ between PMC at 2.6% and OC at 8.9% (P=0.17). Similarly, there was no significant difference in the rate of wound dehiscence (11.7% vs. 3.8%, P=0.064). The 90-day rate of unplanned reoperation was 5.2% in PMC compared to 13.9% in OC (P=0.064). While 30-day readmission rates were similar (PMC at 7.8% vs. OC at 12.7%, P=0.32), PMC patients had longer average hospital stays (11.8 vs. 8.3 days, P<0.001). The median follow-up period was 1.1 years (range: 0.3-5.3 years).

Conclusion

PMC and OC techniques demonstrated similar short-term complications. PMC, however, had longer operative times, hospital stays, and increased drain use. These observations underline the need for larger prospective studies to clarify PMC's role in this patient population considering these drawbacks.

168. WHAT HAPPENS IF YOU WAIT? LARGER CURVES REQUIRE MORE RESOURCES FOR LESS CORRECTION IN NEUROMUSCULAR SCOLIOSIS

Brandon Yoshida, MD; Jacquelyn Valenzuela-Moss, BS; Tyler Tetreault, MD; Tishya Wren, PhD; Nico Silverman-Lloyd, BS; Tiffany N. Phan, BA; Lindsay M. Andras, MD; *Michael J. Heffernan, MD*

Hypothesis

Larger preoperative curve magnitude is associated with increased resource utilization in neuromuscular scoliosis.

Design

Retrospective study

Introduction

Despite previous attempts to assess the impact of curve magnitude on outcomes after posterior spinal fusion (PSF) in neuromuscular scoliosis (NMS), equipoise remains regarding optimal surgical timing. This study assessed the impact of curve magnitude on the complexity of surgery, resources utilized, and outcomes during surgical management of NMS.

Methods

Consecutive patients aged 7-21 years with NMS and fusion to the pelvis were reviewed at a single tertiary pediatric hospital from 2004-2021. Patient demographics, surgical parameters, complications, and radiographic measurements were collected. Clinical and radiographic outcomes were compared between patients with preoperative curves ≥80° and <80°.

Results

337 patients met inclusion criteria with a mean curve of 83.1°±26.5°. Patients with curves ≥80° had greater blood loss (994±607 vs 764±535 ml, p=0.0003), increased transfusion requirement (795±647 vs 478±482 ml, p<0.0001), longer surgical time (418±117 vs 338±117 min, p<0.0001) anesthesia time (552±123 vs 472±122 min, p<0.0001), and ICU stay (3±2 vs 2±1 day, p=0.009) compared to patients with curves <80°. Need for continued intubation was 2.4 times more likely (OR 2.4; 95% CI [1.5, 3.9]; p=0.0002) and the odds of utilizing adjunctive surgical techniques (i.e. intraoperative halo traction, temporary rods, and/or staged procedures) were 4 times more likely for patients with curves ≥80° (OR 4.1; 95% CI [2.5, 6.6]; p<0.0001). The use of spinal osteotomies was more likely among patients with larger curves (OR 4.6; 95% CI [2.8, 7.2]; p<0.0001). 75% of unplanned staging occurred in the ≥80° group. Residual curve magnitude (44.7±20.5 vs 22.6±13.6, p<0.0001) and pelvic obliquity (10.2±12.6 vs 4.8±8.7, p<0.0001) were higher in the ≥80° group. Complications were similar between groups (p=0.81).

Conclusion

Curve magnitude ≥80° was associated with larger residual curves despite increased surgical complexity and greater resource utilization in the management of NMS, which parents and providers should consider when deciding on timing of surgical intervention.

Variable	Curve ≥ 80° at Surgery (N=179)	Curve < 80° at Surgery (N=158)	P value
Estimated Blood Loss (cc)	994 ± 607	763.9 ± 535.4	0.0003
Transfusion Units Utilized (cc)	796 ± 647	478.8 ± 482.4	<0.0001
Length of Surgery (minutes)	418 ± 117	338.8 ± 117.4	<0.0001
Length Under Anesthesia (minutes)	552 ± 123	472.2 ± 121.6	<0.0001
ICU Stay (days)	3 ± 2	2 ± 2	0.002
Length of Hospital Stay (days) - median	7.0 (6.0)	7.0 (4.0)	0.03

Variables are presented as mean ± standard deviation or median (interquartile range). Significance defined as a p-value less than 0.05.

Table 1: Resource Utilization in Patients with Curves ≥80° vs <80°

169. DOES SPINE FUSION LIMIT AMBULATORY STATUS IN SPINA BIFIDA PATIENTS WITH SEVERE SPINE DEFORMITY?

Ambika Paulson, MD; Ryan Seltzer, MD; Kyle Graham, MPH; Douglass Clayton, MD; Jeffrey E. Martus, MD; *Gregory A. Mencio, MD*; Craig R. Louer, MD

Hypothesis

Spina Bifida (SB) patients undergoing posterior spine fusion (PSF) for severe spinal deformities do not have significant changes in ambulatory status compared to patients treated with observation (OBS).

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

PODIUM PRESENTATION ABSTRACTS

Design

Retrospective Cohort

Introduction

The functional impact of PSF in SB patients with severe spinal deformities is under-explored. This study sought to compare how PSF impacts functional capacity in SB patients relative to treatment with OBS.

Methods

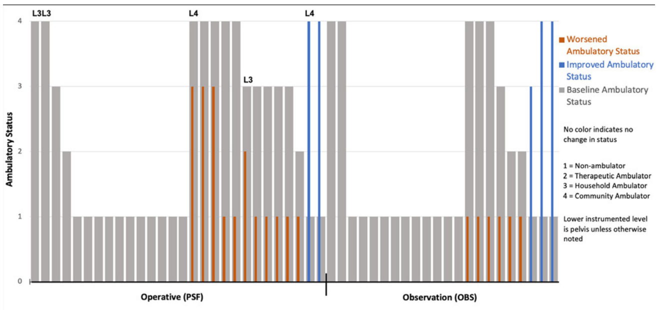
A single-institution SB registry was queried for patients with severe coronal or sagittal deformity >50°, including gibbus deformity. Prospectively collected National Spina Bifida Patient Registry (NSBPR) questionnaire data was used for longitudinal functional assessment. Patients excluded if <2 years of radiographic or NSPBR data. Primary outcomes were ambulatory level and unassisted wheelchair (WC) transfer. Hoffer criteria was used to define ambulatory status (AS) based on four categories: community, household, therapeutic, and non-ambulatory. PSF and OBS groups were compared at baseline and final follow-up, including pairwise analysis of each patient over time.

Results

52 patients met inclusion criteria (30 PSF, 22 OBS). 7 PSF patients without pre-operative NSBPR outcomes were excluded from initial visit and within groups analysis. Length of follow-up was similar between groups (7.1 vs 5.2yrs, p=0.20). At study inclusion, PSF was similar to OBS in age (6.8 vs 7.5yrs, p=0.19), coronal deformity (57.1° vs 50.6°, p=0.26), AS (community ambulators: 26% vs 23%, p=0.19), and unassisted WC transfer rate (50% vs 69%, p=0.35). Major coronal deformity at last follow-up was decreased in PSF cohort (38.0° vs 66.7°, p<0.001). Neither treatment resulted in significant change in AS over time (p=0.11 and p=0.55; Figure 1). Of the 9 patients in each group who performed unassisted WC transfers at initial visit, 6 (66.7%) per group maintained the ability to perform unassisted transfers at last visit.

Conclusion

SB patients with severe spinal deformities undergoing PSF did not show a significant decline in mobility or functional capacity relative to OBS. These findings indicate that while some functional decline may be expected as the natural progression of SB, PSF does not significantly impact this trajectory. This affirms its utility in managing severe spinal deformities and can be used to counsel SB patients considering treatment with PSF.



Initial and final ambulatory status

170. ADULT CONSEQUENCES OF NEUROFIBROMATOSIS TYPE1 PATIENTS WHO HAD SPINAL DEFORMITY SURGERIES

Arihiko Tsukamoto, MD; Koki Uno, MD, PhD; Teppei Suzuki, MD, PhD; Masaaki Ito, MD, PhD; Keita Nakashima, MD

Hypothesis

Postoperative scoliosis patients treated with neurofibromatosis type1 have poorer outcomes than postoperative idiopathic scoliosis patients and are less likely to have a satisfactory social life.

Design

Retrospective study

Introduction

Spinal deformity associated with neurofibromatosis type1(NF-1)is known to be intractable, and it's surgical outcome is known to be poorer than that of idiopathic scoliosis. However, it is not clear whether or not patients are able to lead a healthy social life as adults, and we investigated the surgical outcomes of patients who had reached adulthood after surgery.

Methods

Thirty-eight patients(16 males, 22 females) who had undergone spinal deformity surgery and had reached the age of 18 years at last follow up were included. X-rays, surgery, complications, survival rate, employment status, and married rate were evaluated. HR-QOL(SRS-22, ODI) was compared with those of adolescent idiopathic scoliosis(AIS) operated in our hospital.

Results

The mean age at the initial surgery was 14.6 [4~49] years, and the mean age at the last observation was 29.4 [18~56]years. Anterior and posterior fusion were performed in 18 patients, posterior fixation was performed in 20 patients. Five patients (13.2%) died (3: malignant schwannoma, 1:brain tumor, 1:unknown), with a mean age of 27 [18~35]years at the time of death and 12.2 [3~21] years after the last surgery. Two patients over 40 years of age were treated for vascular system disorders, and 1 patient for a brain tumor. All survivors were ambulators except 1 case of non-ambulator due to neoplastic destruction of the hip joint. The working status was light work in 13 patients, desk work in 7, unemployed in 4, students in 8. Three patients (7.9%) were married. SRS-22 and ODI in the NF-1 group were lower than in AIS, and significant differences were observed especially in Function (3.89/4.41), Pain (4.45/4.72) and Self-image (3.66/4.07).

Conclusion

At an average follow-up of 14.8 years after surgery, 5 of 38 patients had died, 29 patients (76.3%) were able to lead a healthy social life. However, HR-QOL was lower than that of AIS. Patients undergoing NF-1 scoliosis surgery require careful long-term follow-up, taking into account the possibility of reoperation due to osteolysis, malignant changes in the tumor, and vascular problems due to vascular fragility.

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		NF-1	AIS	P value
SRS-22	Function	3.80(±0.57)	4.41(±0.36)	<0.05
SRS-22	Pain	4.45(±0.50)	4.72(±0.39)	<0.05
SRS-22	Self Image	3.66(±0.58)	4.07(±0.52)	<0.05
SRS-22	Mental	4.35(±0.48)	4.48(±0.46)	0.08
SRS-22	Satisfaction	4.30(±0.66)	4.06(±0.72)	0.91
ODI		6.68(0.09)%	5.36(0.07)%	0.93

SRS22 function, Pain, and Self image were lower in NF-1 than in idiopathic scoliosis

171. A CHANGING EOS PHENOTYPE IN SMA: NUSINERSEN USE IS ASSOCIATED WITH INCREASED CURVE MAGNITUDE AND KYPHOSIS AT THE TIME OF INDEX SURGERY

John S. Vorhies, MD; Nicole S. Pham, MPH; Xochitl M. Bryson, BA; Marleni Albarran, BS; Majella Vaughan, MPH; Amy L. McIntosh, MD; Brandon A. Ramo, MD; Daniel Bouton, MD; Brian D. Snyder, MD, PhD; Michael G. Vitale, MD, MPH; John T. Smith, MD; Benjamin D. Roye, MD, MPH; Patrick J. Cahill, MD; Ian Hollyer, MD; Jaysson T. Brooks, MD; Ron El-Hawary, MD; Pediatric Spine Study Group

Hypothesis

Nusinersen administration affects preoperative curve characteristics and flexibility among patients with spinal muscular atrophy (SMA) and early onset scoliosis (EOS).

Design

Retrospective review of a multicenter database

Introduction

Nusinersen provides functional benefits to SMA patients but does not affect the prevalence or progression of scoliosis. The effect of nusinersen on curve characteristics in SMA has not been described. Here we investigate curve characteristics associated with nusinersen use in a SMA patient population undergoing initial surgical treatment for EOS.

Methods

A multicenter international pediatric spinal deformity database was queried for SMA patients undergoing initial surgical treatment (index growing construct implantation or definitive fusion) for scoliosis. Patients were stratified by exposure to nusinersen preoperatively. Preoperative clinical and radiographic characteristics and first erect postoperative radiographic parameters were compared between the two groups.

Results

225 patients were identified, 187 of which were controls (nusinersen naïve) and 38 who were treated with nusinersen preoperatively. Patients in the nusinersen group were treated for a median of 1.9 years(range: 0.02 - 5.9) prior to surgery. Mean age at surgery in the nusinersen group was lower than controls 6.4 vs 7.7yrs (p=0.002). The nusinersen group was more likely to be treated with MCGR 87% vs 45% (p<0.001). 80% of patients were instrumented to the pelvis and this did not differ between the two groups. Mean preoperative major curve and kyphosis were higher among the nusinersen group vs controls 83°vs 74° (p=0.023) and 77° vs 66° (p=0.021) respectively. Mean percent coronal correction was 46% and mean change in kyphosis was 25° and did not differ between the groups. Mean preoperative pelvic obliquity was 20°, was corrected an average of 47% and did not differ between the groups.

Conclusion

Nusinersen use was associated with larger more kyphotic curves and younger age at intervention among SMA patients undergoing initial surgical treatment for EOS. Percent correction of the curves was similar suggesting similar curve flexibility. Further study is needed to understand if Nusinersen directly affects curve characteristics or rather improves function in more severely affected patients allowing them to become surgical candidates.

	No Nusinersin Use (n = 187)		Nusinersin Use (n = 38)		
	Mean	SD	Mean	SD	p-value
Age (years)	7.7	2.7	6.4	2.0	0.002*
BMI	16.7	4.3	16.2	3.0	0.430
Preop Major Curve (degrees)	74	22	83	20	0.023*
Postop Major Curve (degrees)	39	16	45	19	0.094
Percent correction	-45.6%	22.2%	-46.1%	16.4%	0.854
Preop T2-T12 Kyphosis (degrees)	66	29	77	24	0.021*
Postop T2-T12 Kyphosis (degrees)	43	17	49	16	0.035*
Change in Kyphosis (degrees)	-25	25	-27	27	0.552
Preop Pelvic Obliquity (degrees)	20	13	23	13	0.150
Postop Pelvic Obliquity (degrees)	7	6	9	6	0.272
Percent Correction	-46.6%	82.3%	-35.9%	77.7%	0.504
	N	%	N	%	p-value
Surgery Type					
MCGR	84	45%	33	87%	< 0.001*
VEPTR/TGR	79	42%	2	5%	
Other	24	13%	3	8%	
Superior Anchors					
Rib	70	43%	19	54%	0.405
Spine	88	54%	15	43%	
Both	5	3%	1	3%	
Inferior Anchors					
Pelvis	67	41%	15	43%	0.976
Spine	32	20%	6	17%	
Spine and Pelvis	63	39%	14	40%	
Rib and Pelvis	1	1%	0	0%	

Table 1: Summary Data *p<0.05

172. SPINE MRI IN PATIENTS WITH ARTHROGRYPOSIS IS COMPULSORY DUE TO HIGH RATES OF TETHERED CORD/ LOW-LYING CONUS MEDULLARIS AND SCOLIOSIS

Hans K. Nugraha, MD; Arun R. Hariharan, MD; Aaron Huser, DO; Kaveh Asadi, MD; David S. Feldman, MD; *W.G. Stuart Mackenzie, MD*

Hypothesis

Children with arthrogryposis have a high incidence of tethered cord and low lying conus medullaris

Design

Retrospective case series

Introduction

Arthrogryposis is defined by contractures of the multiple joints and is found in conditions such as AMC. These

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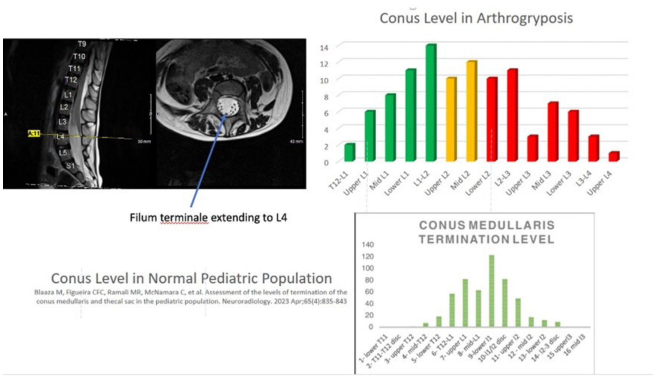
conditions are also associated with scoliosis and neural axis malformations. There have been no studies examining the prevalence of tethered cord in this population. The aim of the study was to determine the incidence of tethered cord (TC), characterized by a low-lying conus medullaris (LLCM), and secondarily, scoliosis, in children with arthrogryposis.

Methods
Patients less than 18 years old with a diagnosis of arthrogryposis and a spine MRI were identified. LLCM is defined by a conus at or below mid-L2 level of the vertebral body indicative of a TC. The MRI were independently reviewed by a pediatric neurosurgeon and a pediatric orthopedic surgeon. Clinical charts and Xrays were also reviewed. Descriptive statistics reported.

Results
39 of 102 patients (38%) had a LLCM, while 37 patients (36%) had spinal deformities, mainly scoliosis (92%). Of the 39, 21 (54%) had scoliosis with a mean Cobb angle of 52o (SD 28). Compared to the typical population, the distribution of conus termination is skewed to the caudal end of the neural axis. Mean age at MRI is 5.6 years old (SD 4.60). Nineteen patients elected to undergo detethering through filum terminale sectioning, with 13 patients having neurologic deficits in addition to their arthrogryposis such as bowel bladder dysfunction and decreased sensation in lower extremities.

Conclusion
There is a high prevalence of TC in children with arthrogryposis due to a LLCM. Nearly 40% of patients had a LLCM/TC, 54% of whom had scoliosis. This highlights the importance of a screening MRI in children with arthrogryposis, particularly with pre-surgical planning, in addition to routine exam and Xrays for scoliosis. More extensive, multicenter prospective research are needed to deepen understanding of this condition and its clinical ramifications in patients with arthrogryposis.



MRI illustrating LLCM/TC and distribution of conus level in Arthrogryposis compared to normal pediatric population

173. REDEFINING PHYSIOLOGICAL WHOLE-BODY ALIGNMENT ACCORDING TO PELVIC INCIDENCE: NORMATIVE VALUES AND PREDICTION MODELS

Marc Khalifé, MD, PhD, MS; Wafa Skalli, PhD; Claudio Vergari, PhD; Pierre Guigui, MD; Valérie Attali, MD, PhD; Rémi Valentin; Olivier Gille, MD, PhD; Virginie Lafage, PhD; Han Jo Kim, MD; Ayman Assi, PhD; Emmanuelle Ferrero, MD, PhD

Hypothesis
Global alignment parameters must be interpreted according to subject's pelvic incidence.

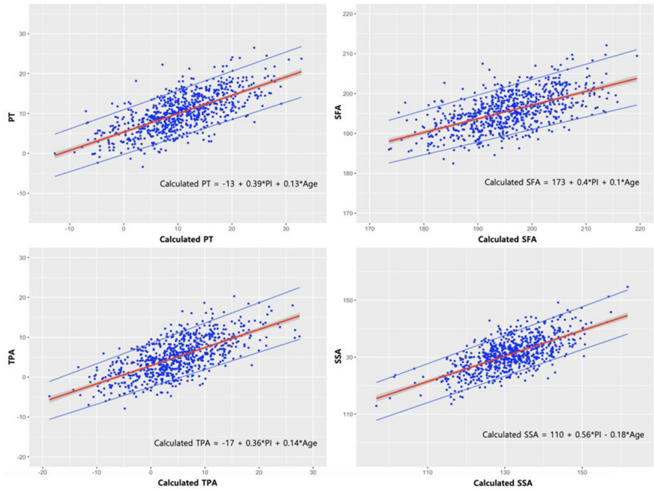
Design
Multicentric retrospective

Introduction
This study aimed at providing normative values for commonly used parameters in whole-body alignment analysis based on pelvic incidence (PI), and prediction formulas for pelvic tilt (PT), T1 pelvic angle (TPA), spino-sacral angle (SSA), maximum lumbar lordosis (LLmax) and sacro-femoral angle (SFA).

Methods
This study included healthy volunteers with full-body biplanar radiograph in free-standing position. All radiographic data were collected from 3D reconstructions: Sagittal vertical axis (SVA), T1 pelvic angle (TPA), spino-sacral angle (SSA), T1 spino-pelvic inclination (T1SPi), sagittal odontoid-hip axis angle (ODHA), pelvic parameters, sacro-femoral angle (SFA), knee flexion angle (KFA), ankle flexion angle (AA), Pelvic shift (PSh), LLmax, segmental lumbar lordoses, thoracic kyphosis (TK) and cervical lordosis (CL). Population was divided into five groups according to PI.

Results
790 subjects were included. Mean age was 33±17.7 years (range: 4-90). Mean PI in the cohort was 48±9.8°(range: 21-87). LL, PT, SFA, SSA and TPA correlated with PI and age. ODHA and the other lower limb parameters were not associated with PI. Cervical lordosis and thoracic kyphosis lost significant relationship with PI after taking age into account. SSA, SFA, TPA, segmental lumbar lordoses, LL and PT significantly increased in every PI subset. All normative values across PI groups are provided, with predictive formulas: PT=-13+0.4*PI+0.1*Age (R^2: 0.46, std error: 5.2°), TPA=-17+0.4*PI+0.1*Age (R^2: 0.45, std error: 5.1°), SSA=110+0.6*PI-0.2*Age (R^2: 0.45, std error: 6.4°), LLmax=-32-0.65*PI+0.15*Age (R^2: 0.34, std error: 8.8°), and SFA=173+0.4*PI+0.1*Age (R^2: 0.34, std error: 6.3°).

Conclusion
SSA, PT, TPA and SFA must be assessed according to patient's PI. This study provides normative values for each PI group, and predictive formulas taking age and PI into account. These results are relevant to define correction goals in adult spinal deformity surgery, but also for short fusions in degenerative surgery and traumatology cases. PI cannot be used to define thoracic and cervical curvatures.



Accuracy of prediction formulas for PT, SSA, TPA and SFA, with 95% confidence intervals (blue lines)

174. NOT ALL ARE CREATED EQUAL: LUMBOSACRAL ANATOMY IS DIFFERENT IN PEDIATRIC SPONDYLOLYSIS

Nakul Narendran, BA; Ryan Finkel, MD; Paal Nilssen, BA; Daniel Farivar, BS; Joshua Langberg, BS; Melodie F. Metzger, PhD; David L. Skaggs, MD, MMM; Kenneth D. Illingworth, MD

Hypothesis
Differences in novel lumbosacral anatomic parameters will exist between patients with and without L5 spondylolysis.

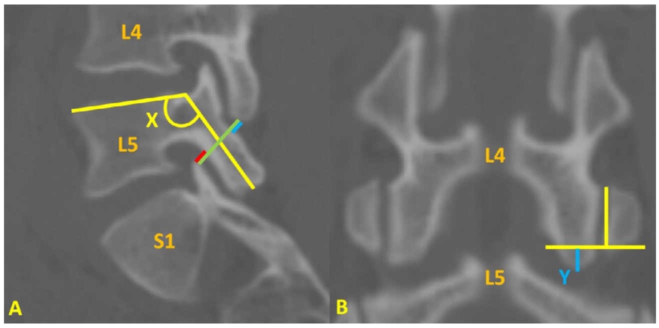
Design
Retrospective Cohort

Introduction
Pediatric spondylolysis is a known source of low back pain. With its low incidence, there is a lack of large, single-center data describing how geometric parameters of the lumbosacral anatomy contribute to its development. This study compares novel parameters on computed tomography (CT) scans of pediatric patients with and without spondylolysis at L5.

Methods
CT-scans of pediatric patients at a single-center (2005-2022) were reviewed. Patients with isolated L5 spondylolysis were identified and matched 1:4 (age, sex, BMI) to patients without spondylolysis. Sagittal parameters were assessed: sacral slope angle, sacral table angle, L4-S1 and L5-S1 Cobb angles, the horizontal angle of the L5 pars interarticularis, and the distances between the L4 inferior articular process (IAP) and the S1 superior articular process (SAP) and their respective individual distances to the L5 pars. On coronal view, the percent subluxation of L4 IAP below the facet joint was assessed. Statistical analyses included two-tailed t-tests for each parameter and Pearson correlation analysis with significance at 0.05.

Results
The incidence of L5 spondylolysis was 3% (32/1084). Spondylolysis patients (mean age 15±2.3, 46.9% female) were compared to 122 patients without spondylolysis. The horizontal angle of the L5 pars was greater in spondylolysis patients (153.1±13.8 vs. 133.5±10.0, p<.001). There was less distance (mm) between L4 IAP and S1 SAP (11.3±3.9 vs. 14.7±2.9, p<.001) in the spondylolysis group. There was less distance (mm) from both L4 IAP (2.6±1.7 vs. 5.4±2.2, p<.001) and S1 SAP (0.7±0.4 vs. 1.5±0.7, p<.001), respectively, to the L5 pars. Spondylolysis patients had greater subluxation of L4 IAP beneath the facet joint (29.0±20.1 vs. 13.2±11.4, p<.001). There was no difference in sacral slope, sacral table, or Cobb angles. Pearson's analyses revealed that a larger horizontal angle of the L5 pars is strongly associated with spondylolysis (0.59).

Conclusion
Pediatric patients with L5 spondylolysis are more likely to have a horizontal L5 pars situated closer to both the L4 IAP and S1 SAP, therefore causing increased impingement on lumbar extension.



A) Horizontal angle of the L5 pars (x) and distances between L4 IAP, L5 pars, and S1 SAP; and B) Subluxation of L4 IAP below facet joint (y).

175. SPONDYLOLISTHESIS IN CHILDREN YOUNGER THAN 10 YEARS: WHO WILL PROGRESS TO A HIGH GRADE SLIP?

Sofía Frank, PhD; Julie Joncas, RN; Soraya Barchi, BSc; Stefan Parent, MD, PhD; Hubert Labelle, MD; Jean-Marc Mac-Thiong, MD, PhD

Hypothesis
It is possible to determine predictors of slip progression in children under 10 years of age with spondylolisthesis.

Design
Retrospective analysis of prospectively collected data.

Introduction
The risk of progression for patients younger than 10 years with spondylolisthesis remains largely unknown, such that there are no guidelines on the follow-up needs for these individuals. We aim to document the progression of spondylolisthesis in children younger than 10 years and identify predictors of progression.

Methods
We reviewed the radiographs of patients younger than 10 years presenting with a spondylolisthesis at our institution, and who attended at least 1 follow-up visit. The percentage of slip, sacral slope, pelvic tilt, and pelvic incidence were measured.

Results
There were 58 girls and 36 boys aged 8.5±1.8 years at

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PODIUM PRESENTATION ABSTRACTS

initial presentation and 13.7±3.4 years at last follow-up. The mean of follow up was 5.1± 3.2 years. There were 91 patients with low-grade spondylolisthesis mean 19.1± 10.7 % slip and 3 patients with high-grade spondylolisthesis 80.1±8.5 % slip at the initial presentation. 22 patients (24%) showed a slip progression greater than 10% during follow-up. A significant association was found between the slip % at the initial presentation vs. last follow-up. No associations were found between pelvic parameters and slip progression. At the end of follow-up, 5 children had a slip greater than 50 % at the age of 12.7±5.7 years (4 were low grade spondylolisthesis and 1 high grade at the initial presentation). The mean slip percentage at the beginning was 46%(29%-73%). All these patients were girls. There were 2 girls who required surgery before the age of 10 years due to high grade spondylolisthesis.

Conclusion

The slip % at initial presentation is the most important predictor of further progression, particularly when it is 40% or greater at initial presentation. Furthermore, all subjects with a high-grade spondylolisthesis were girls. There was no association between slip progression and sagittal morphology/balance. Despite the challenge in predicting progression in children under 10 years, vigilance until skeletal maturity is prudent, particularly for girls and those presenting with a slip percentage of 40% or greater at initial presentation.

176. SOCIAL DETERMINANTS OF HEALTH PREDICT PATIENT REPORTED OUTCOMES 2-YEARS FOLLOWING SURGERY FOR GRADE 2 SPONDYLOLISTHESIS: A QOD STUDY

Vardhaan Ambati, MS; Kai-Ming Gregory Fu, MD; Timothy J. Yee, MD; Jay D. Turner, MD; Juan S. Uribe, MD; Andrew K. Chan, MD; Anthony L. Asher, MD; Domagoj Coric, MD; Michael S. Virk, MD, PhD; Christopher I. Shaffrey, MD; Oren Gottfried, MD; Eric Potts, MD; Mohamad Bydon, MD; Michael Y. Wang, MD; Paul Park, MD; Steven D. Glassman, MD; Kevin T. Foley, MD; Cheerag D. Upadhyaya, MD, MSc, MBA; Dean Chou, MD; Mark E. Shaffrey, MD; Erica F. Bisson, MD, MPH; Anthony M. DiGiorgio, DO, MHA; Praveen V. Mummaneni, MD, MBA

Hypothesis

Certain social determinants of health such as race, education, and socioeconomic status may negatively affect outcomes following surgery for Grade 2 spondylolisthesis. Patients with these identities may benefit from extra support pre-, peri-, and post-operatively.

Design

Retrospective analysis of a prospective multi-center registry

Introduction

We aim to identify which social determinants of health (SDOH) affect patient reported outcomes (PROs) 2 years after surgery for Meyerding grade 2 spondylolisthesis.

Methods

Patients with grade 2 spondylolisthesis who were prospectively enrolled at the 12-highest enrolling Quality Outcomes Database (QOD) sites were identified. Separate multivariate linear regression models were trained to identify predictors of 2-year postoperative PROs, including numerical rating scale (NRS) leg pain (NRS-LP), back pain (NRS-BP), EQ5D (quality of life), and Oswerty Disability Index (ODI). Each model was trained using the following SDOH: race (white, black, Asian, Native American/ Alaskan Native, Native Hawaiian/Pacific islander), insurance payor, education level (at least college degree vs no college degree), and preoperative employment status. Each model controlled for age, gender, (American Society of Anesthesiologists) ASA grade, BMI, and preoperative value of the studied PRO.

Results

In total, 400 patients with grade 2 spondylolisthesis were identified. The follow up rate was 80% 2 years. Protective SDOH: At least a college degree versus no college degree independently predicted improvements in NRS-LP (β-coefficient:-1.02, p=0.04), NRS-BP (β-coefficient:-0.87,p=0.01), EQ5D (β-coefficient:0.05, p=0.03), and ODI (β-coefficient:-4.2, p<0.001). Employment preoperatively predicted improvements in NRS-LP (β-coefficient:-0.85, p=0.04) and NRS-BP (β-coefficient:-0.89,p=0.03). SDOH Risk Factors: Usage of Medicaid versus private insurance was an independent predictor of worse PROs, including NRS-LP (β-coefficient:2.5, p=0.006), NRS-BP (β-coefficient:2.2, p=0.02), EQ5D (β-coefficient:-0.14,p=0.02), and ODI (β-coefficient:6.0, p=0.03).

Conclusion

Many indicators of lower socioeconomic status, such as Medicaid insurance, education level, and employment status were correlated with worse patient reported outcomes after surgery for Grade 2 Spondylolisthesis. These results may help indicate patients for whom more targeted interventions could improve outcomes.

177. INCIDENTAL DURAL TEARS DURING PEDIATRIC POSTERIOR SPINAL FUSIONS

Paal Nilssen, BA; Edward Compton, BS; Stephan Stephen, MD; Lindsay M. Andras, MD; David L. Skaggs, MD, MMM; Kenneth D. Illingworth, MD

Hypothesis

N/A

Design

Retrospective cohort

Introduction

Incidental dural tears are a known complication of spinal surgery. When they occur, several studies advocate for immediate repair if identified intra-operatively and for return to the operating room for surgical repair if identified post-operatively. In the adult population, immediate suture repair has demonstrated resolution of neurological symptoms and equivalent outcomes compared to patients without tears. In pediatric spinal deformity patients, the etiology and management of dural tears is not well documented with the largest prior study only including 6 patients. The purpose of this study is to characterize the cause, treatment modality, and outcomes of incidental dural tears in pediatric patients undergoing posterior spinal fusion (PSF).

§ = Hibbs Award Nominee – Best Clinical Paper † = Hibbs Award Nominee – Best Basic Science/Translational Paper ‡ = SRS Funded Research Grant

Methods
A retrospective review of all pediatric patients who underwent a posterior spinal fusion (PSF) between 2004-2019 at a tertiary children's hospital was conducted. Electronic medical records were reviewed for patient demographics, intra-operative data, presence of an incidental dural tear, repair method, and patient outcomes. Symptoms of CSF leaks, such as headaches, nausea, vomiting, dizziness, and lightheadedness were noted.

Results
3,043 PSFS were reviewed, with 104 dural tears identified in 99 patients (3.4% overall incidence). Mean follow-up was 32.3 months (range 0.1-142.5). When the cause of the dural tear was specified, 84% occurred during exposure, 5% during pedicle screw placement, 4% during osteotomy, 2% during removal of implants, and 2% during intra-thecal injection of morphine. The rate of dural tears during primary PSF was significantly lower than during revision PSF procedures (2.8% vs. 6.2%, p<0.05). 85.6% of dural tears were repaired and/or sealed intraoperatively, while 14.4% had spontaneous resolution. Postoperative headaches developed in 13.5% of patients and resolved at a mean of 7.6 days. There was no difference in the incidence of headaches in patients that were ordered bedrest vs. no bedrest (p>0.99). Postoperative infections occurred in 9.5% of patients and 24.1% patients were identified to have undergone a revision surgery.

Conclusion
Incidence of intra-operative dural tears in pediatric spine surgery is 3.4%. Although complications associated with the dural tear occur, most resolve over time and there were no long-term sequelae in patients with 2 years of follow up.

178. HYDROGEN PEROXIDE FOGGING REDUCES SPINAL SURGICAL SITE INFECTIONS: A QSVI PROJECT

Lorena Floccari, MD; Matthew Holloway, MD; Richard Steiner, PhD; Todd F. Ritzman, MD; Michael Bigham, MD

Hypothesis
Hydrogen peroxide fogging in the operating rooms is feasible and significantly reduces spinal surgical site infection (SSI)

Design
Longitudinal QI study with retrospective comparative analysis

Introduction
Environmental exposure is a contributor to hospital acquired infections. Decontamination with hydrogen peroxide fogging has been shown to reduce bacterial detection and bioburden in the hospital setting. We sought to 1) implement and test feasibility of an operating room-based hydrogen peroxide fogging program and 2) assess the impact of hydrogen peroxide fogging on scoliosis surgical site infections.

Methods
A hydrogen peroxide fogging program was implemented for high-risk surgical patient populations at a freestanding children's hospital in September 2022. The spine operating suite received fogging every two weeks using a third-party vendor. The feasibility assessment was designed to identify safety events related to fogging or interruptions in care/access to operating rooms due to fogging. The time series outcomes were bioburden and bacterial cultures. The primary outcome measure was the incidence of early (90-day) SSI for scoliosis fusion surgeries with comparison Pre- to Post-fogging.

Results
The feasibility assessment identified no harm events, delays or interruptions in operating room utilization related to fogging. The time series evaluation indicated return to baseline bacterial bioburden at 3-4 weeks post-fogging. 221 spinal fusions were performed, including 130 Pre- and 91 Post-fogging. There were similar patient characteristics including age, scoliosis classification, and Cobb angle (p>0.1). In the Pre-fogging group, early SSI occurred in 10/130 (7.7%, 95% CI: 4.23%, 13.58%). Following implementation of the hydrogen peroxide fogging program, early SSI was 87% less likely to occur (Odds Ratio 0.13) with incidence decreasing to 1/91 (1.1%, 95% CI: 0.19%, 5.96%)(p=0.015). This is represented by a center-line shift on the P Chart (Fig 1).

Conclusion
The risk of SSI following spinal fusion can be mitigated by implementing hydrogen peroxide fogging in operating rooms. Hydrogen peroxide fogging is feasible and significantly reduces spinal surgical site infection from 7.7% to 1.1% (p=0.015).

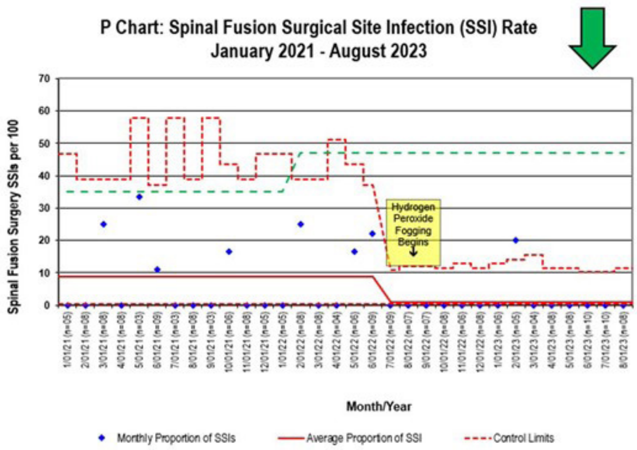

Figure 1: Statistical process control chart showing SSI over time with control limits (3 SDs).

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E-POINT PRESENTATION ABSTRACTS

201. INDICATIONS FOR MAGNETICALLY CONTROLLED GROWING RODS HAVE EVOLVED OVER TIME

Katherine Sborov, MD; David L. Skaggs, MD, MMM; Lindsay M. Andras, MD; Michael J. Heffernan, MD; Scott J. Luhmann,
MD; Peter F. Sturm, MD; Paal Nilssen, BA; Oheneba Boachie-Adjei, MD; *Kenneth D. Illingworth, MD*

Hypothesis
As the use of magnetically controlled growing rods approaches its 10th year of FDA approval, the indications for use have evolved.

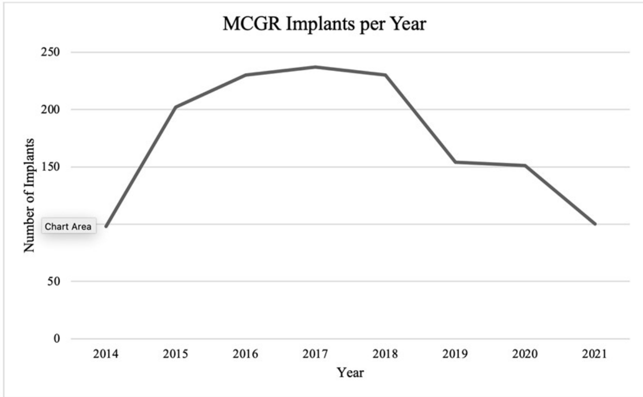
Design
Retrospective cohort

Introduction
Magnetically Controlled Growing Rods (MCGRs) first became available in the US after FDA approval in 2014 to treat early onset scoliosis (EOS). Compared to traditional growing rods, the expectation that MCGRs would reduce surgical burden in scoliosis patients led to quick expansion in their use. Though MCGRs continue to make up a large percentage of implants used in treatment of EOS, it is likely that the indications for its use have evolved overtime. This study examined the relationship between the use of MCGRs and the range of conditions for which they are indicated over time.

Methods
All cases of MCGR implants were identified through the Pediatric Spine Study Group (PSSG) database from 2014 to 2023. MCGR use over time was analyzed with respect to individual variables within the dataset including demographics, etiology, primary vs conversion surgeries, and major curve magnitude.

Results
A total of 1,546 MCGR cases were identified between 2014 and 2023. Use of MCGRs grew quickly until reaching a peak in 2017, then PSSG reporting steadily declined through 2023 (Figure 1). The use of MCGRs as a primary procedure went from 67% in 2014 to 100% in 2023. In the early years of MCGR use, rates of use in idiopathic, syndromic, congenital, and neuromuscular scoliosis were fairly equal; however, over time, relatively more MCGRs were used in neuromuscular scoliosis patients. The use of MCGRs in curves with magnitude <60 degrees declined slowly overtime with corresponding increasing rates of MCGR usage in curves >80 degrees.

Conclusion
Use of MCGRs expanded quickly after initial FDA approval in 2014 with broad indications. Over time, the indications for use of MCGRs has steadily evolved. In recent years, a higher proportion of MCGRs are used in neuromuscular scoliosis and larger curves in contrast to declining use in smaller curves. One can hypothesize that an evolving paradigm shift to more conservative "stalling" treatment options, such as bracing and serial casting or delay to final fusion likely contributed to these findings in smaller curve magnitudes.



Number of MCGRs Implanted per Year

202. FIRST TIME EVALUATION OF CEFUROXIME CONCENTRATIONS IN LONG-LASTING SPINE DEFORMITY SURGERY AFTER REPEATED WEIGHT-DOSED ADMINISTRATIONS *

Magnus A. Hvistendahl, MS; Mats Bue, MD, PhD; Sara Kousgaard Tøstesen, MD; Sofus Vittrup, MD; Maiken Stilling, MD, PhD; Kristian Høy, MD, PhD; Pelle Hanberg, MD, PhD

Hypothesis
We hypothesized that repeated weight-dosed intravenous cefuroxime administrations result in therapeutic peri- and postoperative spine concentrations.

Design
Prospective observational clinical cohort study with a repeated measures design.

Introduction
Prophylactic antibiotics are central in preventing postoperative infections, yet knowledge of peri- and postoperative spine tissue concentrations in clinical settings remains limited. Thus, current antibiotic prophylactic regimens are based on empirical knowledge, surrogate measures (e.g. plasma samples), non-clinical evidence (experimental models), or inferior methodology (e.g. tissue specimens). The aim was to continuously evaluate cefuroxime concentrations in long-lasting spine deformity surgery.

Methods
Twenty patients (15F, 5M) were included (median age: 17.5 years, mean BMI (range): 22 (16-38), mean surgery time (range): 4h 49 min (3h 57 min-6h 9 min). Repeated weight-dosed cefuroxime was administered intravenously (20 mg/kg) to all patients on average 25 min before surgery and again 4h later. Microdialysis catheters were placed for sampling in vertebral bone, paravertebral muscle, and subcutaneous tissue as soon as possible after surgery start. Upon wound closure, the vertebral bone catheter was removed, and two additional catheters were placed in the profound and superficial part of the wound. The total sampling period was up to 12 hours. The primary endpoint was the time above minimal inhibitory concentration of Staphylococcus Aureus of 4 μg/mL in

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percent (%T>MIC 4) of a) patients' individual surgery time, b) first- and c) second dosing interval.

Results

Mean %T>MIC 4 (range) of a) Patients' individual surgery time was 100% (100-100%) in all investigated tissues. b) The first dosing interval was 93% (93-93%) in vertebral bone, paravertebral muscle, and subcutaneous tissue, and 99% (99-100%) in plasma. c) The second dosing interval was 87% (52-100%) in paravertebral muscle, 89% (52-100%) in subcutaneous tissue, 91% (71-100%) in the profound incision, 94% (72-100%) in the superficial incision, and 71% (42-100%) in plasma.

Conclusion

This is the first study to evaluate cefuroxime spine concentrations. Repeated weight-dosed cefuroxime administration resulted in therapeutic cefuroxime spine tissue concentrations (>4 μg/mL) both peri- (up to 6 hours) and postoperative (up to 7.5 hours) in long-lasting spine deformity surgery.

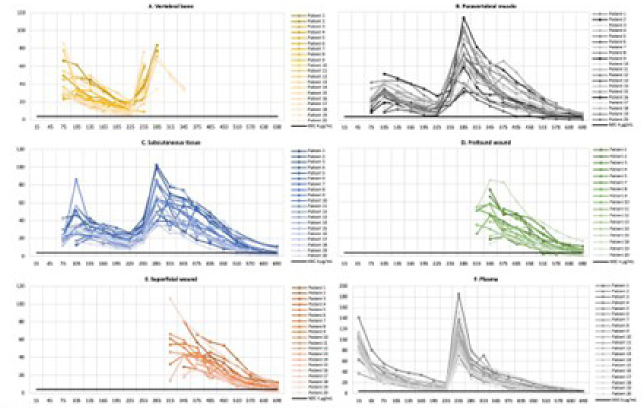

Figure 3. Cefuroxime concentration-time profiles A. Vertebral bone, B. Paravertebral muscle, C. Subcutaneous tissue, D. Profound wound, E. Superficial wound, F. Plasma. X-axis: time in minutes. Y-axis: cefuroxime concentrations in μg/mL. MIC: Minimal inhibitory concentration.

203. CURVE MAGNITUDE AND VERTEBRAL ROTATION INFLUENCES THE MRI PREDICTABILITY OF PEDICLE DIMENSIONS IN ADOLESCENT IDIOPATHIC SCOLIOSIS

Ajoy Prasad Shetty, MS Orth; Karthik Ramachandran, MBBS, MS, DNB (Orth), FNB (Spine Surgery); Rishi M. Kanna, MS, FNB (Spine surgery), MRCS; S. Rajasekaran, MD, PhD, FRCSA, MCh

Hypothesis

The reliability of MRI for predicting pedicle dimensions decreases as the severity of the curve and degree of vertebral rotation increases

Design

A Retrospective Comparative Study

Introduction

Large structural curves in AIS are characterized by increased vertebral rotation at the apex and periapical regionThe purpose of the study is to determine and compare the MRI predictability of pedicle dimensions based on severity of curve magnitude and degree of vertebral rotations

Methods

Operated AIS patients with preoperative MRI (pMRI) and intraoperative CT navigation (iCT) scan images were included. Patients were categorized based on structural curve magnitude into Group 1 (50 -70 0), Group 2 (70 - 900), and Group 3 (> 900). The degree of vertebral rotation was measured by the Nash and Moe method. Bilateral T2–L4 vertebral levels were evaluated for pedicle chord length and pedicle isthmic diameter to determine the correlation between pMRI and iCT

Results

A total of 1860 pedicles in 62 patients were analyzed. We had 31 patients in Group 1, 22 in Group 2, and 9 in Group 3. Comparison between pMRI and iCT for the pedicle diameter showed good to excellent reliability (ICC = 0.87, 95% CI = 0.75 - 0.99) at all levels except the apical levels across three groups. At the apical levels, the comparison showed good correlation (ICC= 0.87, 95% CI = 0.85 - 0.89) in group 1, moderate correlation (ICC = 0.75, 95% CI = 0.62 - 0.89) in group 2, and poor reliability (ICC = 0.37, 95% CI = 0.27-0.47) in group 3. The pedicle length showed good to excellent reliability (ICC = 0.92, 95% CI =0.85-0.99) across all three groups. Comparison showed that Nash and Moe type N and 1+ for pedicle diameter showed excellent correlation (ICC = 0.95, 95% CI = 0.90 - 0.99) whereas type 2+ showed good correlation (ICC = 0.84, 95% CI = 0.74 - 0.94) at all levels. Type 3+ and 4+ showed moderate to good correlation (ICC = 0.77, 95% CI = 0.56 - 0.99) at all levels except the apex. At the apical level type 3+ showed poor to moderate correlation (ICC = 0.50, 95% CI = 0.25- 0.75), and type 4+ showed poor correlation (ICC =0.44, 95% CI = 0.21 - 0.68).

Conclusion

The degree of vertebral rotation and the magnitude of the structural curve both have a significant impact on the MRI prediction of the pedicle dimensions with decrease in the predictability as the curve magnitude and vertebral rotation increases.

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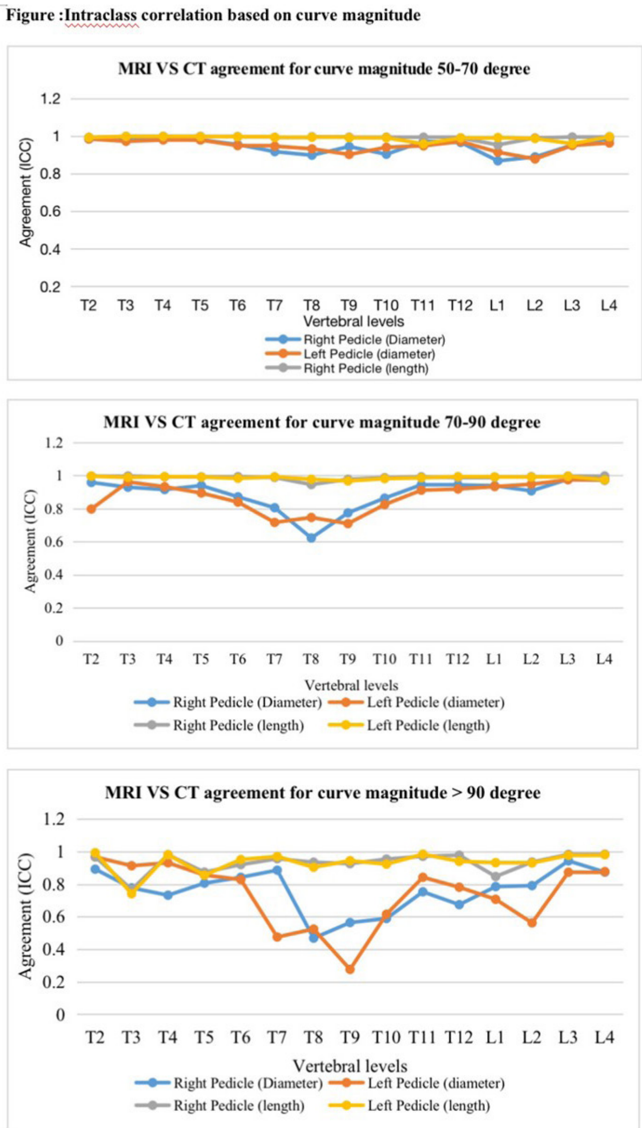


ICC for curve magnitude

204. PREDICTIVE VALUE OF FULCRUM BENDING RADIOGRAPHS ON POSTOPERATIVE THORACIC KYPHOSIS IN ADOLESCENT IDIOPATHIC SCOLIOSIS

Victoria Yuk Ting Hui; Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; Prudence Wing Hang Cheung, PhD, BDSc (Hons)

Hypothesis
Thoracic kyphosis (TK) and TK change under fulcrum bending (FB) are predictors of postoperative normokyphosis.

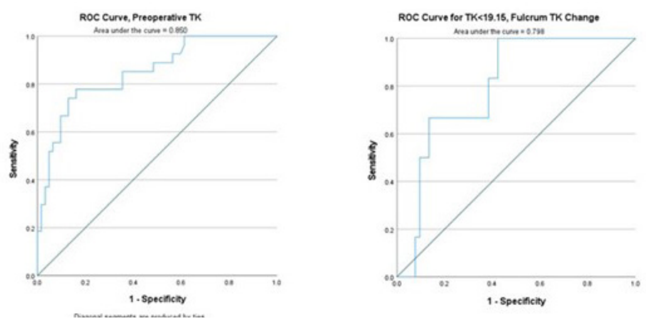
Design
Retrospective single-centre study

Introduction
FB radiographs can predict the direction of surgical TK correction. Adolescent idiopathic Scoliosis (AIS) is associated with hypokyphosis, yet the indications for kyphosis restoration procedures such as Ponte osteotomies remain unclear. This study aims to identify predictors of postoperative normokyphosis (NK) on FB radiographs and identify a cutoff in which additional procedures should be performed to improve sagittal correction.

Methods
Lenke 1 AIS patients undergoing selective thoracic posterior spinal fusion using pedicle screw constructs (±2 hooks) in the past 20 years with minimum 2-year follow-up were included. Patients with poor visualisation of fulcrum T5-T12 TK were excluded. Hypo-, normo- and hyperkyphosis, were defined based on T5-T12 TK as TK<20, TK=20-40 and TK>40 respectively. Measurements include standing main thoracic (MT) Cobb, global T1-T12, T5-T12 TK, T10-L2 thoracolumbar kyphosis, S1-L1 lumbar lordosis; on FB films, MT Cobb and T5-T12 TK. Fulcrum TK change is the difference between standing and fulcrum bending T5-T12 TK. Significant (p<0.2) preoperative factors are entered into logistic regression to find significant predictors of postoperative NK. Cutoffs of identified predictors with the highest sensitivity and specificity are identified from an ROC curve.

Results
89 patients were included (1A: 64; 1B: 20, 1C: 5). Postoperatively, 69.7% (n=62) were hypokyphotic, 30.3% (n=27) normokyphotic. In logistic regression, increase in T5-T12 TK (OR: 1.20; 95%CI: 1.10-1.30; p<0.001) and fulcrum TK change (OR: 1.10; 95%CI: 1.01-1.19; p=0.02) were significant predictors of postoperative NK. TK>19.2 was the cutoff for postoperative NK (AUC: 0.85; 95%CI: 0.76-0.94; sensitivity: 0.78; specificity: 0.84) from the ROC curve (Figure). For TK<19.2, the cutoff of fulcrum TK change for postoperative NK was 4.1 (AUC: 0.80; 95%CI: 0.66-0.94; sensitivity: 0.83; specificity: 0.62).

Conclusion
Increase in T5-T12 TK and fulcrum TK change are predictors of postoperative NK. TK<19.2 and fulcrum TK change<4.1 increases the risk of postoperative hypokyphosis and kyphosis restoration procedures such as Ponte osteotomies should be considered.



ROC curve of postoperative NK using T5-T12 TK (left) and fulcrum TK change for TK<19.15 (right)

205. PELVIC INCIDENCE AS A PREDICTOR OF PROXIMAL JUNCTIONAL KYPHOSIS IN PATIENTS WITH ADOLESCENT IDIOPATHIC SCOLIOSIS LENKE TYPE 5

Takahiro Kitagawa, MD, PhD; Satoshi Suzuki, MD, PhD; Kazuki Takeda, MD, PhD; Toshiki Okubo, MD, PhD; Masahiro Ozaki, MD, PhD; Osahiko Tsuji, MD, PhD; Narihito Nagoshi, MD, PhD; Mitsuru Yagi, MD, PhD; Morio Matsumoto, MD, PhD; Masaya Nakamura, MD, PhD; *Kota Watanabe, MD, PhD*

Hypothesis

Combination of pelvic incidence and the thoracolumbar sagittal profile may predict the onset of proximal junctional kyphosis (PJK) in adolescent idiopathic scoliosis (AIS) type 5 patients.

Design

A retrospective study of prospectively collected data.

Introduction

Recent research has emphasized the importance of sagittal alignment in AIS patients, alongside coronal alignment. However, the risk factors for PJK, a common complication of sagittal malalignment following posterior spinal fusion (PSF) surgery, are not well understood. Given the suggested significance of pelvic morphology in PJK development, our study aimed to explore the relationship between pelvic incidence (PI) and PJK occurrence in patients with AIS type 5.

Methods

We conducted a retrospective analysis of 92 type 5 AIS patients who underwent selective thoracolumbar PSF and had a minimum follow-up of 2 years. Patients were classified into PJK and non-PJK groups based on post-operative outcomes. Binary logistic regression was used to assess the impact of PI on PJK development. Subgroup analyses, based on PI values (low PI, < 45°; high PI, ≥ 45°), were performed to identify factors influencing PJK occurrence.

Results

PJK was observed in 17.4% of cases (16 out of 92). There was no significant demographic difference between the PJK and non-PJK groups. Binary logistic regression indicated that a lower PI was a significant risk factor for PJK (odds ratio, 0.933; p = 0.017). Subgroup analysis revealed that, regardless of PI level, patients with PJK showed a comparable increase in the postoperative upper instrumented vertebra (UIV) slope. However, a significantly larger lordotic change at the fused area was observed in PJK patients with low PI. The Scoliosis Research Society-22 scores post-operatively showed no significant difference between the groups.

Conclusion

Our findings highlight the increased risk of PJK in Lenke type 5 AIS patients with low PI undergoing selective thoracolumbar PSF. The significant lordotic change at the fused area, coupled with limited pelvic compensatory capacity, suggests a higher likelihood of PJK development in this subgroup.

206. SHOULD WE EXPECT CHANGES IN SPIN-PELVIC ALIGNMENT AFTER AIS POSTERIOR SURGERY? *

Kariman Abelin Genevois, MD; Dylane Cherif, MS, MSc

Hypothesis

AIS is a 3D deformity often characterized by a regional flattening of the spine. The main consequences on global alignement are posterior sagittal malalignement and pelvic anteversion. However the spinopelvic parameters are mainly correlated to pelvic morphology. We hypothesize that surgical correction of regional deformity does not affect the spinopelvic alignement.

Design

Prospective radiographic study of AIS before and at least 2 years after spinal correction.

Introduction

Spinal balance involves a complex interaction between the pelvis and vertebral column. In the setting of AIS deformity, prediction of postoperative alignment can be challenging. The main goals are the correction of the regional deformity in all components (translation, rotation and hypokyphosis) with the shorter fusion. The challenge is to reharmonizes the global coronal and sagittal alignement by reciprocal changes. But what shall we except in terms of spinopelvic alignement as most of our patients present with sagittal malalignement?

Methods

The study included 80 AIS patients followed at least 2 years after surgery for whom a preoperative planification and patient specific rods were manufactured. EOS full-length standing films were available for all subjects. Postoperative sagittal alignment was compared to preoperative alignment in terms of Roussouly morphotype. Spinopelvic and spinal parameters modifiable through surgery (lumbar lordosis and thoracic kyphosis) were measured and compared.

Results

Mean preoperative Cobb 56° was corrected to 26°(mean 54%). Preoperatively, patients presented with a posteriorly imbalanced spine (Barrey ratio (-238%) and pelvic anteversion (-8,8°). Only balance ratio was corrected (9%, p<0.01) while spinopelvic parameters slightly varied but no significant change was observed (PT 7,6°, SS 44,7°, PI 52,2°). Moreover, patients did not modify their Roussouly morphotype postoperatively (91% were type 3 or 4). The only spinal parameters that were affected were those modifiable by the construct: T4T12 (29 to 37°, p<0,01) and L1S1 (56° to 61°, p<0.01) without changes in L4S1 lordosis (65%). Both parameters increased in the expected ranges.

Conclusion

Surgical correction of AIS meant to correct regional malalignement (TK, LL) and to normalize the thoracolumbar junction which corrected. No significant impact was observed in the spinopelvic alignement at 2 years postoperatively, patients keeping their pelvic morphotype.

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E-POINT PRESENTATION ABSTRACTS

207. FUSION SHORT OF THE LAST VERTEBRA TOUCHED BY THE CSVL IS SUCCESSFUL FOR LENKE 1A-R CURVES WHEN RISSER 1 OR GREATER

Jack Martinez, MD; Anna McClung, BSN; David C. Thornberg, BS; Chan-Hee Jo, PhD; Daniel J. Sucato, MD, MS

Hypothesis

A lowest instrumented vertebra (LIV) selection proximal to the vertebra last touched by the CSVL for the Lenke 1AR curve achieves good results in skeletally-mature patients.

Design

Retrospective review of prospective single institution registry.

Introduction

Lenke 1A-R curves are often fused more distal to potentially avoid adding on and coronal imbalance. However, previous studies have been limited. The purpose of this study is to analyze a homogeneous patient population of only Lenke 1A-R curves from a single institution to review the results of LIV selection and to provide predictive factors for a successful outcome.

Methods

This is a retrospective review of a prospectively-enrolled patient database of a consecutive series of Lenke 1A-R adolescent idiopathic scoliosis (AIS) patients undergoing surgery) with a minimum of 2 year follow up at a single institution. Radiographic outcome and the SRS 22-R patient-reported outcome scores were reviewed and comparisons made between those fused proximal to the last touched vertebra (PLTV) and those fused to the LTV (TLTV).

Results

There were 54 patients at 14.4 years with coronal Cobb correction from 59.7° to 15.3° with significant improvement in SRS-22 appearance (3.46 to 4.07) and satisfaction (3.9 to 4.41) domains and total score (3.87 to 4.15) ($p<0.001$). The preoperative last-touched vertebra (LTV) by the center sacral vertical line (CSVL) was L3 (59.3%), followed by L2 (35%) while the LIV was generally more proximal with the most common LIV of L2 (64.8%) then L3 (27.8%). The preoperative coronal plane data were similar between the PLTV and TLTV groups. At final follow-up, the PLTV group who were skeletally mature (Risser ≥1) had no differences in radiographic or SRS-22 outcomes compared to the TLTV group. However, at final follow-up for skeletally immature (Risser=0) patients, the PLTV group had a greater distance from LIV to the CSVL (18.9 vs 7.5 mm, $p=0.01$) without differences in coronal Cobb (17.4 vs 14.3°) trunk shift (7.4 vs 4.6 mm), and coronal balance (9.3 vs 7.3 mm) when compared to the TLTV group but without difference in SRS-22R scores at final follow-up.

Conclusion

When planning operative treatment for Lenke 1A-R curves, motion preservation is possible with fusion short of the vertebra last touched by the CSVL as long as the patient is not skeletally immature.

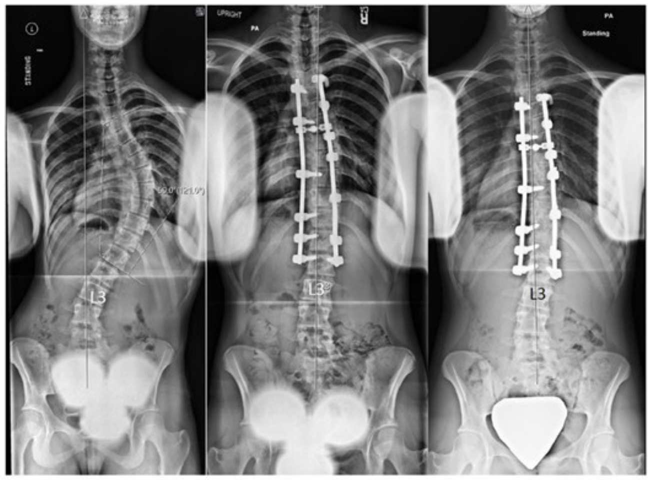

Figure 1A Figure 1B Figure 1C

PLVT patient successfully treated

208. PREOPERATIVE INTRATHECAL MORPHINE INJECTION IS SUPERIOR IN TERMS OF PAIN CONTROL WHEN COMPARED TO A POST-INCISIONAL INJECTION

Vishal Sarwahi, MD; Sayyida Hasan, BS; Keshin Visahan, BS; Katherine Eigo, BS; Peter Boucas, DO; Benita Liao, MD; Matan Grunfeld, BS; Effat Rahman, BS; Jon-Paul P. DiMauro, MD; Yungtai Lo, PhD; Terry D. Amaral, MD

Hypothesis

Administration of intrathecal morphine pre-incision will lead to superior outcomes, such as a reduction in post-op pain.

Design

Retrospective cohort study

Introduction

Intrathecal morphine (ITM) has become a widely used adjunct in pediatric scoliosis surgery due to its benefit in decreasing narcotic use and improving pain scores. While optimal dosages and formulations have been described, it is unclear whether administration should be pre- or post-incision.

Methods

Patients with AIS undergoing primary instrumentation and fusion by three senior attendings between 2018 – 2022 were included. 400 patients met inclusion criteria, with 205 receiving intrathecal morphine pre-incision by the anesthesia team and 195 receiving intrathecal morphine by the surgeon at the time of closure. Outcomes measured include maximum pain score (POD 0 – 2), time to OOB, LOS, packed red blood cell (pRBC) transfusions, complications, narcotic refills, and morphine consumption at various timepoints. Kruskal-Wallis and Chi-Squared tests were used in data analysis to determine statistical significance. Patients in the ITM group were further divided into those who underwent concurrent rib-resectioning during their PSF and those that did not.

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Results
The demographics of the study groups demonstrated no significant differences. Max pain scores were significantly lower in the group receiving intrathecal morphine pre-incision (7.0 vs 8.0, p = 0.047). When looking at individual postoperative days, patients experienced similar pain scores at activity for POD 0, POD 1, and POD 2 (p= 0.29, p= 0.88, and p= 0.23, respectively). OOB and LOS did not show any significant differences between groups. However, the pre-incision group used significantly less morphine during the 24–48-hour post-op period (p= 0.02) and less total morphine overall (p= 0.02). There were no observed differences in transfusion, narcotics refilled, or total complications between groups. There were no differences seen in our analysis on rib resectioned patients compared to patients that did not undergo rib resectioning.

Conclusion
Intrathecal morphine administered pre-incision leads to better and more predictable pain control in AIS patients undergoing instrumented PSF. Furthermore, ITM is effective in controlling post-operative pain even when an additional painful procedure, such as rib-resectioning, is done.

209. HOW ACCURATE ARE ANATOMICAL SURFACE TOPOGRAPHY PARAMETERS IN INDICATING THE PRESENCE OF A SCOLIOSIS?

Adrian Gardner, FRCS (Tr & Orth); Fiona Berryman, PhD; Paul Pynsent, PhD

Hypothesis
An accurate assessment of the presence or absence of a scoliosis can be made using surface data.

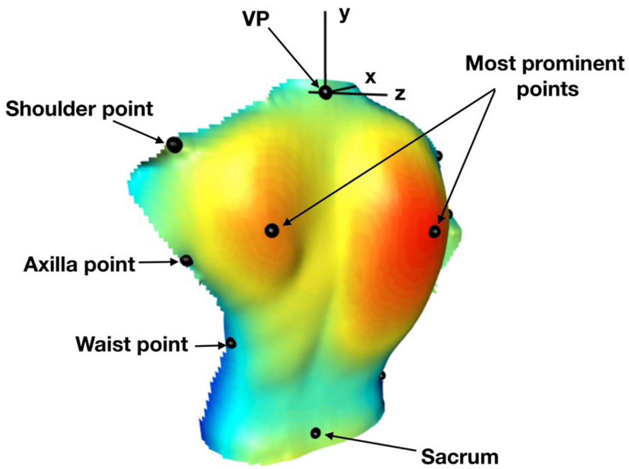
Design
Retrospective analysis of a longitudinal cohort.

Introduction
The identification of AIS can be difficult. Screening programmes are not universal for reasons that include unacceptably high false positive and negative rates. The difficulty in the identification of AIS leads to some adolescents missing out on the possibility of bracing in the management of their scoliosis.

Methods
Logistic regression analysis of previously collected ISIS2 surface topography images in those with AIS was performed. The x and y positions of anatomical landmarks of the shoulders (Sh), axillae (Ax), waist (Waist) and the x,y,z positions of the most prominent points over the posterior torso (Scap) were used in two different models, one for main thoracic curves and one for main thoracolumbar / lumbar curves. The models were used to identify the presence or absence of a 20° or larger scoliosis. The position of the anatomical landmarks were analysed to identify a difference in position comparing the left and right sides, with the suffix 'Ht' representing a difference in the y coordinate, the suffix 'Off' a difference in the x coordinate and 'Depth', the z coordinate of the most prominent points. The accuracy of the models was assessed both as a percentage and as a ROC curve. The size and effect of the coefficients were described as odds ratios.

Results
There were 3139 images from 1286 individuals (1017 females and 269 males) between the ages of 10 and 18 years. The model identified a 20° or larger scoliosis in the thoracic spine with an 85% accuracy (AUC 0.92) and in the thoracolumbar / lumbar spine with a 70% accuracy (AUC 0.74). Non-significant parameters were ScapDiffDepth for the thoracic curves and ShDiffHt, WaistDiffOff, ScapDiffOff, ScapDiffHt and ScapDiffDepth for the thoracolumbar / lumbar curves.

Conclusion
The use of fixed anatomical points around the torso, analysed through a logistic regression technique, has a high level of accuracy for the identification of both thoracic and thoracolumbar / lumbar curves. Whilst this work came from surface topography images, the results raise the possibility of the future use of digital photography as the basis of a tool for the identification of a small scoliosis by those without recourse to standard hospital imaging techniques.



The 3D position of the surface points

210. INCIDENCE AND RISK FACTORS OF POSTOPERATIVE NECK IMBALANCE AT 10-YEARS IN PATIENTS WITH AIS LENKE TYPE 1

Ayato Nohara, MD; Noriaki Kawakami, MD, DMSc; Kazuki Kawakami, MD, B-Kin; Tetsuya Ohara, MD; Hiroko Matsumoto, PhD

Hypothesis
Among patients diagnosed with Adolescent Idiopathic Scoliosis (AIS) Lenke type 1 who underwent posterior spinal fusion (PSF), those who had less correction of the proximal thoracic curve exhibit an increased risk to neck imbalance at a postop duration of 10 years or more.

Design
A single-center retrospective cohort study of AIS patients

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with Lenke type 1 who underwent PSF between 1997 and 2003.

Introduction

Neck and shoulder imbalance frequently manifests in AIS patients subsequent to PSF. While previous studies have explored shoulder imbalance, highlighting overcorrection of the main thoracic curve as a risk factor, studies on neck imbalance remain scarce, particularly regarding long-term evaluations. This study aims to examine the impact of curve correction on neck imbalance, a factor posited to correlate with health-related quality of life (HRQoL) at postop durations of 10 years or more.

Methods

Inclusion criteria encompassed patients diagnosed with AIS Lenke type 1 who underwent PSF with Upper Instrumented Vertebra (UIV) ranging from T3 to T5 and attained a minimum follow-up of 10 years. Radiographic evaluations were conducted at preop, immediate postop, and 10-year postop intervals, alongside HRQoL assessments using the SRS-30 at the 10-year postop mark. Postop neck imbalance was defined as a neck tilt ≥4°.

Results

Among the cohort of 102 patients, neck imbalance manifested in 27 patients (26%) immediately postop and observed in 28 patients (27%) at the 10-year postop. Patients exhibiting greater correction of the proximal thoracic curve demonstrated a reduced risk of the imbalance beyond 10-year postop ($\beta=0.346$, $p=0.01$), adjusted for preop neck imbalance, an identified confounder. The proximal thoracic curve correction was 37.7% in the balanced group cand 24.6% in the imbalanced group ($p=0.001$). Patients experiencing postop neck imbalance reported increased postop pain by 0.2 units, reaching the minimal clinically important difference.

Conclusion

Bigger correction of the proximal thoracic curvature yielded an increased likelihood of harmonious alignment of the neck, thereby potentially alleviating pain over postop durations surpassing 10 years in patients diagnosed with AIS of Lenke type 1, featuring an UIV ranging from T3 to T5.

		Neck Imbalance	Neck balanced	P value
N		28 (27%)	74	
Shoulder Balance	preop	-3.2±3.3	-3.9±3.0	0.25
	postop	2.2±2.6	0.7±2.3	0.01
	PO10y	2.0±1.7	0.9±1.7	0.01
Neck Tilt	preop	2.6±2.6	-0.3±3.2	0.001
	postop	4.0±2.4	1.6±2.3	0.001
	PO10y	5.3±1.4	0.6±1.8	0.001
Proximal Thoracic Curve	preop	26.1±7.0	24.2±7.4	0.07
	postop	16.8±5.4	12.9±4.9	0.001
	PO10y	18.3±6.8	12.7±4.8	0.001
Correction of Proximal thoracic Curve	postop	35%	45%	0.01
	PO10y	27%	46%	0.01
SRS-30 at PO10y				
Function		4.2±0.5	4.1±0.4	0.77
Pain		4.2±0.5	4.4±0.3	0.12
Self-image		3.5±0.6	3.4±0.5	0.96
Mental Health		4.1±0.8	4.2±0.6	0.78
Satisfaction		4.1±0.6	4.1±0.6	0.52

211. GOING BEYOND THE LAST TOUCHED VERTEBRA - USING THE S1-LIV ANGLE TO GUIDE FUSION SELECTION IN ADOLESCENT IDIOPATHIC SCOLIOSIS

Soren Ohrt-Nissen, MD, PhD; Martin Heegaard, MD; Lærke C. Ragborg, MD; Jason Pui Yin Cheung, MD, MBBS, MS, FRCS; Martin Gehrchen, MD, PhD; Thomas B. Andersen, MD, PhD, DMSc; Benny T. Dahl, MD, PhD, DMSc

Hypothesis

A high S1-LIV angle is a predictor for distal adding-on (DA-O)

Design

Retrospective cohort study

Introduction

Selective thoracic fusion in Lenke 1 and 2 curves involves careful consideration when selecting the lowest instrumented vertebra (LIV) to avoid postoperative curve progression with DA-O. The last touched vertebra (LTV) has been suggested as a clinically applicable landmark. The aim of the study was to assess whether fusion levels could be saved by using the S1-LIV angle as a more sensitive guide for fusion selection.

Methods

From a single center we included patients with Lenke 1 and 2 curves with A or B lumbar modifiers. Patients were followed for a minimum of two years with frontal and sagittal radiographic. On preoperative bending x-rays we measured flexibility (or range of motion) of the disc below the LIV (LIV-disc). On frontal radiographs we measured the S1-LIV angle which is the angle between a vertical line and a line from the center of the LIV to the center of S1 (figure). Distal adding-on was defined as a postoperative increase in Cobb angle of at least 5° and distalization of the end vertebra or a change in angulation of >5° in the LIV disc.

Results

We included 178 patients with a mean preoperative Cobb angle of 61±13°. Distal adding-on occurred in 55 patients (30%). Univariate analysis identified DA-O to be associated with apical curve translation, standing LIV-disc angulation, LIV tilt, LIV-LTV distance, S1-LIV angle and L4 tilt ($p<0.005$). Flexibility of the disc below LIV was not associated with DA-O. On multivariate regression analysis, we found S1-LIV angle and L4 tilt to be significantly associated with distal adding-on ($p<0.020$). A S1-LIV angle of more than 10° resulted in and OR of 12.5 (95% CI: 5.9-26.6) for DA-O. Using this threshold would save fusion levels in 15 patients compared to using the LTV. For a L4 right tilt (Lenke 1AR) OR was 2.8 (95%CI: 1.4-5.4).

Conclusion

The S1-LIV angle was a stronger predictor for DA-O than the LTV. Choosing an LIV with a S1-LIV angle of more than 10° results in 12 times higher odds of DA-O and can be used as a clinically meaningful threshold.

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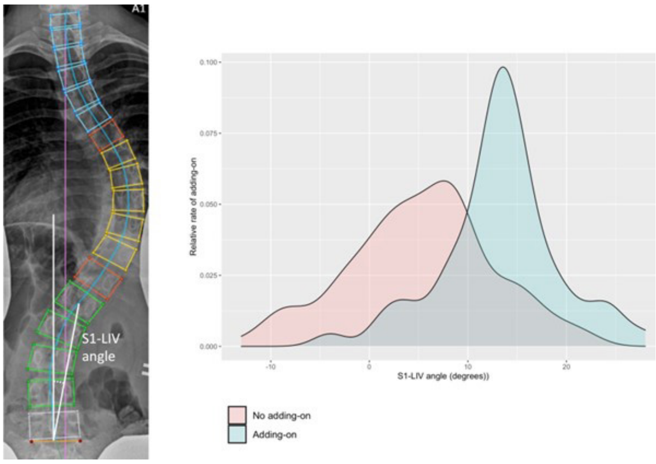

Left. Example of the S1-LIV angle: Right: Showing the distribution of DA-O according to S1-LIV angle.

212. REOPERATIONS AND SAGITTAL ALIGNMENT MODIFY LONG-TERM QOL IN PATIENTS WITH AIS WHO UNDERWENT SURGERY WITH THIRD-GENERATION IMPLANTS DURING ADOLESCENCE ‡

Antonia Matamalas, MD, PhD; Francisco Javier S. Perez-Grueso, MD; Juan Bago, MD, PhD; Javier Pizones, MD, PhD; Lucía Moreno-Manzanaro, BS; Juan Carlos Tortajada Bustelo, MD; Susana Núñez Pereira, MD; Sleiman Haddad, MD, PhD, FRCS; Carlos Villanueva Leal, MD, PhD; Ferran Pellisé, MD, PhD

Hypothesis

Residual deformity and disc degeneration are major drivers of long-term quality of life (QOL) for patients with idiopathic scoliosis (AIS) operated during adolescence.

Design

Multicenter cross-sectional study.

Introduction

AIS surgery aims to improve QOL by correcting spinal deformity and achieving trunk balance through minimal fusion. The long-term factors influencing QoL in patients operated with 3rd-gen implants are not yet well-defined.

Methods

We included AIS patients operated during adolescence with CD or ISOLA systems and ≥25 years of follow-up (FU). QOL was assessed using a numerical pain scale (NRS), SRS-22r, SF-36, and EQ-5D-5L questionnaires. At FU, patients underwent full-spine X-rays and lumbar MRI, evaluated by an independent radiologist. A multivariate analysis controlling for confounding variables was performed. Dependent variables: QOL scores. Independent variables: surgical parameters (unfused lumbar levels, reoperations); coronal and sagittal alignment parameters; L4 to S1 disc degeneration (Pfirrmann, Modic).

Results

Out of 226 eligible patients, 139 (61.3%) (86% women, mean age: 45.1;38-55;) consented for radiologically evaluation, after a mean FU of 30±2.8 years. 70 patients (46.1%) had an LIV below L3. 17 (7.9%) had an unplanned reoperation (UR). At FU, 88.8% of patients were coronally balanced (C7SVL<2.5 cm) (mean 14.4±11.6 mm) and 70.4% sagittally balanced (SVA<5 cm) (mean 17.4 ±34.4 mm). Mean Gap-score was 2.9±3 points (48.9% proportioned). Patients with LIV below L3 exhibited greater L5-S1 disc degeneration and higher pain intensity (mean NRS 2.8 vs 3.9; p<0.05) compared to patients with LIV at or above L3. Patients with SVA>5cm had lower EQ-5D-5L (p=0.04) and SRS-22 self-image (p=0.02) scores than the sagittally balanced. Multivariate analysis showed that the number of UR is associated with worse EQ-5D-5L (p<0.01) and SRS-22 self-image (p<0.01) scores. Sagittal malalignment with worse NRS (p=0.03), SF-36-function (p=0.02), EQ-5D-5L (p=0.01), and SRS-22-self-image (p<0.01). Modic changes at L4-L5 and L5-S1 levels are associated with worse SF-36-function (p=0.02) scores.

Conclusion

While 3rd-generation implants have the ability to control sagittal contour (compared to older systems), sagittal malalignment and unplanned reoperations persist as main determinants of QOL, 30 years after surgery for AIS.

213. PROGRESSIVE CURVE STRAIGHTENING OCCURS IN SKELETALLY IMMATURE PATIENTS AFTER ANTERIOR THORACOSCOPIC SINGLE-ROD FUSION FOR SCOLIOSIS – IS THIS 'THE ULTIMATE TETHER'?

Gin Way Law, MBBS, MRCS, MMed; Glenys Poon, MBBS, MRCS; Sunwoo Sunny Kim; John NM Ruiz, MD; Leok-Lim Lau, FRCS; Gabriel KP Liu, MD; Hee-Kit Wong, FRCS

Hypothesis

Progressive post-operative curve straightening occurs in anterior thoracoscopic instrumented fusion, more commonly observed in the skeletally immature.

Design

Retrospective clinical and radiological study.

Introduction

Post-operative curve straightening is a unique phenomenon seen in thoracoscopic fusion for correction of adolescent idiopathic scoliosis (AIS). This has not been previously described, and its underlying etiology remains unknown.

Methods

We performed a retrospective study of female patients aged 11-20years with Lenke 1 curves that underwent thoracoscopic single-rod fusion for AIS correction from June 2000-July 2013. Patients with post-operative screw pull-outs were excluded. Patients with curve straightening(≥5°) of instrumented levels(Group1) were compared to those without curve straightening(<5° change) (Group2). Our primary outcome measures were maintenance of curve correction over time, complications, and re-operation rates.

Results

19 out of 40 patients (47.5%) demonstrated curve straightening(≥5°) of the instrumented levels. Mean

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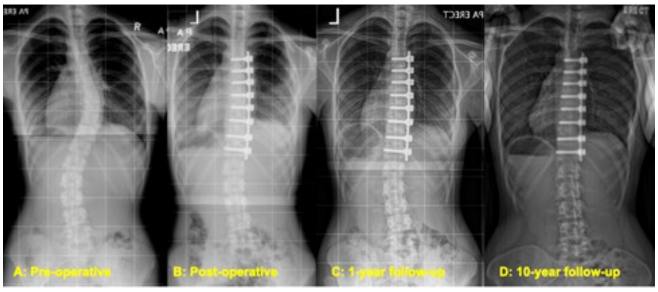
instrumented-level cobbs angle differences at last follow-up were 6.4±1.0° and 1.8±1.7° in Groups 1 (n=19) and 2 (n=21) respectively (p<0.001). Curve straightening in Group1 started within 6 months from surgery (2.5±1.4°), with the majority of change occurring within the first two years (4.3 ± 1.9°). Mean duration of follow-up was 95.7months. Pre-operative main thoracic curve sizes were 46.9±10.4° and 47.2±11.2° for Group1 and 2 respectively (p=0.942). Although Group1 had a slightly higher post-operative residual curve (12.2±4.0° vs 9.0±5.2°, p=0.035), this difference was resolved by 6 months with curve straightening (Group1: 9.8±3.3°, Group2: 9.5±4.8°, p=0.808). The proportion of skeletally immature patients (Risser 0-3) at time of surgery was higher in Group1 at 72.2%, compared to 15.8% in Group2 (p<0.001). Mean Risser grade in Group1 and 2 were 2.7±1.2 and 3.8±0.5 respectively (p=0.002). Complications including adding on, loss of correction(>5°), rod breakage, and re-operation rates were similar between both groups (p>0.05).

Conclusion

Postoperative curve straightening is common in thoracoscopic single-rod fusion for AIS correction especially in the skeletally immature, without increase in complications or re-operation rates.



Pre- and post-operative radiographs with curve straightening

214. THE BURDEN OF MEDICAL AND ORTHOPAEDIC READMISSIONS FOLLOWING POSTERIOR SPINAL FUSION FOR IDIOPATHIC ADOLESCENT SCOLIOSIS

Ignacio Pasqualini, MD; Oguz A. Turan, MS; Omolola Fakunle, MD; Ahmed K. Emara, MD; David P. Gurd, MD; Ernest Y. Young, MD; Thomas E. Kuivila, MD; *Ryan C. Goodwin, MD*

Hypothesis

We hypothesize that within 90 days of PSF for AIS,the rate of readmissions will be higher for medical to orthopedic reasons.

Design

Retrospective cohort study

Introduction

Unplanned hospital readmissions remain one of the largest causes for increased episode of care and adverse events. Since orthopedics has been revolving to the use of value-based care, the 90-day readmissions and their causes must be examined carefully. This study aimed to 1) determine the overall 90-day PSF readmission rate;2) report the timing of readmission post-discharge; and 3) identify the most frequent causes of 90-day readmissions(i.e., medical- or orthopaedic-related).

Methods

A retrospective cohort of 657 consecutive patients undergoing PSF for AIS between 2010 and 2021 at a large tertiary care center was analyzed. Readmissions were examined manually for determination of primary cause and verification. Orthopaedic-related readmissions were specific complications affecting the hardware or the surgical wound. Medical readmissions were due to medical diagnoses requiring medical treatment or management and were grouped by the principal organ system involved.

Results

Overall, the 90-day readmission rate was 6.24% (n=41). The majority of unplanned admissions were during the first 30 days' post-discharge (n= 35; 85.3%), decreasing subsequently at 31-60 days (n=4,8%) and 61-90 days (n=4; 9.7%) post-discharge. The 90-day readmission rate was split between medical with 3.5% and orthopaedic related readmissions with 2.7%, respectively. Wound infections (44%), normal physiological events (27%), and postoperative pain (17%) were the three top orthopaedic readmission causes while gastrointestinal (45%), pulmonary (13%), and neurologic (13%) were the top three medical causes. There was no difference between the rates of ICU admission (p = 0.573), or length of readmission stay (p = 0.201). However, orthopaedic readmissions were significantly more likely to be treated operatively (p = <0.001) and more likely to receive transfusions (p = 0.030).

Conclusion

One of sixteen patients are expected to be readmitted within 90 days of discharge following PSF for AIS with most readmissions occurring early in the post-operative period and much more likely to be medical reasons. Understanding the reasons and risk factors for readmissions will allow for targeted interventions to reduce the burden of readmissions following deformity surgery.

215. REVISION STRATEGIES AFTER FAILED ANTERIOR VERTEBRAL TETHERING FOR ADOLESCENT IDIOPATHIC SCOLIOSIS DIFFER DEPENDING ON TYPE OF COMPLICATION AND TIMING OF INTERVENTION

John T. Braun, MD; Sofia Federico; David F. Lawlor, MD; Brian E. Grottkau, MD

Hypothesis

Early intervention after failed Anterior Vertebral Tethering (AVT) will be more amenable to tether revision alone whereas late intervention will likely require fusion.

Design

Retrospective 2010-24.

Introduction

In 253 patients treated over 14 years with AVT for AIS, 21 revision surgeries were performed for overcorrection

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(OC), inadequate correction (IC), or progression (P). While early intervention in 7 patients with IC or P was accomplished with tether revision alone in 86%, late intervention in 14 patients with OC, IC, or P required fusion in 71% ($p<0.05$). Additionally, 67% of OC and 57% of IC patients required fusion compared to only 36% of P patients.

Methods
Charts and radiographs were used to identify 21 revision surgeries in 253 consecutive AIS patients treated with AVT over 14 years. Revision surgeries included tether revision alone (removal, replacement, or tethering of an adjacent curve) versus fusion for three major complication types (OC, IC, P) treated early (<2 years) or late (≥2 years).

Results
Of 253 AIS patients treated with AVT, 21 revision surgeries were performed. Early intervention in 7 patients allowed tether revision alone in 86% (2/3 IC, 4/4 P), but late intervention in 14 patients required fusion in 71% (2/3 OC, 4/4 IC, 4/7 P) ($p<0.05$). Though the majority of OC (67%) and IC (57%) patients required fusion, the majority of P (64%) patients were treated with tether revision alone.

Conclusion
Early intervention after failed AVT for AIS allowed 86% of patents to be treated with tether revision alone whereas late intervention required fusion in 71% ($p<0.05$). Additionally, most OC and IC patients required fusion while most P patients were treated with tether revision alone.

216. PATTERN OF BACK PAIN IN PATIENTS WITH ADOLESCENT IDIOPATHIC SCOLIOSIS AND ITS IMPACT IN HEALTH-RELATED QUALITY OF LIFE

Wing Ki Cheung, MPhil; Prudence Wing Hang Cheung, PhD, BDSc (Hons); Jason Pui Yin Cheung, MD, MBBS, MS, FRCS

Hypothesis
We hypothesize that back pain is related to the exercise level and can be classified based on the situation when pain occurs in patients with Adolescent Idiopathic Scoliosis (AIS).

Design
A cross-sectional study.

Introduction
While previous studies have investigated risk and predictive factors for back pain in patients with AIS, there is a lack of pain management protocols. This may be due to limited understanding of the circumstances in which pain occurs. Back pain in AIS can be classified into static motion-induced pain, associated with postural stability regulation, and dynamic motion-induced pain, related to muscle contraction and relaxation. Only Makino's study reported the 25.5% prevalence rate of pain at rest in AIS. No study has investigated the dynamic motion-related back pain and its relationship with Health-related quality of life (HQoL). This study aimed to report the prevalence of back pain related static and dynamic motion, and to understand the relationship between back pain and frequency of exercise and HQoL in patients with AIS.

Methods
449 patients with conservative treatment were invited and 203 patients fulfilled the inclusion criteria. They completed a customized pain questionnaire in addition to Refined Scoliosis Research Society-22 Patient Questionnaire and EuroQoL 5-Dimension Youth 5-Level.

Results
In the past 1 month and 6 months, 45.8% and 39.9% of patients experienced back pain, with mean VAS scores of 3±1.7 and 2.9±1.6 respectively. No association was found between frequency of exercise and the occurrence of back pain (all $p>0.05$). The curve severity did not correlate with pain VAS (all $p>0.05$). There was a negative weak to moderate correlation between prevalence of back pain and HQoL parameters (all $p>0.05$). Regarding the circumstances in which pain occurred, 50% and 26.5% reported having back pain during and after static motion, respectively. For dynamic motion, 15.3% and 24.5% experienced back pain during and after. In term of pain location, there were significant association between major curve location and the pain located at scapular (X2(1, N=98)=13.7, $p<0.001$), and upper back (X2(1, N=98)=6.3, $p=0.021$) but no significant association for other location (all $p>0.05$).

Conclusion
Overall, this study provides a more comprehensive understanding of back pain in AIS patients and reported prevalence of back pain in static and dynamic motion.

217. MACHINE LEARNING ALGORITHM IDENTIFIES COBB ANGLE OF ADOLESCENTS WITH IDIOPATHIC SCOLIOSIS USING SURFACE TOPOGRAPHY *

Mostafa Hassan, MS; Jose Maria Gonzalez Ruiz, PhD; Nada Mohamed, BS; Qipei Mei, PhD; Lindsey Westover, PhD

Hypothesis
Machine learning combined with a 3D torso surface topography (ST) can be used to identify Adolescent Idiopathic Scoliosis (AIS) maximum Cobb Angle (CA).

Design
A machine learning supervised prediction approach applied to AIS torso 3D ST scans.

Introduction
Using ST to identify maximum CA can decrease the overuse of X-ray imaging. This study aims to (a)identify the maximum CA in AIS patient without the use of X-ray imaging, (b)Assess its impact and benefits when used in AIS clinical routine.

Methods
The patient group was aged between 10 to 18 years (mean 14.0 ± 1.8). These patients were non-surgical cases, each with at least one spinal curve greater than 10°. All ST scans had corresponding posterior anterior radiographs. The maximum CA of the spine of each radiograph is used in the analysis of this study. A Markerless asymmetry analysis was deployed to get the devia-

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tion information of the ST of the torso. The point cloud information (x and y coordinates) of the posterior half of the ST scan were mapped to a two-dimensional image array (deviation and depth)Fig 1A. This array is fed to the machine learning algorithm (Convolutional neural network) to identify the maximum CA out of ST scans.

Results
A total of 654 ST scans were collected with AIS (Cob-b:32.6±13.1º), split into 585 for training and 69 for testing. The machine learning algorithm showed high accuracy in predicting the maximum CA, closely matching X-ray measurements in the training set ($R = 0.97$, $R^2 = 0.94$) Fig 1B. In the test set, the mean absolute error was 2.42°. The algorithm effectively classified AIS severity, correctly identifying non-severe cases 98.15% of the time and non-mild cases 96.08% of the time Fig 1C.

Conclusion
The machine learning algorithm successfully identifies the maximum CA of ST of AIS patient. The algorithm would spare non severe patients' surgery. Also, it helps managing mild AIS patients, as it can reduce the reliance on and exposure to unnecessary X-ray imaging (as mild cases are only monitored, with no treatment typically prescribed). This supervised approach not only enhances ongoing management of AIS but also aligns with a more patient-centered, non-invasive clinical strategy.

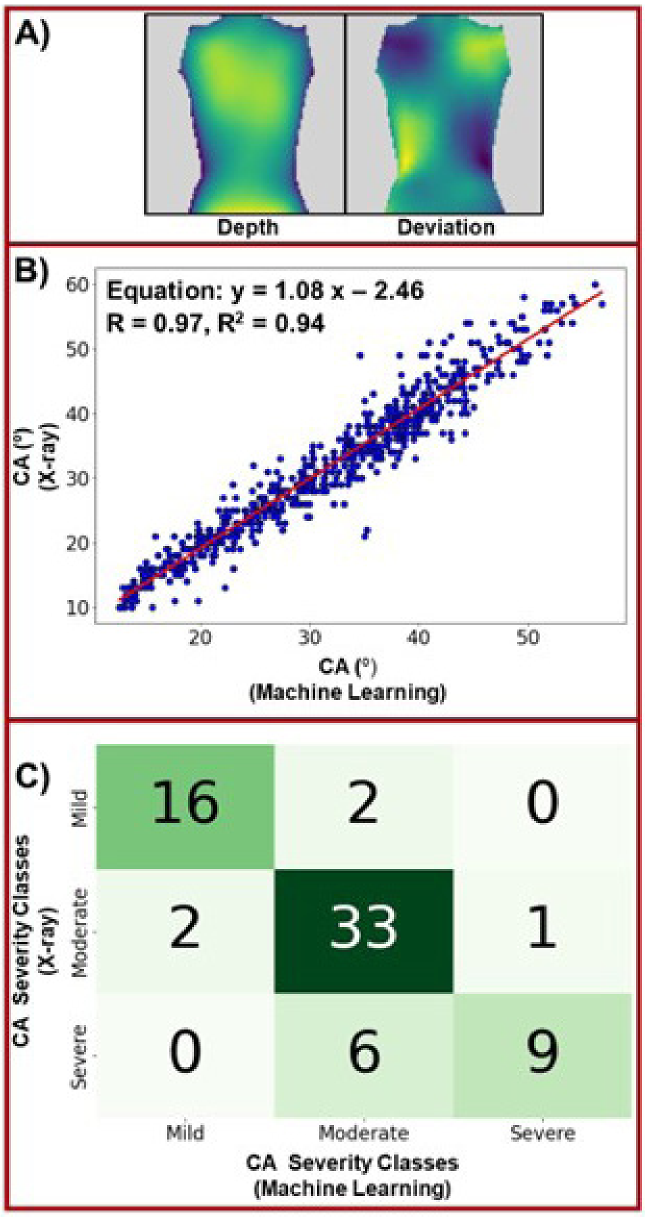

Figure 1: Depth and deviation information of the posterior half of the scan (visual representation). (B) Correlation between CA (X-ray) and CA (machine learning). (C) Classification matrix between CA (X-ray) and CA (machine learning).

218. IMPACT ON PREGNANCY AND CHILDBIRTH OF IDIOPATHIC SCOLIOSIS SURGERY

Francoise Descazeaux, MD; Karen A. Weissmann, MD, PhD

Hypothesis
Patients with operative idiopathic scoliosis have a higher C-section rate and higher requirement for general anesthesia.

Design
Retrospective cohort

Introduction
Concerns about the reproductive implications of scoliosis

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surgery are common among patients and their families, however, limited data exist on this matter.

Methods
We applied an online survey using Google Forms (Google Corp), shared via WhatsApp (Meta Platforms) or through phone calls. We included patients with posterior spinal fusion for juvenile or adolescent idiopathic scoliosis with at least 2 years follow-up. We analyzed demographic, surgical, obstetrical data, and concerns about pregnancy and childbirth. Statistical analysis was done using t-student test and chi-square test ($p<0.05$).

Results
295 female patients answered our survey. Mean age at surgery was 15.64 years(±4). Mean follow up time was 16.13 years(±5.82). Patients were divided into 2 cohorts, <35 (73.9%) and >35 years old (26.1%). 30% were fused to L2 or proximal and 69.8% to L3 or L4. 13.6% had at least 1 miscarriage. 55.6% had children. The average number of children was 1,506. The G>35 group had more children than the G<35 group(1.69±0.71 vs 1.39±0.56 p=0.003). Among patients without children, 59.8% desire to have children, 17.9% are uncertain and 22.2% don't wish to. The most cited reason for not having them yet (43.5%) was not wishing to and 20% because of concerns related to their surgery. Because of their scoliosis surgery, 63% had apprehensions of getting pregnant; and 78.8% had concerns about childbirth. No differences were found in these matters related to distal fusion level. Within total deliveries (N=232), 59.4% were a C-section, similar to the national rate.(58.3%; p=0.72). Obstetric reasons accounted for most C-sections. 2nd leading cause was history of scoliosis surgery followed by the need or advice for general anesthesia. We found no difference related to distal fusion level in this topic. Most patients received anesthesia, (88.5%) the majority of which was neuraxial. Patients fused to L2 or proximal were more likely to receive successful neuraxial anesthesia than those to L3 or L4. (1st P=0.026; 2nd delivery P<0.00001).

Conclusion
C-Section rate was similar to national rate. Patients fused to L2 or proximal were more likely to receive neuroaxial anesthesia than those to L3 or L4. Pregnancy and childbirth should be accompanied by a multidisciplinary team in patients with operative scoliosis history.

219. IS IDIOPATHIC SCOLIOSIS SURGERY EFFECTIVE IN IMPROVING QUALITY OF LIFE IN PATIENTS WHO HAVE WAITED MORE THAN 2 YEARS BEFORE THEIR SURGERY?

Manuel Jaramillo Jimenez, MD; Julie Joncas, RN; Maxence Coulombe, BEng; Soraya Barchi, BSc; Stefan Parent, MD, PhD; Hubert Labelle, MD; Felix L. Brassard, MD; Jean-Marc Mac-Thiong, MD, PhD

Hypothesis
Waiting for an AIS surgery can be detrimental for quality of life preoperatively, but surgery will be as effective to achieve high quality of life (QoL) regardless of waiting time for surgery.

Design
Retrospective analysis of a prospective cohort.

Introduction
Prolonged surgical waiting times for AIS surgery are associated with higher risks of adverse events and curve progression. While individuals with AIS have poorer health-related QoL when compared with their peers, it is possible that a prolonged wait prior to surgery will lead to further deterioration in QoL. We aim to investigate the association between wait time and QoL prior to surgery and after surgery.

Methods
We performed a retrospective study using our prospective cohort of AIS patients scheduled for fusion surgery at our institution. QoL was evaluated with the SRS-22 questionnaire, administered at the first visit, every 6 months while waiting for surgery and 2 years after surgery. T-test and linear regression analysis were used to evaluate the association between wait times and QoL scores.

Results
There were 204 patients, (78.1% female and 21.9% male). Of these patients, 16 waited <6 months, 29 waited between 6 and 12 months, 56 waited between 12 and 18 months, 53 waited between 18 and 24 months, and 50 waited >24 months before undergoing surgery. We saw a decrease of the SRS total scores of 0.17 (p=0.007) after 1 year and 0.4 ($p < 0.001$) after 2 years on the surgical waitlist, with a decrease in the pain domain of 0.21 (p=0.006) and mental health domain of 0.23 (p=0.017) after 1 year. A higher increase in SRS score post-surgery was associated with longer pre-op waiting times, using linear regression. However, there were no statistical differences in post-surgery SRS scores associated with longer waiting times.

Conclusion
Patients waiting for AIS surgery have a progressive deterioration in QoL preoperatively. However, QoL was improved by surgery, and patients with more declining QoL due to a prolonged wait time tend to improve more with surgery. Therefore, surgery is effective in patients who have waited longer for surgery for achieving a postoperative QoL similar to their peers who did not wait as long. According to our results, patients should be reassured that a prolonged wait time for surgery – if it occurs – would not be detrimental to achieving high QoL after surgery.

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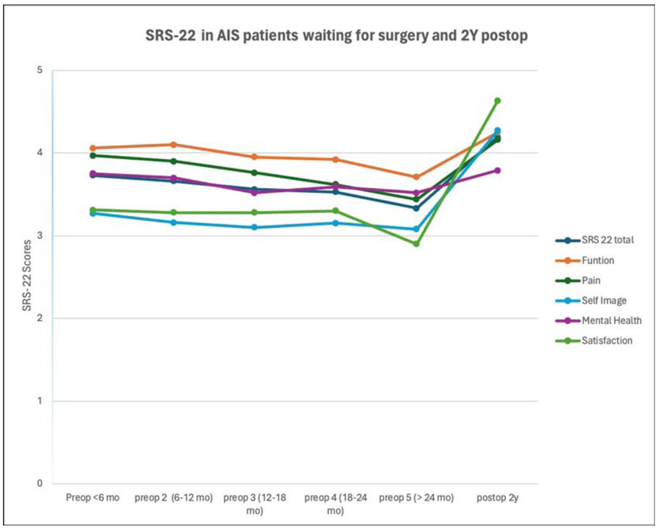
E-POINT PRESENTATION ABSTRACTS



220. PAIN CATASTROPHIZERS UNDERGOING POSTERIOR SPINAL FUSION (PSF) FOR IDIOPATHIC SCOLIOSIS (IS) DO NOT REQUIRE INCREASED PERIOPERATIVE NARCOTICS

Elaine Y. Tran, MD; David C. Thornberg, BS; Chan-Hee Jo, PhD; _Brandon A. Ramo, MD_

Hypothesis
Pain catastrophizing does not affect postop narcotic use following a PSF in idiopathic scoliosis (IS).

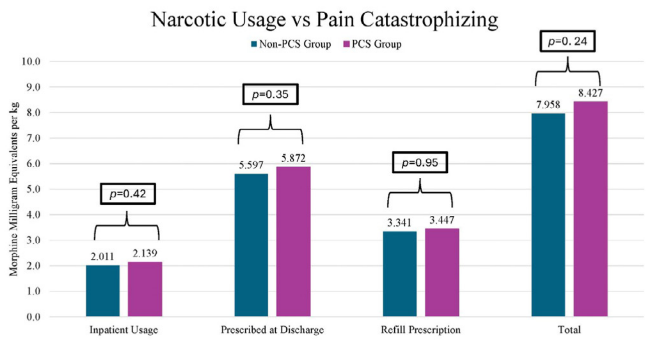
Design
Retrospective Comparative Study

Introduction
Pain catastrophizing (rumination, magnification and helplessness) results in an exaggerated negative perception of painful events and can be measured by the Pain Catastrophizing Scale (PCS). Patients who score highly on this scale (PCS>75th%ile = catastrophizers) have been shown to have greater pain both before and 2 years after PSF for IS. The purpose of this study was to determine if pain catastrophizers undergoing PSF for IS have higher perioperative pain scores and greater perioperative narcotic usage.

Methods
Prospective prognostic study. We hypothesized that pain catastrophizers undergoing PSF for IS would report higher perioperative pain scores and require increased narcotic use perioperatively.Patients aged 8-25 years undergoing PSF for IS over a 7-year period at a single pediatric hospital were given the PCS questionnaire preoperatively. Patients scoring >75th %ile on the PCS were termed “catastrophizers.”. Multivariable regression included Sex, Ethnicity, use of liposomal bupivacaine, Pain Catastrophizing, Surgical Year, Surgical Time, SRS Scores, Age, LOS, 24HR Postop Pain Score, postop narcotic use in the hospital, and discharge narcotics. Narcotic was calculated as total morphine equivalents/kg.

Results
517 patients underwent PSF with complete data sets. 58 pain catastrophizers reported slightly higher VAS pain scores in the first 24 hours than their 462 non-catastrophizing peers (2.20±0.77 vs 1.92±0.73, p=0.015), however, there was no difference in VAS pain scores between 24-48 hours or >48 hours postoperatively. There was no difference in narcotic ‘use’ during the hospital stay, at discharge, or if refilled (Table 1). In multivariate logistic regression modeling, no variable correlated with increased likelihood of narcotic refill.

Conclusion
Preop pain catastrophizing had a small effect on increased pain during the first 24 hours of hospitalization after PSF for IS but did not affect overall narcotic consumption or the likelihood of a narcotic refill request post-discharge. Pain catastrophizing, despite its association with lower pain scores pre and 2yr post-operatively, is associated with slightly increased pain in the first 24 hours but does not require different pain management of narcotic usage.



221. DOES A LEVELED LOWEST INSTRUMENTED VERTEBRA(LIV) LEAD TO BETTER OUTCOMES WHEN ENDING L3 OR L4

Mohseni A. Ahmed, MD; Mohamed Zairi, MD; Ahmed Msakni, MD; RIM Boussetta, MD

Hypothesis
Extension of fusion distally to L4 remains reported in the literature to a less outcomes Fusing to L4 is associated with leveling of the LIV results with long-term disk degeneration under the fusion.

Design
Retrospectative study

Introduction
Extension of fusion distally to L4 remains reported in the literature to a less outcomes Fusing to L4 is associated with leveling of the LIV results with long-term disk degeneration under the fusion. Thus, the decision to include L4 remains difficult. There may be unrecognized benefits of extending the fusion distally to include L4.

Methods
All patients of all curve types with a fusion either to L3 or L4 with pre-op and 5-year post-operative visits were included. We evaluated the score with SRS-22 r pain score. Chi-square and CART analysis were performed to

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determine if leveling the distal fusion level to a tilt <5° would result in an improvement for SRS 22pain score.

Results
We collected 128 patients. When leveling of the LIV showed greater rate of improvement for both . CART showed that for Pain, leveling the LIV was more impactful than extent of fusion with a 63% rate of improvement compared to 44% when not leveled. When LIV tilt was <5% patients with a fusion to L4 did not improve as much 41% as patients fised to L3 46%.

Conclusion
Surgeons try to avoid extending the fusion down to L4 based on the risk of disk degeneration under the fusion. In our cohort overall levelling the LIV <5° resulted in greater improvement in SRS 22R pain score.

222. SPINAL FUSION PERFORMED IN ADULTHOOD FOR THORACIC IDIOPATHIC SCOLIOSIS DECREASES THE DISC HEIGHT OF THE UNFUSED LUMBAR SEGMENT COMPARED TO THAT PERFORMED IN ADOLESCENCE

Masaaki Ito, MD, PhD; Keita Nakashima, MD; Yoshiki Takeoka, MD, PhD; Teppei Suzuki, MD, PhD; Koki Uno, MD, PhD

Hypothesis
The timing of posterior fusion for AIS (in adolescence or adulthood) might affect the HRQOL and radiological outcomes.

Design
Retrospective case series study

Introduction
The timing for AIS surgery is determined considering curve magnitude, skeletal maturity and patient's background, etc. The purpose of this study is to compare the HRQOL and radiological outcomes between AIS patients who underwent surgery in adolescence and adulthood.

Methods
Among forty-one AIS (Lenke type 1 or 2) patients who were followed at least 5 years after posterior fusion, we divided those patients into 2 groups according to the timing of surgery (Group Y; 22 patients who underwent surgery under the age of 19 [12-18, mean 14.6], Group A; 19 patients between the ages 19 and 39, [20-39, mean 30.7]). We retrospectively examined the radiological outcomes and HRQOL (SRS-22 and ODI) in these two groups. On radiological assessment, the lumbar disc height was measured to average the anterior, central, and posterior intervertebral disc distances immediately after surgery and at 5 years follow-up.

Results
The follow-up period was 10.8 years in group Y and 8.0 years in the group A (P <0.01). The Cobb angle of the main thoracic curve was corrected from 55˚ to 14˚ in group Y immediately after surgery (correction rate 74%), and from 55˚ to 19˚ in group A (correction rate 65%). The correction rate was significantly higher in group Y (P<0.01). The Cobb angle at the final follow-up was 15˚ in group Y and 21˚ in group A. When the disc height of the unfused lumbar segment immediately after surgery was defined as 100%, the mean disc height at 5 years follow-up was 98% in group Y and 89% in group A, which was significantly decreased in group A (P<0.01). In addition, the mean disc height at 5 years follow-up showed a significant negative correlation with age (R=-0.6, P<0.01). The Pain and Mental-health domain of SRS-22 showed a significant negative correlation with age (Pain; R=-0.5, P<0.01, Mental-health; R=-0.5, P<0.01), and also ODI showed a significant positive correlation with age (R=0.5, P<0.01).

Conclusion
Surgical intervention for AIS should be performed before 18 years old to obtain better clinical and radiological outcomes. Further study is necessary to examine the relation between the disc height decrease in the unfused lumbar spine and the clinical outcomes.

223. THE EFFECT OF AXIAL ROTATION ON PATIENT REPORTED OUTCOMES AND PULMONARY FUNCTION IN ADOLESCENT IDIOPATHIC SCOLIOSIS

Carlos Monroig-Rivera, MD; Stephanie Goldstein, MD; David C. Thornberg, BS; Chan-Hee Jo, PhD; Brandon A. Ramo, MD; *Megan E. Johnson, MD*

Hypothesis
Increased vertebral body rotation will correlate with worse PROs measured by the SRS-22 and PFTs in patients with AIS.

Design
Retrospective single-center chart review

Introduction
Previous studies suggest little effect of 2D radiographic measurements on patient-reported outcomes (PROs) for adolescent idiopathic scoliosis (AIS) but do show worse lung function in patients with severe deformity. Using biplanar spine imaging, we sought to correlate vertebral axial rotation with preoperative PROs and pulmonary function tests (PFTs) in patients with AIS.

Methods
Retrospective review of prospectively enrolled AIS patients from a single institution. Patients with complete preoperative biplanar spine 3D reconstructions, SRS-22, and PFTs were included. Mean Absolute Axial Vertebral Rotation (MAAVR) was calculated within the major curve ∑|xAxial Rotation|/number of vertebrae in curve. Patients were categorized based on the location of their major curve: thoracic; thoracolumbar (TL); and lumbar. Pearson's correlation was used to determine the relationship between major curve Cobb, MAAVR, SRS-22 scores, and PFTs.

Results
126 patients (97 female) were included. The location of the major curve was thoracic in 103 (82%) patients (mean Cobb 60.2°+/- 9.8), TL in 15 (12%) (mean Cobb 62.2°+/-

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12.1), and lumbar in 8 (6%) (mean Cobb 60.6° +/- 7.9). When considering all curves, there was no correlation between major curve Cobb and SRS-22 scores, however, major curve Cobb did correlate to FVC % predicted for each curve location (thoracic -0.32 p=0.0107; TL -0.30 p=0.0107; lumbar -0.67 p=0.0107, Table 1). Conversely, within major thoracic, TL, and lumbar curves, MAAVR inversely correlated with FEV1 % predicted (-0.36 p=0.0178; -0.08 p=0.0178; 0.17 p=0.0178, respectively). For patients with major thoracic, TL, and lumbar curves, the MAAVR was also inversely correlated with preop SRS-22 activity scores (-0.15 p=0.0119; -0.59 p=0.019; -0.31 p=0.0119).

Conclusion

Increased major curve Cobb and vertebral body rotation are associated with worse PFTs in patients with AIS. While major curve Cobb did not have any impact on SRS-22 scores, increased vertebral body rotation did negatively correlate with SRS-22 activity scores but not the other domains. Therefore, 3D-measured curve rotation may play a larger role in PROs and pulmonary function than 2D/coronal curve magnitude alone.

Table 1: Correlation between Major Curves Cobb, MAAVR, SRS-22, and PFT values

Variables	Major Curve Location	SRS-22 Pain		SRS22 Appearance		SRS22 Activity		FVC % Predicted		FEV1 % Predicted	
		Corr.	p	Corr.	p	Corr.	p	Corr.	p	Corr.	p
Major Curve Cobb	Thoracic	-0.08	0.9	-0.15	0.6	-0.09	0.5	-0.32	**0.0107**	-0.21	0.2
	Thoracolumbar	0.43	0.9	0.53	0.6	0.06	0.5	-0.30	**0.0107**	-0.05	0.2
	Lumbar	0.35	0.9	0.38	0.6	0.07	0.5	-0.67	**0.0107**	-0.50	0.2
Mean Absolute Axial Vertebral Rotation	Thoracic	-0.11	1.0	-0.09	0.7	-0.15	**0.0119**	-0.28	0.1	-0.36	**0.0178**
	Thoracolumbar	0.11	1.0	-0.20	0.67	-0.59	**0.0119**	-0.04	0.1	-0.08	**0.0178**
	Lumbar	0.50	1.0	0.07	0.67	-0.31	**0.0119**	-0.04	0.1	0.17	**0.0178**

Bold, Red values mean statistical significance

224. INTRA-OP CT-BASED TECHNOLOGY SIGNIFICANTLY INCREASES RADIATION EXPOSURE IN THE PEDIATRIC POPULATION

Vishal Sarwahi, MD; Sayyida Hasan, BS; Aravind Patil, MD, BS; Austen Katz, MD; Katherine Eigo, BS; Effat Rahman, BS; Himanshu Rao, BS; Junho Song, BS; Keshin Visahan, BS; Sanjeev Suratwala, MD; Yungtai Lo, PhD; Terry D. Amaral, MD

Hypothesis

Intra-op CT based technology increases exposure to harmful radiation in adolescents during spine surgery.

Design

Retrospective Chart Review

Introduction

In the past, pedicle screw insertion had been done using a free-hand technique or fluoroscopy guidance. Recently, intra-op CT-based navigation has been adopted to aid in visualization of pedicle screw insertion to allow for screw accuracy and safety in spine surgery. Albeit the safety benefits of this new technology, it runs the risk of increasing radiation exposure in the vulnerable pediatric population.

Methods

A retrospective chart review of 596 AIS patients between 2015-2022 from a single institution was done. 110 patients were operated on with just CT-based technology (CT-nav group), 268 patients were operated on using fluoroscopy guidance, and 218 patients were operated on utilizing a hybrid, TNT (technique n' technology), approach. Patients were categorized based on the visualization/insertion technique used during their surgery. Surgical and clinical outcomes were compared. Kruskal-Wallis tests were used for continuous variables and Chi-Squared tests were used for categorical variables.

Results

There were no significant differences in demographic or radiographic variables. CT-nav and TNT had a significantly higher radiation dose when compared to fluoroscopy (p<0.001), CT-nav having the highest radiation dose at 21.2 mGy, while fluoroscopy was at a dose of 2.6 mGy. CT-nav and Fluoroscopy groups had similar time under radiation, TNT having significantly less time under radiation at 18.5s. Operative time in the CT-nav group was significantly higher than the other two groups, taking 278.5 minutes to complete surgery compared to 253.0 minutes (fluoroscopy) and 234.0 minutes(TNT)(p<0.001).

Conclusion

New technology in the medical field comes with advantages as well as disadvantages. In this case, CT-based technology can give surgeons confidence in their screw placement, creating a safer and more accurate procedure, however the added radiation and operative time is harmful for adolescents. Adopting a hybrid approach can help balance out these effects to benefit the patient.

225. IATROGENIC INCREASED UPPER LUMBAR LORDOSIS IN AISS CAN RESULT IN COMPENSATORY KYPHOSIS OF THE UNFUSED DISTAL SEGMENTS

Arun R. Hariharan, MD; David S. Feldman, MD; Hans K. Nugraha, MD; Tracey P. Bastrom, MA; Craig R. Louer, MD; John S. Vorhies, MD; Peter O. Newton, MD; Suken A. Shah, MD; Harry L. Shufflebarger, MD; Baron S. Lonner, MD; Nicholas D. Fletcher, MD; Michael P. Kelly, MD; Harms Study Group

Hypothesis

Increased lordosis of the fused upper lumbar spine results in relative kyphosis of the unfused segments below.

Design

Retrospective review of a prospectively collected multicenter cohort

Introduction

The distribution of lumbar lordosis is based on spinopelvic parameters and is not uniform for all patients. The effects of changes in fused segment lumbar lordosis (FSLL) on the unfused lumbar segments in AIS is not known. The aim of this study was to understand how a change in FSLL affects the distal unfused segments and overall alignment.

Methods

Lenke 1/2 patients who underwent PSF into the upper lumbar spine and with 2yr follow up were included from a prospective multi-center registry. They were grouped by

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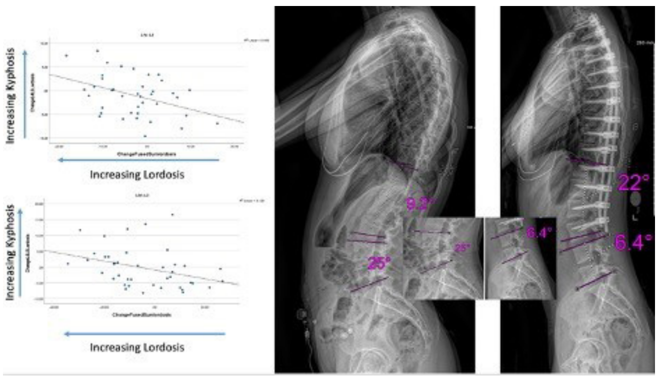
LIV: L1, L2, L3. MATLAB 3D data used for segmental lordosis angles to account for rotation. Pre and post-op segmental angles, T5-T12 (TK), T12-S1 (LL), T4PA, L1PA, PT, SS, PI, PI-LL, SVA were measured and changes in these at pre and 2yr were analyzed. Pearson correlation coefficients and linear regression analyzed.

Results

158 patients with 3D segmental data met inclusion criteria; 78 at L1, 39 at L2, and 41 at L3. Changes in FSLL were not significantly correlated with changes in T4PA, L1PA, SVA, PT, SS, or PI-LL. At 2yrs overall sagittal alignment was maintained and PI-LL remained <10°. But, increase in FSLL resulted in a kyphosing of lower unfused arc of lordosis. In LIV L2, increased FSLL correlated with reduction in lordosis of L4-5 (r=-.4, p=.01) and for LIV L3, increased FSLL correlated with reduction in lordosis of L4-5 (r=-.347, p=.02) and L5-S1 (r=-.332, p=.03). Post-op changes in TK were not significantly correlated to changes in these distal segments.

Conclusion

In this study of segmental changes in lumbar lordosis following fusion in AIS, the patients maintained overall sagittal alignment despite instrumented changes in the fused segments. However, an increase in the FSLL results in changes in the unfused segments and induces kyphosis of the lower segments to maintain this balance. Given these downstream effects, understanding normal segmental lumbar lordosis distribution is critical in surgical planning (i.e. rod contouring) and in understanding the health of the unfused segments long term.



Scatterplot demonstrating inverse relationship of FSLL to unfused L4-5 and case example ok post-op distal unfused kyphosis.

226. CORRELATION OF 3D SPINAL PARAMETERS TO PULMONARY FUNCTION TESTS IN ADOLESCENT IDIOPATHIC SCOLIOSIS

Lorena Floccari, MD; Alexandria Rundell, BS; Richard Steiner, PhD; Todd F. Ritzman, MD

Hypothesis

Pulmonary Function Tests (PFTs) inversely correlate to 3D measures of coronal, sagittal, and axial plane spinal deformity.

Design

Prospective cross-sectional study

Introduction

Prior studies have demonstrated an inverse correlation between scoliosis Cobb angle and pulmonary function. However, axial plane deformity measured by the Nash-Moe method has not been found to correlate with PFT impairment. 3D reconstructions can more accurately describe deformity in AIS, but it is unknown how 3D axial and sagittal plane deformity affects PFT results.

Methods

PFTs were obtained prospectively in a cohort of consecutive preoperative AIS patients at a single institution. Radiographic measurements were obtained via 3D reconstructions created from biplanar radiographs using SterEOS software. Correlations were performed between PFTs and 3D coronal, sagittal, and maximum axial plane deformity.

Results

101 AIS patients with major Cobb 60.5° (R 42-90°) were included, with mean 91.0% forced vital capacity (FVC), 88.2% predicted forced expiratory volume in 1 second (FEV1), and 88.2% predicted total lung capacity (TLC). 6% had moderate-severe pulmonary impairment (FEV1, FVC, TLC <65%), while 16% had mild impairment (65-80%). Main thoracic Cobb angle had moderate but significant correlation to % FEV1 (r=0.38), % FVC (r=0.34), and %TLC (r=0.38, all p<0.001, Fig 1), as did the upper thoracic Cobb (r=0.35, 0.29, and 0.34 respectively, p<0.001). However, there was no significant correlation between lumbar Cobb angle, thoracic or lumbar flexibility indices, 3D T5-T12 kyphosis, or thoracic 3D axial rotation (all p>0.1). There was significant correlation between thoracic rib prominence on scoliometer and % FEV1 (r=0.40, p<0.001), %FVC (r=0.28, p=0.01), and %TLC (r=0.26, p=0.019), but no significant correlation with lumbar prominence. On multivariate regression analysis, main thoracic Cobb accounts for only 19.8% of variation in %FVC and 26.4% variation in %FEV1 (R^2 = 0.198 and 0.264 respectively, p<0.001).

Conclusion

Thoracic curve magnitude has a moderate inverse correlation to preoperative pulmonary function testing but only explains 19.8% of variation in vital capacity. While scoliometer measures likewise correlate to PFTs, 3D reconstruction measures of thoracic kyphosis, axial plane rotation, lumbar deformity, and curve flexibility do not correlate with PFT results.

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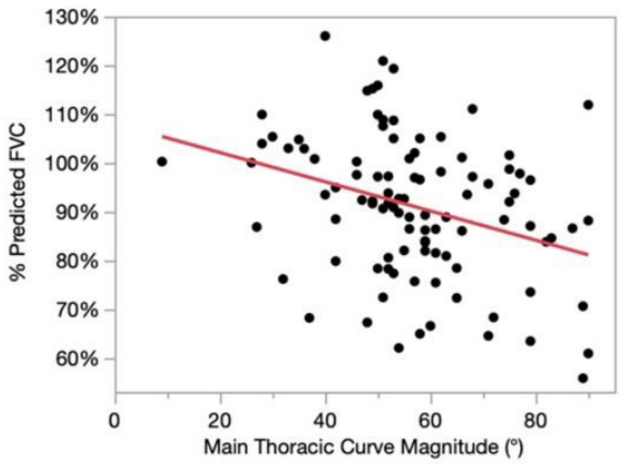

Fig 1: Plot of %FEV vs. Main Thoracic Cobb with Regression Line

227. PROXIMAL THORACIC ALIGNMENT CHANGE INFLUENCES CERVICAL SAGITTAL ALIGNMENT AFTER CORRECTION SURGERY IN PATIENTS WITH LENKE TYPE 2 ADOLESCENT IDIOPATHIC SCOLIOSIS

Xi Lin, MD, PhD; Satoshi Suzuki, MD, PhD; Kazuki Takeda, MD, PhD; Toshiki Okubo, MD, PhD; Masahiro Ozaki, MD, PhD; Osahiko Tsuji, MD, PhD; Narihito Nagoshi, MD, PhD; Morio Matsumoto, MD, PhD; Masaya Nakamura, MD, PhD; Kota Watanabe, MD, PhD

Hypothesis
We hypothesize that, in patients with Lenke type 2 adolescent idiopathic scoliosis (AIS) undergoing posterior correction and fusion surgery (PSF), correcting thoracic kyphosis changes postoperative cervical sagittal alignment (CSA). Our study aims to identify factors that may influence CSA.

Design
Retrospective study of prospectively accumulated data

Introduction
Growing emphasis on understanding the surgical impact of CSA in AIS. Few studies have exclusively assessed the association between CSA and sagittal alignment in patients with Lenke type 2 AIS who underwent PSF.

Methods
A total of 102 female patients with type 2 AIS, who had a minimum follow-up of 2 years after surgery, with a mean age of 14.7 years at surgery, were included in this study. The upper instrumented vertebra was T2 in all patients. Sagittal and coronal parameter were measured before and 2 years after surgery. We divided the patients into cervical malalignment (CM) and noncervical malalignment (NCM) groups based on Passias' criteria [1. T1 slope minus C2–C7 lordosis more than 20°; 2. C2–C7 SVA more than >40 mm; 3. C2–C7 cervical lordosis (CL) less than 10°]. Then, the radiographic factors influencing CSA were analyzed.

Results
Preoperatively, 57 patients (55.9%) were assigned to the CM group and 45 patients (44.1%) to the NCM groups. The CM group was more kyphotic CL (19.3°vs. 3.3°), smaller proximal thoracic kyphosis (PTK; 9.7°vs. 15.4°), and smaller T1 slope (7.1°vs. 14.0°) than those in the NCM group. Main thoracic kyphosis (MTK) did not show significantly difference between the two groups (11.3° vs. 14.4°, P=0.085). Two years after surgery, the CM group demonstrated significant improvements in CSA. PTK increased from 9.7°to 13.5°, T1 slope increased from 7.1°to 10.5°, and CL significantly improved from -19.3°to -8.8, while MTK remained unchanged (11.3°vs. 11.6°, P=0.645). Univariate correlation analyses showed that CL changes were significantly related to T1 slope (r=0.570, P<.001) and PTK (r=0.655, P<.001), but not with MTK.

Conclusion
In patients with preoperative CM, CSA significantly improved after PSF. Notably, improves in CL were significantly correlated with increases in both T1 slope and PTK. These findings suggest that not increasing MTK but PTK by PSF leads to a subsequent elevation of the T1 slope, ultimately contributing to an improvement in CSA.

228. RISK FACTOR ANALYSIS FOR CARDIAC ABNORMALITIES IN PATIENTS WITH IDIOPATHIC SCOLIOSIS

Li Zhang, MD; Zhibo Song, MD; *Yingsong Wang, MD*; Zhi Zhao, MD; Ni Bi, MD; Tao Li, MD; Zhiyue Shi, MD; Jingming Xie, MD

Hypothesis
The incidence of cardiac abnormalities in patients with idiopathic scoliosis is relatively high and related to gender, age, chest aspect ratio and main site/direction/severity of scoliosis.

Design
A retrospective study.

Introduction
The incidence of cardiac abnormalities in patients with idiopathic scoliosis who require surgical treatment is relatively high, but the specific cause is not yet clear, and the potential risk factors have not been well elucidated.

Methods
289 patients with idiopathic scoliosis admitted to our center from January 2015 to March 2023 were retrospectively studied, and the records of echocardiography, plain radiograph of the entire spine and magnetic resonance imaging of the entire spine were reviewed. Calculate the incidence of cardiac abnormalities in patients with idiopathic scoliosis, and screen the risk factors affecting the incidence of cardiac abnormalities in patients with idiopathic scoliosis by multivariate analysis.

Results
There were 12 patients suffered from congenital heart disease, with a incidence of 4.15%, and the most common type is atrial septal defect(1.73%). And 88 patients suffered from other cardiac abnormalities, with a inci-

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dence of 30.45%, and the most common type is mild tricuspid regurgitation (28.72%). There were no statistically significant differences in the incidence of congenital heart disease among groups based on gender(P=0.096), age(6~10 vs 11-18, P=0.200), ethnicity(Han vs Minority, P=0.969), BMI grade(Emaciation vs Normal vs Overweight/Obesity, P=0.512), altitude(<2000m vs ≥2000m, P=0.078), main curvature location(Thoracic vs Thoracolumbar vs Lumbar, P=0.326), severity of scoliosis(Non-severe vs Severe, P=0.841), main direction(P=0.102), and chest aspect ratio(<0.45 vs ≥0.45, P=0.341). The incidence of other cardiac abnormalities is higher in males, patients with scoliosis in thoracolumbar and patients with left-sided scoliosis. And the results of multivariate analysis showed that males and scoliosis in thoracolumbar are risk factors for other cardiac abnormalities in patients with IS.

Conclusion

The incidence of congenital heart disease in patients with idiopathic scoliosis is 4.15%, and the incidence of other cardiac abnormalities is 30.45%. Males and scoliosis in thoracolumbar are risk factors for other cardiac abnormalities in patients with idiopathic scoliosis.

Table 4 Risk factors for idiopathic scoliosis combined with congenital heart disease

Risk factors		No. (without CHD)	No. (with CHD)	χ^2	P
Gender	Male	59	5	2.767	0.096
	Female	218	7		
Age	6-10 (year)	19	2	1.642	0.200
	11–18 (year)	258	10		
Nation	Han nationality	232	10	0.001	0.969
	Minority nationality	45	2		
BMI Grade	Emaciation	89	2	1.338	0.512
	Normal	173	9		
	Overweight/Obesity	15	1		
Altitude	<2000m	203	6	3.115	0.078
	≥2000m	74	6		
Main site of scoliosis	Thoracic	182	10	2.242	0.326
	Thoracolumbar	37	0		
	Lumbar	58	2		
Severity of scoliosis	Non-severe (<90 °)	249	11	0.040	0.841
	Severe(over 90 °)	28	1		
Main direction of scoliosis	Left	84	1	2.679	0.102
	Right	193	11		
AP/LR	<0.45	197	7	0.906	0.341
	≥0.45	80	5		

Table 5 Risk factors for idiopathic scoliosis combined with other cardiac abnormalities

Risk factors		No. (without OCA)	No. (with OCA)	χ^2	P
Gender	Male	36	28	6.866	0.009
	Female	165	60		
Age	6–10 (year)	12	9	1.646	0.199
	11–18 (year)	189	79		
Nation	Han nationality	167	75	0.206	0.650
	Minority nationality	34	13		
BMI Grade	Emaciation	63	28	1.103	0.576
	Normal	125	57		
	Overweight/Obesity	13	3		
Altitude	<2000m	144	65	0.151	0.698
	≥2000m	57	23		
Main site of scoliosis	Thoracic	141	51	7.198	0.027
	Thoracolumbar	19	18		
	Lumbar	41	19		
Severity of scoliosis	Non-severe (<90 °)	180	80	0.125	0.724
	Severe(over 90 °)	21	8		
Main direction of scoliosis	Left	50	35	6.542	0.011
	Right	151	53		
AP/LR	<0.45	142	62	0.001	0.974
	≥0.45	59	26		

Table 6 Multivariate analysis of idiopathic scoliosis combined with other cardiac abnormalities

Risk factors		Odds Ratio (OR)	95%CI	P
Gender	Male	1		
	Female	0.425	(0.231, 0.781)	0.006
Age	6–10 (year)	1		
	11–18 (year)	0.424	(0.160, 1.123)	0.084
Nation	Han nationality	1		
	Minority nationality	0.834	(0.400, 1.738)	0.627
BMI Grade	Emaciation	1		
	Normal	1.074	(0.595, 1.939)	0.812
	Overweight/Obesity	0.396	(0.097, 1.608)	0.195
Altitude	<2000m	1		
	≥2000m	0.829	(0.450, 1.530)	0.549
Main site of scoliosis	Lumbar	1		
	Thoracic	1.346	(0.567, 3.197)	0.501
	Thoracolumbar	2.972	(1.193, 7.406)	0.019
Severity of scoliosis	Non-severe (<90 °)	1		
	Severe(over 90 °)	0.785	(0.299, 2.062)	0.623
Main direction of scoliosis	Left	1		
	Right	0.474	(0.224, 1.004)	0.051
AP/LR	<0.45	1		
	≥0.45	0.868	(0.463, 1.626)	0.658

Risk factors

229. RATE OF BROKEN TETHERS AND REVISION SURGERY: A COMPARISON STUDY BETWEEN THORACIC AND LUMBAR CURVES

Abel De Varona-Cocero, BS; Djani Robertson, MD; Nicholas S. Vollano, MBS; Camryn Myers, BS; Fares Ani, MD; Constance Maglaras, PhD; Juan Carlos Rodriguez-Olaverri, MD

Hypothesis

The main preoperative risk factors for early tether breakage after 2RVBT are a high curve magnitude and limited flexibility. There is an increased chance of tether breakage if postoperatively, the second structural curve

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overcompensates for the correction of the primary structural curve. Furthermore, outcomes are influenced by the Lenke curve type. Although patients with lumbar curves experience higher rates of tether breakage, lower revision rates are observed.

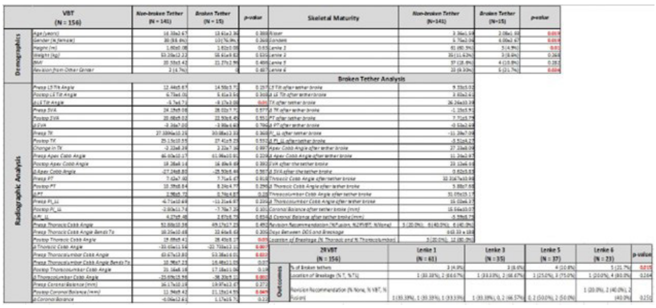
Design
Single-center retrospective cohort study.

Introduction
Two-Row VBT (2RVBT) shows promising results as a fusion-alternative to treat AIS patients. However, there is still around an 18% change of breakage. Given the novelty of 2RVBT, results of cord breakage in the learning curve of the technique can improve with better indication. This study compares non-broken 2RVBT cases to cases whose tether broke after the index surgery with more than 2 years follow up of index surgery, with a sub-analysis based on Lenke type (Lenke 1, 3, 5, or 6 curves).

Methods
Patients with AIS whose curves were <65 degree, flexible and residual curves after correction were <30 degrees were included. The cohort was separated into non-broken tether (NBT) cases or broken tether (BT) cases. Analysis was focused on breakage location and revision rates. Pre/post-op apex cobb angles, thoracic (T) cobb angle, thoracolumbar (TL) cobb angle, coronal balance, SVA, L5 slope, thoracic kyphosis (TK), pelvic incidence lumbar lordosis mismatch (PI-LL), and pelvic tilt (PT) were included.

Results
156 2RVBT (Lenke 1, N=61; Lenke 3, N=35; Lenke 5, N=37; Lenke 6, N=23) patients met the cohort criteria. There was a lower rate of tether breakage in the Lenke 1 group (3 (4.9%) vs 3 (8.6%) vs 4 (10.8%) vs 5 (21.7%)). Most broken tethers were in the TL curves 10 (76.9%) versus T curves 3 (23.1%). Most of the BT cases 6 (46.2%) were not indicated for revision surgery, while 3 (23.1%) were indicated for fusion and 4 (30.8%) were indicated for revision 2RVBT. Lumbar curves (Lenke types 5 and 6) demonstrated a lower revision rate 2/4 and 3/5 respectively versus thoracic curves (Lenke types 1 and 3), which demonstrated revision rates of 2/3 and 2/3 respectively.

Conclusion
Lumbar curve types have more cord breakage, but the revision rates are lower than the Lenke types whose structural curve is thoracic. Additionally, all coronal parameters are corrected and there was no loss of sagittal parameters.



230. A DEDICATED SPINE TEAM APPROACH IN POSTERIOR SPINAL FUSION (PSF) SURGERY FOR ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS) PATIENTS: IS THE OPERATING THEATRE (OT) EFFICIENCY AND PERIOPERATIVE OUTCOMES CONSISTENT BETWEEN THE FIRST, SECOND, AND THE LAST CASE?

Mun Keong Kwan, MBBS, MSOrth; Sin Ying Lee, MBBS; Weng Hong Chung, MD, MSOrth; Chee Kidd Chiu, MBBS, MSOrth; Mohd Shahnaz Hasan, MBBS; Chris Yin Wei Chan, MD, MSOrth

Hypothesis
A dedicated spine team can achieve consistent OT efficiency and good perioperative outcomes for patients in a consecutive case list.

Design
Retrospective study.

Introduction
OT inefficiency can increase hospital costs and healthcare system burden. A dedicated surgical team was established to improve OT efficiency in scoliosis surgeries. However, perioperative outcomes of AIS patients operated by a dedicated surgical team in the consecutive case operation list were unknown.

Methods
We recruited all AIS patients who were listed in three consecutive surgeries day (8:00AM to 8:00PM) and operated by a dedicated surgical team from 2021 to 2022. The team comprised three senior spine consultants who employed dual attending surgeon strategy, an anaesthetic consultant, dedicated surgical scrub nurses, anaesthesiology nurses, radiographers, and neuromonitoring technicians. All recruited patients were classified based on the sequence of operation list. Case 1 was the first case, Case 2 was the second case, and Case 3 was the last case of the day. OT efficiency (preoperative time, operative time, postoperative time, total OT time, and turnover time) and perioperative outcomes across all three groups were evaluated.

Results
102 cases were analyzed. The mean major Cobb angle was 63.3±15.5°. On average, Case 1 started at 8:38AM whereas Case 3 ended by 5:54PM of the day. OT efficiency was consistent between Case 1, Case 2, and Case 3 with comparable OT time in all five stages (p>0.05). The

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mean turnover time was 15.1±13.5 mins and the mean operative time was 123.0±28.1 mins. Intraoperative blood loss and blood transfusion requirements were comparable between groups (p>0.05). Mean intraoperative blood loss was 638.2±252.5mL (p=0.832) and none of the patients required allogeneic blood transfusion. The complication rate was 2.0%, i.e., 2 cases of superficial surgical site infection.

Conclusion

Enhanced OT efficiency with the dedicated spine team did not compromise patient safety, as all three cases in the consecutive list had consistent perioperative outcomes.

231. PSYCHOLOGICAL EFFECTS OF BRACING AMONG ADOLESCENT IDIOPATHIC SCOLIOSIS (AIS) PATIENTS AND THEIR COPING STRATEGIES

Chee Kidd Chiu, MBBS, MSOrth; Weng Hong Chung, MD, MSOrth; Lip Siang Tan, MSOrth; Chris Yin Wei Chan, MD, MSOrth; Mun Keong Kwan, MBBS, MSOrth

Hypothesis

AIS patients on brace treatment have a higher risk of psychological tendencies such as anxiety and depression, lower quality of life (QOL) and different coping strategies as compared to their non-brace counterparts.

Design

Cross-sectional, questionnaire-based study

Introduction

There was conflicting evidence as to whether psychological tendencies such as anxiety and depression were higher and whether QOL was lower among AIS patients on brace treatment. In this study, we aimed to determine the psychological well-being of AIS patients undergoing brace treatment compared to AIS patients who were not on brace. We also assessed the QOL, self-image, and expectations of AIS patients on brace treatment as well as their coping strategies while on brace treatment.

Methods

50 AIS patients treated with braces and 50 AIS patients under observation were recruited. Data were collected from a self-report questionnaire derived from Hospital Anxiety and Depression Scale (HADS), Scoliosis Research Society – 22r (SRS – 22r), Spinal Appearance Questionnaire (SAQ) and Brief Coping Orientation to Problems Experienced Questionnaire (Brief COPE).

Results

The mean age for brace and non-brace group was 13.6 ± 1.6 years and 15.1 ± 2.3 years (p<0.001). The mean Cobb angle during interview for the brace and non-brace group was 29.4 ± 9.4˚ and 27.3 ± 11.8˚, respectively (p=0.313). The prevalence of anxiety disorder for brace and non-brace group was 38% and 22%, respectively (p=0.126). The prevalence of depression in the brace and non-brace groups was 12% and 16%, respectively (p=0.774). Respondents in the non-brace group fared better in terms of function (p=0.028) and self-image (p=0.002) in SRS-22r scores. The assessment of patients' perception of their current body shape (p=0.258) and their expectations (p=0.164) using SAQ questionnaire were insignificant. Patients in the brace group practiced denial (p=0.001) and venting (p=0.003) as their coping mechanisms throughout their brace treatment.

Conclusion

AIS patients on brace were not more likely to have anxiety and depression, however, their QOL was lower compared to non-brace patients. Denial and venting were the most common coping strategies during brace treatment.

232. PREOPERATIVE LOW PSOAS MUSCLE INDEX AND MODERATE TO HIGH ANGULATION OF THE UIV SCREWS ARE MORE COMMONLY OBSERVED IN PATIENTS WHO DEVELOP PJK/PJF FOLLOWING ADULT SPINAL DEFORMITY SURGERY

Esteban Quiceno, MD; Bernard K. Okai, BS; Hendrick Francois, BS; Mohamed Soliman, MD; Asham Khan, MD; *Jeffrey Mullin, MD*

Hypothesis

Patients with low psoas muscle index (PMI) could have a higher risk of developing proximal junctional kyphosis/proximal junctional failure (PJK/PJF) after adult spinal deformity (ASD) surgery.

Design

Retrospective analysis of a prospective single-center data base

Introduction

PJK and PJF can be catastrophic complications associated with ASD surgery. These complications can be influenced by sarcopenia, leading to mechanical failure. The newly Magnetic Resonance Imaging (MRI) based PMI is a newly developed tool that can be used to assess sarcopenia.

Methods

Retrospective analysis of patients aged 50 years and older who underwent ASD surgery involving >5 thoracolumbar levels, with a minimum follow-up of two years. Demographic information, spinopelvic parameters, and procedure-related variables were collected for each patient. The PMI for each patient was calculated using preoperative T1-weighted MRI scans, which involved determining the average of the maximum right and left anteroposterior and transverse diameters of the psoas muscle at the L3 vertebra and dividing it by the patient's body mass index. Univariate analysis was performed to identify potential risk factors associated with PJK/PJF.

Results

A total of 116 patients were included in the analysis, with a mean age of 63.0±7 years. Among them, 38 patients(32%) developed PJK/PJF. Significant differences between the groups included the mean psoas muscle index, 0.41±0.16 vs 0.3±0.16(p< 0.001), for patients without PJK/PJF versus those with PJK/PJF, respectively. Additionally, patients with PJK/PJF exhibited a higher UIV

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screw/superior endplate angle of 9.6°±7.4° compared to 4.8°±5.6° in the non-PJK/PJF group(p<0.003). Furthermore, patients with PJK had a lower UIV screw-rod angulation, with 83.3°±11.5° versus 90.3°±7.0° in the non-PJK/PJF group.

Conclusion

Patients who developed PJK/PJF exhibited a significantly lower PMI, indicative of sarcopenia. Additionally, patients with PJK/PJF showed higher UIV screw/superior endplate angle and lower screw-rod angulations. These findings suggest that sarcopenia could serve as a crucial predictive factor for PJK/PJF. Moreover, maintaining an appropriate contour of the proximal rod, coupled with minimal angulation of the UIV screws and harmonious alignment between the rod and the screws, are essential factors in preventing PJK/PJF.

233. FACTORS PREDICTING TWO-YEAR PATIENT REPORTED OUTCOMES AFTER SURGERY FOR GRADE 2 SPONDYLOLISTHESIS: AN EXTREME-GROUP DESIGN ANALYSIS USING QUALITY OUTCOMES DATABASE (QOD)

Ken Porche, MD, MS; Kai-Ming Gregory Fu, MD; Jay D. Turner, MD; Juan S. Uribe, MD; Anthony L. Asher, MD; Domagoj Coric, MD; Michael S. Virk, MD, PhD; Christopher I. Shaffrey, MD; Oren Gottfried, MD; Eric Potts, MD; Mohamad Bydon, MD; Michael Y. Wang, MD; Paul Park, MD; Steven D. Glassman, MD; Kevin T. Foley, MD; Cheerag D. Upadhyaya, MD, MSc, MBA; Dean Chou, MD; Mark E. Shaffrey, MD; Anthony M. DiGiorgio, DO, MHA; Praveen V. Mummaneni, MD, MBA; Erica F. Bisson, MD; *Andrew K. Chan, MD*

Hypothesis

Multiple risk factors will be predictive of outcomes.

Design

Multicenter prospective cohort.

Introduction

High-grade spondylolisthesis poses a significant challenge to patients' outcomes. This study aims to identify the predictors associated with good vs poor outcomes after surgery for grade 2 spondylolisthesis.

Methods

The QOD High Grade Spondylolisthesis (HGS) dataset was analyzed. We categorized patients into two distinct groups based on their two-year postoperative ODI, EQ5D, VAS-back, and VAS-leg scores compared to their baseline scores: those with poor outcomes (lowest 25th percentile) and those with good outcomes (highest 25th percentile). Multivariate binary logistic regression models were then developed to identify factors influencing these extreme outcomes. Inclusion criteria: patients with 2-year and baseline scores of any outcome.

Results

Out of 400 patients in the HGS QOD database with grade 2 spondylolisthesis, 343 met the inclusion criteria. Factors associated with the ODI improvement included not having a complication (OR 9.2, p=0.043), not having depression (OR 6.5, p=0.001), having central stenosis (OR 4.5, p=0.003), not using BMP (OR 3.6, p=0.013), lower BMI (OR 3.1/5kg/m2, p=0.013), and higher baseline ODI scores (OR 2.9/10 pts, p=0.005). Factors associated with the EQ5D improvement included not having a liability or disability claim filed (OR 206, p<.0005), having anxiety (OR 5.0, p=0.002), and having lower baseline EQ5D scores (OR 3.6/10%, p<.0001). Factors associated with the VAS-back improvement included only higher baseline VAS-back scores (OR 8.9/point, p=0.004). Factors associated with VAS-leg improvement similarly included higher VAS-leg scores (OR 18.0/point, p<.0003), higher VAS-back scores (OR 7.1/point, p=0.006), or having stenosis (OR 2.5, p=0.002).

Conclusion

Our study highlights key predictors of outcomes two years after surgery for grade 2 spondylolisthesis. Worse baseline scores were associated with a greater potential for improvement. Having anxiety was associated with EQ5D improvements while depression was associated with ODI worsening. Having stenosis was found to be associated with ODI and leg pain improvement possibly due to the potential for neural element decompression with surgery. Other factors associated with ODI worsening included postoperative complication, use of BMP, and higher BMI.

234. HOW DOES ROD MATERIAL AND DIAMETER IMPACT RADIOGRAPHIC CORRECTION AND MECHANICAL COMPLICATIONS FOLLOWING ADULT SPINAL DEFORMITY SURGERY?

Omar Zakieh, MBBS; Hani Chanbour, MD; Ambika Paulson, MD; Walter Navid, BS; Mitchell Bowers, MD; Iyan Younus, MD; David C. Liles, MD; Ranbir Ahluwalia, MD; Julian Lugo-Pico, MD; Amir M. Abtahi, MD; Scott Zuckerman, MD, MPH; *Byron F. Stephens, MD*

Hypothesis

Larger rod diameter and cobalt chrome rods provide better deformity correction and reduce mechanical complications following adult spinal deformity (ASD) surgery.

Design

Retrospective cohort study

Introduction

The interplay of rod material and rod diameter on outcomes following ASD surgery remains understudied. In a cohort of patients undergoing ASD surgery, we sought to determine the impact of rod characteristics on: 1) radiographic correction, and 2) mechanical complications and reoperations.

Methods

A single-institution, retrospective cohort study was performed for patients undergoing ASD surgery from 2009-21. Inclusion criteria were: ≥5-level fusion, sagittal/

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coronal deformity, and 2-year follow-up. Primary exposure was rod material (Titanium alloy or Cobalt chrome) and rod diameter. The primary objective was sagittal/coronal radiographic correction. Secondary outcomes included mechanical complications and reoperations. Multivariable regression models controlled for age, BMI, and osteoporosis.

Results

Of 199 patients included, mean age was 63.1±17.3, 49 (24.6%) were males and mean instrumented levels was 10.3±3.1. 156 (78.4%) patients had titanium rods; 43 (21.6%) had cobalt rods. The range of rod diameters was 3.50-6.35mm, the most common being 5.5mm (58.9%) and 6.0mm (20.1%). Radiographically comparing titanium and cobalt rods, no difference was found in postoperative SVA (52.4±58.7 vs 45.6±49.6mm, p=0.526), CVA (21.3±20.5 vs 17.4±17.5mm, p=0.354), T1PA (22.9±12.5 vs 20.2±10.3°, p=0.236), max coronal cobb (17.9±8.7 vs. 17.5±9.5°, p=0.849), PT (24.8±10.7 vs 22.7±10.4°, p=0.268), L4-S1 (-29.1±12.8 vs -27.8±13.8°, p=0.629), L1-S1 (-24.9±35.0 vs -24.2±38.6°, p=0.921), or amount of correction (p>0.05). No correlation was found between rod diameter and postoperative radiographic measurements/correction (p>0.05). Postoperatively, titanium rods were associated with a significantly shorter time to rod fracture (17.5±10.2months) on univariate and multivariate regression than cobalt rods (38.5±46.2months) (β=26.30, 95%CI=9.34-43.25, p=0.003). No association was found between rod material/diameter and other mechanical complications or reoperations.

Conclusion

In patients undergoing ASD surgery, using titanium rods resulted in a significantly shorter time to rod fracture than cobalt rods, with no impact on other mechanical complications, radiographic correction, or reoperation.

236. CHANGES IN RETROPERITONEAL ANATOMY WITH LUMBAR SPINE MRI PERFORMED IN THE SUPINE, LATERAL, AND PRONE POSITIONS

Gabriel Mason, MD; *Miles W. Fisher, MD*; James Aden, PhD; Richard K. Hurley, MD

Hypothesis

We hypothesize that there will be a decrease in the left retroperitoneal space when in the right lateral decubitus position.

Design

Morphometric Analysis

Introduction

The impact of lumbar lordosis in restoring or maintaining sagittal balance is well documented. Recently, anterior retroperitoneal (RP) and lateral transpsoas techniques have become more widely adopted in the restoration of lumbar lordosis. The type of approach is often determined based on supine magnetic resonance imaging (MRI) of the RP space and the surrounding structures. However, it is not well understood how the change in positioning influences the cross-sectional anatomy. The aim of this study was to investigate the changes in anatomy of the RP space and lumbar lordosis based on MRIs acquired in the supine, lateral and prone positions.

Methods

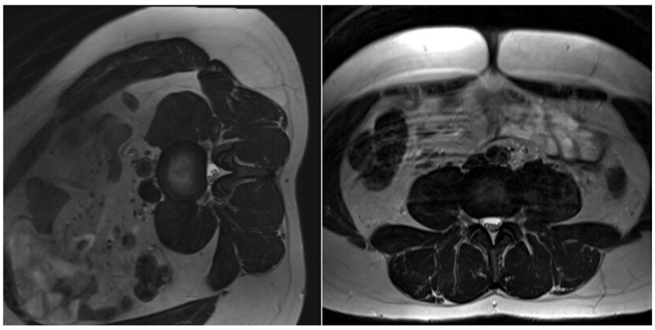
Twelve adult subjects without low back pain or prior lumbar surgery underwent T2-weighted MRI acquisition in the sagittal and axial planes. Imaging was obtained in the supine, prone, and right-lateral decubitus positions. The surface area of the psoas, the RP space, distance to the great vessels were measured at each lumbar disc space as well as the lumbar lordosis.

Results

At L2-3, there was an increase in the mean left RP space in the lateral decubitus position compared to prone (11.4cm2 vs 6.9 cm2, p<0.01). Additionally, at L3-4 the left RP space was decreased in the lateral position compared to supine (6.9 cm2 vs 10.3 cm2, p<0.01). The mean distance from the disc space to the aorta was significantly increased in the lateral position(11.4mm) compared to prone(9.2mm) and supine(6.9mm, p<0.01). Distance between the disc space to the inferior vena cava and psoas area were similar in each position. Mean lumbar lordosis was similar between supine and prone positioning, but the lateral decubitus position demonstrated a lower lumbar lordosis when compared to two other positions (p<0.05).

Conclusion

Variations in retroperitoneal anatomy as well as distribution of the lumbar plexus play important roles in determining the approach for addressing lumbar deformity corrections. This study found that the size of the RP space varies depending on positioning while also demonstrating a flattening affect as RP areas decreased at L3-4 in the lateral position. A nuanced understanding of the RP anatomy may influence the decision-making to maximize safe operative corridors.



Flattening of left RP space.

†Louis A. Goldstein Best Clinical Research E-Point Presentation *John H. Moe Best Basic Research E-Point Presentation ‡SRS Funded Research Grant

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E-POINT PRESENTATION ABSTRACTS

237. ARE WE GETTING BETTER AT ACHIEVING OPTIMAL LUMBAR SEGMENTAL SAGITTAL ALIGNMENT IN ADULT SPINE DEFORMITY SURGERY?

Peter G. Passias, MD; Tobi Onafowokan, MBBS; Renaud Lafage, MS; Justin S. Smith, MD, PhD; Kojo D. Hamilton, MD, FAANS; Ankita Das, BS; Jamshaid Mir, MD; Bassel G. Diebo, MD; Alan H. Daniels, MD; Breton G. Line, BS; Darryl Lau, MD; Michael P. Kelly, MD; Juan S. Uribe, MD; Kai-Ming Gregory Fu, MD; Michael Y. Wang, MD; Richard G. Fessler, MD; Pierce D. Nunley, MD; Neel Anand, MD; Adam S. Kanter, MD; Themistocles S. Protopsaltis, MD; Robert K. Eastlack, MD; Gregory M. Mundis Jr., MD; David O. Okonkwo, MD, PhD; Khaled M. Kebaish, MD; Alex Soroceanu, MD, FRCS(C), MPH; Praveen V. Mummaneni, MD, MBA; Dean Chou, MD; Han Jo Kim, MD; Richard Hostin, MD; Munish C. Gupta, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Shay Bess, MD; Virginie Lafage, PhD; Lawrence G. Lenke, MD; International Spine Study Group

Hypothesis
To investigate how realignment advances have impacted lumbar segmental correction.

Design
Retrospective cohort

Introduction
The understanding of sagittal spine alignment and ASD management continues to advance. However, it remains unknown how these advances have influenced lumbar segmental alignment changes.

Methods
Patients undergoing primary thoracolumbar fusion were stratified by enrolment in two multicenter registries; forming an 'EARLY' (2009-2018) and 'RECENT' cohorts (2019-present). Patients were isolated by the recent dataset's enrolment criteria (T1-pelvic angle ≥ 30 or pelvic incidence-lumbar lordosis mismatch≥ 25 or sagittal vertical axis >15cm). Patients were further stratified by pelvic incidence (PI) and Roussouly (R) type. PI-based and R-based alignment were determined by Pesenti's and Chung's normative values. Means comparison tests and multivariate analyses compared segmental & regional parameters.

Results
1240 patients included (Age:61.4±14.5 years, BMI:28.0±5.8 kg/m², CCI:1.55±1.70). 70.2% of patients were female. There were 622 EARLY and 618 RECENT patients. At baseline (BL), RECENT had lower BMI (26.8 vs 27.8 kg/m², p<0.002) and CCI (1.00 vs 1.85, p<0.001). For BL PI, EARLY had 20.2% low PI patients, 42.2% average PI and 37.7% high PI vs RECENT with 24.5% low PI, 43.3% average PI and 32.3% high PI (p=0.029). By R type, EARLY had 0.2% type 1, 60.3% type 2, 26.8% type 3 and 12.6% type 4, while RECENT had 0.2% type 1, 55.9% type 2, 27.6% type 3 and 16.3% type 4 patients (p=0.417). RECENT consistently displayed better L5-S1 alignment across all PI and R types (p=0.001) EARLY demonstrated better L4-L5 alignment (p=0.001). Both cohorts demonstrated low rates of matching L4-S1 and L1-S1 alignment, with no differences between both groups. By lordosis distribution index, both groups had predominantly hyperlordotic maldistribution postop, but EARLY had more 'Aligned' patients (15.9 vs 11%, p<0.001).

Conclusion
Over the past 15 years, surgeons are better at restoring ASD patients' ideal L5-S1 segmental sagittal alignment. However, achieving optimal L4-5 and more cephalad lumbar alignment has not increased accordingly, and thus opportunity still exists for improvements in these critical measures.

Postoperative rates of matching PI-based segmental values by Cohort

	Cohort	L4-5	L5-S1	L1-S1	L4-S1
Low PI (<45)	Early, %	27.7	33.1	0.5	1.5
	Recent, %	19.4	40.0	0.4	0.4
	Sig.	**0.001**	**0.017**	0.805	0.067
Average PI (45-60)	Early, %	21.5	33.7	0	0.3
	Recent, %	13.8	40.2	0	0.2
	Sig.	**<0.001**	**0.026**	-	0.672
High PI (>60)	Early, %	24.2	41.4	0	1.5
	Recent, %	16.4	51.0	0	0.4
	Sig.	**0.001**	**0.001**	-	0.067

Postoperative rates of matching Roussouly segmental values by Cohort

	Cohort	L4-5	L5-S1	L1-S1	L4-S1
Roussouly Type 1	Early, %	23.5	17.2	0.3	0
	Recent, %	17.6	25.0	0.3	0.2
	Sig.	**0.016**	**0.001**	0.995	0.316
Roussouly Type 2	Early, %	25.9	15.9	0	0.8
	Recent, %	20.8	23.6	0	0.2
	Sig.	**0.048**	**0.001**	-	0.103
Roussouly Type 3	Early, %	17.9	14.0	0	0
	Recent, %	11.8	22.8	0	0.2
	Sig.	**0.005**	**<0.001**	-	0.316
Roussouly Type 4	Early, %	16.2	24.9	0	0
	Recent, %	12.0	37.2	0	0.2
	Sig.	**0.048**	**<0.001**	-	0.316

Rates of matching segmental alignment post-operatively before PI/ Roussouly-stratification

Parameter	Early	Recent	
L4-L5	50.9%	36.6%	**<0.001**
L5-S1	71.1%	78.8%	**0.004**
L4-S1	42.1%	24.0%	**<0.001**

Surgical Approach	Early	Recent	Sig
ALIF	27.7%	21.8%	**0.018**
TLIF/ PLIF	18.2%	7.4%	**<0.001**
LLIF	33.3%	35.8%	0.358

238. DO MALES AND FEMALES HAVE SIMILAR PATIENT-REPORTED OUTCOMES IN ASD SURGERY?

Ganesh Swamy, MD, PhD; Sigurd H. Berven, MD; Marinus de Kleuver, MD; Yong Qiu, PhD; Yukihiro Matsuyama, MD, PhD; Lawrence G. Lenke, MD; Ahmet Alanay, MD; Ferran Pellisé, MD, PhD; Kenneth M. Cheung, MD, MBBS, FRCS; Maarten Spruit, MD; David W. Polly, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Michael P. Kelly, MD; Benny T. Dahl, MD, PhD, DMSc; Stephen J. Lewis, MD, FRCS(C)

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Hypothesis
Female ASD patients will have worse patient-reported outcomes in ASD surgery.

Design
Prospective, international, multi-center cohort

Introduction
ASD cohorts are largely female (80-85%), but the outcome difference between males and females is incompletely studied. Bumpass et al. (2017) suggested no outcome differences between sexes in an ASD cohort, and there are no other reports. There is much interest in sexual dimorphism in patient-reported outcomes in surgery. In total knee replacement, female patients generally report worse pain and function pre-op, and outcomes are worse in females. In 80% of reports involving sex differences in lumbar degenerative surgeries, female patients had at least one category of worse outcome scores. Therefore, we sought to examine sex differences in ASD surgery outcomes.

Methods
Elderly ASD (>60 years) patients in the international, multicentre Prospective Evaluation of Elderly Deformity Surgery (PEEDS) study were divided into male and female cohorts. Unadjusted linear mixed-effects regression models with the interaction of time and gender were used for patient-reported outcomes (SRS, ODI, EQ5D) and radiologic parameters. Two-sided Wald tests were performed to test for significant differences (α=0.05).

Results
Of 219 patients, there were 176 females (80.3%) and 43 males (19.6%) with 2-year follow-up. There were no differences in demographics or comorbidities between sexes, except for a significantly increased rate of osteopenia (51% vs 17%) in females (p=0.006); however, osteoporosis rates were not different (11% females vs 13% males). The only significant sex difference between the pre- and postoperative radiographic measurements was a higher SVA in males (p=0.036) with least square mean difference of the change in time and sex of 22mm (95% CI: 1; 42). There were no significant sex differences between pre- and postoperative SRS, ODI or EQ-5D.

Conclusion
While there are large differences in incidence of ASD between sexes, there are no apparent differences in pre- and post-operative radiographic measures or patient-reported outcomes at 2-years after ASD surgery. The exception was pre-operative SVA with a significant change in time and sexes. These findings are in accordance with Bumpass et al. (2017). Whatever etiological factors account significant sexual dimorphism in ASD incidence, there is no sexual dimorphism in ASD surgery outcomes.

239. THE EFFECT OF DEGENERATIVE SCOLIOSIS ON SEGMENTAL THORACOLUMBAR SAGITTAL ALIGNMENT COMPARED TO AGE-AND PELVIC INCIDENCE-MATCHED REFERENCE VALUES

Yann Philippe Charles, MD, PhD; Vincent Lamas, MD; Renan Chapon, MD; Solène Prost, MD; Benjamin Blondel, MD, PhD; Stéphane Fuentes, PhD; Erik-André Sauleau, MD, PhD

Hypothesis
In asymptomatic subjects, variations of segmental thoracolumbar sagittal alignment according to age and pelvic incidence (PI) exist. Age- and PI-adjusted alignment might be influenced by compensation mechanisms in adult spinal deformity (ASD). This gap should be known when planing surgery.

Design
Retrospective register study.

Introduction
The aim of this observational study was to describe the distribution of thoracolumbar kyphosis and lordosis distribution according to age and PI in subjects with and without degenerative scoliosis to evaluate to what extent compensatory phenomena are due to ASD.

Methods
Full spine radiographs of 235 asymptomatic subjects and 243 scoliosis patients were analyzed: cervico-thoracic inflexion point (CTIP), thoraco-lumbar inflexion point (TLIP), lumbar lordosis (LL) L1-S1, LL (TLIP-S1), LL superior arch (TLIP-lumbar apex), LL inferior arch (lumbar apex-S1), PI, PI–LL, thoracic kyphosis (TK) T5-T12, TK T1-T12, number of vertebrae CTIP-TLIPandTLIP-S1. The distribution of parameters was analyzed using a Bayesian inference (significant when Pr>0.975 or Pr<0.025). Comparisons between reference (R) and pathologic (P) groups were matched according to age (40-60 years; >60 years) and PI (<45°; 45-60°; >60°).

Results
LL L1-S1 was significantly lower in the P-group (Pr=1.0), decreased with age (Pr>0.99) and increased with PI (Pr<0.001). In contrast, there was no significant decrease with age for LL (TLIP-S1) or LL (superior arch) (respectively Pr<0.92 and Pr>0.19). LL in the inferior arch was significantly lower in the P-group (Pr=1.0) and decreased with age (Pr=0.99). The number of vertebrae TLIP-S1 was significantly lower in the P-group compared to the reference group (Pr<0.001). Thoracic kyphosis T1-T12 was significantly lower in the P-group (Pr<0.001), without significant influence of age or PI. The number of vertebrae CTIP-TLIP increased significantly in the P-group (Pr<0.001) and with PI (Pr<0.004).

Conclusion
This observational study highlights specific thoracolumbar sagittal alignment adaptations in degenerative scoliosis, matched on age and PI. Beyond the decrease in LL due to aging, degenerative scoliosis leads to a distal

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Meeting Information
Meeting Agenda
Abstracts
Industry Workshops
Disclosures
Author Index
About SRS

migration of the TLIP, an increase in the number of vertebrae in TK and a decrease in LL. This phenomenon was linked to kyphosis at the thoracolumbar junction due to scoliosis and was more important in high PI.

240. ASSESSING THE UTILITY OF THE ROUSSOULY CLASSIFICATION IN PRIMARY VS REVISION FUSION IN ADULT SPINE DEFORMITY

Tobi Onafowokan, MBBS; Ankita Das, BS; Jamshaid Mir, MD; Lefko Charalambous, MD; Matthew Galetta, MD; Nathan Lorentz, MD; Pawel P. Jankowski, MD; Samuel Montgomery, MD; Stephane Owusu-Sarpong, MD; Andrew Chen, BS; Jordan Lebovic, BA; Neel Anand, MD; Bassel G. Diebo, MD; Alan H. Daniels, MD; Han Jo Kim, MD; Zeeshan M. Sardar, MD; Thomas J. Buell, MD; Aaron Hockley, MD; M. Burhan Janjua, MD; Christopher I. Shaffrey, MD; Kojo D. Hamilton, MD, FAANS; Renaud Lafage, MS; Virginie Lafage, PhD; Daniel M. Sciubba, MD; Justin S. Smith, MD, PhD; *Peter G. Passias, MD*

Hypothesis
To investigate predictive ability of the Roussouly classification in primary and revision surgery.

Design
Retrospective cohort

Introduction
Restoring adult spine deformity (ASD) patients' ideal Roussouly type is reported to prevent mechanical complications. The predictive ability of this schema has not been extensively investigated in the context of primary and revision surgery.

Methods
ASD patients with clinical and radiographic data from baseline (BL) to 2 years (2Y) were stratified by primary (PRY) and revision (REV) surgery, by Roussouly type, and then by matching ideal Roussouly types as described by Latouissat, (with type 1 and 2 corresponding to pelvic incidence [PI] < 45°, type 3 to PI 45°–60°, & type 4 to PI > 60°). Means comparisons tests were used to assess differences between both groups. Logistic regression analyses were used to analyze associations between Roussouly matching and various outcomes, including mechanical complications (MCs).

Results
464 patients were included (Age: 60.4 ± 14.9 years, BMI: 27.5 ± 5.8 kg/m2, CCI: 1.67 ± 1.66). 74% of patients were female. At baseline (BL), 8.2% of patients were type 1, 51.8% type 2, 26.6% type 3 and 13.2% type 4. Roussouly (R) types in PRY were 9.1% type 1, 49.8% type 2, 27.2% type 3 and 14% type 4, compared to REV (8.6% type 1, 58.6% type 2, 24.1% type 3 & 8.6% type 4) [p=0.171]. BL rates of matching ideal R type were not significantly different (p=0.106). REV patients were older, with worse deformity, disability and comorbidity profiles at BL (all p<0.001). Ideal R type match rates and degree of deformity correction (by SAAS) did not differ between both cohorts post-op. In ideal R-matched patients, REV had higher MC rates by 2Y (25.5 vs 16.9%, p=0.023). Controlling for age, BL disability and deformity, REV had higher 2Y MC risk (OR 1.7, 95% CI 1.1-2.6, p=0.024). Reoperation at 2Y did not differ (20.2% REV vs 13.5% PRY, p=0.183). Disability and functional metrics did not differ post-op at all time points.

Conclusion
Revision surgery patients experienced higher rates of mechanical complications, which correlated with lower rates of matching ideal Roussouly type. Thus, the Roussouly classification appears to perform similarly in primary and revision surgery at predicting poor outcomes

Baseline comparisons			
Variable	PRY	REV	Sig.
Age	57.9	63.4	**<0.001**
BMI	26.4	27.9	**0.003**
CCI	1.50	2.01	**0.001**
Rouss type, %	9.1 (1), 49.8 (2), 27.2 (3), 14.0 (4)	8.6 (1), 58.6 (2), 24.1 (3), 8.6 (4)	0.171
Rouss match, %	42.8	35.5	0.106
Gender, % female	84.4	74.1	**0.006**
PT	21.4	26.8	**<0.001**
PI-LL	10.0	22.3	**<0.001**
T1PA	18.5	27.9	**<0.001**
SAAS	3.9	4.7	**<0.001**
SAAS match, %	34.2	21.4	**<0.001**
ODI	38.5	48.3	**<0.001**
SRS-22	2.95	2.64	**<0.001**
EQ5D	0.77	0.73	**<0.001**
ASD-mFI	5.5	8.2	**<0.001**
Levels fused	11.1	10.9	0.533
Outcomes			
ODI 6W	48.6	48.2	0.853
SRS 6W	3.03	3.00	0.620
EQ5D 6W	0.73	0.75	0.211
PT 6W	17.7	20.9	**<0.001**
PI-LL 6W	0.3	2.9	**0.036**
T1PA 6W	13.8	17.0	**<0.001**
SAAS 6W	1.3	1.1	0.696
SAAS match 6W, %	29.1	29.1	0.975
Rouss match, %	53.8	44.1	**0.040**
PJK, %	36.2	38.6	0.591
Mechanical complications, %	16.9	25.5	**0.023**

241. FACTORS ASSOCIATED WITH TIMING FOR REVISION SURGERY FOR PROXIMAL JUNCTIONAL KYPHOSIS (PJK)

Kojo D. Hamilton, MD, FAANS; Rohit P. Kumar, BA; Nitin Agarwal, MD; Lawrence G. Lenke, MD; Peter G. Passias, MD; Eric O. Klineberg, MD; Virginie Lafage, PhD; Shay Bess, MD; Justin S. Smith, MD, PhD; Jeffrey L. Gum, MD; Renaud Lafage, MS; Jeffrey Mullin, MD; Michael P. Kelly, MD; Bassel G. Diebo, MD; Thomas J. Buell, MD; Justin K. Scheer, MD; Breton G. Line, BS; Han Jo Kim, MD; Khaled M. Kebaish, MD; Rida Mitha, MBBS; Robert K. Eastlack, MD; Alan H. Daniels, MD; Alex Soroceanu, MD, FRCS(C), MPH; Gregory M. Mundis Jr., MD; Richard Hostin, MD; Themistocles S. Protopsaltis, MD; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; International Spine Study Group

Hypothesis
Six-week (6W) spinopelvic parameters are similar among patients who receive PJK revision surgery within two years, between two years and four years, and no revision at all.

Design
Multicenter, prospective cohort

†Louis A. Goldstein Best Clinical Research E-Point Presentation *John H. Moe Best Basic Research E-Point Presentation ‡SRS Funded Research Grant
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Introduction

PJK is a radiographic complication following adult spinal deformity (ASD) surgery. This study aims to compare characteristics between ASD patients who received PJK revision at various time points.

Methods

Data was obtained from a multicenter database. Patients with ASD diagnosed with PJK were identified; those who had a revision within 6W were excluded due to the lack of postoperative films before 6W. The remaining patients were separated into groups: received revision surgery within two years, between two and four years, or no revision surgery within four years. Demographic variables were included. The SRS-22 questionnaire was used to assess health-related quality-of-life (HRQOL) at baseline. Spinopelvic parameters at 6W were collected, including C2-pelvic angle (C2PA), T4-pelvic angle (T4PA), L1-pelvic angle (L1PA), and T4PA-L1PA mismatch. Additionally, the incidence of preceding neurologic complications (within one year of PJK diagnosis) was determined. Hart-PJK severity score (PJKSS) was calculated without instrumentation or fracture components due to a lack of specific data. Bivariate analysis was performed with the Kruskal-Wallis and chi-squared tests.

Results

A total of 113 patients diagnosed with PJK were included. Six patients who had revision before six weeks postoperatively were excluded. Forty-seven patients (41.6%) had a revision surgery between 6 weeks and 2 years, 18 had a revision between 2 and 4 years (15.9%), and 48 patients (42.5%) had no revision surgery within 4 years. There were no significant differences between C2PA (p = 0.719), T4PA (p = 0.701), L1PA (p = 0.934), and T4PA-L1PA mismatch (p = 0.613) at 6W between the three groups. Likewise, the incidence of neurologic complications was not significantly different (p = 0.797).

Conclusion

Early 6W postoperative spinopelvic parameters and the incidence of neurologic complications do not explain the timing of revision surgery. Additionally, demographics and HRQOL are similar among patients who received revision surgery for PJK and those who did not. Surgeons may be utilizing different variables for early risk stratification of PJK revision.

Table 1.

Variable	Overall (n=113)	Revision in > 6 weeks and <2 Years (n=47)	Revision in 2 to 4 Years (n=18)	No Revision at 4 Years (n=48)	P-value
Age	66.1 ± 9.2	65.2 ± 10.4	66.51± 5.5	66.8 ± 9.5	0.786
Female (%)	83 (73.4)	27 (57.4)	11 (61.1)	42 (87.5)	0.394
CCI	2.1 ± 1.6	1.9 ± 1.7	2.7 ± 1.8	2.0 ± 1.4	0.527
BMI	27.9 ± 5.2	27.0 ± 5.0	26.6 ± 4.9	28.5 ± 5.5	0.578
Osteoporosis (%)	20 (17.7)	6 (12.8)	6 (33.3)	7 (14.6)	0.159
Baseline SRS-22	2.6 ± 0.6	2.5 ± 0.5	2.8 ± 0.7	2.6 ± 0.6	0.726
Number of levels fused posteriorly	11.6 ± 3.7	10.4 ± 3.8	11.3 ± 3.1	12.4 ± 3.5	0.055
Spinopelvic parameters					
6W C2PA	22.0 ± 9.1	23.4 ± 8.6	21.6 ± 7.2	21.0 ± 10.2	0.719
6W T4PA	13.4 ± 9.1	14.9 ± 8.3	13.0 ± 7.7	12.4 ± 10.1	0.701
6W L1PA	9.4 ± 8.1	9.4 ± 8.1	9.1 ± 7.7	8.3 ± 8.1	0.934
6W T4PA – L1PA mismatch	4.6 ± 4.7	5.5 ± 4.9	3.9 ± 4.7	4.1 ± 4.6	0.613
Preceding neurologic complication? (%)	10 (8.8)	4 (8.5)	2 (11.1)	3 (6.3)	0.797
Hart-PJKSS	3.8 ± 2.4	3.7 ± 2.4	4.6 ± 2.4	3.7 ± 2.3	0.427

242. BASELINE HISTORY OF PRIMARY FRAGILITY FRACTURE PREDICTS MEDICAL COMPLICATIONS AND REVISION THROUGH 1-YEAR IN ADULT SPINAL DEFORMITY PATIENTS UNDERGOING THORACOLUMBAR FUSION

Neil V. Shah, MD, MS; Alejandro J. Freidman, MA, BS; Rachel Baum, MPH; Alex La Poche, BS; Stefani Manis, BA; Dario Fucich, BS; Kyle Smith, BS; Henna Purewal, BS; Juhayer Alam, BS; Chibuokem P. Ikwuazom, MD; Prasenjit Saha, BA; Chadi Tannoury, MD; Jad Bou Monsef, MD; Carl B. Paulino, MD

Hypothesis

History of fragility fracture is associated with increased adverse postop outcomes following thoracolumbar fusion (TLF) for Adult Spinal Deformity (ASD).

Design

Retrospective multicenter cohort

Introduction

History of fragility fractures (FFx) can be indicative of osteoporosis or other metabolic bone disorders, which can influence complications following thoracolumbar posterior spinal fusion (PSF) in ASD pts. This relationship has not been well studied. We sought to evaluate the impact of a hx of FFx on adverse postop outcomes following ≥3-level TLF.

Methods

The Mariner10 PearlDiver database was queried to identify pts ≥ 50y undergoing ≥3-level posterior spinal fusion (PSF) for ASD from 2010-2022. Trauma/infection/tumor cases were excluded. Pts with and without hx of primary FFx were identified (fx of hip, prox humerus, distal radius, vertebral body, and pelvis) and stratified (FFx vs. No-FFx). Univariate comparison of postop med complics (30d, 90d) and surg complics (6mo, 1yr) was carried out between cohorts; multivariable logistic regression (covariates: age, sex, CCI, and obesity) identified predictors of adverse outcomes.

Results

1460 pts were included; 60 had a hx of fragility fx. FFx pts had higher total med (38.3 v 5.2%) and individual complications, including respiratory failure (8.3 v 2%), DVT (8.3 v 0.6%), and infection (6.7 v 0.9%) at 90-days postop ($p<0.05$). FFx pts had higher total surg (20 v 2.5%) and individual complications, including revision/extension (15 v 0.4%) and decompression/laminectomy (6.7 v 0.8%) at 6 mo or 1 year post op ($p<0.005$). FFx hx was associated with higher risk of wound disruption (OR=3.9), respiratory failure (OR=3.1), pneumonia (OR=2.4), and PE (OR=1.1) (all, $p<0.05$). FFX hx was also associated with higher odds of revision/extension (OR=3.5, $p<0.001$).

Conclusion

These findings emphasize the importance of consideration of bone quality in ASD patients. Baseline hx of fragility fx predicted both med & surg complications through 1-year postop. Bone mineral density assessment is a critical component to preoperative assessment, but these findings demonstrate that potentially important

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risk stratification/optimization data can be identified from simple preoperative assessment of presence of a hx of fragility fx.

Complications	Odds Ratio	P-value
Total Medical Complications	2.03 [1.11-3.67]	**0.020**
Infection		
90 days	0.62 [0.10-2.17]	0.531
1 year	0.56 [0.09-1.95]	0.445
Wound Disruption		
90 days	5.46 [2.18-12.3]	**<0.001**
1 year	3.90 [1.54-8.78]	**0.002**
Blood Transfusion		
90 days	0.39 [0.02-2.03]	0.374
1 year	0.55 [0.08-2.04]	0.440
Deep Vein Thrombosis		
90 days	1.92 [0.43-6.08]	0.321
1 year	1.40 [0.32-4.32]	0.599
Pulmonary Embolism		
90 days	1.95 [0.30-7.28]	0.391
1 year	1.14 [0.18-4.15]	0.860
Pneumonia		
90 days	2.53 [1.04-5.52]	**0.028**
1 year	2.44 [1.16-4.77]	**0.013**
-Acute Kidney Failure		
90 days	0.19 [0.01-0.96]	0.113
1 year	0.92 [0.30-2.43]	0.882
Respiratory Failure		
90 days	2.69 [1.13-5.83]	**0.017**
1 year	3.14 [1.48-6.31]	**0.002**
Surgical Infection		
90 days	0.62 [0.10-2.17]	0.531
1 year	0.56 [0.09-1.95]	0.445
Wound Disruption		
90 days	5.46 [2.18-12.3]	**<0.001**
1 year	3.90 [1.54-8.78]	**0.002**
Blood Transfusion		
90 days	0.39 [0.02-2.03]	0.374
1 year	0.55 [0.08-2.04]	0.440
Total Surgical Complications	3.11 [1.30-7.10]	**0.008**
Revision/Extension		
6 months	2.68 [1.18-5.50]	**0.011**
1 year	3.52 [1.70-6.85]	**<0.001**
Decompressive Laminectomy		
6 months	2.60 [0.69-7.61]	0.111
1 year	2.21 [0.61-6.28]	0.173

Table 1. Odds Ratios for post-TLF complications, multivariate analysis.

243. REMOVAL OF PAINFUL PELVIC SCREWS FOLLOWING SPINE FUSION SURGERY: OUTCOMES AND COMPLICATIONS

Anthony L. Mikula, MD; Nikita Lakomkin, MD; Zach Pennington, MD; Michael Martini, MD, PhD; Ahmad Nassr, MD; Brett A. Freedman, MD; Arjun Sebastian, MD; William W. Cross, MD; Christopher P. Ames, MD; Benjamin D. Elder, MD, PhD; Jeremy L. Fogelson, MD

Hypothesis
Removal of painful pelvic screws is effective and safe.

Design
Retrospective review.

Introduction
While pelvic fixation is often critical to the distal integrity of a spine fusion construct, pelvic screws can cause pain and disability. The purpose of this study was to evaluate the risks and benefits of removing painful pelvic screws in spine fusion surgery patients.

Methods
A retrospective chart review identified patients who had traditional iliac and S2-alar-iliac (S2AI) screws removed for pain.

Results
Fifty-two patients (75% women) were included with an average age of 63 and BMI of 28. Most patients were diagnosed with pelvic screw pain by trigger point injections along the screw heads (83%) followed by patient reported pain localizing to the screw region (8%), SI joint injections (6%), and pain to palpation (6%). Most of the removed screws were S2AI (86%) compared to traditional iliac pelvic fixation (14%). Average estimated blood loss for pelvic screw removal was 64ml, surgical time was 82 minutes, and length of stay was 0.73 nights. Most patients (83%) had improvement in their pelvic screw related pain following removal with improved patients having higher Hounsfield units (HU p=0.01), more often partially threaded screws (p=0.004) and trended toward an SI joint vacuum sign prior to removal (p=0.08). Eight patients (15%) suffered mechanical complications following pelvic screw removal including sacral fracture (6%), and/or L4-5 or L5-S1 rod fracture (13%). Risk factors for mechanical complications following pelvic screw removal included female sex (p=0.04), SI joint vacuum sign before screw removal (p=0.02), lack of BMP (p=0.005), and pelvic screw haloing in the sacrum (p=0.02). Ten patients (19%) underwent revision sacropelvic instrumentation including SI joint fusion, with risk factors that included female sex (p=0.003), baseline SI joint vacuum sign (p<0.001), and higher pelvic incidence PI (p=0.02).

Conclusion
Removal of painful pelvic screws resulted in a high rate of postop pain relief, albeit with a risk of mechanical complications and revision sacropelvic instrumentation and SI joint fusion. Patients most likely to benefit from pelvic screw removal include those with higher HU and partially threaded S2AI screws. Patients at risk for mechanical complications, revision sacropelvic reconstruction, and/or SI joint fusion include female patients, those with an SI joint vacuum sign, and/or high PI.

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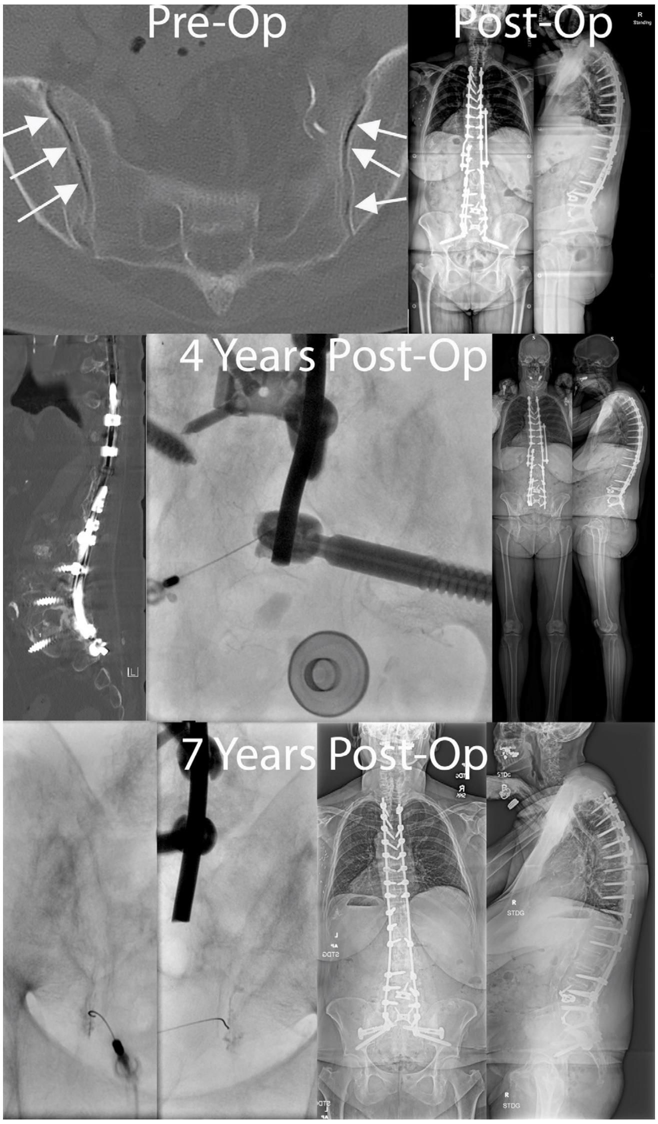

244. IMPACT OF CEPHALAD VS CAUDAL LUMBAR LORDOSIS CORRECTION ON SPINAL SHAPE AND OUTCOMES OF COMPLEX DEFORMITY SPINE SURGERY

Bassel G. Diebo, MD; Mohammad Daher, BS; Abel De Varona-Cocero, BS; Mariah Balmaceno-Criss, BS; Renaud Lafage, MS; Lawrence G. Lenke, MD; Christopher P. Ames, MD; Douglas C. Burton, MD; Stephen J. Lewis, MD, FRCS(C); Eric O. Klineberg, MD; Robert K. Eastlack, MD; Munish C. Gupta, MD; Gregory M. Mundis Jr., MD; Jeffrey L. Gum, MD; Kojo D. Hamilton, MD, FAANS; Richard Hostin, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Khaled M. Kebaish, MD; Han Jo Kim, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Breton G. Line, BS; Juan S. Uribe, MD; Praveen V. Mummaneni, MD, MBA; Jay D. Turner, MD; Pierce D. Nunley, MD; Shay Bess, MD; Virginie Lafage, PhD; Frank J. Schwab, MD; Alan H. Daniels, MD; International Spine Study Group

Hypothesis
Correcting lumbar lordosis on the expense of the cephalad region (L1-L4) alters the spine shape by increasing posterior inclination and translation of the upper instrumented vertebra (UIV).

Design
Retrospective analysis of prospectively collected data.

Introduction
This study aims to compare the impact of lumbar lordosis correction by cephalad versus caudal techniques on the surgical outcomes of adult spinal deformity (ASD).

Methods
Patients were included if they: (1) underwent ASD surgery, (2) had a UIV of L1 or above, (3) a PI_LL >10 at baseline, and (4) had clinical and radiographic follow-up at 2 years post-operatively. Patients with 3-column osteotomies were excluded. Patients were stratified into two groups: Caudally restored (L4-S1 between 35 and 45, UIV translation <15) (G1), and those with cephalad lordosis based correction (L1-L4) (G2). Comparative analyses were performed on patient demographics, baseline and 2 year radiographic parameters, complications, and PROMs.

Results
114 patients were included: 69 (G1), 45 (G2) without sig differences in baseline sagittal alignment, age, sex, BMI, comorbidities, and prior spine surgeries. All of G2 had two or more LLIFs above L4 while G1 did not have any. PROMs were similar, except for worse SRS-total in G2 at 2 years (3.8 vs. 3.5, $p=0.045$). At 2 years, G2 had worse SVA (30.2 vs. 56mm), T1PA (17.7 vs. 22.5), and more kyphotic T10_L2 (-7.8 vs. -13.3°), $p\leq0.02$. G2 had a higher UIV inclination at 6 weeks (-2.5 vs. -13.8°, $p<.001$), 1 yr (-1.9 vs. -11.2° $p=0.007$), and 2 yr (-2.5 vs. -9.2°, $p=0.03$), and were more posteriorly translated at 6 weeks (-9.3 vs. -12.1°), and 2 yr (-9.3 vs. -12.1°) $p=0.01$ (Figure 1). G2 had a higher rate of implant-related (5.8 vs. 20%) and radiographic complications (1.4 vs. 17.8%), abnormal post-operative neurologic exam (29.2 vs. 65.5%), and reoperation for PJK (1.4 vs. 11.1%) at 2 yr FU, $p\leq0.02$.

Conclusion
Patients who underwent cephalad lordosis-based correction of spinal deformity had potentially less optimal spinal alignment and shape, with greater inclination of the UIV zone and posterior translation of the construct. They also exhibited a higher rate of implant related complications, neurological deficits, and revision for PJK. Caution should be taken when considering performance of more than 2 LLIF's in the treatment of ASD, especially above L4.

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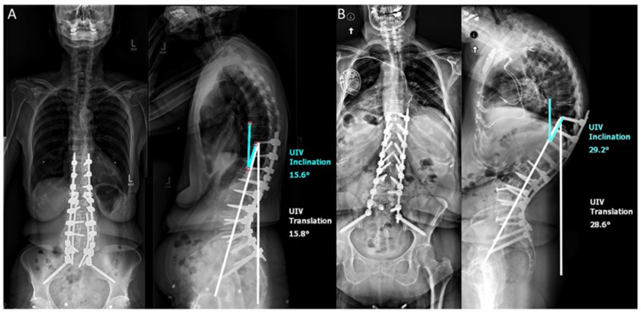

Figure 1: Anteroposterior and Lateral standing radiographs of patients A) in G1 and B) in G2

245. OUTCOMES OF SURGICAL STRATEGIES TO TREAT CONCURRENT ADJACENT SEGMENT DISEASE AND SAGITTAL IMBALANCE AFTER DISTAL LUMBAR FUSIONS

Darryl Lau, MD; Michael P. Kelly, MD; Lawrence G. Lenke, MD; Justin S. Smith, MD, PhD; Shay Bess, MD; Virginie Lafage, PhD; Renaud Lafage, MS; Eric O. Klineberg, MD; Han Jo Kim, MD; Sean N. Neifert, BS; Jeffrey L. Gum, MD; Khaled M. Kebaish, MD; Robert K. Eastlack, MD; Alex Soroceanu, MD, FRCS(S), MPH; Richard Hostin, MD; Themistocles S. Protopsaltis, MD; Kojo D. Hamilton, MD, FAANS; Munish C. Gupta, MD; Frank J. Schwab, MD; Christopher I. Shaffrey, MD; Douglas C. Burton, MD; Christopher P. Ames, MD; International Spine Study Group

Hypothesis

In patients with prior lumbar fusion who present with sagittal malalignment and symptomatic adjacent segment disease (AjSegD), surgical strategies geared toward treating both pathologies (vs. AjSegD-alone) achieve superior outcomes.

Design

Retrospective review of multi-institutional prospective data

Introduction

The optimal surgical solution for patients with sagittal imbalance and symptomatic AjSegD can be challenging when deciding to treat AjSegD alone or both pathologies. This study compares perioperative and long-term outcomes between surgery for AjSegD vs AjSegD with deformity correction.

Methods

A consecutive cohort of patients with prior fusion (L4-S1 or L3-S1), symptomatic AjSegD and sagittal malalignment (SVA>4.5 cm and PI-LL>10) were identified. Patients were categorized based on surgical goals: AjSegD only, AjSegD and deformity via extension of fusion (correction), and AjSegD and deformity via PSO within fusion (PSO). Perioperative and long-term outcomes were compared up to 2 years.

Results

129 patients were included:11 AjSegD, 90 correction, 28 PSO. Mean SVA, PI-LL mismatch, and L4-S1 LL was 11.7 cm, 29 deg, and 17 deg, respectively. There was a significant difference in preoperative LL: AjSegD (39.9 deg), correction (31.7 deg), and PSO (23.0 deg) (p=0.020). AjSegD and PSO groups had greater disproportional LL compared to the correction group; L4-S1 LL made up 24.7% of overall LL in AjSegD group, 31.9% in correction, and 20.1% in PSO group. Correction with PSO was associated with higher ICU admissions (36.4% vs. 48.9% vs. vs. 75.0%, p=0.026) and blood loss (711.4 vs. 1148.7 vs. 1795.2 ml, p=0.021), but no difference in neurological deficits rates: 9.1%, vs. 1.1% vs. 3.6% (p=0.224). AjSegD had significantly higher revision rates at 36.4% compared to 10.0% (correction) and 21.4% (PSO) (p=0.011). At 2-year follow-up, both deformity surgery groups had significant improvements across all SRS-22 domains, particularly pain (p=0.008) and appearance (p=0.004). While AjSegD surgery improvement in PROMs was partial and dwindled with no improvement at 2 years.

Conclusion

Findings from this study suggest surgery geared towards treatment of AjSegD alone in patients with concurrent deformity is associated with suboptimal outcomes with higher revision rates and no improvements long-term.

246. THE BIOLOGICAL RESPONSES TO TITANIUM ALLOY DEBRIS USING A PEDIATRIC ANIMAL MODEL

Ying Li, MD; Brandon Henry, BS; Paige Cordts, BS; Conor Locke, MSE; Adam C. Abraham, PhD; Karl Jepsen, PhD; Megan L. Killian, PhD

Hypothesis

Titanium (Ti) debris deposited in paraspinal muscles during growth leads to systemic accumulation of Ti debris in organs.

Design

Animal model.

Introduction

Patients with early onset scoliosis treated with TGR, MCGR, and VEPTR were shown to have persistently elevated serum Ti levels with no evidence of renal excretion. Ti implant studies revealed metal debris deposition in the spleen, lungs, kidneys, heart, and liver in an adult animal model, but this has not been studied during growth nor has the impact of debris on bone strength development been assessed. We used a pediatric mouse model to 1) assess if presence of Ti debris affects vertebral body structure and strength, and 2) evaluate systemic accumulation of Ti debris in organs.

Methods

Ti debris suspension or saline was injected into paraspinal muscles of 4-week old mice (Ti-mice, Control-mice; n=40/group). Mice were euthanized at 4- and 24-weeks post-injection. L1 vertebrae, femurs, paraspinal muscles, and organs were evaluated using nano-computed tomography (nanoCT).

Results

Weight did not differ between control and Ti-mice at either time point. NanoCT showed a significantly smaller

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L1 vertebral body total area (mean 1.40 mm2 vs 1.52 mm2, p=0.011) and cortical area (mean 0.37 mm2 vs 0.48 mm2, p=0.0005) but no difference in trabecular bone at 28 weeks in Ti-mice compared to controls (Figure 1a). Ti debris was observed in lung nanoCT images after 28 weeks in Ti-mice (Figure 1b).

Conclusion

The smaller vertebral bodies in young mice exposed to Ti debris suggested that metal debris has a negative effect on periosteal expansion and mass accumulation of the vertebral body during growth. Finding that metal debris accumulates in the lungs indicated Ti debris adjacent to the spine can lead to its accumulation in organs. Future work will histologically evaluate the vertebrae and organs to further characterize Ti debris deposition and its effects on cell and tissue quality, including presence of inflammation.

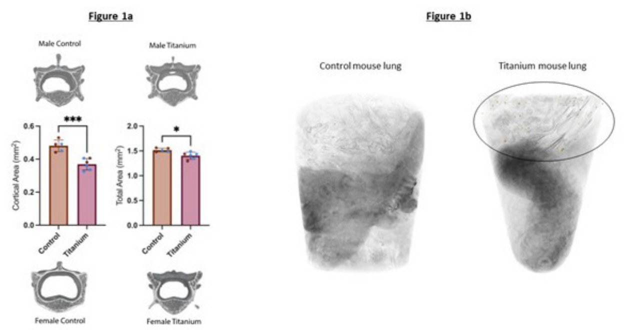

Figure 1a. Comparison of vertebral body cortical area and total area between control mice and Ti-mice, and cross-sectional imaging from both groups. Figure 1b. Lung nanoCT images demonstrating Ti debris deposition in the Ti-mouse lung tissue.

247. A HARD PILL TO SWALLOW: FACTORS ASSOCIATED WITH DYSPHAGIA FOLLOWING ADULT CERVICAL DEFORMITY SURGERY

Ankita Das, BS; Tobi Onafowokan, MBBS; Jamshaid Mir, MD; Nathan Lorentz, MD; Stephane Owusu-Sarpong, MD; Jordan Lebovic, BA; Samuel Montgomery, MD; Robert K. Eastlack, MD; Andrew Chen, BS; Bassel G. Diebo, MD; Alan H. Daniels, MD; Zeeshan M. Sardar, MD; Lee A. Tan, MD; Kojo D. Hamilton, MD, FAANS; Christopher I. Shaffrey, MD; <u>*Peter G. Passias, MD*</u>

Hypothesis

The development and evolution of dysphagia is difficult to predict.

Design

Retrospective cohort study of prospectively enrolled database

Introduction

Dysphagia has long been intertwined with cervical interventions and impacts patients' quality of life.

Methods

Patients with complete preoperative baseline(BL) and 2-year(2Y) data were analyzed via descriptive statistics. Patients who reported dysphagia as a postoperative complication or registered a SWAL-QOL score<25th percentile were identified. Descriptive analyses, means comparison tests, and regression analyses were run to register significant differences/associations.

Results

265 patients met inclusion criteria (mean age 58.2±11.4 yrs 51.2% F, BMI 28.5±7.6 kg/m2, CCI: 0.93±1.3). For the total cohort, mean operative time was 348±194.9 minutes, mean EBL was 834.5±1180.3 mL, and mean levels fused was 5.9±3.6). 82(30.9%) of patients reported postoperative dysphagia. At baseline,dysphagia group demonstrated significantly greater BL frailty score(p<.001) and greater BL C2-C7(p=0.002) and cSVA(p=0.001). Those with BL morphologic focal kyphosis were more likely to experience dysphagia(OR 4.3, p<.001). There was no difference amongst those who previously had cervical surgery from any approach. Longer operative time was also associated with higher likelihood of acquiring dysphagia(OR 1.004, CI 95% 1.002-1.006, p<.001). Those who had an osteotomy from anteriorly at any level from C3-C7 demonstrated significantly greater rates of dysphagia(p<.02, all). Degree of correction significantly influence likelihood of dysphagia. Correction of C2-C7 and MGS from severe→moderate/low were significant predictors of dysphagia(OR 3.6, p<.001; OR 17.0, p=0.009). Patients who could not successfully be extubated immediately postoperatively demonstrated significantly greater occurrence of dysphagia(80% v. 20%, p=0.015); failure to extubate increased the odds of dysphagia 9.3x(OR 9.5, p=0.047). There was a significantly greater rate of dysphagia amongst those who experienced DJF by M3(p=0.034). In HRQLs, the dysphagia cohort reported a significantly greater M3 NSR Neck(p<.001).

Conclusion

Dysphagia may occur in patients who initially exhibit greater frailty/deformity, those who undergo osteotomies from mid-lower cervical region, and those who receive a significant degree of correction from baseline. Furthermore, delays in extubation can considerably increase dysphagia risk.

248. FRAIL PATIENTS REQUIRE LONGER FUSIONS FOR SUCCESS FOLLOWING ADULT CERVICAL DEFORMITY SURGERY

Tobi Onafowokan, MBBS; Ankita Das, BS; Jamshaid Mir, MD; Pawel P. Jankowski, MD; Nathan Lorentz, MD; Matthew Galetta, MD; Samuel Montgomery, MD; Aaron Hockley, MD; Neel Anand, MD; Zeeshan M. Sardar, MD; Han Jo Kim, MD; Praveen V. Mummaneni, MD, MBA; Bassel G. Diebo, MD; Alan H. Daniels, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Thomas J. Buell, MD; M. Burhan Janjua, MD; Andrew Chen, BS; Christopher I. Shaffrey,

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MD; Justin S. Smith, MD, PhD; Robert K. Eastlack, MD; Jordan Lebovic, BA; Daniel M. Sciubba, MD; Peter G. Passias, MD

Hypothesis

To investigate impact of fusion length in frail patients undergoing ACD surgery.

Design

Retrospective cohort

Introduction

Adult cervical deformity (ACD) surgery is more frequently being performed in frail patients. Although surgical outcomes are largely successful, there remains significant risk of poor outcomes. The ideal length of fusion constructs in these patients remains debatable.

Methods

Patients undergoing cervical fusion for ACD with lower instrumented vertebra (LIV) at T4-or-above, with complete data from baseline (BL) to 2 years (2Y) were stratified by CD-modified frailty index into not frail (NF), frail (F) and severely frail (SF). ACD defined as at least one of the following: C2-C7 Cobb >10°, cervical lordosis >10°, cervical sagittal vertical axis (cSVA) >4 cm, chin brow vertical angle >25°. Deformity was classified by Kim et al criteria. Means comparison tests and logistic regressions analyzed associations between frailty categories, lower instrumented vertebra (LIV) and outcomes.

Results

286 patients (Age: 57.3 ± 10.9 years, BMI: 28.9 ± 6.4 kg/m2, CCI: 0.84 ± 1.26). 47% of patients were female. 32.2% of patients were NF, 50.3% F and 17.5% SF. By deformity, 66% were focal kyphosis (FK), 12% were flatneck, and 22% were cervicothoracic. Only FK type differed between NF and F/SF patients (39.2 vs 73.6%, p=0.005). At baseline (BL), differences in age, BMI, CCI and deformity were not significant. F/SF patients had longer LOS (p=0.018) and higher rates of distal junctional kyphosis/failure (DJK/F) at 2 years. Controlling for baseline disability, F/SF patients were more likely to experience DJK/F at 2 years with C7 vs more distal LIVs: C7 vs T1 (OR 4.8, 95% CI: 1.2-18.9, p=0.023), C7 vs T2 (OR 7.5, 1.6-34.7, p=0.010), C7 vs T3 (OR 9.1, 1.6-51.1, p=0.012) and C7 vs T4 (OR 13.7, 2.2-83.9, p=0.005). DJK/F risk was not significant with thoracic LIVs: T1 vs T2 (p=0.486), T1 vs T3 (p=0.391), T1 vs T4 (p=0.189). Similar trends were seen comparing F vs SF patients, C7 vs T1 (OR 6.8, 1.8-24.9, p=0.004), C7 vs T2 (OR 11.4, 2.8-46.9, p<0.001), C7 vs T3 (OR 27.2, 5.5-133.6, p<0.001), and C7 vs T4 (OR 21.8, 3.7-127.2, p<0.001).

Conclusion

Frail patients are at risk for poor outcomes following ACD surgery due to their comorbidities. These patients appear to be at even greater risk for poor outcomes with a lower instrumented vertebra proximal to T1.

249. SKELETAL DYSPLASIA PATIENTS UNDERGOING CERVICAL SPINE FUSIONS HAVE SIMILAR RE-OPERATION RATES REGARDLESS OF POST-OPERATIVE BRACING AND FUSION TO THE OCCIPUT

John P. Avendano, BA; Tej D. Azad, MD; William G. Elnemer, BS; Mari L. Groves, MD; Paul D. Sponseller, MD, MBA

Hypothesis

Skeletal dysplasia patients with neurologic deficits can recover after improving cord anatomy; instrumentation is reliable in these patients without high risk of fixation failure. Fusion to the occiput results in lower reoperation rate, while post-operative bracing doesn't affect reoperation rate.

Design

Single center retrospective cohort

Introduction

Skeletal dysplasia patients often have cervical stenosis and instability. These patients may undergo cervical and occipital-cervical spinal decompressions and fusions to improve cord anatomy and mitigate neurologic symptoms. Our study evaluates the efficacy of these procedures in improving these patients' baseline neurologic deficits and whether fusing to the occiput and postoperative bracing influence reoperation rate.

Methods

A retrospective review of skeletal dysplasia patients who underwent cervical or occipital-cervical decompression and fusion was performed. All patients required a 2 year minimum for latest follow-up visit. Outcomes included radiographic evidence of fusion, re-operation rate, and long-term neurologic course. Chi-squared tests compared outcomes between patients who underwent cervical vs. occipital-cervical fusion and patients who braced vs. did not brace post-operatively.

Results

16 patients with a mean age of 27 years were included. Our patients had achondroplasia, chondrodysplasia punctata, spondyloepiphyseal dysplasia, osteogenesis imperfecta, Morquio Syndrome, and Hurler Syndrome. All patients showed adequate fusion at latest follow-up; none showed signs of fixation failure. 81% of our cohort improved neurologically relative to baseline at latest follow-up; 19% worsened neurologically. Chi-squared tests revealed no statistically significant differences in re-operation rates between occipital-cervical and cervical fusion and bracing and non-bracing patients (p=0.755; 1.000).

Conclusion

Cervical and occipital-cervical decompressions and fusions can aid skeletal dysplasia patients in improving their neurologic function relative to baseline. Instrumentation is reliable in these patients with no signs of fixation failure or pseudoarthrosis in our cohort. Fusion to the occiput and post-operative bracing do not decrease rate of re-operation. Cervical instability in these patients can be adequately addressed with internal fixation.

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	Total	No Occiput	Fusion to occiput	P
Re-operations	5	3	2	0.755
	Total	Post-op bracing	No post-op bracing	P
Re-operations	5	2	3	1.000

Table 1: Assessing outcomes by patient subgroup.

250. TRADITIONAL VS MAGNETIC-CONTROL GROWTH RODS: LENGTH AND CORRECTION ACHIEVED IN EARLY-ONSET SCOLIOSIS (EOS) TREATMENT †

Rikki M. Koehler, MD; Tiffany Thompson, BS; Amareesa Robinson, BS; Charles E. Johnston, MD

Hypothesis
TGR is more efficient than MCGR in achieving more spine length and curve correction, albeit with more complications/UPRORs.

Design
Retrospective single institution results of growth-friendly methods

Introduction
There is no study directly comparing efficacy of MCGR and TGR from implantation to pre-definitive fusion or final lengthening w/ retained implants.

Methods
All patients treated by TGR or MCGR were evaluated. Patients with single rods, without complete data or still in lengthening phase were excluded. T1-T12 and T1-S1 lengths and curve magnitude were recorded at 3 time points: pre-rod implantation, immediate post-implantation and immediately prior to definitive fusion or most recent f/u with retained TGR and no further distractions. EOSQ-24 scores, PFTs and complications were collected. TGR patients treated in an earlier era had fewer PFTs and EOSQs available which could not be analyzed.

Results
51 patients (27 MCGR, 24 TGR) out of 158 total EOS patients had complete radiographs and inclusion criteria. There were no differences between treatment groups in age at index implantation, age at definitive fusion/observation with retained TGRs, #levels spanned by construct, or time in lengthening phase treatment. MCGRs had significantly more lengthenings than TGR (9.5 vs 5.4, p=.0001). TGR patients had larger initial curves (90 vs 81O p=.02) but final/pre-definitive curves were no different. T1-12 length was initially shorter for TGR (14.6 vs 16.3 cm, p=.02) but no different at final/pre-definitive due to more length gain TGR>MCGR 5.6 vs 3.7 cm p=.006. Similarly, TGR>MCGR in T1-S1 segment (8.8 vs 6.1 cm, p=.01) to make final T1-S1 lengths no different. TGR had more complications than MCGR (1.7 versus 1.0 p=0.0035), requiring UPRORs. Comparing EOSQ scores, post-implantation pulmonary scores were better than pre-implant (94 vs 76, definitive; pre-definitive emotion was worse than post-implant 62 vs 79, p=.005. No other differences in any domain between time points were found. Similarly, there were no PFT differences at any time point.

Conclusion
TGR lengthens more effectively than MCGR. Maximal length gain and correction occur at initial implantation. TGR achieves and maintains comparatively more correction, at the expense of more complications. Patient-reported outcomes and PFTs were not significantly affected by MCGR treatment.

251. THE VALUE OF ANOTHER CENTIMETER: ASSESSING THE IMPACT OF MAGNETICALLY CONTROLLED GROWING ROD REPLACEMENT IN THORACIC HEIGHT GAIN AND SCOLIOSIS CORRECTION †

Brett Shannon, MD; Yusuke Hori, MD, PhD; David J. Fralinger, MD; Ali Asma, MD; Norihiro Isogai, MD, PhD; Luiz Silva, MD; Kacey McGinnes, RN; Kenneth J. Rogers, PhD; W.G. Stuart Mackenzie, MD; Peter G. Gabos, MD; William G. Mackenzie, MD; Suken A. Shah, MD

Hypothesis
EOS patients who underwent MCGR replacement gained rod length and T1-T12 height but not further scoliosis correction.

Design
Single-center retrospective cohort.

Introduction
The risk of magnetically controlled growing rod (MCGR) extension failure increases with repeated lengthening, potentially necessitating rod replacement. This study aimed to investigate the benefits of replacing MCGR for additional lengthening before definitive fusion compared with direct transition to fusion without replacement.

Methods
We included patients with early-onset scoliosis (EOS) who were treated with MCGR and underwent definitive fusion, excluding those with previous growth-friendly surgery. Rod lengthening, T1-T12 height gain, and major curve correction were compared between patients with and without MCGR replacement. Additionally, lengthening of first and second rods was compared among patients who underwent MCGR replacement.

Results
Of 39 patients, 13 underwent MCGR replacement. Patients who had replacement were younger at the time of initial MCGR implantation (7.5 vs. 9.2 years, p=0.034). They achieved greater total lengthening (37 vs. 20 mm, p<0.001) over a longer period (6.2 vs. 3.5 years, p<0.001). The replacement group also showed higher T1-T12 height gain after definitive fusion than the control group (61 vs. 47 mm, p=0.011). In contrast, the major curve correction rate was significantly lower in the replacement group (51% vs. 65%, p=0.033), with less correction achieved at definitive fusion surgery (8° vs. 13°, p=0.037). In 11 of 13 replacement patients, the initial MCGR achieved more lengthening than the secondary, although the difference was not statistically significant (21 vs. 16 mm, p=0.094).

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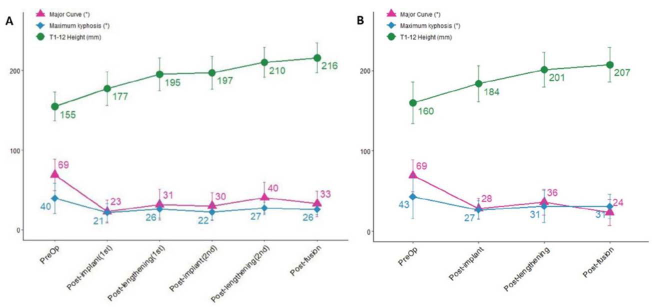
E-POINT PRESENTATION ABSTRACTS

Conclusion
MCGR replacement leads to additional lengthening and T1-T12 height gain but is associated with diminished scoliosis correction. These findings question the value of the modest 14-mm increase in thoracic height from MCGR replacement considering the decreased deformity correction and the additional time and cost.



Comparisons of T1-T12 height, scoliosis, and kyphosis for (A) patients who underwent replacement of MCGR, and (B) control group treated with single set of MCGR. Green circles indicate T1-T12 height (mm), red circles indicate major curve magnitude (°), and blue diamonds indicate maximum sagittal kyphosis (°); bars show standard deviations from means.

252. COMPARISON OF PERIOPERATIVE COMPLICATION RATES IN CONGENITAL SCOLIOSIS PATIENTS WITH TETHERED CORD †

Andrea Muñoz, BS; Allyn Morris, MD; Leila Mehraban Alvandi, PhD; Edina Gjonbalaj, BS; Paul D. Sponseller, MD, MBA; Richard Anderson, MD; Pediatric Spine Study Group; Jaime A. Gomez, MD

Hypothesis
We hypothesize that congenital early onset scoliosis (EOS) patients with tethered cord syndrome (TCS) who underwent spinal deformity correction (SDC) with growing instrumentation or fusion will exhibit lower rates of perioperative complications.

Design
Data from 751 congenital EOS patients in the Pediatric Spine Study Group registry were analyzed. After applying inclusion and exclusion criteria, 479 patients were divided into groups: those with TCS (n=90) and those without (n=389). Among TCS patients, the majority had detethering (n=61), with 29 patients who did not. Demographics, MRI findings, treatment history, and surgical complications were assessed.

Introduction
Congenital EOS often co-occurs with TCS, necessitating surgical intervention to address both conditions to prevent worsening neuromuscular function. Detethering can be done concurrently with SDC, be completed prior to SDC, or not done at all. This study explores perioperative complications in EOS patients with and without TCS who underwent SDC with growing instrumentation or fusion.

Methods
Statistical analyses, including comparisons of age, pre-index major cobb angles, and complication rates, were performed using appropriate tests.

Results
No significant age differences (p=0.45) or pre-index major cobb angles (p=0.26) were found between detethered and not detethered cohorts. TCS patients without detethering had higher rates of postoperative complications (p=0.007) and hardware failure (p=0.005). Comparing EOS patients with and without TCS revealed no significant age (p=0.83) or cobb angle differences (p=0.20). Additionally, no significant differences were observed in intraoperative complications, postoperative complications, hardware failure, infections, and neurological complications.

Conclusion
This study underscores the importance of detethering in EOS patients with concurrent TCS. Detethering significantly reduced the risk of postoperative complications and hardware failure during SDC with growing instrumentation or fusion. These insights advocate for individualized treatment decisions, emphasizing the potential benefits of detethering in enhancing surgical outcomes for this patient population.

Table 1. Complication Rates of Congenital EOS Patients Without and With TCS.

Complication	Congenital EOS Patients without TCS (n=389)	Congenital EOS Patients with TCS (n=90)	Detethered TCS Patients (n=61)	Not Detethered TCS Patients (n=29)	P-value (Patients without vs with TCS)	P-value (TCS Detethered vs Not Detethered)
Intraoperative, n (%)	27 (6.9%)	12 (13.3%)	8 (13.1%)	4 (13.8%)	0.055	0.93
General Postoperative, n (%)	165 (42.4%)	43 (47.8%)	23 (37.7%)	20 (69.0%)	0.41	**0.007**
Hardware Failure, n (%)	115 (28.3%)	36 (40.0%)	18 (29.5%)	18 (62.1%)	0.06	**0.005**
Infection, n (%)	38 (9.8%)	13 (14.4%)	8 (13.1%)	5 (17.2%)	0.25	0.75
Neurological, n (%)	34 (8.7%)	10 (11.1%)	6 (9.8%)	4 (13.8%)	0.54	0.72

Abbreviations: EOS, Early onset scoliosis; TCS, Tethered cord syndrome.

253. GRADUATES OF GROWTH GUIDANCE SURGERY †

William G. Elnemer, BS; Zaid Elsabbagh, BS; Myung-Jin Cha, BS; Lindsay M. Andras, MD; Behrooz A. Akbarnia, MD; David B. Bumpass, MD; Scott J. Luhmann, MD; Richard E. McCarthy, MD; Pediatric Spine Study Group; Paul D. Sponseller, MD, MBA

Hypothesis
Most individuals undergoing growth guidance construct (GGC) removal will eventually need posterior spinal fusion (PSF) to control growing curves.

Design
Retrospective Multicenter Cohort Study.

Introduction
Treatment with growth guidance constructs (GGC) typically concludes with "graduation", defined as patients achieving skeletal maturity or undergoing a definitive procedure. Our study examined patients who graduated from GGC treatment.

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Methods

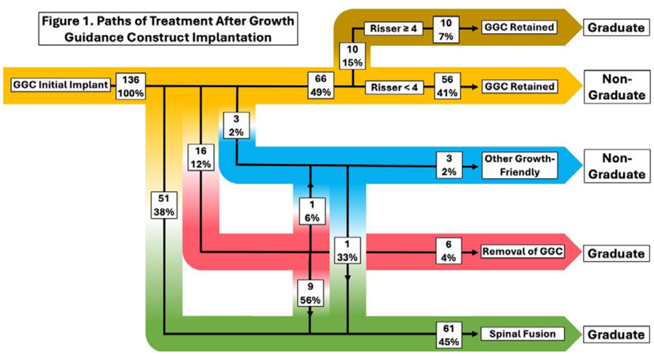
A multicenter early-onset scoliosis database was analyzed for patients who underwent GGC implantation. Radiographs were evaluated for major Cobb angle and skeletal maturity defined by a Risser Score≥4. Graduating patients were defined as reaching skeletal maturity during their treatment, undergoing implant removal, or spinal fusion. Reasons for graduation were qualified by the authors. Children converted to another growth-friendly construct are not considered graduates. Outcomes are summarized with descriptive statistics.

Results

Of the 136 patients included, 10 (7%) patients reached skeletal maturity with GGC without conversion to another construct, 51 (38%) were converted to PSF, 16 (12%) had GGC removed, and 3 (2%) were converted to another growth-friendly construct. The remaining patients (n=56, 41%) did not graduate at latest follow-up. Of the 16 patients who had their GGC removed, 9 (56%) later required definitive PSF, 1 (13%) was converted to another growth-friendly construct, and the remaining 6 (31%) kept the GGC removed. These 16 patients went an average of 1.8±1.5 years with removed GGC, with curves progressing at an average rate of 17±16° per year. Common reasons for graduating from GGC were deformity progression (n=21, 31%), rod breakage (n=16, 24%), outgrowing the rods (n=13, 19%), screw pull-out (n=4, 6%), deep wound infection (n=6, 9%), and other reasons (n=7, 10%). At latest follow-up 6 (9%) patients were without a spinal construct, while 61 (87%) converted to PSF. The treatment course of all patients is diagramed in Figure 1. Of the 10 patients who retained GGCs, 2 (20%) experienced instrumentation complications.

Conclusion

Many patients who elect for spinal construct removal eventually undergo PSF for deformity progression. Fusing the spine after GGC treatment should be encouraged, and rod removal alone should be avoided to prevent large deformity progression. Patients who retain GGC after skeletal maturity are also at risk for further complications.



Percentages on vertical arrows are relative to the parent arrow.

255. CLINICAL AND RADIOLOGICAL OUTCOMES OF POSTERIOR-ONLY HEMIVERTEBRA RESECTION AND SHORT-SEGMENT FUSION WITH PEDICLE SCREW FIXATION IN CHILDREN UNDER THE AGE OF 5, FOLLOWED UNTIL SKELETAL MATURITY †

Bilge K. Yilmaz, MD; Ugur Yuzuguldu, MD; Hamisi M. Mraja, MD; Halil Gok, MD; Emre Kurt, MD; Baris Peker, MD; Tunay Sanli, BE, MA; Selhan Karadereler, MD; *Meric Enercan, MD*; Azmi Hamzaoglu, MD

Hypothesis

Posterior hemivertebra (HV) resection and short-segment fusion (SSF) with pedicle screw fixation will provide satisfactory corrections in both planes for congenital scoliosis in children operated before the age of 5 yrs and these corrections will be maintained until skeletal maturity.

Design

Retrospective

Introduction

Previous studies have evaluated the outcomes of posterior hemivertebrectomy (PHV) and SSF in pts under the age of 5. There is no report on the long-term outcomes of pts who reached skeletal maturity following surgery. We evaluate long-term outcomes of pts who had reached skeletal maturity after having posterior hemivertebrectomy and SSF before 5 yrs of age.

Methods

16 pts (10F, 6M) who underwent PHV and SSF, and pedicle screw fixation before the age of 5 and who had reached skeletal maturity were included. Coronal and sagittal parameters were measured on pre, post, f/up x-rays. F/up x-rays were reviewed for a new curve development. Clinical assessment was done with SRS22r at f/up.

Results

Mean age was 18.9 yrs and f/up was 16.2 (15-22) yrs. Mean age at the time of surgery was 3.5 (1-5)yrs. 11 pts had single-level HV and 5 pts had 2 HV located at different levels both in thoracal(T) and lumbar(L) spine. Among 11 pts with single HV (5TL and 6L), 10 pts (%90) had a stable residual curve of 8.7° (0-28) until skeletal maturity. In 5 pts a new C-shaped, flexible curve developed during the growing period. 4 of them were observed with TLSO brace until skeletal maturity without any surgery. Surgery was recommended only in 1 pt due to curve progression. In 5 pts with 2 different level HV, HV resection was performed for thoracolumbar and lumbar HV. Observed thoracal HV progressed over time to 43.5° curve without causing any imbalances. None of the pts had revision or surgery for adding on.Mean SRS22 score was 4.5 at f/up.

Conclusion

Our study showed that thoracolumbar and lumbar posterior HV resection and short-segment fusion with pedicle screw fixation before the age of 5, provided

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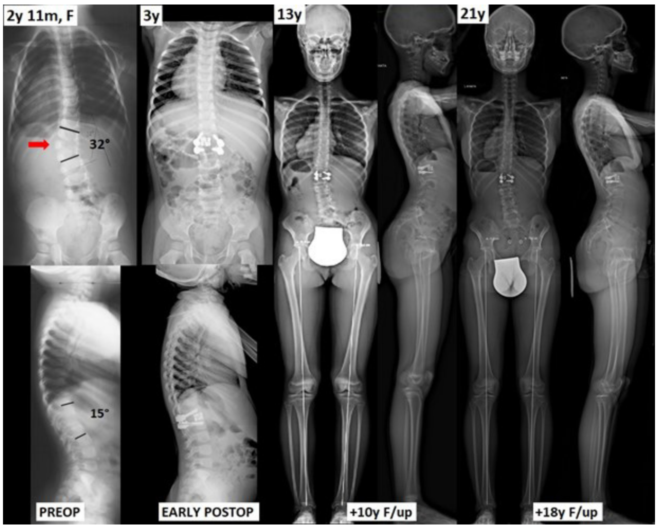
satisfactory and stable correction in both planes in 90% (10/11) of the pts with a residual curve of 8.7° (0-28) until they reached skeletal maturity. In the presence of 2 different level hemivertebra, we recommend performing lumbar hemivertebra resection, and following thoracal hemivertebra's progression and perform surgery if needed.



256. LIMITED FUSION FOR CONGENITAL SCOLIOSIS: TRULY ONE AND DONE?

Brandon Yoshida, MD; Tyler Tetreault, MD; Luke C. Drake, MD; Tiffany N. Phan, BA; Jacquelyn Valenzuela-Moss, BS; Tishya Wren, PhD; David L. Skaggs, MD, MMM; Lindsay M. Andras, MD; *Michael J. Heffernan, MD*

Hypothesis
Larger preoperative curve magnitude will be associated with the need for reoperation following limited fusion for congenital scoliosis.

Design
Retrospective study

Introduction
Limited spinal fusion is a common surgical strategy in the treatment of congenital scoliosis. Due to the heterogeneity of deformity and treatment strategies, long term outcomes, including the need for additional surgery, are poorly understood. The purpose of the study was to understand the rate and risk factors for reoperation following limited fusion for congenital scoliosis.

Methods
Congenital scoliosis patients initially treated with a limited instrumented fusion at a tertiary pediatric medical center were reviewed for clinical and radiographic data. Curve progression, complications, and the surgical details were compared between patients who underwent additional surgery and patients who did not require additional surgery. Risk factors for reoperation were compared between groups.

Results
35 patients underwent limited instrumented fusion at an average age of 4.9 years (SD: 2.5). The mean number of levels fused was 3.5 (SD: 1.3). Index surgery location included: thoracic (46%), thoracolumbar (31%), lumbar (17%), and lumbosacral (6%). Average follow-up was 7.6 years (range: 2.2-14.1, SD: 3.4). Average curve magnitude improved from 51° to 30°, with a mean improvement of 21° (range: 11° to 50°, SD: 15°, $p=0.002$). Eighteen patients (51%) required reoperation at a mean of 5.2 years, with a mean of 1.8 (SD: 3.0) additional surgeries. Preoperative curve magnitude was greater in patients who had reoperation compared to patients who did not require reoperation (66.7±20.3 vs 34.2±6.7, $p<0.001$). Pre-operative curves ≥ 45° had a 94% (17/18) reoperation rate compared to only 6% (1/17) in curves < 45°, odds ratio of 272 (95% CI: [15.7,4724.2], $p<0.0001$). Additionally, constructs that did not span the upper and lower end vertebrae were associated with the need for additional surgery ($p = 0.04$). Age at index surgery, medical comorbidities, addressing all congenital anomalies during index procedure, number of levels fused, and location did not differ between groups.

Conclusion
Limited fusion for congenital scoliosis resulted in a 51% reoperation rate at a mean of 5.2 years. The results suggest that limited fusion should be considered prior to the curve reaching 45° and instrumentation should span the deformity to minimize the need for reoperation.

	All Participants (N=35)	No Additional Surgery (N=17)	Additional Surgery (N=18)	p-value
Age (year)	4.9 (2.5)	5.4 (3.2)	4.6 (1.5)	0.32
Sex				0.31
Female	14 (40.0%)	5 (29.4%)	9 (50.0%)	
Male	21 (60.0%)	12 (70.6%)	9 (50.0%)	
Race/Ethnicity				0.24
Latinx	9 (25.0%)	5 (29.4%)	4 (22.2%)	
Non-Hispanic White	18 (51.4%)	10 (58.9%)	8 (44.4%)	
Other	5 (13.9%)	0	5 (27.8%)	
Not specified	3 (8.3%)	2 (11.8%)	1 (5.6%)	
Syndromic Etiology	19 (54.3%)	9 (52.9%)	10 (52.6%)	1.00
Comorbidities	22 (62.9%)	11 (64.7%)	11 (61.1%)	1.00
# levels fused	3.5 (1.4)	3.3 (1.2)	3.7 (1.5)	0.43
Location				
Thoracic	16 (45.7%)	7 (41.1%)	9 (50.0%)	0.51
Thoracolumbar (T11-L1)	11 (31.4%)	6 (35.3%)	5 (27.8%)	0.73
Lumbar	6 (17.1%)	2 (11.8%)	4 (22.2%)	0.66
Lumbosacral (L5-Sacrum)	2 (5.7%)	2 (11.7%)	0 (0)	0.23
All congenital anomalies addressed during index procedure	28 (80.0%)	13 (76.5%)	15 (83.3%)	0.69
Preop curve magnitude (°)	50.9 (22.3)	34.0 (6.7)	66.7 (20.3)	**<0.0001**
Percent curve correction (%)	32.8 (31.9)	40.0 (37.5)	47.4 (30.7)	0.52
Post-op curve magnitude (°)	29.6 (22.7)	20.9 (13.7)	37.7 (26.7)	0.79
Construct spans end vertebrae	14 (40.0%)	10 (58.8%)	4 (22.2%)	**0.041**

Continuous variables are presented as mean (SD). Categorical values are presented as n (%).

Table 1: Clinical Variables

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257. PRESENCE OF COMPENSATORY CURVE PREDICTS POSTOPERATIVE CURVE PROGRESSION IN CONGENITAL SCOLIOSIS AFTER THORACOLUMBAR HEMIVERTEBRA RESECTION AND SHORT FUSION

Yanjie Xu, MD; _Zezhang Zhu, PhD_; Zhen Liu, PhD; Yong Qiu, PhD

Hypothesis
The presence of the compensatory curve was associated with a higher incidence of postoperative curve progression in CS patients who underwent thoracolumbar HV resection and short fusion.

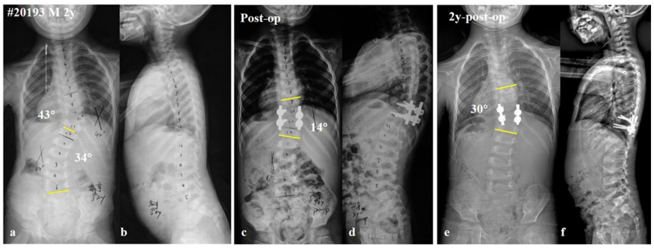
Design
A retrospective study.

Introduction
Previous studies reported that the occurrence of progression may be originated from the preoperative compensatory curve. Currently, it remains unclear whether the presence of compensatory curves affects the selection of fusion segments and whether the current HV resection and short fusion strategy is still applicable to these CS patients.

Methods
This study retrospectively reviewed a consecutive cohort of CS patients who underwent single thoracolumbar HV resection and short fusion with a minimum of 2 years follow-up. The preoperative compensatory curve was defined as the Cobb angle of the primary curve ≥ 20°, and the upper end vertebra (UEV) and lower end vertebra (LEV) of the curve tilt towards opposite directions. Based on the postoperative coronal curve magnitude, patients were divided into the progressed group (Group P, with curve decompensation ≥ 20°) and the non-progressed group (Group NP, characterized by well-compensated curves). Factors associated with the postoperative curve progression were analyzed.

Results
A total of 31 patients were included in this study. The mean age at the time of surgery was 5.9±3.1 years. Postoperative coronal curve progression was identified in 11 patients (11/31, 35.5%). Compared with Group NP, Group P showed greater preoperative upper instrumented vertebra (UIV) translation (21.3±10.7 mm vs. 12.5±9.5 mm, P=0.025), and larger postoperative UIV tilt (7.5±4.3° vs. 3.0±4.4°). All of the patients in Group P were treated with bracing once the postoperative curve progression arose, and none required surgical intervention. Multiple logistic regression demonstrated that preoperative UIV translation and postoperative UIV tilt were two independent risk factors for postoperative curve progression.

Conclusion
The presence of the compensatory curve was associated with a higher incidence of this complication. A larger preoperative UIV translation and postoperative UIV tilt were found to be the risk factors for postoperative curve progression.



A 2-year-old boy with a thoracolumbar HV located at T10 and a preoperative caudal compensatory curve. The main curve aggravated at the 2-year follow-up

258. GROWTH GUIDANCE SURGERY: WHAT MAKES IT FAIL?

William G. Elnemer, BS; Zaid Elsabbagh, BS; Myung-Jin Cha, BS; Lindsay M. Andras, MD; Behrooz A. Akbarnia, MD; David B. Bumpass, MD; Scott J. Luhmann, MD; Richard E. McCarthy, MD; Pediatric Spine Study Group; Paul D. Sponseller, MD, MBA

Hypothesis
We hypothesize that rods break closer to the curve apex. Thicker rods are associated with less breakage. Idiopathic patients will have more rod breakages.

Design
Retrospective Multicenter Cohort Study.

Introduction
The Growth Guidance surgery (GGS) reduces reoperation rates compared to other growth sparing methods yet is still associated with instrumentation complications. Our study used a multicenter early–onset–scoliosis database to determine characteristics of these implant failures.

Methods
An early-onset scoliosis multicenter database was analyzed for patients who underwent GGS. All radiographs as well as complication and procedure reports were evaluated for instances and characteristics of instrumentation failure and deep wound infection. Descriptive statistics and chi-square tests were utilized for differences in complication.

Results
136 GGS patients were studied. Rod thicknesses were 4.5 mm (n=83, 61%), 5.5 mm (n=45, 33%), or unknown (n=8, 6%). There were 189 instrumentation complications, comprising 60 (32%) rod breakages, 49 (26%) screw pull-outs, 34 (18%) instances of prominence, 6 (3%) instances of skin breakage, 30 (16%) instances of outgrowing the rods, and 10 (5%) other complications. Rod breakages more often occurred below the apex vs above (68% vs 32%, p=0.007) and within 4 vertebrae closer to the deformity apex vs beyond (81% vs 19%, p<0.001). Instrumentation prominence more often occurred at the proximal vs distal instrumentation (77% vs 24%, p=0.004). Compared to the population distribution of rod thickness, breakage (86% vs 14%, p<0.001) and instances of prominence (85% vs 15%, p=0.012) occurred more often in 4.5 mm vs 5.5 mm rods. Time to first rod breakage was not significantly different between 4.5 mm and 5.5 mm rods

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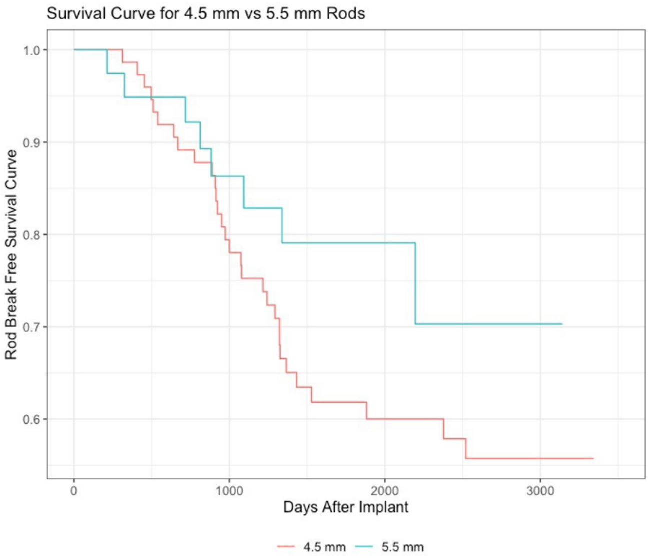
E-POINT PRESENTATION ABSTRACTS

(946 days vs. 1078 days, p=0.587), and Figure 1 displays the Kaplan-Meier rod breakage free survival rate of 4.5 mm vs. 5.5 mm rods. Idiopathic and syndromic patients accounted for disproportionately greater and fewer, respectively, rod breakages compared to their population distribution (p=0.001).

Conclusion

When possible, thicker rods should be used to minimize the risk of rod breakage and prominence. Rob breakages are likely to occur below and closer to the apex. Idiopathic patients should be closely monitored for rod breakage, most likely due to their increased activity level. Minimizing these complications allows surgeons to further reduce reoperation rates of GGS.



259. MODERN LUQUE TROLLEY VS STANDARD GROWTH SPARING SURGERY FOR EOS: A PROSPECTIVE COHORT STUDY WITH MATCHED HISTORICAL CONTROL GROUP

Jean A. Ouellet, MD; Tiara Ratz, PhD; Tina Szocik, M.E. Industrial & Management Engineering; Romain Dayer, MD; Pediatric Spine Study Group

Hypothesis

Patients with EOS treated with Modern Luque Trolley (MLT) will undergo fewer re-operations than patients treated with other growth sparing surgery while maintaing cobb correction and growth.

Design

Prospective multicentre cohort study with matched historical control.

Introduction

Correction and prevention of curve progression while maintaining spinal growth remain challenging considering the complexity of EOS and high rates of revision surgeries. MLT technique was developed to normalize forces across the spine growth plates and harness them to drive spinal implant growth while minimizing revisions.

Methods

Eighteen EOS patients were enrolled from three European centers. Forty-three controls (16 DGR, 9 VEPTR, 18 MCGR rods) were drawn from the Pediatric Spine Study Group registry with mandatory matching criteria of age, curve magnitude and etiology, and optional criteria of spine length and gender. The primary outcome was all reoperations of the spine within 3 yrs, secondary outcomes included known unplanned and definitive reoperations, maintenance of Cobb, and growth.

Results

The two groups did not differ significantly at initial surgery for: age (6.8 ±1.4 yrs.), gender, body measurements, etiology of EOS, Cobb angle 68°(±14), and spine length. Within 3 yrs, only one patient in the MLT group had a reoperation which was an unplanned revision surgery for loose proximal anchor, while the control group registered 122 reoperations (65/15 DGR, 49/9 VEPTR, 8/6 MCGR - # reop / # of patients), of which 22 were unplanned or definitive reoperations (12/7 DGR, 5/4 VEPTR, 5/3 MCGR patients). With the control group as reference, Poisson regressions showed a rate ratio (RR) of 0.02 (95% confidence interval [CI]: 0.0-0.12, p<0.001) for all reoperations and 0.04 (95% CI: 0.1-0.29, p=0.001) for only unplanned and definitive reoperations. The MLT group had better initial correction than the control group (Cobb at discharge: 33°±13 vs 41°±12, p=0.044), however had greater loss of correction at 3 yrs 48°±12 vs 42°±17 (p=0.1). Spinal (T1-S1) growth was slightly less in the MLT group 3.8 cm±3.6 vs 5.4 cm±3.3 (p=0.16).

Conclusion

MLT significantly reduces incidence of reoperations compared to other growth sparing techniques. However MLT may result in slightly less growth and greater deformity correction loss though not statistically significant compared to other growth sparing techniques.

260. "SKIPPING" POSTERIOR HEMIVERTEBRAE RESECTION WITH SHORT SEGMENTAL FUSION FOR CONGENITAL KYPHOSCOLIOSIS

You Du, MD; Shengru Wang, MD, PhD; Terry Jianguo Zhang, MD; Guanfeng Lin, MD; Yiwei Zhao, PhD

Hypothesis

Posterior multiple nonadjacent hemivertebrae resection with short segmental fusion is an effective and safe procedure for progressive congenital kyphoscoliosis.

Design

This study was a retrospective case series.

Introduction

Posterior hemivertebra resection with short segmental fusion has been proven to be an effective and safe procedure for progressive congenital kyphoscoliosis due to a single hemivertebra. The treatment of multiple nonadjacent hemivertebrae has not been well studied. Traditionally, either long fusion or fusionless techniques were used, which may have the drawback to the growth

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potential and mobility of the spine. In this study, we introduced a technique of "´skipping´ hemivertebra resection with short segmental fusion" for selected patients with this kind of deformity; we also tried to correct and control the deformities with limited fusion levels.

Methods

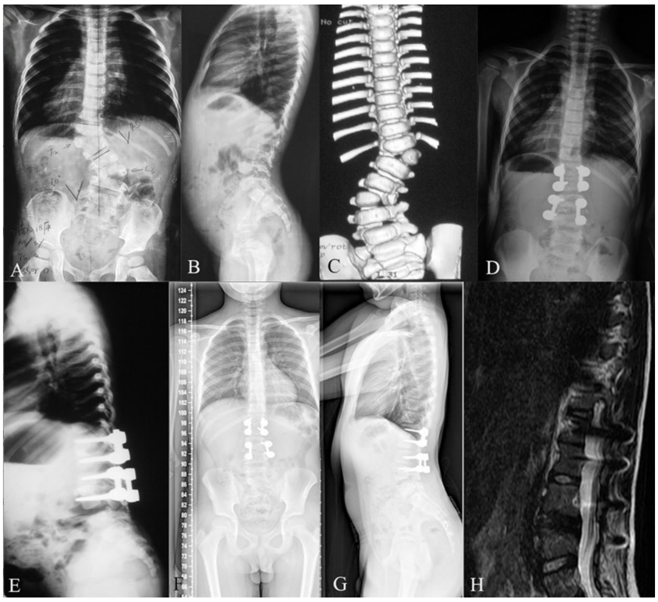
Twelve patients (M/6, F/6) with congenital kyphoscoliosis due to nonadjacent fully segmented hemivertebrae and with an average age of 4.6 (3-9) years were enrolled. Whole standing spine radiographs were used to measure the Cobb angle of the segmental curve and the compensatory curve; segmental kyphosis; thoracic kyphosis; lumbar lordosis; trunk shift; sagittal vertical alignment; and T1-S1 length before surgery, after surgery and at the latest follow-up evaluation. The hemivertebral location, fused segment, operation time and blood loss were assessed.

Results

All patients were followed for at least 2 years. The average number of fused segments was 2.6 for each patient and 1.3 for each hemivertebra. The segmental scoliosis measurement was 43.0° before surgery, 4.7° after surgery and 7.8° at the latest follow-up evaluation. Segmental kyphosis measurements improved from 15.4° to 6.5°. The correction of the compensatory cranial and caudal curves was 86.7% and 83.5%, respectively. Trunk shift improved from 22.3 mm to 7.9 mm. The T1-S1 length was 25.3 cm before surgery, 27.5 cm after surgery, and 34.7 cm at the latest follow-up evaluation. Revision surgery was indicated for 2 patients who developed decompensation during the follow-up period.

Conclusion

"Skipping" posterior hemivertebra resection with short segmental fusion could provide satisfactory correction with limited fusion. However, decompensation may occur during follow-up. The prognosis of the discs between two fusion masses needs to be evaluated in the future.



261. BACK PAIN PREVALENCE AND PROMIS SCORES IN CHILDREN WITH HYPERKYPHOSIS COMPARED TO IDIOPATHIC SCOLIOSIS

Karina A. Zapata, PhD, PT, DPT; Eliza Lovrich, BS; Chan-Hee Jo, PhD; Caitlin Nadolny, PT, DPT, FAAOMPT; *Brandon A. Ramo, MD*

Hypothesis

Children with hyperkyphosis have increased back pain and worse Patient Reported Outcome Measurement Information Systems (PROMIS) scores compared to idiopathic scoliosis (IS).

Design

Retrospective review

Introduction

The prevalence of back pain and PROMIS scores in children with hyperkyphosis are unknown. The purpose is to compare back pain prevalence and PROMIS Pain Interference, Mobility, and Anxiety scores in children with hyperkyphosis and IS.

Methods

Children with hyperkyphosis and IS ages 8 to 18 years who completed the PROMIS Pediatric Computer Adapted Test Pain Interference, Mobility, and Anxiety measures were retrospectively evaluated from April 2021 to June 2023. Comparisons were made between hyperkyphosis and IS groups and within Scheuermann kyphosis (SK) and postural kyphosis subgroups.

Results

308 children (161 boys, 147 girls) with hyperkyphosis and 1150 children (272 boys, 878 girls) with IS were included. Children with hyperkyphosis did not report back pain significantly more than those with IS (44% vs. 39%) but had a higher pain intensity (1.5 vs. 1.2 out of 5, $p<0.01$). The hyperkyphosis group had increased age, male sex, BMI percentile (63 vs. 57, $p<0.001$), Spanish than English speakers, public insurance type, depression or anxiety, Oswestry Disability Index (ODI) scores, and worse PROMIS Pain and Mobility scores than the IS group (Table). Worse ODI, PROMIS Pain and Mobility scores remained significant after multivariate regression analysis adjusted for age, sex, BMI percentile, language, insurance type, and race/ethnicity ($p<0.01$). Children with SK did not report back pain significantly more than those with postural kyphosis (54% vs. 41%) nor at a higher intensity. Children with SK had increased age, male sex, BMI percentile, botheration by their appearance, and worse PROMIS Pain and Mobility scores than postural kyphosis. Higher PROMIS Pain and lower PROMIS Mobility did not remain significant after multivariate analysis adjusted for age, sex, and BMI percentile.

Conclusion

Back pain prevalence did not differ in children with hyperkyphosis than IS nor in SK than postural kyphosis. However, PRO scores were worse in hyperkyphosis and in SK. Worse PROMIS Pain and Mobility scores remained

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significant only in the hyperkyphosis group after adjusting for confounding variables. Children with hyperkyphosis have worse PRO scores regardless of diagnosis subtype.

	Idiopathic Scoliosis	Kyphosis	p-value	Scheuermann Kyphosis	Postural Kyphosis	p-value
Age (years)	13.9±2.0 (n=1150)	14.4±2.0 (n=308)	<0.001*	15.0±2.0 (n=67)	14.2±2.1 (n=241)	0.002*
Biologic Sex Female Male	 76% (n=878) 24% (n=272)	 48% (n=147) 52% (n=161)	<0.001*	 25% (n=17) 75% (n=50)	 54% (n=130) 46% (n=111)	<0.001*
Race/Ethnicity White Hispanic Black Asian Other	 45% (n=515) 21% (n=242) 20% (n=225) 10% (n=115) 5% (n=52)	 44% (n=136) 35% (n=109) 3% (n=9) 7% (n=20) 11% (n=34)	<0.001*	 51% (n=34) 31% (n=21) 3% (n=2) 3% (n=2) 12% (n=8)	 43% (n=102) 37% (n=88) 3% (n=7) 8% (n=18) 11% (n=26)	0.59
Language English Spanish	 91% (n=1039) 9% (n=102)	 84% (n=258) 16% (n=48)	<0.001*	 85% (n=57) 15% (n=10)	 84% (n=201) 16% (n=38)	0.85
Insurance Private Public Self-pay	 60% (n=688) 29% (n=335) 11% (n=127)	 55% (n=169) 36% (n=112) 9% (n=27)	0.042*	 52% (n=35) 34% (n=23) 13% (n=9)	 56% (n=134) 37% (n=89) 8% (n=18)	0.31
Body Mass Index Percentile	57±31 (n=1144)	63±34 (n=307)	<0.001*	75.1±32.3 (n=67)	59.4±33.7 (n=240)	<0.001*
Back Pain Yes	38% (n=442)	44% (n=135)	0.088	54% (n=36)	41% (n=99)	0.066
Depression or Anxiety Yes	35% (n=155)	45% (n=60)	0.041*	36% (n=13)	49% (n=47)	0.20
Bothered by Appearance Yes	26% (n=279)	31% (n=66)	0.112	46% (n=21)	27% (n=45)	0.014*
Pain Intensity (0-5)	1.2±0.9 (n=437)	1.5±1.0 (n=134)	<0.001*	1.3±0.8 (n=35)	1.6±1.0 (n=99)	0.23
ODI (%)	14.8±12.0 (n=416)	17.8±11.3 (n=130)	0.001*	18.6±9.1 (n=35)	17.5±12.1 (n=95)	0.38
PROMIS Pain Score	43.4±10.7 (n=1150)	45.4±10.9 (n=308)	0.005*	48.6±10.6 (n=67)	44.5±10.8 (n=241)	0.004*
PROMIS Mobility Score	53.2±8.8 (n=1140)	50.6±9.6 (n=308)	<0.001*	48.1±10.1 (n=67)	51.2±9.4 (n=241)	0.029*
PROMIS Anxiety Score	42.6+10.1 (n=1132)	43.1+10.5 (n=308)	0.59	41.9+10.1 (n=67)	43.4+10.6 (n=241)	0.37

262. SURGICAL TREATMENT OF DYSTROPHIC KYPHOSCOLIOSIS SECONDARY TO NEUROFIBROMATOSIS TYPE 1: IS THREE-COLUMN OSTEOTOMY NECESSARY?

Song Li, MD, PhD; Sai-hu Mao, PhD; Zezhang Zhu, PhD; Zhen Liu, PhD; Yong Qiu, PhD

Hypothesis
Three column osteotomy is not necessary to treat kyphosis in DKS-NF1 patients.

Design
A retrospective study

Introduction
Dystrophic kyphoscoliosis secondary to neurofibromatosis type 1 (DKS-NF1) can be characterized by complex different types of kyphosis. The purpose of this study was to evaluate whether the patients with DKS-NF1 must undergo three-column osteotomy during deformity correction surgery.

Methods
84 patients with DKS-NF1 were retrospectively analyzed, and the average age was 17.7±6.9 years. According to whether the patient has undergone three column osteotomy, they were divided into two groups: None three column osteotomy group (N-3CO) and three column osteotomy group (3CO). The preoperative, postoperative and follow-up imaging parameters of the two groups were measured and analyzed to evaluate the surgical effect.

Results
74 patients were divided into the N-3CO group and 3CO consisted of 10 patients. The proportion of preoperative traction in this group was significantly higher than that in the 3CO group (26/74 vs. 0, P=0.027). The magnitude of kyphosis in the two groups were 73.8±20.9° and 63.1±21.4° before surgery, respectively (P=0.136). After surgery, they were corrected to 43.1±20.9° and 21.1±22.8°, respectively (P=0.003), with correction rates of 43.7±19.6% and 84.1±78.7%, respectively (P<0.001). At the last follow-up, they were maintained at 46.5±20.9° and 24.6±25.5°, respectively (P=0.003). The Cobb angle of the main curve was corrected from preoperative 83.0±29.0° and 66.3±17.7° (P=0.081) to postoperative 50.6±20.8° and 40.8±15.6° (P=0.155), with correction rates of 38.3±16.6% and 39.3±12.7% (P<0.849), respectively. At the last follow-up, they were maintained at 52.3±20.5° and 43.1±18.2°, respectively (P=0.185). The incidence of complications in the two groups was 12.2% (N-3CO group, 9/74) and 20% (3CO group, 2/10), respectively, (P=0.613).

Conclusion
Three column osteotomy is mainly used to treat adult kyphosis in DKS-NF1 patients. While the none-three-column-osteotomy methods were mainly applied in young patients. Posterior approach with posterior column osteotomy was the mostly used plan, while anterior supplementary fusion was also an important option. For severe cases, preoperative Halo gravity traction can be used as a routine treatment strategy.

263. RISK MODEL FOR PROXIMAL JUNCTIONAL KYPHOSIS (PJK) FOLLOWING SPINE DEFORMITY SURGERY IN SPINAL MUSCULAR ATROPHY (SMA)

Hiroko Matsumoto, PhD; Taylor M. Adams, BS; Lennert Plasschaert, MD; David Liu, MD; Brian D. Snyder, MD, PhD

Hypothesis
The risk of PJK in SMA patients with scoliosis treated with spinal instrumentation depends on UIV ≤T1, pre-op global kyphosis, and % sagittal correction.

Design
Single-center retrospective cohort study of SMA patients who underwent spinal deformity surgery from 2004 to 2023.

Introduction
PJK following spinal surgery has been explored in children with early onset scoliosis (EOS), but not in SMA patients with severe global kyphoscoliosis. While prior studies identified associations between select risk factors and PJK in EOS, these studies were constrained by an inability to explore interactions among multiple risk factors. Thus, this study aimed to develop and validate a prognostic model for quantifying PJK likelihood in SMA patients undergoing spinal surgery based on preop radiographic parameters (global sagittal deformity) and perioperative variables (% kyphosis correction and UIV).

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Methods
Presence of PJK (>10°) was evaluated at 2-year postop in SMA patients treated for spinal deformity. Candidate predictors included: pre-op global kyphosis, thoracic kyphosis, major coronal scoliosis, cervical lordosis, proximal junctional angle, lumbar lordosis, pelvic obliquity, sagittal vertical axis, pelvic incidence, pre-op halo gravity traction and UIV. Predictor selection was executed through logistic regression to formulate several models. Subsequently, the dataset underwent random partitioning into training and testing subsets, followed by 5-fold cross-validation to assess discrimination, calibration, and risk of overfitting across each model, culminating in the definitive model.

Results
Of 51 patients evaluated, 6 developed PJK (11.8%). Predictors of PJK were preop global kyphosis ≥90°, cervical lordosis >40°, preop halo gravity traction, ≥50% correction of kyphosis, and UIV ≤T1. The model attained excellent predictive ability, achieving an area under the operating characteristic curve of 0.81 (Fig. 1). No patient with UIV >T1 developed PJK.

Conclusion
The risk model achieved 81% predictive ability of PJK in SMA patients, encompassing radiographic variables assessed in previous studies of EOS patients with diverse etiology. This risk model suggests that SMA patients with global kyphosis ≥90° and cervical lordosis >40° who achieve ≥50% correction of global sagittal deformity with preop halo gravity traction should be instrumented >T1.

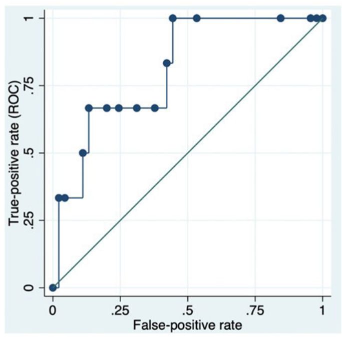

Figure 1a. ROC of PJK predictor model in SMA

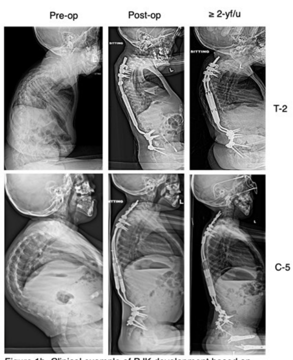

Figure 1b. Clinical example of PJK development based on UIV: T2 vs. C5 at preop, immediate post op, and most recent follow up

264. WHAT KIND OF KYPHOSIS? STRATIFYING THORACOLUMBAR KYPHOSIS IN ACHONDROPLASIA

Luiz Silva, MD; Yusuke Hori, MD, PhD; Colleen Ditro, RN, DNP, CPNP; Kenneth J. Rogers, PhD; James R. Bowen, MD; William G. Mackenzie, MD; *W.G. Stuart Mackenzie, MD*

Hypothesis
Classifying thoracolumbar kyphosis (TLK) in patients with achondroplasia will better delineate risk and dictate surgical treatment options.

Design
Single-center retrospective cohort

Introduction
When treating TLK in patients with achondroplasia (Ach), predicting outcomes, correction and surgical complications is essential. There is limited literature describing the treatment and risk among different types of TLK. This study aimed to classify deformities of the thoracolumbar junction, describe effective operative treatment, and compare surgical complications.

Methods
Medical records from 2004-2021 reviewed with inclusion criteria: Ach diagnosis, TLK, symptomatic spinal stenosis, surgery and at least two year follow-up. Demographics, clinical notes, and radiographs were analyzed. Post-operative complications were classified by Clavien-Dindo System. Intra-observer reliability was measured with Cohen's kappa-coefficient, and interobserver reliability with Fleiss kappa-coefficient.

Results
40 patients with Ach and TLK requiring spinal decompression and fusion were treated at average age of 16±5 years, with mean follow-up of 5±4 years. We identified four classes of patients: Class 1 with gradual multi-level TLK with diffuse stenosis; Class 2 with focal TLK associated with apical vertebral wedging and localized stenosis, with flattened or lordotic thoracic spine above; Class 3 with severe post-laminectomy kyphosis; and Class 4 is a heterogenous group with additional diagnoses related to TLK. Intra-observer kappa index of classification was 0.90 ($p<0.001$), and inter-observer was 0.83 ($p<0.001$). Class 1 patients underwent posterior spinal decompression and fusion alone, while all others required additional posterior spinal osteotomies or anterior fusion. Kyphosis correction averaged 81%, with 52.5% (21/40) rate of intraoperative complication. Class 1 patients had shorter surgical time and lower estimated blood loss(Table 1). Classes 3/4 had more major postop complications compared to classes 1/2 ($p=0.04$).

Conclusion
Treatment of TLK and symptomatic spinal stenosis in patients with Ach involves advanced technique and has a high rate of complication. Surgical options and risk can be stratified based upon this reliable classification system. With improved communication and preoperative planning, patients with Ach can be successfully managed with excellent correction and managed risk.

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E-POINT PRESENTATION ABSTRACTS

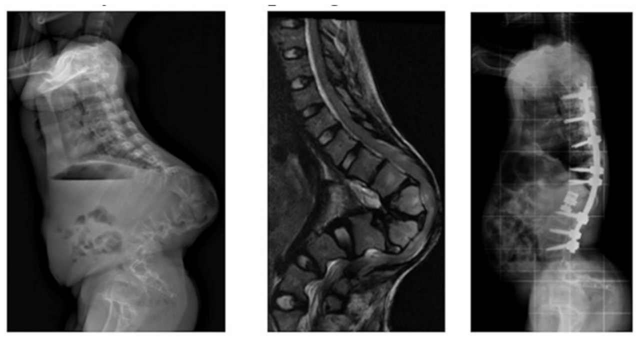

Table 1. Comparison of Peri-operative Variables and Sagittal Parameters for each of the Classification

	Class 1 (n=17)	**Class 2** (n=14)	**Class 3** (n=5)	**Class 4** (n=4)	**All** (n=40)	*p-value*
Time of Surgery (min)	441±128	370±60	435±111	574±120	568±213	***0.024***
Estimated Blood Loss (mL)	1735±1185	1168±602	2007±1305	2910±1289	1719±1507	***0.044***
TK Pre-operative (°)	23±16	-4±12	-25±36	-11±21	4±25	***<0.001***
TLK Pre-operative (°)	24±10	45±21	109±42	78±29	48±35	***<0.001***
TLK Post-operative (°)	8±4	13±13	25±12	14±2	12±10	***0.006***
Kyphosis Correction Rate (%)	73±16	71±19	72±15	77±9	81±9	*0.257*

TK, thoracic kyphosis; TLK, thoracolumbar kyphosis; PI, pelvic tilt; PT, pelvic tilt; SS, sacral slope

Comparison of peri-operative variables and sagittal parameters

265. CHIN-BROW VERTICAL ANGLE IS NOT CONSISTENTLY RELIABLE FOR SURGICAL PLANNING IN THORACOLUMBAR KYPHOSIS SECONDARY TO ANKYLOSING SPONDYLITIS ‡

Hongda Bao, MD; Yong Qiu, PhD; Bangping Qian, MD

Hypothesis
Determining the osteotomized vertebra angle (OVA) using the CBVA may not be universally appropriate for all AS pts when performing surgical planning.

Design
A single-center retrospective study

Introduction
Previous studies demonstrated a negative correlation between reduced CBVA and OVA, underlining CBVA's value in determining expected OVA. However, when the cervical spine is flexible, the CBVA method often falls short of providing satisfactory remodeling. Clinical experience prompts us to consider that the CBVA method may not be universally appropriate for all AS pts.

Methods
64 primary AS pts with thoracolumbar kyphosis, who underwent one-level lumbar or thoracic pedicle subtraction osteotomy (PSO) between January 2015 and December 2019, were categorised into three groups: Group A (CROM ≤ 10°), Group B (10° < CROM ≤ 20°), and Group C (CROM > 20°) based on cervical ranges of motion (CROM). The correlation between CBVA-S (the angular difference of CBVAs between pre-operation and immediate post-operation) and OVA among the three groups was assessed to define the cervical ankylosis group (CA) and the cervical non-ankylosis group (CNA). Sagittal parameters were evaluated, including Cobb C2-C7, CBVA, global kyphosis (GK), SVA C7-S1, and PT.

Results
A significant correlation between CBVA-S and OVA was observed in Group A (r=0.881, P<0.05) and Group B (r=0.932, P<0.05), while no correlation was found in Group C (r=0.198, P=0.31). Consequently, patients in Group A and Group B were included in the cervical ankylosis (CA) group (CROM ≤ 20°), and Group C was designated as the cervical non-ankylosis (CNA) group (CROM > 20°). In the CA group, no significant correlation was found between OVA-S (the difference between anticipated OVA [approximately equal to CBVA-S] and actual OVA) and CROM (P=0.69). In the CNA group, a significant kyphosis change in the cervical spine was observed after surgery (pre-op: 27.36; post-op: 5.57; difference: 21.79) compared to the patients in the CA group (pre-op: 11.06; post-op: 9.31; difference: 1.75).

Conclusion
CBVA is not consistently reliable in determining the OVA for correcting thoracolumbar kyphosis in AS patients, and its reliability is closely linked to cervical range of motion (CROM). In AS pts with extensive CROM (CROM > 20°), CBVA is not recommended as a reliable parameter to guide the determination of OVA.

TABLE 1. Pearson correlation analysis between CBVA-S and OVA among the three groups

	Group A(N=24)	Group B(N=12)	Group C(N=28)
CBVA-S	33.38±14.45°	28.33±10.20°	13.86±13.84°
OVA	34.67±11.19°	31.17±09.19°	33.32±07.05°
r value	0.881	0.932	0.198
P value	**<0.001**	**<0.001**	0.314

TABLE 2. Comparison of Cobb C2-C7 between pre-operation and immediate post-operation in the cervical ankylosis (CA) group and the cervical non-ankylosis (CNA) group

	CobbC2-C7	
	Group CA	Group CNA
Pre-op	11.06±10.46	27.36±09.85
Post-op	09.31±09.65	05.57±10.57
P-value	**<0.001**	**<0.001**

TABLE 3. Pearson correlation analysis between Cobb C2-C7S+ CBVA-S and OVA in the cervical ankylosis (CA) group and the cervical non-ankylosis (CNA) group

	Group CA	Group CNA
Cobb C2-C7S + CBVA-S	33.67±12.94	35.64±11.54
OVA	33.50±10.57	33.32±07.05
r value	0.89	0.38
P value	**<0.001**	**0.047**

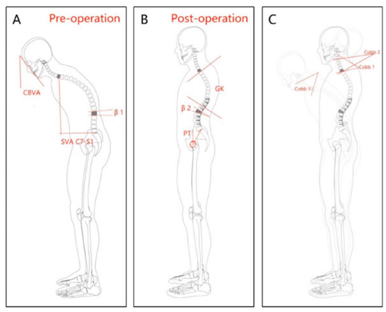

Table and illustrations

266. OUTCOMES OF PEDIATRIC AND YOUNG ADULT KYPHOTIC DEFORMITIES TREATED WITH VERTEBRAL COLUMN RESECTIONS AT AN SRS - OUTREACH SITE IN WEST AFRICA WITH 2-YEAR FOLLOW-UP

Kushagra Verma, MD, MS; Arthur Sackeyfio, MD; Kwadwo Poku Yankey, MD; Derrick Owusu Nyantakyi, MPH; Jessie Rapoza, MS; Irene A. Wulff, MD; Oheneba Boachie-Adjei, MD; Liliane Luu, BS

Hypothesis
VCR enables excellent sagittal correction but with known intra and post-operative complication risks.

Design
Retrospective

Introduction
Vertebral column resection (VCR) is useful for correction of spinal deformities but the complication risk remains high. This study provides an updated outcome analysis of

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vertebral column resections performed at an SRS-Outreach site in west Africa.

Methods
A retrospective review was performed using prospectively collected data from the FOCOS hospital in west Africa. Thirty-nine patients underwent VCR for severe kyphotic deformity between 2013 and 2018 with a minimum of two-year outcomes. Sagittal radiographic parameters and SRS-22 scores were analyzed via paired t-tests between pre and postoperative data.

Results
39 patients aged 11 to 27 (median age: 16; mean BMI: 19.85 ± 2.99) underwent VCR. 29 patients returned for 2-year follow up (74%). There were five 1-level VCRs, sixteen 2-level VCRs, seventeen 3-level VCRs, and one 4-level VCR. Mean radiographic parameters improved significantly in T2-T5 kyphosis (-3.18˚ to 6.97˚, P=0.0010), T5-T12 kyphosis (58.3˚ to 33.3˚, P=0.012), and L1-S1 lordosis (62.5˚ to 42.6˚, P=4.5E-4). Meanwhile, mean sagittal vertical axis improved insignificantly (55.6mm to 43.6mm, P=0.09). Mean SRS-22 scores improved significantly in all categories: pain (2.87 to 3.99, P=2.3E-5), self-image (2.29 to 3.90, P=4.4E-6), general function (3.06 to 3.86, P=1.4E-4), mental health (3.36 to 4.05, P=1.7E-4), satisfaction (3.25 to 4.1, P=6.6E-3), total (2.95 to 3.99, P=1.00E-7). Mean operating time was 318 ± 87 minutes. Mean estimated blood loss was 1844 ± 852cc. 21 patients had intra-operative complications, with 19 neuromonitoring changes that improved with corrective maneuvers and blood pressure elevation, two dural tears, and two pleural tears. Two patients experienced postoperative neurologic complications.

Conclusion
In this pediatric surgical outreach setting, VCRs enabled drastic improvements in both radiographic sagittal parameters and SRS-22 scores with generally favorable outcomes despite the complexity of these cases. Complications were 54% but a majority were related to intra-operative neuromonitoring changes without lasting neurologic deficits. Re-operation rate was 15.3%.

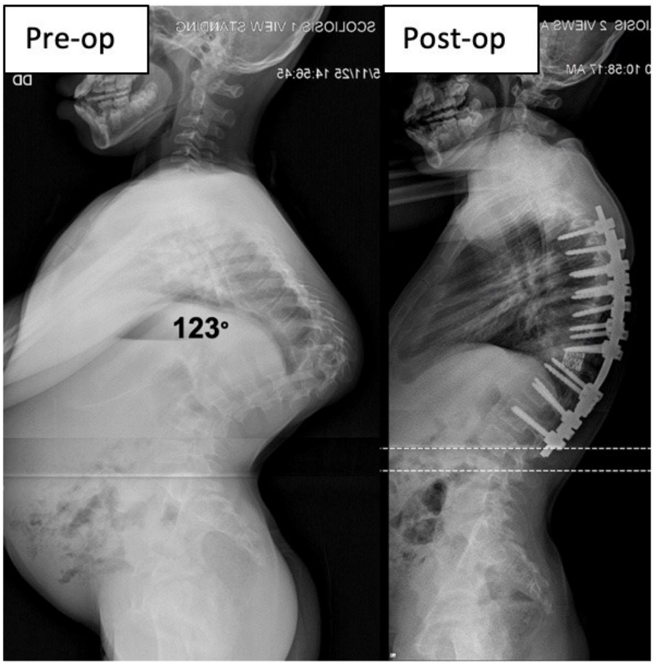

Figure 1: Radiographic images of case examples.

267. SURGICAL WOUND HEALING POST SPINE FUSION IN MYELOMENINGOCELE: TRADITIONAL MEDIAL VERSUS MODIFIED-Y INCISIONS

Luiz Müller Avila, MD; Luca E. Cordeiro, MD; Andre Moreira Castilho, MD; Kristie Cordeiro, MD student; Lucas de Melo Castro Deligne, BS; Carlos A. Aguiar, MD; Luis E. Munhoz da Rocha, MD

Hypothesis
Modified inverted Y incision will result in less wound complications compared to the traditional medial approach.

Design
Retrospective transversal study.

Introduction
Myelomeningocele (MMC), a subtype of spina bifida, presents intricate challenges in treatment, primarily associated with neural tube closure defects. With a global prevalence of 0.8 to 1 per 1,000 live births and a 75% survival rate, the neurological consequences often manifest as paralysis-induced scoliosis, necessitating surgical intervention for deformity correction. Previous incision scarring and decubitus ulcers present challenges for wound healing in already fragile patients, therefore the choice of incision method is pivotal for optimizing the recovery process and preventing complications and plastic intervention.

Methods
Inclusion criteria were patients who underwent posterior spine fusion (PSF) who had a MMC diagnosis and min. 2 yr follow up after surgery. 67 patients fit the criteria between 2013 and 2022, 51 undergoing the traditional incision and 16 the modified inverted Y incision. Presence

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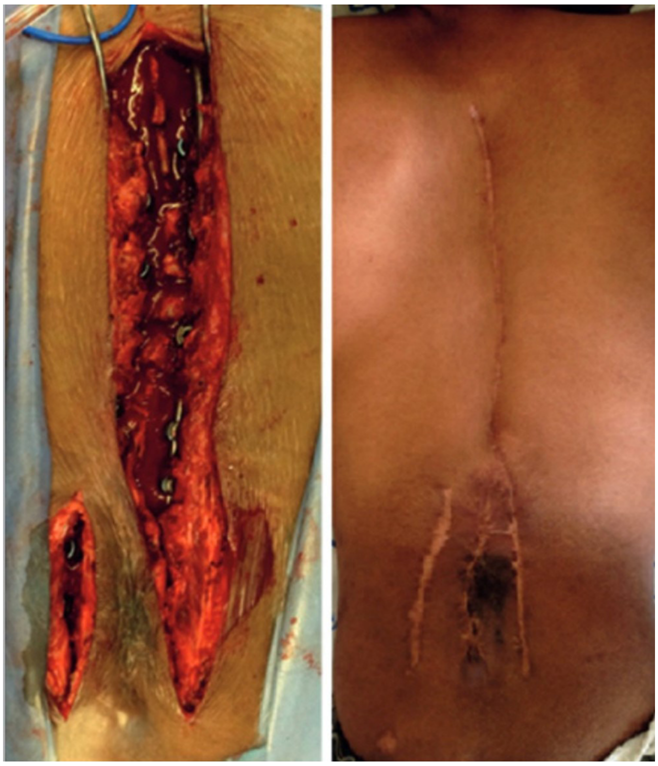
of neurogenic bladder (NB), chronic urinary tract infection (UTI) and hydrocephalus were evaluated for each patient. Categorical variables such as wound infection, dehiscence and debridement were compared using Chi-square.

Results
Patient profile was similar in both groups regarding mean age (11 years), and comorbidities (NB, chronic UTI and hydrocephalus). The statistical analysis revealed no significant differences in the post-operative incidence of wound complications. The traditional group had a 9.8% infection and 31.4% debridement incidence, while the modified inverted Y group had a 6.25% infection and 25% debridement incidence rates. The rate of rehospitalization and reintervention in the two year follow-up was 10% and 20% respectively in the traditional group and 0% and 12.5% in the modified inverted Y group.

Conclusion
The modified inverted Y incision emerges as a safe alternative, demonstrating promising trends to minimize wound healing complications, rehospitalization rates and the need for major reinterventions in fragile patients. Further studies with larger sample size are imperative to further validate these findings and solidify the modified incision's superiority in optimizing wound healing in MMC patients.



Modified inverted Y incision. On the left: Intraoperative view. On the right: Final aspect of healing.

268. IMPACT OF COMORBIDITIES ON MORTALITY IN NEUROMUSCULAR PATIENTS WITH EARLY ONSET SCOLIOSIS

Taylor M. Adams, BS; Bhavana Gunda, BS; Sydney Lee, BS; Maria F. Canizares, MD, MS; Yoko Matsumoto, MD; Mark A. Erickson, MD; John T. Smith, MD; Paul D. Sponseller, MD, MBA; Pediatric Spine Study Group; Brian D. Snyder, MD, PhD; *Hiroko Matsumoto, PhD*

Hypothesis
Associated medical comorbidities impact mortality in patients with neuromuscular disease (NMD) undergoing surgical correction of early onset scoliosis (EOS).

Design
A multi-center retrospective cohort study of NMD patients who underwent surgery for their EOS from 1995 to 2021.

Introduction
Patients with NMD often present with EOS. Compared to natural history studies of untreated patients, spine surgery has demonstrated to increase survival and improve quality of life; however, correcting the spinal deformity may have limited impact on ameliorating the multitude of medical co-morbidities associated with NMD.

Methods
Mortality risk was calculated at the 1-year, 2-year, 5-year, and 10-year. Co-morbidities were compared to mortality rate. Hazard ratio was calculated for unequal follow-up and time to death. Interaction terms were included. Stratified analyses determined covariates as confounders or effect modifiers. Sensitivity analyses confirmed all patients and those who were lost to follow-up were similar, indicating limited threat of selection bias.

Results
There were 889 patients identified: 38% cerebral palsy (CP), 24% spinal muscular atrophy (SMA), 13% muscular dystrophy (MD), 12% myelodysplasia and 4% myopathy. Co-morbidities were: 48% gastrointestinal (GI), 42% neurologic, 41% musculoskeletal, 38% developmental delay, 37% pulmonary, 11% cardiac, 7% renal, 4% blood or connective tissue, and 2% endocrine. Mortality was 1.2% at 1-year, 5.1% at 2-year, 10.6% at 5-year and 32.0% at 10-year. When stratified by diagnosis, co-morbidity interactions increased mortality: in particular, cardiac + pulmonary (13.7x in SMA) or cardiac + GI (30.7x in SMA and 34.7x myelodysplasia). Multiple comorbidities increased death rate in EOS children compared to those without comorbidities or NMD patients with only one comorbidity ($ps<0.05$) (Table 1).

Conclusion
Increased mortality rates after surgery were associated with NMD entities and related co-morbidities, independent of the extent of spine correction. Increased risk of death could not be identified for any co-morbidities. While spinal pathoanatomy may exacerbate certain

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comorbidities (especially cardiopulmonary), our results indicate that surgical treatment of EOS may have limited influence on ameliorating disease specific pathophysiologic processes that threaten the health and well-being of NMD patients.

		95% Confidence Interval	
	Hazard Ratio	Lower Limit	Upper Limit
CP			
Cardiac	2.03^{t}	0.94	4.40
Endocrine	2.02	0.49	8.37
GI & Cardiac	2.05^{t}	0.91	4.64
SMA			
Pulmonary	2.23	0.73	6.83
Cardiac	10.33*	2.72	39.19
Musculoskeletal	2.36	0.76	7.31
Gastrointestinal	2.18	0.76	6.24
Cardiopulmonary	13.74*	3.59	52.67
GI & Pulmonary	3.86*	1.34	11.08
GI & Cardiac	30.73*	7.65	123.36
Myelodysplasia			
Cardiac	4.03	0.37	44.45
Gastrointestinal	5.37	0.49	59.37
Developmental Delay	5.37	0.49	59.43
GI & Cardiac	34.68*	2.17	555.21
MD			
Neurologic	2.23	0.53	9.37
Myopathy			
Neurologic	4.57^{t}	0.76	27.36
Developmental Delay	4.84^{t}	0.75	31.19
Musculoskeletal	3.24	0.54	19.47
GI & Pulmonary	2.04	0.33	12.76

*Effect Measures≥2.00 are listed. *p<0.05, ^{t}p<0.10*

Table 1. Hazard ratio by neuromuscular diagnosis with co-morbidity interaction

270. OLDER CONGENITAL SCOLIOSIS PATIENTS CAN ATTAIN SIMILAR CURVE CORRECTION AND OUTCOMES AS AIS PATIENTS WITHOUT HEMIVERTEBRA EXCISION

Vishal Sarwahi, MD; Sayyida Hasan, BS; Keshin Visahan, BS; Katherine Eigo, BS; Effat Rahman, BS; Brian Li, BS; Sanjeev Suratwala, MD; Yungtai Lo, PhD; Terry D. Amaral, MD

Hypothesis

Correction of congenital scoliosis can be achieved through the use of pedicle screws and a posterior-only approach without hemivertebra excision in most cases.

Design

Retrospective case-controlled matched study.

Introduction

Hemivertebra excision in patients is the current gold standard for congenital scoliosis patients, resulting in the best possible correction while decreasing the number of levels fused. However, it is a technically challenging procedure and complications can include nerve root injury, spinal cord injury, and CSF leak. We have utilized a hemivertebra-sparing approach in patients alongside multi-level Ponte osteotomies and all pedicle screw constructs. The fusion levels are determined in a similar manner as in AIS, as the hemivertebrae patients have presented at a later age (>10 years) with deformities that extend over multiple segments. Our hypothesis is that this approach in congenital patients leads to similar correction and outcomes to AIS patients.

Methods

IRB-approved review of spine deformity patients operated on between 2005 – 2021. 27 patients with congenital scoliosis and associated hemivertebra were included. These patients were matched to a pool of 311 AIS correction surgeries by gender, preop Cobb angle, and levels fused. Overall, 21 pairs were analyzed after accounting for possible confounding variables. Wilcoxon signed-rank test and Fisher's Exact test were utilized.

Results

Age($p = 0.23$), BMI($p = 0.96$) and preoperative Cobb($p = 0.32$) were similar between hemivertebra and AIS patients. Cobb correction(71.8% vs 72.9%, $p = 0.94$) and EBL($p = 0.12$) were similar. Surgical time and length of stay($p < 0.001$) were significantly longer for HV patients.

Conclusion

Choosing fusion levels in congenital patients, on similar principles akin to AIS, leads to avoidance of hemivertebra excision in most cases, including lumbosacral hemivertebras. Radiographic and perioperative outcomes in these patients were similar to AIS patients. This hemivertebra sparing approach is safer compared to excision and has similar or better curve correction than previously reported.

271. SURGICALLY RELEVANT ANATOMY OF MARFAN SPINAL DEFORMITY

Myung-Jin Cha, BS; *William G. Elnemer, BS*; Paul D. Sponseller, MD, MBA

Hypothesis

Pedicles and lamina of patients with Marfan syndrome are thinner than those of typically developing patients (TDP) and are affected by the curve and dural ectasia.

Design

Retrospective cohort study

Introduction

Understanding pedicle and laminar anatomy is crucial for secure fixation of spinal instrumentation. This study explores the spinal morphology in the Marfan vertebrae and compares it to vertebrae of TDP.

Methods

The morphology of 134 vertebrae from T1 to L5 were measured in 16 Marfan patients with spine deformity, using MRI and CT scans. The morphology of 140 vertebrae from T1 to L5 were measured in TDP, using MRI, CT, and X-rays. These values were then compared to each other. Comparisons via paired Student's t-test were made between the concave and convex side of the curve.

Results

On average, Marfan pedicles were significantly thinner (by mean 2mm) than those in TDP ($p<0.001$) (Fig. 1). Thirty-four percent of the total Marfan pedicles were type

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D (< 2mm wide) vs only 9% in TDP (p<0.001). Marfan type D pedicles were found in 36% of atypical locations (outside of the concave apex). Pedicle width was significantly correlated with both vertebral level and distance from the apex. The average thickness of the Marfan lamina was significantly thinner (by mean 1mm) than those in TDP (p<0.001). Marfan patients with dural ectasia had significantly thinner lamina in the lumbar spine than those without (p=0.023). Pedicle width and laminar thickness measurements from CT and MRI were not significantly different. X-ray pedicle width measurements correlated moderately well with both MRI and CT pedicle width measurements (R2=0.52 and 0.59, respectively). Pedicle measurements by X-ray were larger than by CT scans 82.5% of the time (by mean 1.7mm).

Conclusion

Marfan spines are associated with thinning of fixation sites, most pronounced at the apex of the curve. Laminar thinning was more common on the concavity and with dural ectasia. Such unique vertebral morphology finding supports obtaining preoperative routine MRI or CTs when operating on Marfan spine with pedicle screws and lamina hooks. X-rays can be useful in identifying narrow pedicles, but often overestimates the width.

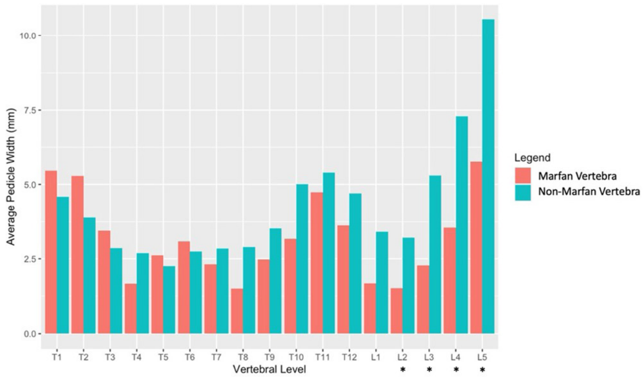

Figure 1. Average Pedicle Width by Vertebral Level (* denotes vertebral levels where pedicle widths were significantly different)

272. COMPARISON OF SURGICAL OUTCOMES FOR NF-1 DYSTROPHIC SCOLIOSIS BETWEEN DEFINITIVE FUSION AND GROWING RODS (TGR AND MCGR): RESULTS FROM THE PEDIATRIC SPINE STUDY GROUP (PSSG) DATABASE

Michael Lam; *Kenny Y. Kwan, MD*

Hypothesis

Definitive fusion can achieve similar surgical outcomes to growing rods with fewer complications.

Design

Retrospective review of prospectively collected cohort.

Introduction

No definitive conclusion has been drawn regarding the efficacy and safety of definitive fusions in NF-1 dystrophic scoliosis due to small patient number, retrospective cohort, mixed aetiology in existing studies, and lack of non-radiographic outcomes. Our purpose was to investigate the surgical outcomes of fusion vs growing rods in NF-1 dystrophic scoliosis.

Methods

Patients with NF-1 scoliosis treated with definitive fusion, TGR and MCGR with a minimum of 2-year follow-up were identified from the PSSG database.

Results

33 patients between age 8-11 were identified. 10 had definitive fusion (DF), and 23 underwent growing rods (GR) (8 TGR and 15 MCGR). Patients in DF group were older than those in GR group at index surgery (10.8 vs. 9.4 yr, p<0.001). Preoperative data, sex ratio and preoperative major Cobb angles were not significantly different. At minimum of 2 year follow-up, there was no significant difference in Cobb correction rate (23.6 vs. 32.7%, p=0.31), T1-S1 height gain (52.4 vs 48.3mm, p=0.7), FVC% predicted (81.3 vs 68.8%, p=0.52), FEV1% predicted (82 vs 62.7%, p=0.33), and mean complication rate per patient (0.1 vs 0.65, p=0.07). However, mean the number of surgeries was lower in DF vs GR groups (1.3 vs 4.0, p<0.001). Subgroup analyses between TGR and MCGR groups showed no significant differences in Cobb correction rates, T1-S1 height gain, FVC% predicted, FEV1% predicted, and complication rate per patient at minimum of 2 years. However, patients in TGR group had more surgeries (7.4 vs 2.3, p<0.001) compared with MCGR group. One-way ANOVA revealed association between elevated complication rate and TGR (p=0.02) but not DF (p=0.77) or MCGR (p=0.71).

Conclusion

Definitive fusion achieved similar surgical outcomes, pulmonary function with fewer complications than growing rods in NF-1 dystrophic scoliosis. MCGR achieved similar outcomes compared with TGR with fewer surgeries and lower complication rates per patient.

273. DOES OPEN TRIRADIATE CARTILAGE LEAD TO POOR OUTCOMES AMONG CEREBRAL PALSY PATIENTS UNDERGOING SPINAL FUSION?

John S. Vorhies, MD; Nicole S. Pham, MPH; Marleni Albarran, BS; Maty Petcharaporn, BS; Craig R. Louer, MD; Arun R. Hariharan, MD; Peter O. Newton, MD; Burt Yaszay, MD; Firoz Miyanji, MD; Harms Study Group

Hypothesis

Spinal fusion (SF) yields equivalent radiographic and clinical results in skeletally immature patients with cerebral palsy (CP) compared to patients nearing skeletal maturity.

Design

Retrospective review of a prospectively multicenter registry

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Introduction
The optimal timing for SF in patients with CP and scoliosis remains a subject of debate. This study investigates whether SF in skeletally immature patients during or before peak height velocity provides equivalent radiographic and clinical results versus those nearing skeletal maturity.

Methods
We identified patients with GMFCS 4 and 5 CP undergoing SF to the pelvis with minimum 2-year follow-up. Patients were classified based on skeletal maturity at the time of surgery: open or closed triradiate cartilage (TRC). We compared perioperative clinical and radiographic outcomes and Caregiver Priorities and Child Health Index of Life with Disabilities (CPCHILD) scores.

Results
Of 127 patients with 2-year follow-up 86(68%) had TRC-closed at the time of SF and 41(32%) had TRC-open. TRC-open group mean age was 11.9y (range: 9.6-21) vs 15.4y (range: 8.47-17.2) ($p<0.001$). TRC-open patients were more likely to be G-tube fed, 82.9% vs 47.7% ($p < 0.001$). Demographics were similar between the groups. Preoperative mean major curve was 77° and mean pelvic obliquity was 26° and did not differ between the two groups. Two years postoperatively there was improvement in major curve magnitude by 65% and pelvic obliquity by 17°, which did not differ between the two groups or among the 46% of patients who had 5-year follow-up. There was no significant difference in blood loss, length of hospital stay, infection, or medical complications. TRC-open group had more instrumentation-related complications vs TRC-closed group (24% vs 9% $p<0.03$), often prominent implants, but this did not result in a higher rate of reoperation. TRC-open group transiently improved in CPCHILD communication subdomain scores, but there were no other score differences at any time points between the groups. (Table 1)

Conclusion
CP patients aged 8.5-21 undergoing SF achieved similar perioperative outcomes and radiographic results at 2 and 5 years, regardless of open or closed TRC. Skeletally immature patients may have increased risk of implant related complications. These results suggest that definitive SF is a viable treatment option in CP patients approaching adolescence with open TRC.

	Triradiates Closed (N=86)	Triradiates Open (N=41)	P-value
Baseline Demographics			
Age	15.4 (SD: 2.3), [9.6, 21.0]	11.9 (SD: 1.9), [8.4, 17.2]	<0.001*
Sex (Female)	41 (47.7%)	19 (46.3%)	> 0.999
Weight (kg)	35.2 (SD: 8.6), [22.0, 68.0]	33.7 (SD: 21.2), [18.5, 143]	0.654
GMFCS Level V	73 (84.9%)	34 (82.9%)	0.798
Gastrotomy Tube Feeding	41 (47.7%)	34 (82.9%)	<0.001*
Verbal Communicator	14 (16.3%)	3 (7.3%)	0.078
Tracheostomy	1 (1.6%)	2 (5.7%)	0.285
Seizure Disorder	59 (68.6%)	32 (78.0%)	0.300
Posterior Approach Only	81 (94.2%)	39 (95.1%)	0.340
Major Curve Magnitude			
Preop	77 (SD: 23.0), [27, 138]	76 (SD: 21.1), [48, 131]	0.873
First Erect	25 (SD:16.1), [2, 81]	22 (SD: 12.1), [5, 57]	0.181
% Correction	-66.8 (SD:17.2)	-70.0 (SD:15.7)	0.298
2-year Follow-up	28 (SD: 15.9), [4, 80]	24 (SD: 13.2), [8, 63]	0.204
% Correction	-63.5 (SD:16.2)	-67.1 (SD:16.5)	0.257
5-year Follow-up	29 (SD: 15.3), [6, 64]	27 (SD: 12.9), [10, 67]	0.419
% Correction	-60.3 (SD:16.9)	-64.0 (SD:18.4)	0.418
Pelvic Obliquity (PO)			
Preop	26.5 (SD:15.2), [0, 61]	25.5 (SD:13.6), [3, 56]	0.712
First Erect	8.0 (SD:7.69), [0, 40]	6.6 (SD:7.1), [0, 37]	0.337
Δ from preop	-19.4 (SD:12.3)	-19.2 (SD:12.2)	0.945
2-year Follow-up	9.3 (SD: 8.5), [0, 40]	6.6 (SD:5.6), [0, 20]	0.046
Δ from preop	-17.3 (SD:13.1)	-18.4 (SD:12.6)	0.671
5-year Follow-up	9.5 (SD:8.6), [0, 33]	8.4 (SD:6.0), [0, 23]	0.537
Δ from preop	-16.5 (SD:13.2)	-18.5 (SD:12.9)	0.555
CPCHILD			
Preop	63.4 (SD:25.2)	62.8 (SD:23.0)	0.901
2-year Follow-up	72.8 (SD:22.5)	67.0 (SD:25.9)	0.251
5-year Follow-up	68.2 (SD:23.2)	62.9 (SD:28.5)	0.471
Complications			
Death	4 (4.7%)	5 (12.2%)	0.147
GI	9 (10.5%)	8 (19.5%)	0.174
Instrumentation	8 (9.3%)	10 (24.4%)	0.0303*
Medical	22 (25.6%)	5 (12.2%)	0.106
Neurologic	6 (7.0%)	4 (9.8%)	0.726
Pain	6 (7.0%)	2 (4.9%)	> 0.999
Pulmonary	24 (27.9%)	15 (36.6%)	0.411
Surgical Site/Infection	17 (19.8%)	7 (17.1%)	0.812
Reoperation	12 (14.0%)	3 (7.3%)	0.383

Table 1: Summary

274. FLUID RETENTION FOLLOWING SURGERY IN NEUROMUSCULAR SCOLIOSIS: A FORM OF SIADH?

Cody Orton, BA; Joshua Speirs, MD; Joshua Klatt, MD; John A. Heflin, MD; John T. Smith, MD

Hypothesis
Children with Neuromuscular Scoliosis (NMS) develop a syndrome of inappropriate antidiuretic hormone (SIADH) in the immediate post-operative period resulting in fluid overload and low urine output.

Design
Retrospective review

Introduction
Scoliosis is common in children with neuromuscular diseases, and often requires surgical management. These surgeries are associated with a significant incidence of post-operative complications including infection, wound healing problems, pulmonary complications, and fluid retention. Low urine output in the immediate post-operative period is common, and typically does not respond to fluid boluses. Multiple fluid boluses often results in fluid overload. SIADH following spinal fusion surgery has been reported and in children with NMS, this pattern is predictable. The purpose of this study is to evaluate post-operative fluid management following spinal fusion.

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E-POINT PRESENTATION ABSTRACTS

Methods
Retrospective chart review of 50 consecutive patients undergoing spine surgery for neuromuscular scoliosis between May 2018 and December 2022. Curve magnitude, fluid intake, fluid output, and fluid balance were documented for each day following surgery to assess for fluid retention. Length of stay, hematocrit, sodium level, and any record of a transfusion were also documented. All patients admitted to the PICU post-operatively were included.

Results
50 consecutive patients undergoing surgery for neuromuscular scoliosis who were admitted to the PICU were included. The diagnoses were varied but the most prominent was spastic quadriplegia (31). There were 20 females and 30 males with an average of 14.5 years (range 9-24 yrs). The mean curvature was 79 degrees (40-140 degrees). 100% of patients had a positive fluid balance on post-operative day 0. 98% had a positive balance on day1, 88% on day 2, 88% on day 3, 71% on day 4, 63 % on day 5 and 65% on day 6. Serum sodium levels remained level. Hematocrit decreased over the first two days and then remained stable.

Conclusion
SIADH has been reported following spinal fusion. Patients with neuromuscular scoliosis frequently have reduced urine output following surgery which mimics SIADH. Attempts to improve measured urine output with fluid boluses are often unsuccessful and result in excessive fluid retention and third-spacing and may result in pulmonary edema. Focusing on fluid balance rather than urine output in the immediate post-operative period improves patient safety.

275. MULTI-DISCIPLINARY PERIOPERATIVE PATHWAY FOR NEUROMUSCULAR SCOLIOSIS PATIENTS

Bryce Pember, BS; *Lorena Floccari, MD*; Richard Steiner, PhD; Todd F. Ritzman, MD

Hypothesis
A comprehensive perioperative pathway for high-risk scoliosis patients will reduce intensive care unit (ICU) utilization, shorten length of stay (LOS) and decrease complications

Design
Retrospective comparative cohort study

Introduction
Neuromuscular scoliosis (NMS) patients undergoing posterior spinal fusion (PSF) are at high risk for surgical complication, so multidisciplinary involvement is essential. A comprehensive perioperative pathway for high-risk patients was implemented to optimize and standardize perioperative care. This study evaluates the effect of the pathway on early outcomes, including ICU utilization, hospital LOS, and complications.

Methods
This was a retrospective comparative study of consecutive NMS patients pre- versus post- implementation of the high-risk pathway in May 2018. The pathway emphasizes preoperative multidisciplinary optimization, standardized antibiotics, ICU and inpatient care protocols, standardized bowel and pain regimen, early transition to oral medications, and early and frequent mobilization.

Results
There were 91 patients, including 30 pre- and 61 post-pathway implementation. Baseline patient characteristics were similar, including age, BMI, weight, gender, major Cobb (75.1 vs 85.5 degrees, p=0.107), T2-T12 kyphosis (70.4 vs 85.6 degrees, p=0.44), ASA class, use of feeding tube (73% vs 62%), oxygen dependency (40% vs 39%), and wheelchair dependency (93% vs 95%) (all p>0.1). The post-pathway group had greater use of pelvic instrumentation (43% vs 74%, p=0.005), more fusion levels (14.4 vs 15.3, p=0.015) and longer operative time (316 vs 357 min, p=0.032), though with decreased use of a central line (50% vs 28%, p=0.039), similar blood loss (893 vs 775 ml, p=0.327) and allogeneic transfusion (38% vs 54%, p=0.473). ICU LOS dropped from 3.8 to 2.5 nights post-pathway (p=0.017), while total hospital LOS also significantly decreased (mean 8.3 vs 6.8, median 7 vs 5 nights, p<0.001). There were no differences in surgical site infection (10% vs 13%, p=0.664), postoperative ED visits, readmissions, or reoperations (p>0.1).

Conclusion
A comprehensive multidisciplinary perioperative pathway for high-risk NMS patients results in shorter ICU and total hospital LOS, despite greater use of pelvic instrumentation and longer operative duration, without increase in infection, ED visits, readmissions, or reoperations. This pathway conserves hospital resources and should decrease cost of hospitalization.

276. EFFECTIVENESS OF PREOPERATIVE HALO-GRAVITY TRACTION IN SPINAL MUSCULAR ATROPHY CHILDREN WITH EARLY ONSET SCOLIOSIS

Lennert Plasschaert, MD; Taylor M. Adams, BS; David Liu, MD; Hiroko Matsumoto, PhD; Sydney Lee, BS; Grant D. Hogue, MD; *Brian D. Snyder, MD, PhD*

Hypothesis
For children with spinal muscular atrophy (SMA) and early onset scoliosis (EOS), preoperative halo-gravity traction (PHGT) corrects kyphosis > scoliosis, and thoracic deformity > thoracolumbar or lumbar deformity.

Design
Single-center retrospective study of SMA children with EOS treated with PHGT from 2004 to 2023.

Introduction
PHGT is used for patients with severe, rigid, spinal deformity to decrease the risk of neurological injury incurred during precipitous intra-operative maneuvers

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used to achieve better deformity correction. Spinal deformity correction by PGHT in SMA patients undergoing spinal instrumentation for EOS has been little studied.

Methods
We evaluated sagittal and coronal plane deformity correction achieved with PHGT applied 1-6 weeks at 50% patient body weight in SMA children with EOS. Induced changes in major AP Cobb angle, cervical lordosis, thoracic kyphosis, global/thoracolumbar kyphosis, lumbar lordosis, and sagittal vertical axis (SVA), for secondary analysis segregated according to the location of the deformity apex cranial vs. caudad to T10, were compared by student's t-test.

Results
20 children (age 7.5±4 yrs.) with SMA (11%, 67%, 22% had 1, 2 or 3 SMN2 copy numbers respectively) underwent PHGT for an average duration of 3.6 weeks. MCGR instrumentation was used in 75% of patients. Average follow-up was 26±22 months. Preoperative major AP Cobb, pelvic obliquity, cervical lordosis, thoracic kyphosis, and lumbar lordosis measured 90.3°±24, 15.9°±10, 38.1°±25, 88.4°±36 and 54.6°±20 respectively. In patients with thoracolumbar hyperkyphosis (n=12, 97.2°±27), PHGT corrected sagittal deformity more than major coronal deformity (53.3% vs. 30.8%, p=0.0002)(Figure). Scoliosis and kyphosis improved equivalently (40.9% vs. 36.3%, p=0.66) for thoracic kyphosis only (n=8). Both cervical and lumbar lordosis improved by 15.3%, while the preoperative SVA shifted from +2.4cm to 0.5cm after PHGT. The location of the deformity apex cranial vs. caudal to T10 did not influence the % correction of the major coronal curve (35.5% vs. 34%;p=0.79), thoracic kyphosis (41.4% vs. 33.3%;p=0.36) or thoracolumbar kyphosis (50.5% vs. 40.2%;p=0.30)(Table).

Conclusion
PHGT corrected sagittal plane deformity more than coronal plane deformity in SMA patients with thoracolumbar hyperkyphosis. PHGT was equally effective for correction of thoracic/high thoracolumbar curves and lumbar/low thoracolumbar curves.

Table: Comparison of % correction by preoperative halo gravity traction (PHGT) by apex deformity location.

	Apex above T10 (n=12)		Apex below T10 (n=8)		p
	Preoperative (°)	PHGT Correction (%)	Preoperative (°)	PHGT Correction (%)	
Major Cobb angle	95.1	35.5	83.0	34.0	0.79
Cervical lordosis	42.0	34.3	32.1	59.2	0.23
Thoracic kyphosis	95.4	41.4	77.9	33.3	0.36
Thoracolumbar kyphosis	111.7	50.5	86.4	40.2	0.30
Lumbar lordosis	57.1	19.2	50.8	9.2	0.58

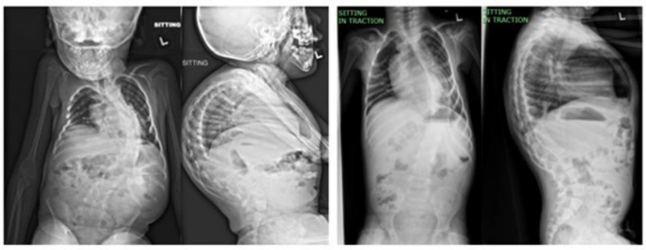

Figure: X-rays (AP/Lateral) of a patient with thoracolumbar kyphosis showing spinal deformity before (L) and after (R) PHGT.

277. RANDOMIZED CLINICAL TRIAL TO COMPARE THE IMPACT ON QUALITY OF LIFE BETWEEN FULL-TIME AND NIGHT-TIME BRACES IN ADOLESCENT IDIOPATHIC SCOLIOSIS: 12-MONTH TREATMENT OUTCOMES *

Alejandro Peiro-Garcia, MD; Inmaculada Vilalta-Vidal, MD; Victor Martin-Gorgojo, MD; Carles Fabres-Martin, MD; Rocio Garcia-Garcia, MS

Hypothesis
Night-time brace has better results on SRS-22 compared to full-time brace (FT) for adolescent idiopathic scoliosis (AIS)

Design
Randomizedclinical trial (PI20/00962)

Introduction
Conservative treatment of Adolescent Idiopathic Scoliosis (AIS) with full-time (FT) braces has proven to prevent the risk of progression and the need for surgery, with an inversely proportional relationship to the number of hours worn. However, therapeutic adherence and its effect on quality of life continue to pose a clinical challenge. This clinical trial aims to compare the effect on quality of life of FT versus night-time (NT) braces using SRS-22 questionnaires.

Methods
Randomized clinical trial (PI20/00962), comparing the quality of life of FT with NT in AIS. Results are presented at 12 months from the start of treatment. The SRS-22 questionnaire was used to assess the effect on quality of life before the start of treatment, at 3 months with the brace, as well as at 6 and 12 months.

Results
A total of 78 AIS patients were recruited, with 35 (44.30%) receiving FT treatment and 43 (55.69%) receiving NT treatment. The mean initial main curve was 35.59° for FT and 34.40° for NT (p 0.232). SRS-22 questionnaire data at the initial visit did not show statistically significant differences comparing both groups in any of the sections. Despite finding significant differences at 6 months, no statistically significant differences were observed in function (p 0.516), pain (p 0.411), mental health (p 0.674), satisfaction (p.718), or self-image (p 0.182). Comparing the evolution of SRS-22 results over 12 months, a trend towards higher values at 12 months compared to the initial assessment was observed. Patients with higher brace adherence in both groups showed better satisfaction results at 6 months, and NT showed better results in pain and total score. Additionally, patients requiring surgery had worse SRS-22 results in total score and self-image.

Conclusion
At 12 months of treatment, both braces show no statistically significant differences in SRS-22 results. However, patients eventually requiring surgery had worse results in total score and self-image.

†Louis A. Goldstein Best Clinical Research E-Point Presentation *John H. Moe Best Basic Research E-Point Presentation ‡SRS Funded Research Grant
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E-POINT PRESENTATION ABSTRACTS

278. ARE WE "UNDER-BRACING" IDIOPATHIC SCOLIOSIS? EFFECTIVENESS OF A PROVIDENCE NIGHT BRACE FOR CURVES UNDER 25 DEGREES

Mathieu Boulet, MD; Julie Joncas, RN; Hubert Labelle, MD; Jean-Marc Mac-Thiong, MD, PhD; Olivier Chémaly, MD; Felix L. Brassard, MD; Stefan Parent, MD, PhD

Hypothesis

The Providence night brace reduces progression rate in the treatment of immature idiopathic curves between 18 and 24°.

Design

Prospectively collected data from a cohort of idiopathic scoliosis was retrospectively analyzed.

Introduction

Observational studies have shown a significant progression rate (68%) in skeletally immature curves between 20 - 30°. Untreated immature curves have been previously shown to progress to a full-time bracing indication. Most bracing studies reported that conservative management is more effective with smaller and more flexible curves. The objective of this study was to determine if the 25° threshold for brace initiation should be revisited.

Methods

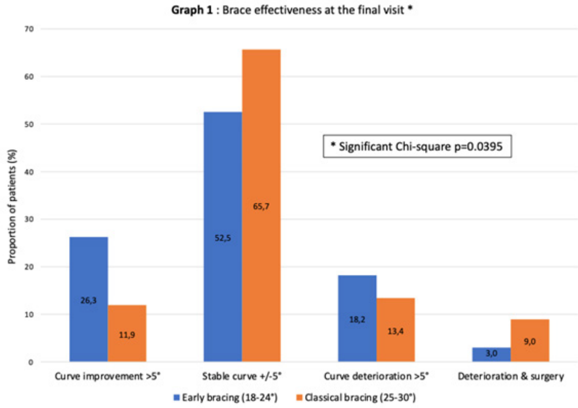
A prospective cohort of 166 idiopathic scoliosis was divided into two groups for comparison: 99 curves between 18° - 24° and 67 curves between 25° - 30°. Only skeletally immature patients were included (Risser 0 - 1 and 2).

Results

For the cohort with early bracing (18° - 24°), mean age at initiation was 12.6 years (mean Risser 0.5 / Sanders 2.6). The average treatment duration with the night brace was 1.7 years. Mean Cobb angle did not significantly progress (22.2° at initiation of treatment vs. 22.5° after treatment (paired T-test p=0.37). For the 25° - 30° cohort, mean age was 13.3 years at the brace initiation (mean Risser 0.8 / Sanders 3.7). This cohort spent an average of 1.2 years in a brace. Cobb angle means were 27.3° before, and 29.6° after treatment (paired T-test p=0.017). Globally, patients were followed for a mean of 2.4 years until maturity at mean age of 15.3 (mean Risser 4.2 / Sanders 6.9). Curve improvement (decrease >5°) was seen more often in the earlier cohort when compared to the classical bracing cohort (26.3% vs 11.9%). Of the patients with curve deterioration (increase >5°), fewer patients had to be consented for surgery in the early start group (3% vs 9%). These differences were significant on a Chi-square test (p=0.039).

Conclusion

Night-time bracing in curves under the classical SRS bracing guidelines resulted in a greater proportion of patients with improved radiographic outcomes and a smaller proportion of patients undergoing surgery. An earlier night brace approach could be effective in reducing the burden of care when compared to a more delayed classical strategy often relying on full-time bracing.



Graph 1 : Brace effectiveness at the final visit

279. ETIOLOGICAL FACTORS OF PROXIMAL JUNCTIONAL KYPHOSIS AND FAILURE IN ADULT SPINAL DEFORMITY

Jamshaid Mir, MD; Tobi Onafowokan, MBBS; Ankita Das, BS; Renaud Lafage, MS; Bassel G. Diebo, MD; Alan H. Daniels, MD; Thomas J. Buell, MD; Robert K. Eastlack, MD; Peter G. Passias, MD

Hypothesis

Acute compared to chronic developoment of PJK has different etiology and risk factors.

Design

Retrospective cohort study of a prospectively collected single-center database

Introduction

Proximal junctional kyphosis (PJK) although mostly asymptomatic, entails a spectrum, with the severe end classified as proximal junctional failure. Despite proximal junctional kyphosis being a well-studied entity, there is a paucity of studies evaluating factors associated with different PJK etiologies.

Methods

Adult spinal deformity(ASD) patients with 4-year(4Y) data, fused from at least T1 to sacrum were included. Groups based on timing of PJK and PJF. Subanalysis of upper instrumented vertebra (UIV) at lower thoracic or upper thoracic regions was conducted. Thoracolumbar inflection point(IP), thoracic decompensation(TD),lumbar lordosis apex (LLA) and distribution (LDI) was assessed. ANCOVA analysis adjusted for age, BMI, CCI, frailty, invasiveness, and PJK prophylaxis was used. Multivariable logistic regression controlled for baseline differences.

Results

683 patients were included. 67.5% had no PJK or PJF(nPJK), 14.3% had TD, 20.5% had early PJK with no PJF(PJKe), 11.1% had late-PJK(PJKL), 6.3% had early-PJF(PJFe), and 10.2% developed PJF-late(PJFL). 19% of PJFe had implant failure, of which 16% were due to rod fracture. PJFL had 33% implant failure, 20% rod fracture, and 9% implant dislocation. Major rod breakage rates were higher in PJFL and TD compared to PJKL(p<.05). In those with lower thoracic UIV, PJFe had significantly higher SVA compared

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to PJFL(p=0.003). Multivariable regression depicted higher postoperative PT and decreased postoperative PI-LL to be predictive of PJF in those fused to lower thoracic(p<0.001). Those fused to upper-thoracic depicted decreased postoperative PT was predictive of PJFe(p=0.032).

Conclusion

Patients who developed proximal junctional failure were more likely to have higher upper instrumented vertebra inclination angles.Earlier PJF was associated with hardware failure or fracture and was more likely to occur in highly frail overcorrected patients. The delayed presentation of PJK occurred in those with inadequate correction of pelvic tilt and suboptimal LDI.

280. COMPARING 3 AND 4 ROD CONSTRUCTS IN ADULT SPINAL DEFORMITY PATIENTS FUSED TO THE SACRUM: IS THERE A DIFFERENCE IN ROD FRACTURES AND REVISION RATES AT A MINIMUM 2 YEAR FOLLOW-UP?

Fthimnir Hassan, MPH; SIrthak Mohanty, BS; Erik Lewerenz, BS; Christopher Mikhail, MD; Stephen Stephan, MD; Andrew Platt, MD; Joshua Bakshеshian, MD; Nathan J. Lee, MD; Justin Reyes, MS; Gabriella Greisberg, BS; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

Hypothesis

4 rod constructs (4R) across the lumbosacral junction (LSJ) are protective against rod fractures and revisions when compared to 3 rod constructs (3R).

Design

Retrospective analysis w/in a prospectively collected single center database of adult spinal deformity (ASD) pts instrumented to the sacrum/pelvis w/ ≥6 levels fused and min 2yr follow up(FU).

Introduction

The literature espouses the use of >2 rods for increasing construct rigidly and reducing pseudarthrosis and rod fracture (RF) rates among ASD pts undergoing a 3-column osteotomy (3CO). However, a comparison between 3R and 4R constructs in ASD pts fused to the sacrum has not been performed.

Methods

ASD pts undergoing long instrumented fusions to the sacrum w/ a mean total instrumented levels (TIL) of 15.5±4.0 were dichotomized between 3R and 4R constructs extending to the sacrum/pelvis. Outcomes of interest include the occurrence of RFs and RFs requiring revision (RFR). Appropriate statistical tests were conducted for bivariate analyses and multivariable logistic regression models were built.

Results

145 pts were included (3R=57, 4R=88). Both groups were comparable at in terms of age, gender, and number of revision cases aside from the 4RC having a greater BMI (28.0±6.9 vs 24.9±4.9, p=0.002). The 4RC had longer OR time (8.6±1.8 vs 7.8±1.4hr,p=0.002), greater EBL (1700±171 vs 1330±666 vs, p-0.002), TIL (16.1±4.1 vs 14.6±3.7, p=0.028), and more 3COs performed (20.5% vs 7.0%,p=0.028). Radiographically, 4R pts had greater preop CVA (28.2±24.9 vs 18.5±16.9mm, p=0.006) and SVA (55.1±64.8 vs 30.4±41.8mm, p=0.006). At final FU, 4R pts had a greater CVA (22.9±16.7 vs 16.5±15.9, p=0.028) and TK (43.3±10.4 vs 39.3±13.1, p=0.047). 3R pts had similar rates of RF overall (28.1% vs 14.8%, p=0.0506) and RFR (14.9% vs 10.2%, p=0.486) when compared to 4R pts. After adjusting for the change in SVA, CVA, TIL, 3COs performed, and BMI, 3RC were associated with a 4.85x greater odds (p=0.0073) of experiencing RFs overall vs 4RC (AUC=0.74). However, this was not the case for RFR (OR=2.89 [0.69-12.15], p=0.0862).

Conclusion

This is the largest single center series of ASD pts comparing 3R vs 4R constructs for long fusions to the sacrum. We found that 3R constructs were at greater risk of developing RF, but not RFR, compared to 4R constructs despite worse preoperative radiographic and clinical parameters.

Odds of a rod fracture occurring by final follow up				
	Univariate	p-value	Adjusted	p-value
3 RC vs 4 RC	2.25 (0.99 – 5.14)	0.0538	**4.85 (1.53 – 15.35)**	**0.0073**
BMI	1.00 (0.94 – 1.07)	0.5905	1.00 (0.93 – 1.08)	0.9093
TIV	1.01 (0.91 – 1.12)	0.8599	1.05 (0.92 – 1.21)	0.4836
3CO performed	2.14 (0.78 – 5.88)	0.1338	**5.46 (1.17 – 25.42)**	**0.0306**
TLIF Mean levels	0.65 (0.34 – 1.27)	0.2078	0.67 (0.32 – 1.42)	0.2969
Δ CVA (mm)	1.01 (0.99 – 1.03)	0.3431	1.00 (0.98 – 1.03)	0.8167
Δ SVA (mm)	1.00 (0.99 – 1.01)	0.6910	1.00 (0.99 – 1.01)	0.8015
Odd of a rod fracture and pseudarthrosis requiring revision by final follow up				
	Univariate	p-value	Adjusted	p-value
3 RC vs 4 RC	1.43 (0.52 – 3.96)	0.4879	2.89 (0.69 – 12.15)	0.0862
BMI	1.02 (0.95 – 1.10)	0.5905	1.00 (0.92 – 1.08)	0.9083
TIV	1.04 (0.91 – 1.18)	0.5865	1.09 (0.91 – 1.30)	0.3577
3CO performed	**3.82 (1.24 – 11.75)**	**0.0195**	**12.12 (2.19 – 67.14)**	**0.0043**
TLIF Mean levels	0.65 (0.28 – 1.54)	0.3284	0.65 (0.25 – 1.72)	0.3835
Δ CVA (mm)	1.01 (0.99 – 1.04)	0.3467	1.02 (1.00 – 1.01)	0.1171
Δ SVA (mm)	1.00 (0.99 – 1.01)	0.9694	1.00 (0.99 – 1.05)	0.5317

RC – rod construct; *BMI* – body mass index; *OR* – operating room; *EBL* – estimated blood loss; *TIL* – total instrumented levels; *3CO* – 3-column osteotomy; *TLIF* – transforaminal interbody fusion; *CVA* – coronal vertical axis; *SVA* – sagittal vertical axis; *TK* – thoracic kyphosis

281. DOES AN IMPROVEMENT IN INTRAOPERATIVE NEUROMONITORING CORD DATA INDICATE A REDUCED RISK FOR POSTOPERATIVE DEFICIT IN SPINE DEFORMITY SURGERY?

Nathan J. Lee, MD; Fthimnir Hassan, MPH; Alexandra Dionne, BS; Chidebelum Nnake, BS; Mitchell Yeary, BS; Michael Fields, MD, BS; Matthew Simhon, MD; Ted Shi, BS; Varun Arvind, MD, PhD; Anastasia Ferraro, BS; Matthew Cooney, BS; Erik Lewerenz, BS; Justin Reyes, MS; Steven G. Roth, MD; Chun Wai Hung, MD; Justin K. Scheer, MD; Thomas M. Zervos, MD; Earl D. Thuet, BS; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

Hypothesis

Improvement in intraoperative Neuromonitoring(IONM) data is associated with lower risk for postoperative exam deficit.

Design

Retrospective Single Surgeon

†Louis A. Goldstein Best Clinical Research E-Point Presentation *John H. Moe Best Basic Research E-Point Presentation ‡SRS Funded Research Grant

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E-POINT PRESENTATION ABSTRACTS

Introduction
Multimodal IONM is a standard adjunct for spinal deformity surgery. The incidence and timing of IONM loss and protocols to mitigate IONM changes have been studied in prior literature; however, it remains unclear what the impact of IONM data improvement has on actual postoperative exam.

Methods
A consecutive series of 1,065 patients underwent spine deformity surgery from 2015 to 2023 by a single surgeon. IONM data was reviewed with the senior member of the neuromonitoring team. Cord alerts were defined by Somatosensory Evoked Potentials(SSEP;warning criteria:10% increase in latency or >50% loss in amplitude) and Motor Evoked Potentials(MEP;warning criteria:75% loss in amplitude w/o return to acceptable limits after stimulation up 100volts above baseline level), Descending Neurogenic Evoked Potentials(DNEP) and Stagnara Wake-up Test(WUT). Timing of IONM loss, interventions, and baseline/post-operative day 1(POD1) lower extremity motor scores were analyzed.

Results
IONM Cord loss was 5%(53/1065) and 34%(18/53) of patients with cord alerts had a POD1 deficit compared to preop motor exam. MEP loss and SSEP loss attributed to 98%(52/53) and 40%(21/53) of cord alerts, respectively. Abnormal DNEP was seen in 86%(12/14) and detected 92%(11/12) with POD1 deficit. Abnormal WUT was seen in 39%(5/13) and detected 100%(5/5) with POD1 deficit. Most cord alerts occurred during a 3-column osteotomy(N=23; decompression =12, compression=7, exposure=4) and rod placement(N=14). Interventions were performed in all 53 patients with cord loss. Common interventions included removing rods/less correction(N=11), increasing mean arterial pressure alone(N=10), and further decompression with 3-column osteotomy(N=9). After intervention, IONM data improved in 85% of patients(Full improvement:N=28; Partial improvement:17). For those with full and partial IONM improvement, POD1 deficit was 11%(3/28) and 41%(7/17), respectively. For those without any IONM improvement(15%, 8/53) by closure, 100%(8/8) had a POD1 deficit, P<0.001.

Conclusion
A full and partial improvement in IONM data after intraop intervention was significantly associated with a lower risk for POD1 deficit with an absolute risk reduction of 89% and 59%, respectively.

Timing of IONM Cord Loss, N=53	#	%
3CO	23	43.4%
3CO_Decompression	12	
3CO_Compression	7	
3CO_Exposure	4	
Rod Placement/Correction	14	26.4%
Decompression/PCO	8	15.1%
After Screws	3	5.7%
Unclear	2	3.8%
Other Anesthesia	2	3.8%
Intra-op Hypotension Alone	1	1.9%
Interventions	**#**	**%**
Removed Rods/Less Correction	11	20.8%
Increased MAP Alone	10	18.9%
Other 3CO for Further Decompression	9	17.0%
Completion of VCR + Shortening	9	17.0%
Completion of VCR	4	7.5%
Posterior Decompression	7	13.2%
Other_Compression	2	3.8%
Positional	1	1.9%

283. A CLINICAL EFFICACY OF THE CHECKLIST WITH STIMULUS ADJUSTMENT FOR THE RESPONSE TO INTRAOPERATIVE NEUROMONITORING

Tomohisa Hashimoto, BS; Koki Uno, MD, PhD; Teppei Suzuki, MD, PhD; Masaaki Ito, MD, PhD; Yoshiki Takeoka, MD, PhD; Keita Nakashima, MD

Hypothesis
The use of Amplitude Technique with the intraoperative neuromonitoring (IONM) alert response checklist reduces the false-positive cases.

Design
Retrospective study

Introduction
IONM using Transcranial-Motor-Evoked-Potentials (TcMEP) has become a standard for spinal deformity surgeries. However, TcMEP are susceptible to false-positive alert, which confounds decisions on surgical intervention. At our institution, the increase of TcMEP stimulus intensity or pulse is used when TcMEP degrades into alert point (>70%), as an adjunct method to verify the authenticity of the alert,"Amplitude Technique". The aim of this study was to determine the diagnostic sensitivity of TcMEP and the potential therapeutic impact of using Amplitude Technique with the Scoliosis Research Society Checklist for IONM alerts.

Methods
A retrospective review of consecutive 2054 cases of spinal deformity surgery over a 12-year period at a single institution were compared in 2 groups: without Amplitude Technique (fixed stimulus) and With Amplitude Technique. Subjects were included in the study only if surgeries used the TcMEP. We analyzed the course of surgery, and the clinical outcome of TcMEP.

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Results
A total of 1883 cases were included in the study and in 920 of them Without Amplitude Technique was used, while in 963 cases Amplitude Technique was used. TcMEP alerts (Without/With Amplitude Technique) were showed in 30.4 and 47.5%, waveform recoveries were achieved 10.4 and 43.8%, respectively. In the Without Amplitude Technique cohort, false-positive cases of incomplete surgery in 0.3% was performed because waveform recovery was not achieved, with no similar response in Amplitude Technique cohort. Clinical outcome of TcMEP was showed true-positive18(2%)/19(2%), false-positive167(18.2%)/35(3.6%), true-negative720(78.3%)/886(92%), false-negative 8(0.9%)/4(0.4%), and waveform recoveries by surgical intervention 7(0.8%)/19(20%), respectively. Therefore, with Amplitude Technique, there was greater percentage of improvement in sensitivity (75.8%/90.5%), in specificity (81.3%/96.2%), and in positive-predictive-value (13%/52.1%).

Conclusion
IONM using Amplitude Technique is more effective and accurate in assessing spinal cord and nerve root function during spine surgeries and reduces false-positive findings compared to IONM using fixed stimulus. We recommend IONM using Amplitude Technique in all complex spinal deformity surgeries.

285. THE ASSOCIATION BETWEEN MULTIFIDUS DEGENERATION AND SAGITTAL PARAMETERS, QUALITY OF LIFE, AND POSTOPERATIVE COMPLICATIONS IN OSTEOPOROTIC VERTEBRAL COMPRESSION FRACTURE PATIENTS WITH KYPHOSIS DEFORMITY

Junyu Li, MD; Zimo Wang, MD; Gengyu Han, MD; Zhuoran Sun, MD; Yongqiang Wang, MD; Miao Yu, MD; Weishi Li, MD; Yan Zeng, MD

Hypothesis
There are potential associations between MF degeneration and QoL,sagittal parameters and mechanical complications in OVCF patients with kyphosis deformity.

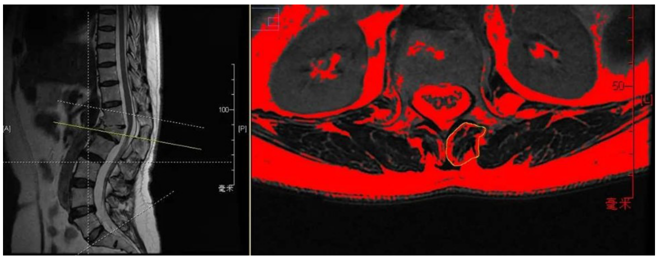
Design
Retrospective cohort study.

Introduction
OVCF is a serious condition affecting the elderly, causing pain, insomnia, kyphosis, neurological impairment, increased fracture risk, and mortality. Corrective surgery for OVCF-related kyphosis is challenging in severe osteoporosis and advanced age patients. MF muscle degeneration is key in multiple OVCFs. This study aims to investigate potential associations between MF muscle degeneration and QoL, sagittal parameters, and mechanical complications. Understanding these relationships could lead to more effective treatment and management of OVCF patients with kyphosis.

Methods
Included were 104 OVCF patients with kyphosis who underwent corrective surgery and were followed for 2 years. MRI was used to assess paraspinal muscle morphology. Preoperatively, VAS, ODI, JOA, and SRS-22 were conducted. Spine sagittal parameters were analyzed pre-op, post-op, and last follow-up. We looked at the link between MF degeneration and post-op mechanical complications. Correlations between paraspinal muscle parameters and QoL/sagittal parameters were tested. We also compared muscle parameters between groups based on sagittal parameters and complication occurrence.

Results
Strong correlations were observed between VAS and FI, rFCSA, and rGCSA. Preoperatively, rFCSA and rGCSA were strongly related to LL, TLK, TK. FI and TLK loss, TK loss; rGCSA and SVA loss, TPA loss; rGCSA and TPA loss, FI and GK loss. FI was higher in the complication-presence group.

Conclusion
MF degeneration significantly impacts QoL, sagittal parameters, and mechanical complications in OVCF patients with kyphosis. Incorporating paravertebral muscle pathology into surgical and rehabilitation strategies can improve outcomes in these patients.



Measurement of fatty infiltration of the multifidus muscle: Measurements of mutifidus parameters on axial T2-weighted MRI (a 52-year-old woman) Thresholding technique to highlight fat area (red area).

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INDUSTRY WORKSHOPS & NETWORKING SESSIONS

The Scoliosis Research Society gratefully acknowledges Medtronic and Stryker for supporting the DEI table.

INDUSTRY WORKSHOPS

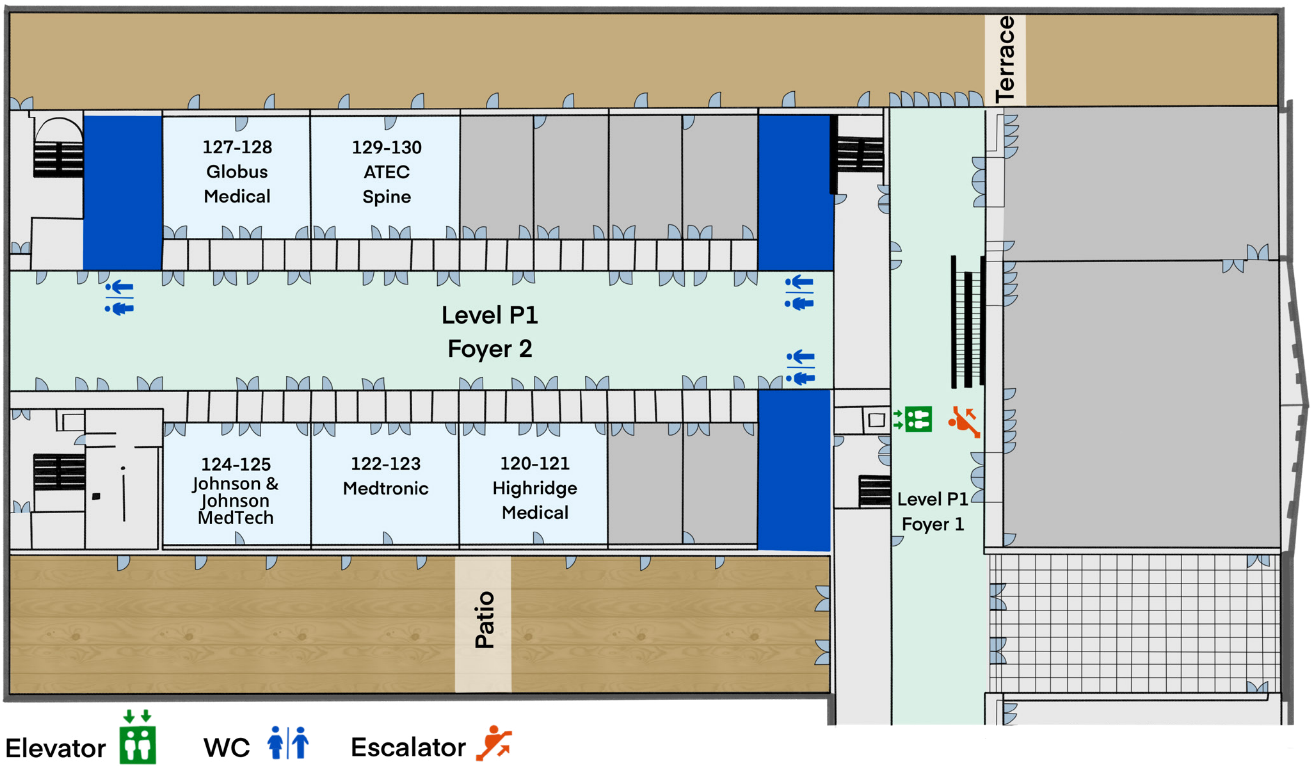
Annual Meeting delegates are encouraged to attend the Industry Workshops. Each workshop is programmed by a single-supporting company and will feature presentations on topics selected by the company.

Please note: CME credits are not available for Industry Workshops.

Thursday, September 12 | 13:30-15:00

Location: Level P1, Foyer 2

Room	Company
Room 120-121	Highridge Medical
Room 122-123	Medtronic
Room 124-125	Johnson & Johnson MedTech
Room 127-128	Globus Medical
Room 129-130	ATEC Spine



INDUSTRY WORKSHOPS

INDUSTRY WORKSHOPS | THURSDAY, SEPTEMBER 12 | 13:30-15:00

13:30-15:00 | Room 120-121

Highridge Medical – What have we learned in the past 5 years?

Faculty: Amer Samdani, MD; John Braun, MD; Ahmet Alanay, MD; Steve Hwang, MD

Description: Vertebral Body Tethering preserves motion while stopping curve progression in select AIS patients. Join world-class surgeons as they share a joint understanding of VBT applications through case discussions with over five years of patient follow-up

13:30-15:00 | Room 122-123

Medtronic – Modular Solutions and the Evolution of Intelligence Based Planning Utilizing New Levels of Intraoperative Imaging

Moderator: Marinus de Kleuver, MD, PhD

Panelist: Lindsay Andras, MD; Jeff Gum, MD; Tenner Guillaume, MD; Gregory Mundis, MD

Description: Discover the latest transformative deformity solutions, including enhanced visualization with modular systems and patient specific approaches to spine surgery. Learn strategies for planning sagittal alignment goals using UNiD™ASI, executing your planned ModuLeX™ screw trajectories in the O.R by leveraging the Mazor X Stealth Edition™ robotic guidance system and Stealth™ Navigation with the new O-arm™ 3D Long Scan, and verifying the plan intra-operatively using O-arm™ 2D Long Film.

13:30-15:00 | Room 124-125

Johnson & Johnson MedTech – Lessons I Wish I Had Learned in Complex Spine

Faculty: Amit Jain, MD; Eric O. Klineberg, MD; A. Noelle Larson, MD; Julian Leong, MD; Daniel Sciubba, MD; Suken A. Shah, MD; Burt Yaszay, MD

Description: The orthopaedics solutions of J&J MedTech provides one of the most comprehensive orthopaedics portfolios in the world that helps heal and restore movement for the millions of patients we serve. J&J MedTech's solutions, in specialties including joint reconstruction, trauma, extremities, craniomaxillofacial, spinal surgery and sports medicine, in addition to the VELYS™ Enabling Tech portfolio, are designed to advance patient care while delivering clinical and economic value.

13:30-15:00 | Room 127-128

Globus Medical – Challenges and controversies in the surgical management of adult complex spinal deformity

Faculty: Neel Anand, MD; Martin Gehrchen, MD; Serena Hu, MD; Ferran Pellise, MD, PhD; Rajiv Sethi, MD

Description: Hear from our esteemed faculty as they lead a case-based discussion around tips, pearls, and strategies that they employ to tackle the biggest challenges in the surgical treatment of complex adult spinal deformity.

13:30-15:00 | Room 129-130

ATEC Spine – AI-Informed Surgery with EOS: Shaping the Future of Deformity

Faculty: Christopher Ames, MD; Tyler R. Koski, MD; Virginie Lafage, PhD

Description: We cordially invite you to join our esteemed surgeon panel featuring Drs. Chris Ames, Tyler Koski, Rajiv Sethi, and Virgie Lafage for an insightful discussion on the critical challenges and complexities in spinal deformity. We will also explore the transformative potential of recent advancements in end-to-end technology platforms, such as EOS. Engage with the panel to gain valuable perspectives on how integrated, AI-powered solutions are poised to streamline standardization and enhance the application of the latest insights in our field. These innovations aim to significantly improve predictability and outcomes at the point of care.

INDUSTRY NETWORKING SESSIONS

NETWORKING SESSIONS | THURSDAY, SEPTEMBER 12 | 17:00 - 18:30

Delegates are encouraged to attend hosted Networking Sessions immediately following the last session of the day. Networking Sessions will be hosted by:

Location Level P1, Foyer 2

ATEC Spine	Room 119
Highridge Medical	Room 133
Medtronic	Room 118
Stryker	Room 131

Please note: CME credits are not available for Industry Networking Sessions.

ATEC Spine

At ATEC, we are dedicated to advancing spine surgery through the development of innovative, cutting-edge technologies. As a leader in the field, we create advanced solutions designed to empower surgeons and improve outcome predictability. Our focus on innovation is highlighted by the acquisition of EOS imaging. Leveraging the EOSedge standardized imaging platform, ATEC has created EOSInsight, an integrated, end-to-end ecosystem comprised of point-of-care software solutions, a unified cloud-based portal, and AI algorithms to better inform clinical decisions.

Join us at the networking session to hear Pat Miles, our Chairman and CEO, share the ATEC/EOS vision and our commitment to the advancement of complex spine and deformity surgery."

Highridge Medical

Highridge Medical – Confidence That Moves

Join Highridge Executive Chairman of the Board Eric Major and Chief Executive Officer Rebecca Whitney to discuss the future of the largest privately held spinal implant company in the world. Headquartered outside of Boulder, CO, Highridge is a new company with a rich history and experienced leadership team. Come learn more about our exciting vision for the future of Spine.

Medtronic

Please join us for drinks and lively discussion around our AiBLE Ecosystem. Engage with business and customer engagement leaders as we celebrate the 75th anniversary of Medtronic and the incredible legacy and impact of CD Horizon technology on patients around the world.

Stryker

Hola! Bienvenido! Hello! Welcome!

Please join us for tapas and vino in our hospitality suite, room 131, and learn more about cutting-edge enabling technologies like the Q Guidance System and Airo TruCT, as well as our trusted Stryker implants like the Mesa and Everest Spinal Systems. Meet our leaders and hear more about our commitment to advancing healthcare alongside you.

RELEVANT FINANCIAL RELATIONSHIP DISCLOSURES

The Scoliosis Research Society gratefully acknowledges Stryker for their Educational Grant support of the Annual Meeting.

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Meeting Information
Meeting Agenda
Abstracts
Industry Workshops
Disclosures
Author Index
About SRS

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Name	Country	Disclosure(s)
Joseph P. Gjolaj, MD, FACS, FAOA	United States	DePuy Synthes (b, e); NuVasive (b); NuVasive (a); Carlsmed (b); Cerapedics (a)
Patrick C. Hsieh, MD, MBA, MSc	United States	Medtronic (g)
Ki S. Hwang, MD	United States	Stryker Spine (b)
Pawel P. Jankowski, MD	United States	SI Bone (b); Seaspine (b, g); Spine Vision (b); NEO (b)
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David B. Bumpass, MD	United States	Medtronic (b, d)
Patrick J. Cahill, MD	United States	Intellectual property of Dynamic lung MRI (g); Pediatric Spine Foundation (a); Setting Scoliosis Straight Foundation (a); Intellectual property of novel pediatric spinal implant (g)
Michael S. Chang, MD	United States	Corelink (b); Stryker Spine (b); Spinewave (b); BK (g); MiRus (g)
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Michael J. Faloon, MD	United States	Stryker Spine (a, b); Centinel Spine (a)
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William F. Lavelle, MD	United States	DePuy Synthes (a, b); Medtronic (a); Abryx (a); 3 Spine (a); Innovasis (e); Spinal Kinetics, Inc. (a); Vertebral Technologies, Inc. (a); Emprical Spine (a); 4-Web (b, c); Expanding Innovations (c); TruSpine (e); AO Foundation (a); Vertiflex (e)
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Ibrahim Obeid, MD	France	Alphatec Spine (g); DePuy Synthes (a, b); Medtronic (b); Spineart, Medicrea (g)
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Khoi D. Than, MD	United States	Bioventus (b); DePuy Synthes (b); SI Bone (d); NuVasive (b); Cerapedics (b)
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Mitsuru Yagi, MD, PhD	Japan	Medtronic (b); DePuy Synthes (b); Zimmer Biomet (b); MDsim (c, e)

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Name	Country	Disclosure(s)
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Mark A. Erickson, MD	United States	NuVasive (b, d); Medtronic (b, d)
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Nitin Agarwal, MD	United States	Thieme Medical Publishers (g); Springer International Publishing (g)
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Jason B. Anari, MD	United States	DePuy Synthes (b)
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Anthony L. Asher, MD	United States	Globus Medical (b)
Teresa Bas, MD, PhD	Spain	Globus Medical (d); Medtronic (d); Zimmer Biomet (d); Novartis (d)
Sigurd H. Berven, MD	United States	Globus Medical (e); Medtronic (b, e, g); Stryker Spine (b, g); Accelus (b); Innovasis (b, e); Camber spine (b, g); Novapproach (b, g); Green Sun Medical (e, g); Aclarion (b)

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Shay Bess, MD	United States	DePuy Synthes (a); Globus Medical (a); Stryker Spine (a, b, d, e, g); Medtronic (a); NuVasive (a, g); DePuy Synthes (a); SI Bone (a); Stryker Spine (a, b, d, e, g); carlsmed (a); Alphatec Spine (b)
Markku Biedermann, MD	Germany	Biedermann Motech (e, f)
Michael Bigham, MD	United States	ForTec Medical (b)
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Benjamin Blondel, MD, PhD	France	Medicrea / Medtronic (b); Stryker Spine (b); Implanet (b); Silony Medical (b)
Oheneba Boachie-Adjei, MD	Ghana	Stryker Spine (a, b, e, g); WEIGAO (b, d)
Louis Boissiere, MD	France	Spinevision (b); Euros (b); Spineart (b)
Maryse Bouchard, MD, FRCS(C)	Canada	OrthoPediatrics (b); MD Orthopaedics (g); NuVasive (b); OrthoFlexion (c)
Houssam Bouloussa, MD, MS	United States	Spineart (b)
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Morgan Brown, MS	United States	Norton Healthcare (f); Biom'Up (a); Empirical Spine, INC. (a); Alan L. & Jacqueline B. Stuart Spine Research (a); Cerapedics, Inc. (a); Scoliosis Research Society (SRS) (a); Medtronic (a); Stryker Spine (a); National Spine Health Foundation (a); The International Spine Study Group Foundation (a)
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Mats Bue, MD, PhD	Denmark	Advanz Pharma (e)
Joshua Bunch, MD	United States	Globus Medical (b); Acuity Surgical (g); DePuy Synthes (b)
Shane Burch, MD	United States	Medtronic (a, b, e); NuVasive (b, f)
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Amalia Capilla, PhD	Spain	EpiDisease S.L. (f)
Leah Y. Carreon, MD	United States	Medtronic (a); Pfizer, Cerapedics, Empirical Spine (a); Stryker Spine (a)
Germán Casabó-Vallés, MS	Spain	EpiDisease SL (f)
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Peter J. Cundy, MBBS	Australia	OrthoPediatrics (a)
Matthew E. Cunningham, MD, PhD	United States	Sustain Surgical (c)
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David Essig, MD	United States	Stryker Spine (b); SI Bone (b)
David S. Feldman, MD	United States	NuVasive (b); OrthoPediatrics (b); Medacta (b)
Emmanuelle Ferrero, MD, PhD	France	Implanet (b); Medtronic (d)
Richard G. Fessler, MD	United States	DePuy Synthes (b); Spinal Elements (b); InQ Innovations (g); Orthofix (b)
John M. Flynn, MD	United States	Zimmer Biomet (g); Wolters Kluwer publishers (g)
Jeremy L. Fogelson, MD	United States	Medtronic (b)
Kevin T. Foley, MD	United States	Medtronic (b, c, g); NuVasive (c); Discgenics (c, e); RevBio (c, e); Accelus (c); Triad Life Sciences (c); DuraStat (c, e); True Digital Surgery (c, e)
Wouter Foppen, MD, PhD	Netherlands	Pfizer (b); SyntryX (b)
Sofía Frank, PhD	Argentina	Medtronic (a)
Brett A. Freedman, MD	United States	Medtronic (a, g); Clear Choice Therapeutics, Inc (c, g); Ankasa (a); NeuroInnovations, Inc (g); Kuros (b)
Kai-Ming Gregory Fu, MD	United States	DePuy Synthes (b); Alphatec Spine (b); Misonix (b)
Stéphane Fuentes, PhD	France	Medtronic (b); safe orthopaedics (g)
Peter G. Gabos, MD	United States	DePuy Synthes (b)
José Luis García-Giménez, PhD	Spain	Epidisease (c)
Eva García-López, PhD	Spain	Epidisease (f)
Sumeet Garg, MD	United States	Medtronic (b)
Steven Garvin, CRNA	United States	Edwards LifeSciences (d)
Martin Gehrchen, MD, PhD	Denmark	Medtronic (d); Stryker Spine (a, d); NuVasive (a, d); Cerapedics (a); Smaio (d)

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Name	Country	Disclosure(s)
Paul Gerdhem, PhD	Sweden	DePuy Synthes (g)
Soufiane Ghailane, MD	France	Spinevision (a, b); Spineart (a, b)
Steven D. Glassman, MD	United States	Medtronic (a, b, g); Stryker Spine (a, b); Cerapedics (a); Biom'Up (a); Empirical Spine (a); DePuy Synthes (b)
Jaime A. Gomez, MD	United States	Stryker Spine (b)
C. Rory Goodwin, MD	United States	Medtronic (b); Stryker Spine (b)
Ryan C. Goodwin, MD	United States	Stryker Spine (b); OrthoPediatrics (b); Zimmer Biomet (b); might oak medical (b)
Brian E. Grottkau, MD	United States	Tissellis BioSciences, Inc (c); ZimVie (b)
Raymond J. Hah, MD	United States	NuVasive (a, b, e); SI Bone (b); Cerapedics (b); Alphatec Spine (a)
Matthew A. Halanski, MD	United States	OrthoPediatrics (a); Medtronic (a); Alcyone Therapuetics (e)
Azmi Hamzaoglu, MD	Turkey	Medtronic (b)
Hamid Hassanzadeh, MD	United States	NuVasive (b, c, d); Orthofix (b, d); DePuy Synthes (b)
Daniel Hedequist, MD	United States	Medtronic (a)
John A. A. Heflin, MD	United States	Globus Medical (b, g); OrthoPediatrics (b, g); Wishbone Medical (b, c)
Ilkka J. Helenius, MD, PhD	Finland	Medtronic (a, b); Stryker Spine (a); NuVasive (a, b); Globus Medical (b); Cerapedics (a)
Dennis Hey, MD, MBBS, FRCS	Singapore	NuVasive (b)
Aaron Hockley, MD	Canada	Cerapedics (e)
Grant D. Hogue, MD	United States	Tether Implant Corporation (g); Medtronic (b)
Aaron Huser, DO	United States	Biomarin (d, e)
Brice Ilharreborde, MD, PhD	France	Implanet (b); Medtronic (b); Zimmer Biomet (g)
Kenneth D. Illingworth, MD	United States	OrthoPediatrics (b)
Keita Ito, MD, PhD	Netherlands	NC Biomatrix BV (b)
Amit Jain, MD	United States	Stryker Spine (b); DePuy Synthes (b); Globus Medical (b)
Andre Jakoi, MD	United States	Medtronic (b, d); Stryker Spine (b)
Sunil Jeswani, MD	United States	Kyocera (b); Novappraoch (b)
Charles E. Johnston, MD	United States	Medtronic (g); Elsevier (g)
Kristen E. Jones, MD, FAANS	United States	Medtronic (a); SI Bone (a, b); Mizuho (a)
Adam S. Kanter, MD	United States	NuVasive (e, g); Zimmer Biomet (g)
Brian Karamian, MD	United States	DePuy Synthes (b)
Khaled M. Kebaish, MD	United States	DePuy Synthes (b, g); Stryker Spine (g); Orthofix (g); SpineCraft (g)
Michael P. Kelly, MD	United States	Setting Scoliosis Straight Foundation (a); Wolters Kluwer (f)
Marc Khalifé, MD, PhD, MS	France	NovaSpine (c); SOFCOT (a)
Han Jo Kim, MD	United States	Zimmer Biomet (g); Stryker Spine (g); Alphatec Spine (b); Surgical Acuity (g); Vivex Biologics (e); Aspen Medical (e); SI Bone (a); NuVasive (b, e)
Frank S. Kleinstueck, MD	Switzerland	DePuy Synthes (a, d)
Tyler Koski, MD	United States	NuVasive (b, g); Medtronic (g); Alphatec Spine (b); Orthofix (b)
Moyo C. Kruyt, MD, PhD	Netherlands	Cresco spine (c)
Eren Kuris, MD	United States	Seaspine (b); Spineart (b); Stryker Spine (b)
Hubert Labelle, MD	Canada	Spinologics Inc (c, g)
Renaud Lafage, MS	United States	Carlsmed (b)
Virginie Lafage, PhD	United States	Alphatec Spine (b); NuVasive (g); DePuy Synthes (d); Stryker Spine (d); Implanet (d)
Vincent Lamas, MD	France	CLARIANCE (b); TEKNIMED (b)
Darryl Lau, MD	United States	Stryker Spine (b); Alphatec Spine (b); Isto Biologics (b, e); NuVasive (b); Medtronic (b)
David F. Lawlor, MD	United States	Zim Vie (d)

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RELEVANT FINANCIAL RELATIONSHIP DISCLOSURES

Name	Country	Disclosure(s)
Sang Hun Lee, MD	United States	Medtronic (b, d); DePuy Synthes (b, d); Elliquence (b, d)
Ronald A. Lehman, MD	United States	Medtronic (b, g); Stryker Spine (g); Department of Defense (a)
Lawrence G. Lenke, MD	United States	Medtronic (b); broadwater (g); ABRYX (b); AOSPINE (a, g); Setting Scoliosis Straight Foundation (a); Acuity Surgical (b, g); Scoliosis Research Society (g)
Stephen J. Lewis, MD, FRCS(C)	Canada	Medtronic (a, d); Stryker Spine (b, d, e); DePuy Synthes (a, d); Scoliosis Research Society (d); AO Spine (a, d, e)
Ying Li, MD	United States	Medtronic (e)
Breton G. Line, BS	United States	International Spine Study Group (b)
Baron S. Lonner, MD	United States	DePuy Synthes (a, b, d, e); Zimmer Biomet (b, g); Spine Search (c); Setting Scoliosis Straight Foundation (a, e)
Craig R. Louer, MD	United States	NSite Medical (e, g); DePuy Synthes (d); NuVasive (a)
Philip K. Louie, MD	United States	Alphatec Spine (a, b); DePuy Synthes (b); Viseon (b)
Scott J. Luhmann, MD	United States	Stryker Spine (g); OrthoPediatrics (b, g); Medtronic (g); Globus Medical (g); Lippincott (g); Medtronic (g)
Jon D. Lurie, MD, MS	United States	Spinol (c, e); UptoDate (g)
Jean-Marc Mac-Thiong, MD, PhD	Canada	DePuy Synthes (a); Medline Industries (a); Medtronic (a); Spino-logics and subsidaries (c, e); Abbvie (a); Asahi Kasei Pharma (a)
Colleen Mahoney, BA	United States	Alan L. and Jacqueline B. Stuart Spine Research Center (a); Biom'Up (a); Cerapedics, Inc (a); Empirical Spine, Inc. (a); Medtronic (a); National Spine Health Foundation (a); Scoliosis Research Society (SRS) (a); Stryker Spine (a); The International Spine Study Group Foundation (a)
David S. Marks, MBBS, FRCS, FRCS(Orth)	United Kingdom	NuVasive (d)
Michelle Claire Marks, PT	United States	Setting Scoliosis Straight (f)
Jeffrey E. Martus, MD	United States	NuVasive (a)
Richard E. McCarthy, MD	United States	OrthoPediatrics (b, e); Medtronic (b, d)
Kathryn McCarthy Mullooly, MD	United States	Medtronic (b)
Jwalant S. Mehta, MD, FRCS (Orth), MCh (Orth), MS (Orth), D Orth	United Kingdom	Stryker Spine (a, b, g); DePuy Synthes (a); NuVasive (a); POSNA (a); FDA (a); Growing Spine Foundation (a); Childrens' Spine Foundation (a); Elite Health Services (c); AO Spine (d); Kuros Medical (e)
Salvador Mena, PhD	Spain	EpiDisease (c)
Cristiano Magalhaes Menezes, MD, PhD	Brazil	NuVasive (a, b, d, e)
Gregory A. Mencio, MD	United States	NuVasive (a)
Melodie F. Metzger, PhD	United States	Arthrex (a)
Todd A. Milbrandt, MD, MS	United States	Medtronic (b); OrthoPediatrics (b); Zimmer Biomet (b); Viking Scientific (b, c); seaspine (b); DePuy Synthes (b)
Stuart L. Mitchell, MD	United States	Pfizer (c); OrthoPediatrics (b)
Sander Muijs, MD, PhD	Netherlands	DePuy Synthes (d)
Jeffrey Mullin, MD	United States	Medtronic (a, b, e); NuVasive (b); SI Bone (b)
Gregory M. Mundis Jr., MD	United States	Stryker Spine (g); NuVasive (a, b, c, e, g); SeaSpine (a, b, e); VISEON (b, e); Carlsmed (b, c); SI Bone (b)
Ahmad Nassr, MD	United States	AO Spine NA (a); Premia Spine (a); 3 Spine (a); AlloSource (g)
Venu M. Nemani, MD, PhD	United States	Medtronic (b, d); NuVasive (d); Alphatec Spine (b)
Peter O. Newton, MD	United States	Spinologics (g); Globus Medical (b); DePuy Synthes (a, g); SeeAllAI (b, c); Alphatec Spine (a); Stryker Spine (a, b, g); Medtronic (a); Pacira (b); NuVasive (a); OrthoPediatrics (a); Thieme Publishing (g); ZimVie (a); Acellus (c); International Pediatric Orthopedic Think Tank (e); Harms Study Group/Setting Scoliosis Straight Foundation (e)
Edward K. Nomoto, MD	United States	Seaspine (b); NuVasive (b); Medtronic (b)

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Name	Country	Disclosure(s)
Pierce D. Nunley, MD	United States	Stryker Spine (a, b, g); Zimmer Biomet (a, b, d, g); NG Medical (b); Spineology (a, b, c, d, g); Camber Spine (b, c, d, g); IMSE (b, c, d, g); Accelus Spine (b, c, g); Kuros (a, b); Intrinsic Therapeutics (b, d); NEO Spine (b, d); Regeltec (b, c); NuVasive (a, b); Centinel Spine (a, b); Providence Medical (a, b, d); 3Spine (a, c, e); RedRock (b, c); SAIL Fusion (a, b, c); Spinal Stabilization Technologies (a, b); Spinal Elements (a, b)
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Matthew E. Oetgen, MD	United States	Medtronic (b)
David O. Okonkwo, MD, PhD	United States	NuVasive (b, g); Zimmer Biomet (b, g)
jean A. ouellet, MD	Canada	DePuy Synthes (a, b); AO Fondation (a); Momentum Health (c)
Kirk Owens, MD	United States	Medtronic (a, b); NuVasive (b, g)
Joshua M. Pahys, MD	United States	NuVasive (b); Zimmer Biomet (b); DePuy Synthes (b)
Nicholas A. Pallotta, MD, MS	United States	Stryker Spine (b); Medtronic (a); Alphatec Spine (a)
Stefan Parent, MD, PhD	Canada	Spinologics Inc. (c, f, g); EOS Imaging (a, b, g); Setting Scoliosis Straight Foundation (a); The Canada Foundation for Innovation (a); The Natural Sciences and Engineering Research Council of Canada (a); Canadian Institute of Health Research (a); Medtronic (a, b); DePuy Synthes (a, b); Stryker Spine (b); Orthopediatrics (d, g)
Paul Park, MD	United States	Globus Medical (b, g); NuVasive (b); DePuy Synthes (a, b); ISSG (a); SI Bone (a); Cerapedics (a); Accelus (b); Medtronic (b)
Saba Pasha, PhD	United States	Alphatec Spine (f)
Peter G. Passias, MD	United States	Spinevision (b); Allosource (g); CSRS (a); Globus Medical (g); Medtronic (a, b); SpineWave (b); Terumo (b)
Ashish Patel, MD	United States	NuVasive (a, b, g); Alphatec Spine (g); Stryker Spine (b); SurGenTec (b)
Alejandro Peiro-Garcia, MD	Spain	Spineart (b, g)
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Jacquelyn S. Pennings, PhD	United States	3Spine (b)
Gisselle Pérez-Machado, PhD	Spain	Epidisease (f)
Nicolas Plais, MD	Spain	Medtronic (b); Spinewave (c)
David W. Polly, MD	United States	SI Bone (b, g); Globus Medical (b); Medtronic (a); MizuhoOSI (a); Springer (g)
Selina C. Poon, MD	United States	OrthoPediatrics (d); Medtronic (d)
Eric Potts, MD	United States	Medtronic (b, g)
Themistocles S. Protopsaltis, MD	United States	Globus Medical (b); NuVasive (b); Stryker Spine (b); Medtronic (b); Altus (g); OnPoint Surgical (g); Medtronic (a); 3Spine (a)
Tiara Ratz, PhD	Switzerland	DePuy Synthes (a)
K. Daniel Riew, MD	United States	Zimmer Biomet (g); NuVasive (b, g); Happe Spine (b, c, g); Global Spine Journal (e); Axiomed, Expanding Orthopedics, Spineology, Spinal Kinetics, Amedica, Vertiflex, Benvenue Medical, Paradigm Spine (c)
Todd F. Ritzman, MD	United States	Medtronic (b, e)
Wael Saasouh, MD	United States	Edwards Lifesciences (a, e); Takeda Pharmaceuticals (e)
Comron Saifi, MD	United States	NuVasive (b, c); Alphatec Spine (c); Medtronic (a, b); Restor3d (c)
Amer F. Samdani, MD	United States	DePuy Synthes (b); Ethicon (b); Globus Medical (b); NuVasive (b, g); Stryker Spine (b); ZimVie (b, g); Medical Device Business Services (b); Mirus (b); Orthofix (b)
James O. Sanders, MD	United States	OrthoPediatrics (b); Greensun (c); Tether Implant Corporation (g); GE (c); Abbott Labs (c); Abbvie (c)
Zeeshan M. Sardar, MD	United States	Medtronic (b)
Vishal Sarwahi, MD	United States	DePuy Synthes (b); Precision Spine (g)

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RELEVANT FINANCIAL RELATIONSHIP DISCLOSURES

Name	Country	Disclosure(s)
Andrew J. Schoenfeld, MD	United States	AAOS (d); North American Spine Society (e); Journal of Bone and Joint Surgery (e); Springer (g); Wolters Kluwer Health (g); Vertex Pharmaceuticals (g)
Frank J. Schwab, MD	United States	Stryker Spine (g); International Spine Study Group (e); Zimmer Biomet (b, g); Medtronic (b, g); VFT Solutions, See Spine (c); Mainstay Medical (b)
Richard Schwend, MD	United States	OrthoPediatrics (b)
Daniel M. Sciubba, MD	United States	DePuy Synthes (b); Medtronic (b); Stryker Spine (b); Baxter (b); NuVasive (b)
Arjun Sebastian, MD	United States	DePuy Synthes (a, b); Cerapaedics (b, e); Osteocentric (b)
Peter R. Seevinck, PhD	Netherlands	MRIguidance BV (c, f)
Brett Shannon, MD	United States	Liberty Surgical (Arthrex Distributor) (g); Miach (g)
Harry L. Shufflebarger, MD	United States	Stryker Spine (b, d, g); OnPoint Surgical (e)
Wafa Skalli, PhD	France	EOS Imaging (g); Skairos (g)
Brian G. Smith, MD	United States	Green Sun (c)
John T. Smith, MD	United States	Globus Medical (b, g); NuVasive (b); Wishbone (b); GS Medical (b); Zimvie (b)
Brian D. Snyder, MD, PhD	United States	OrthoPediatrics (a, b, g)
Reuben CC Soh, MBBS, FRCS	Singapore	NuVasive (d); Medtronic (b, d)
Paul D. Sponseller, MD, MBA	United States	DePuy Synthes (a); Globus Medical (g); OrthoPediatrics (g)
European Spine Study Group	Spain	DePuy Synthes (a); Medtronic (a); NuVasive (a)
Harms Study Group	United States	DePuy Synthes (a); Alphatec Spine (a); NuVasive (a); Stryker Spine (a); Medtronic (a); FDA (a); Zimmer Biomet (a); Washington University (a); CHU University (a); Biedermann Motech (a)
International Spine Study Group	United States	DePuy Synthes (a); Stryker Spine (a); Medtronic (a); Globus Medical (a); NuVasive (a); SI Bone (a); Carlsmed (a); SeaSpine (a)
Pediatric Spine Study Group	United States	NuVasive (a, g); DePuy Synthes (a, g); OrthoPediatrics (a, g); Zimmer Biomet (a); Medtronic (a, g); Globus Medical (g); ATEC Spine (g); Stryker Spine (g); Children's Hospital Colorado Orthopedics Institute (g); Intermountain Primary Children's Hospital (g); nView Medical (g); ZimVie (g)
Peter F. Sturm, MD	United States	NuVasive (b); Green Sun Medical (c); Biedermann Motech (b)
Daniel J. Sucato, MD, MS	United States	Globus Medical (g)
Sanjeev Suratwala, MD	United States	Recuperet Health (c)
Ganesh Swamy, MD, PhD	Canada	Torus Biomedical Solutions Inc (c, f); Stryker Spine (b)
Lee A. Tan, MD	United States	Medtronic (b); Accelus (b)
Chadi Tannoury, MD	United States	DePuy Synthes (b, g); 4Web medical (c)
Alekos A. Theologis, MD	United States	Alphatec Spine (b, g); DePuy Synthes (b); Stryker Spine (b); Ulrich Medical USA (e); Restor3D (b, e); Surgalign (b); Icotec (b)
Jay D. Turner, MD	United States	NuVasive (a, b); SeaSpine (a, b, g); Alphatec Spine (b); SI Bone (a, b)
Koki Uno, MD, PhD	Japan	Stryker Spine (d); Surgical Spine (b)
Cheerag D. Upadhyaya, MD, MSc, MBA	United States	BK Medical (b, d)
Vidyadhar V. Upasani, MD	United States	DePuy Synthes (a, b); Stryker Spine (b); Indius (b); nView (a); OrthoPediatrics (a, b, g); Orthofix (b)
Juan S. Uribe, MD	United States	Misonix (b); Alphatec Spine (a, b); SI Bone (b)
Tijl van der Velden, PhD	Netherlands	MRIguidance BV (f)
Anand Veeravagu, MD	United States	Medtronic (b); NuVasive (b); DePuy Synthes (b); Stryker Spine (b)
Kushagra Verma, MD, MS	United States	NuVasive (a); Stryker Spine (a)
Michael S. Virk, MD, PhD	United States	DePuy Synthes (b); OnPoint Surgical (c)
Corey T. Walker, MD	United States	Globus Medical (d); Alphatec Spine (b)

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RELEVANT FINANCIAL RELATIONSHIP DISCLOSURES

Name	Country	Disclosure(s)
Michael Y. Wang, MD	United States	NuVasive (b); Stryker Spine (b); DePuy Synthes (b, g); Spineology (b); ISD (c); Medical Device Partners (c); Kinesiometrics (c); Pacira (b)
Karen A. Weissmann, MD, PhD	Chile	DePuy Synthes (b); OrthoPediatrics (b)
Hee-Kit Wong, FRCS	Singapore	SpineGuard (e)
Yu Yamato, MD, PhD	Japan	Medtronic (g); Japan medical dynamic marketing (g)
Michael Yang, MD, MS, FRCS(C), MBiotech	Canada	Stryker Spine (b)
Burt Yaszay, MD	United States	Stryker Spine (a, b, g); DePuy Synthes (a, b); NuVasive (a, b, g); Globus Medical (g); OrthoPediatrics (g); Biogen (b); Medtronic (b); Pacira (b)
Caglar Yilgor, MD	Turkey	Medtronic (b)
Jang Yoon, MD, MSc	United States	Kinesiometrics, INC (c, g); DePuy Synthes (a, b); TrackX (b, c); Richard Wolf (b, d); Pacira (b); MedCyclops, LLC (c); Medyssey (b)

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AUTHOR INDEX

AUTHOR INDEX

Podium Presentations: 1-178; E-Points: 201-285; HIBBS: Hibbs Society; PMC: Pre-Meeting Course; LTS 1: Hypo to Hyper Kyphosis: Challenges in Sagittal Plane Management; LTS 2: A Step Towards Improving Pre-Operative Optimization for Deformity Surgery - Creating a Pre-Operative Optimization Conference (POC); LTS 3: Surgeon Longevity in Spine Surgery: Helping Our Patients While Protecting Ourselves

AUTHOR INDEX

Podium Presentations: 1-178; E-Points: 201-285; HIBBS: Hibbs Society; PMC: Pre-Meeting Course; LTS 1: Hypo to Hyper Kyphosis: Challenges in Sagittal Plane Management; LTS 2: A Step Towards Improving Pre-Operative Optimization for Deformity Surgery - Creating a Pre-Operative Optimization Conference (POC); LTS 3: Surgeon Longevity in Spine Surgery: Helping Our Patients While Protecting Ourselves

AUTHOR INDEX

Podium Presentations: 1-178; E-Points: 201-285; HIBBS: Hibbs Society; PMC: Pre-Meeting Course; LTS 1: Hypo to Hyper Kyphosis: Challenges in Sagittal Plane Management; LTS 2: A Step Towards Improving Pre-Operative Optimization for Deformity Surgery - Creating a Pre-Operative Optimization Conference (POC); LTS 3: Surgeon Longevity in Spine Surgery: Helping Our Patients While Protecting Ourselves

Meeting Information
Meeting Agenda
Abstracts
Industry Workshops
Disclosures
Author Index
About SRS

AUTHOR INDEX

Podium Presentations: 1-178; E-Points: 201-285; HIBBS: Hibbs Society; PMC: Pre-Meeting Course; LTS 1: Hypo to Hyper Kyphosis: Challenges in Sagittal Plane Management; LTS 2: A Step Towards Improving Pre-Operative Optimization for Deformity Surgery - Creating a Pre-Operative Optimization Conference (POC); LTS 3: Surgeon Longevity in Spine Surgery: Helping Our Patients While Protecting Ourselves

AUTHOR INDEX

Podium Presentations: 1-178; E-Points: 201-285; HIBBS: Hibbs Society; PMC: Pre-Meeting Course; LTS 1: Hypo to Hyper Kyphosis: Challenges in Sagittal Plane Management; LTS 2: A Step Towards Improving Pre-Operative Optimization for Deformity Surgery - Creating a Pre-Operative Optimization Conference (POC); LTS 3: Surgeon Longevity in Spine Surgery: Helping Our Patients While Protecting Ourselves

AUTHOR INDEX

Podium Presentations: 1-178; E-Points: 201-285; HIBBS: Hibbs Society; PMC: Pre-Meeting Course; LTS 1: Hypo to Hyper Kyphosis: Challenges in Sagittal Plane Management; LTS 2: A Step Towards Improving Pre-Operative Optimization for Deformity Surgery - Creating a Pre-Operative Optimization Conference (POC); LTS 3: Surgeon Longevity in Spine Surgery: Helping Our Patients While Protecting Ourselves

AUTHOR INDEX

Podium Presentations: 1-178; E-Points: 201-285; HIBBS: Hibbs Society; PMC: Pre-Meeting Course; LTS 1: Hypo to Hyper Kyphosis: Challenges in Sagittal Plane Management; LTS 2: A Step Towards Improving Pre-Operative Optimization for Deformity Surgery - Creating a Pre-Operative Optimization Conference (POC); LTS 3: Surgeon Longevity in Spine Surgery: Helping Our Patients While Protecting Ourselves

AUTHOR INDEX

Podium Presentations: 1-178; E-Points: 201-285; HIBBS: Hibbs Society; PMC: Pre-Meeting Course; LTS 1: Hypo to Hyper Kyphosis: Challenges in Sagittal Plane Management; LTS 2: A Step Towards Improving Pre-Operative Optimization for Deformity Surgery - Creating a Pre-Operative Optimization Conference (POC); LTS 3: Surgeon Longevity in Spine Surgery: Helping Our Patients While Protecting Ourselves

AUTHOR INDEX

Podium Presentations: 1-178; E-Points: 201-285; HIBBS: Hibbs Society; PMC: Pre-Meeting Course; LTS 1: Hypo to Hyper Kyphosis: Challenges in Sagittal Plane Management; LTS 2: A Step Towards Improving Pre-Operative Optimization for Deformity Surgery - Creating a Pre-Operative Optimization Conference (POC); LTS 3: Surgeon Longevity in Spine Surgery: Helping Our Patients While Protecting Ourselves

AUTHOR INDEX

Podium Presentations: 1-178; E-Points: 201-285; HIBBS: Hibbs Society; PMC: Pre-Meeting Course; LTS 1: Hypo to Hyper Kyphosis: Challenges in Sagittal Plane Management; LTS 2: A Step Towards Improving Pre-Operative Optimization for Deformity Surgery - Creating a Pre-Operative Optimization Conference (POC); LTS 3: Surgeon Longevity in Spine Surgery: Helping Our Patients While Protecting Ourselves

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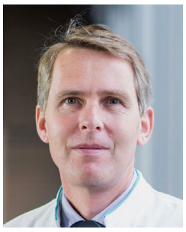
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Regional Course Committee Saumyajit Basu, MD

Research Grant Committee Peter G. Passias, MD

Research Promotion & Oversight Committee Michelle C. Marks, PT, MA

Safety & Value Committee Karen A. Weissmann, MD, PhD

Social Media Committee Ali Baaj, MD

Website Committee Denis Sakai, MD

SRS OVERVIEW

Founded in 1966, the Scoliosis Research Society is an organization of medical professionals and researchers dedicated to improving care for patients with spinal deformities. Over the years, it has grown from a group of 37 orthopaedic surgeons to an international organization of more than 1,600 health care professionals.

MISSION STATEMENT

The purpose of the Scoliosis Research Society is to foster the optimal care of all patients with spinal deformities.

DEI STATEMENT

The SRS recognizes the benefit of bringing the knowledge, perspectives, experiences, and insights of a diverse membership to our society. We are committed to including outstanding members from the broad spectrum of human ethnicities, genders, sexual orientations, national origins, geographic backgrounds, abilities, disabilities, religious beliefs, and ages. We will create a culture that is equitable and inclusive, where everyone has a voice and differences are celebrated. By building a membership and leadership who better reflect the diverse communities we study and care for, we foster better and more equitable care for patients with spinal disorders.

MEMBERSHIP

SRS is open to orthopaedic surgeons, neurosurgeons, researchers, and allied health professionals who have a practice that focuses on spinal deformity. Visit www.srs.org/membership for more information on membership types, requirement details, and to apply online.

PROGRAMS AND ACTIVITIES

SRS is focused primarily on education and research that include the Annual Meeting, the International Meeting on Advanced Spine Techniques (IMAST), Worldwide Courses, the Research Education Outreach (REO) Fund, which provides grants for spine deformity research, and development of patient education materials.

WEBSITE INFORMATION

For the latest information on SRS meetings, programs, activities, and membership please visit http://www.srs.org. The SRS Website Committee works to ensure that the website information is accurate, accessible, and tailored for target audiences. Site content is varied and frequently uses graphics to stimulate ideas and interest. Content categories include information for medical professionals, patients/public, and SRS members.

SOCIETY OFFICE STAFF

Ashtin Neuschaefer, CAE - *Executive Director*
Rachel Davis - *Administrative Manager*
Grace Donlin - *Meetings Manager*
Erica Ems - *Membership & Development Manager*
Sammie Farrall - *Digital Communications Manager*
Madison Lower - *Education Manager*
Laura Pizur - *Research Program Manager*
Kate Reed - *Website Manager*
Rebecca Scardino - *Education Manager*
Michele Sewart, PMP - *Senior Communications Manager*
Leah Skogman, CMP - *Senior Meetings Manager*

SOCIAL MEDIA

Join the conversation surrounding the SRS Annual Meeting by including **#SRSAM24** in your social media posts.

@srs_org

@ScoliosisResearchSociety

@srs_org

@Scoliosis Research Society

@srs_org

SCOLIOSIS RESEARCH SOCIETY

555 East Wells Street, Suite 1100
Milwaukee, WI 53202
Phone: 414-289-9107
Fax: 414-276-3349
www.srs.org

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SAVE THE DATE | 2025 SRS MEETINGS

MEETING OUTLINE

WIRELESS INTERNET
Network: SRS Meeting | Password: SRSAM2024

MONDAY, SEPTEMBER 9, 2024			
09:00 - 17:00	SRS Board of Directors Meeting*	M211-M212	Level M2
TUESDAY, SEPTEMBER 10, 2024			
07:00 - 08:00	Committee Chair Breakfast*	Room 127-128	Level P1
08:00 - 16:30	Committee and Council Meetings*	Rooms 118-134	Level P1
12:00 - 17:00	Registration Open	Entrance Hall C	Ground Level
12:00 - 17:00	Speaker Ready Room Open	Room 114	Level P1
13:00 - 17:00	Hibbs Society Meeting	Room 112	Level P1
18:30 - 21:30	SRS Leadership Dinner* (by invitation only)	Offsite	
WEDNESDAY, SEPTEMBER 11, 2024			
08:00 - 19:30	Registration Open	Entrance Hall C	Ground Level
08:00 - 19:30	Speaker Ready Room Open	Room 114	Level P1
09:00 - 12:59	Pre-Meeting Course (PMC)	Room 115-117	Level P1
The Pre-Meeting Course is supported, in part, by Medtronic			
13:00 - 13:15	Lunch Pick-Up	Foyer 1	Level P1
13:15 - 14:15	Lunchtime Symposia (3 Concurrent Sessions)	Room 111, 112, 115-117	Level P1
Lunchtime Symposia are supported, in part, by ATEC Spine			
14:15 - 14:30	Break		
14:30 - 16:00	Abstract Session 1 | Adolescent Idiopathic Scoliosis	Room 115-117	Level P1
16:00 - 16:20	Refreshment Break	Foyer 1	Level P1
16:20 - 18:05	Abstract Session 2 | Adult Spinal Deformity	Room 115-117	Level P1
18:05 - 18:20	Break		
18:20 - 19:40	Opening Ceremonies*	Room 115-117	Level P1
19:40 - 22:00	Welcome Reception*	Banquet Hall	Level P2
THURSDAY, SEPTEMBER 12, 2024			
08:00 - 17:00	Registration Open	Entrance Hall C	Ground Level
08:00 - 17:00	Speaker Ready Room Open	Room 114	Level P1
07:30 – 08:30	L.E.A.D. SRS Cohort Breakfast & Panel* (by invitation only)	Room 111	Level P1
09:00 - 10:50	Abstract Session 3 | Quality/Safety/Value/ Complications	Room 115-117	Level P1
10:50 - 11:10	Refreshment Break	Foyer 1	Level P1
11:10 - 13:15	Abstract Session 4 | Quality/Safety/Value/ Complications II, Harrington Lecture and Lifetime Achievement Awards	Room 115-117	Level P1
13:15 - 13:30	Lunch Pick-Up	Foyer 2	Level P1
13:30 - 15:00	Industry Workshops* (5 Concurrent Sessions)	Rooms 120-130	Level P1
15:00 - 15:10	Break		
15:00 - 17:00	L.E.A.D. SRS Cohort Session* (by invitation only)	Room 111	Level P1
15:10 - 16:55	Abstract Session 5A | Adult Spinal Deformity II Abstract Session 5B | Adolescent Idiopathic Scoliosis II	Room 115-117 Room 112	Level P1
17:00 - 18:30	Industry Networking Sessions*	Varied	Level P1
FRIDAY, SEPTEMBER 13, 2024			
08:00 - 18:00	Registration Open	Entrance Hall C	Ground Level
08:00 - 18:00	Speaker Ready Room Open	Room 114	Level P1
07:30 - 08:30	Past Presidents' Breakfast* (by invitation only)	Room 120-121	Level P1
09:00 - 10:50	Abstract Session 6 | Hibbs Award-Nominated Papers	Room 115-117	Level P1
10:50 - 11:10	Refreshment Break	Foyer 1	Level P1
11:10 - 13:00	Abstract Session 7 | Adult Spinal Deformity III and Presidential Address	Room 115-117	Level P1
13:15 - 14:30	Member Business Meeting (lunch pick-up at 13:00))	Room 211-212	Level P2
13:15 - 13:45	Non-Member Information Session (lunch pick-up at 13:00)	Room 112	Level P1
14:30 - 14:45	Break		
14:45 - 16:30	Abstract Session 8A | Cervical Deformity and Early Onset Scoliosis Abstract Session 8B | Kyphosis and Basic Science	Room 115-117 Room 112	Level P1
16:30 - 16:50	Refreshment Break	Foyer 1	Level P1
16:50 - 18:35	Abstract Session 9 | Adolescent Idiopathic Scoliosis III and Non-Operative Treatment Methods	Room 115-117	Level P1
19:30 - 20:30	President's Reception* (by invitation only)	Offsite	
20:00 - 22:00	Farewell Reception* (tickets required)	Offsite	
SATURDAY, SEPTEMBER 14, 2024			
07:30 - 08:30	SRS Board of Directors Meeting*	Room 122-123	Level P1
08:30 - 11:30	Registration Open	Entrance Hall C	Ground Level
08:30 - 12:30	Speaker Ready Room Open	Room 114	Level P1
09:00 - 11:10	Abstract Session 10 | Adult Spinal Deformity IV, Miscellaneous, Hibbs Award Presentation & Transfer of Presidency	Room 115-117	Level P1
11:10 - 11:30	Refreshment Break	Foyer 1	Level P1
11:30 - 13:15	Abstract Session 11 | Neuromuscular and Miscellaneous	Room 115-117	Level P1
13:15	SRS 59th Annual Meeting Concludes		

*Denotes non-CME Session/Activity