Session 9 | Adolescent Idiopathic Scoliosis III Abstracts

Papers are listed in presentation order

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*

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.
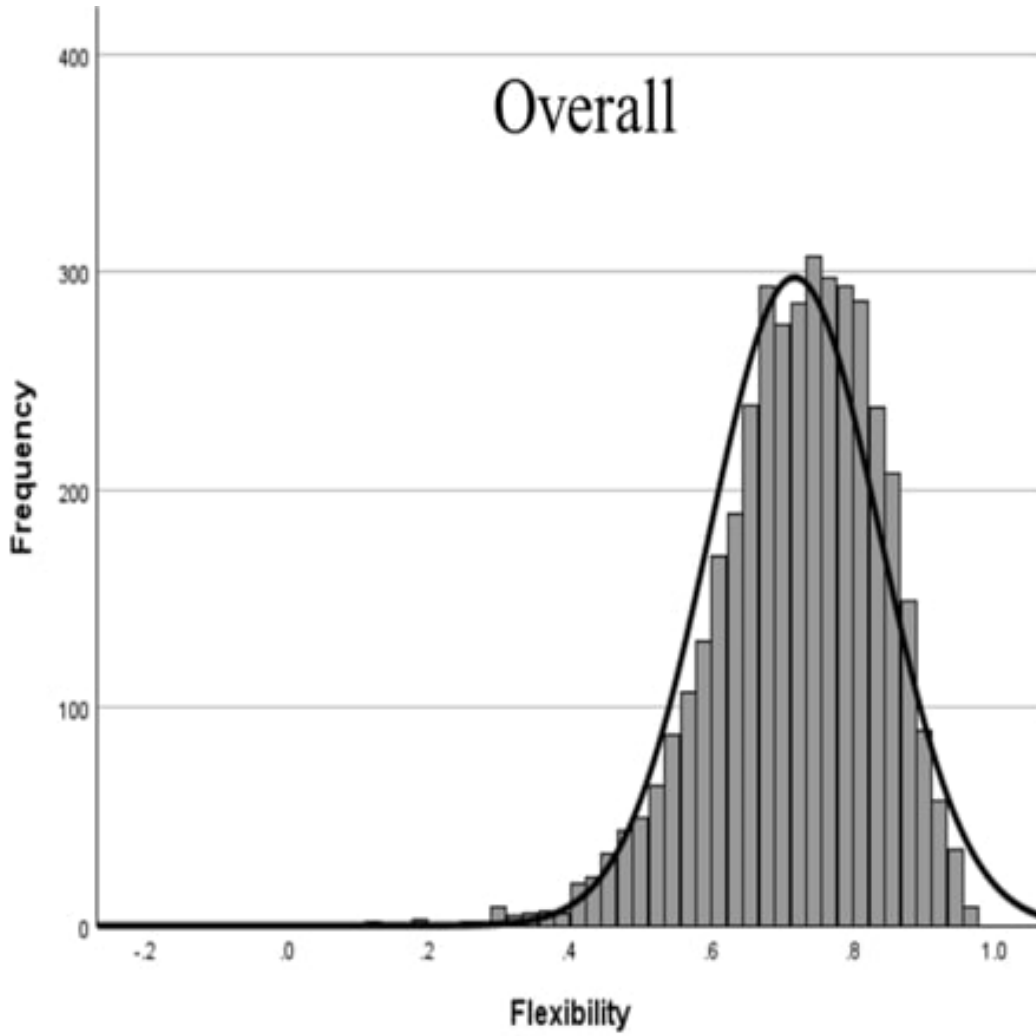
Flexibility Distribution

Paper #135. Association Between Lower Bone Mineral Density and Increased Cobb Angle in Adolescent Idiopathic Scoliosis

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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.

Paper #136. Development of Scoliview: An Artificial Intelligence Tool for the Automated and Reproducible Calculation of Cobb Angles

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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 interpretation 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.

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*

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		P-Value
		No (N=50)	Yes (N=25)	
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

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

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

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

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 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.
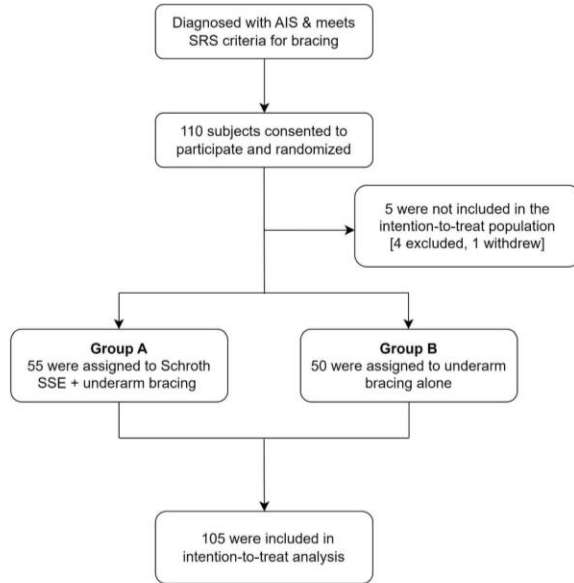
Primary Efficacy Analysis (ITT Population)

	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.

Paper #140. Rapid Response During Spinal Deformity Surgery Can Successfully Save Spinal Cord Function Using Intraoperative Monitoring

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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).

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.

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

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.

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; Yang Junlin, 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 patients based on an ITT analysis. A larger baseline curve, smaller Risser Stage, and smaller IBC rate were associated with treatment failure.
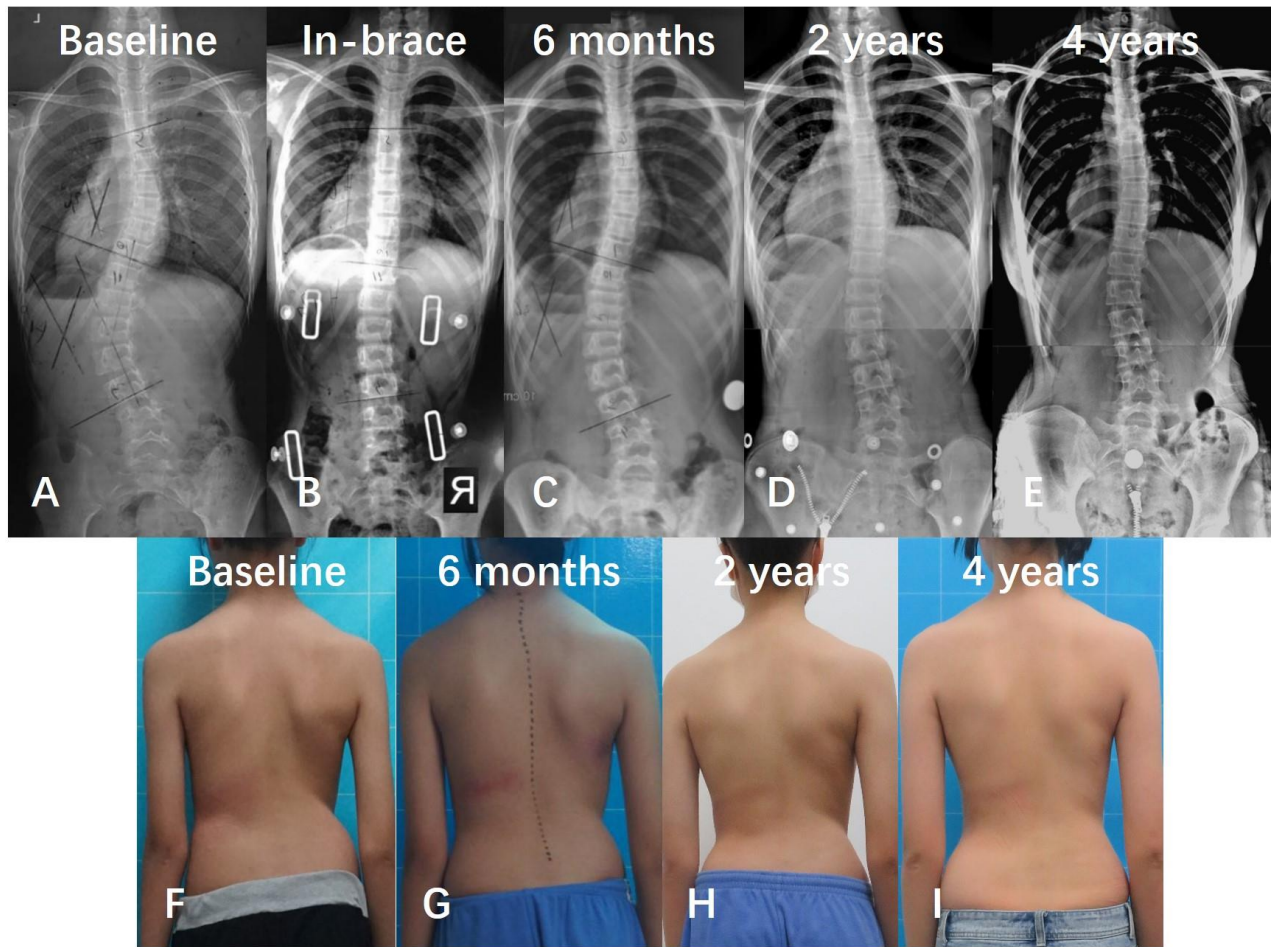
An AIS case with lumbar curve of 50°

Paper #143. Optimal Selection of Lower Instrumented Vertebra Can Minimize Distal Junctional Kyphosis After Posterior Spinal Fusion for Thoracic Adolescent Idiopathic Scoliosis

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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.
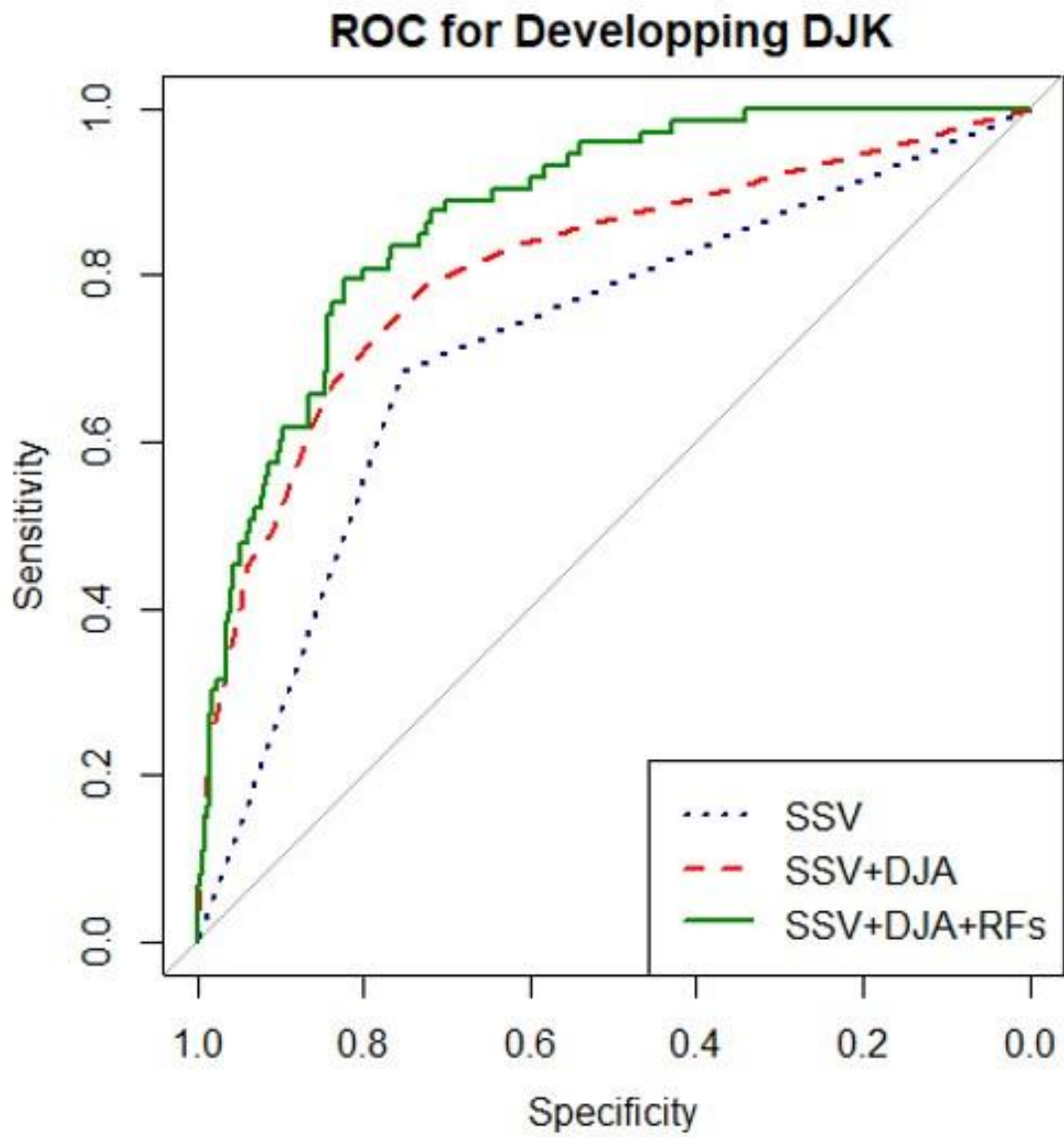
ROC for developing DJK with different prediction models.RFs: risk factors.

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_

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.

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.
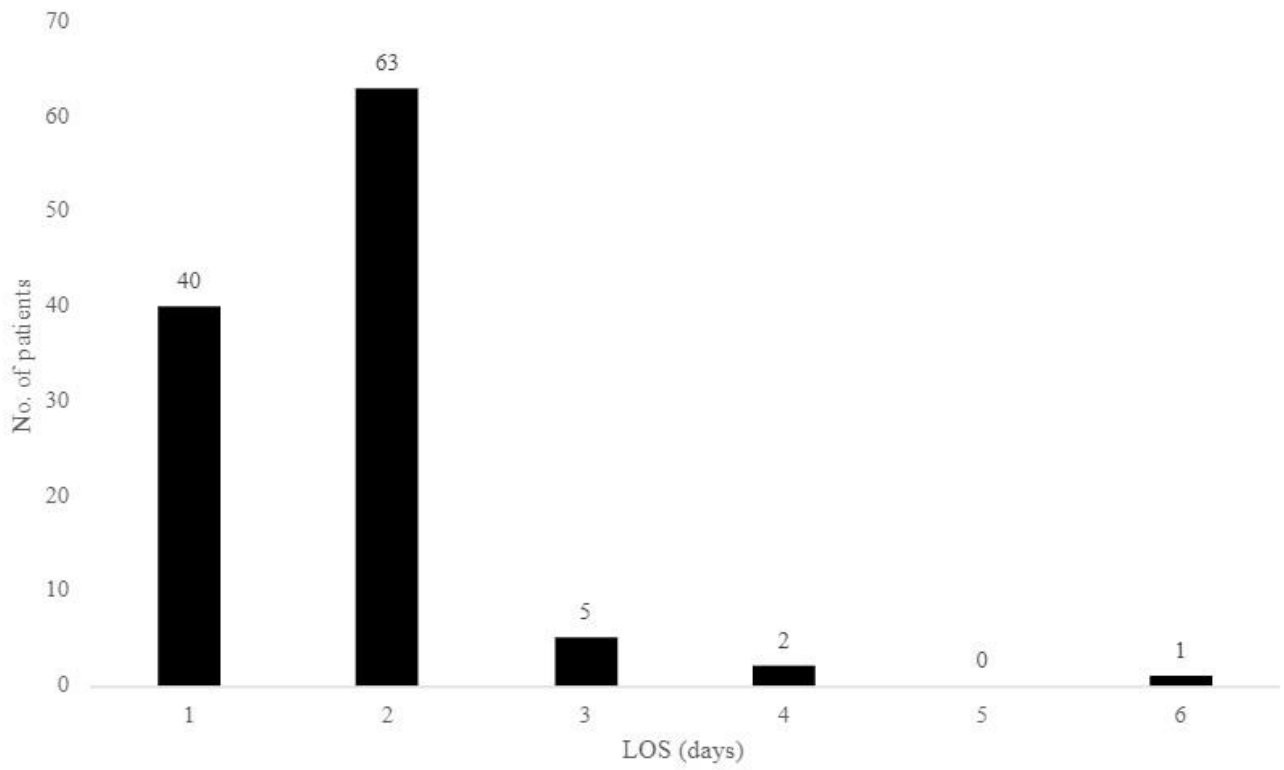
Figure 1: Bar chart depicting the length of stay (LOS).

Paper #145. Local Wound Infiltration Reduces Acute Postoperative Opioid Requirements in Adolescent Idiopathic Scoliosis ‡

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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.

Figure 1. Between Group Differences in Average Pain (A) and Opioid Consumption (B) 24 hours after Surgery

(A) Average Pain Scores 24 hours after Surgery

(B) Opioid Consumption 24 hours after Surgery
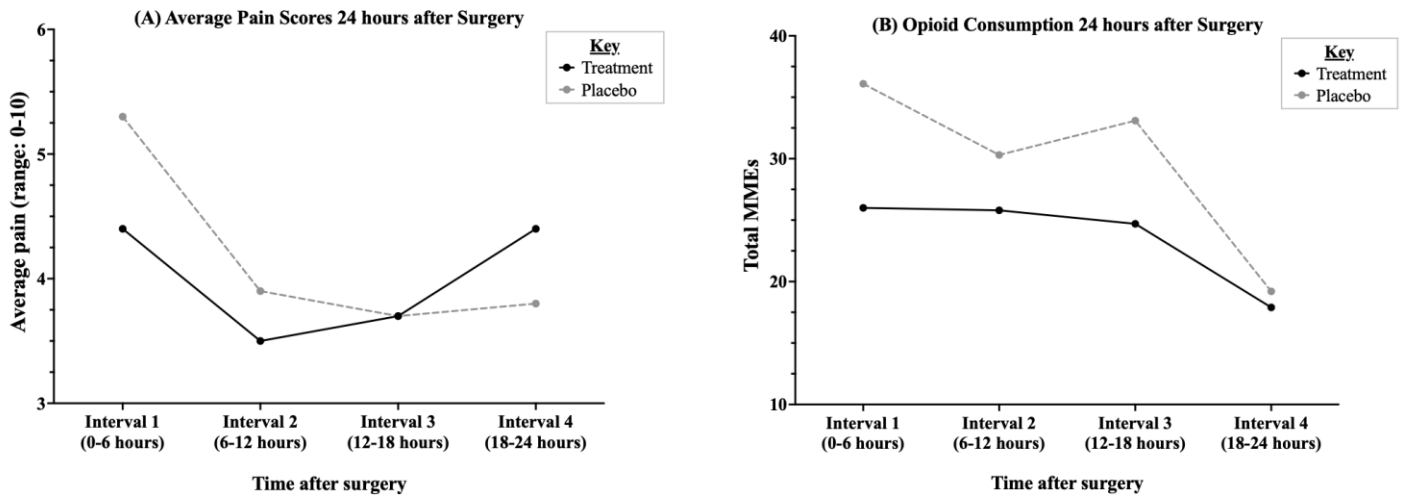
Paper #146. Outcomes of Revision Surgeries Following Index Anterior Vertebral Body Tethering

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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 $55.8 \pm 11.5°$ and $37.5 \pm 13.2°$, 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 (38.9%)	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	17.3 ± 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

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

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 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.
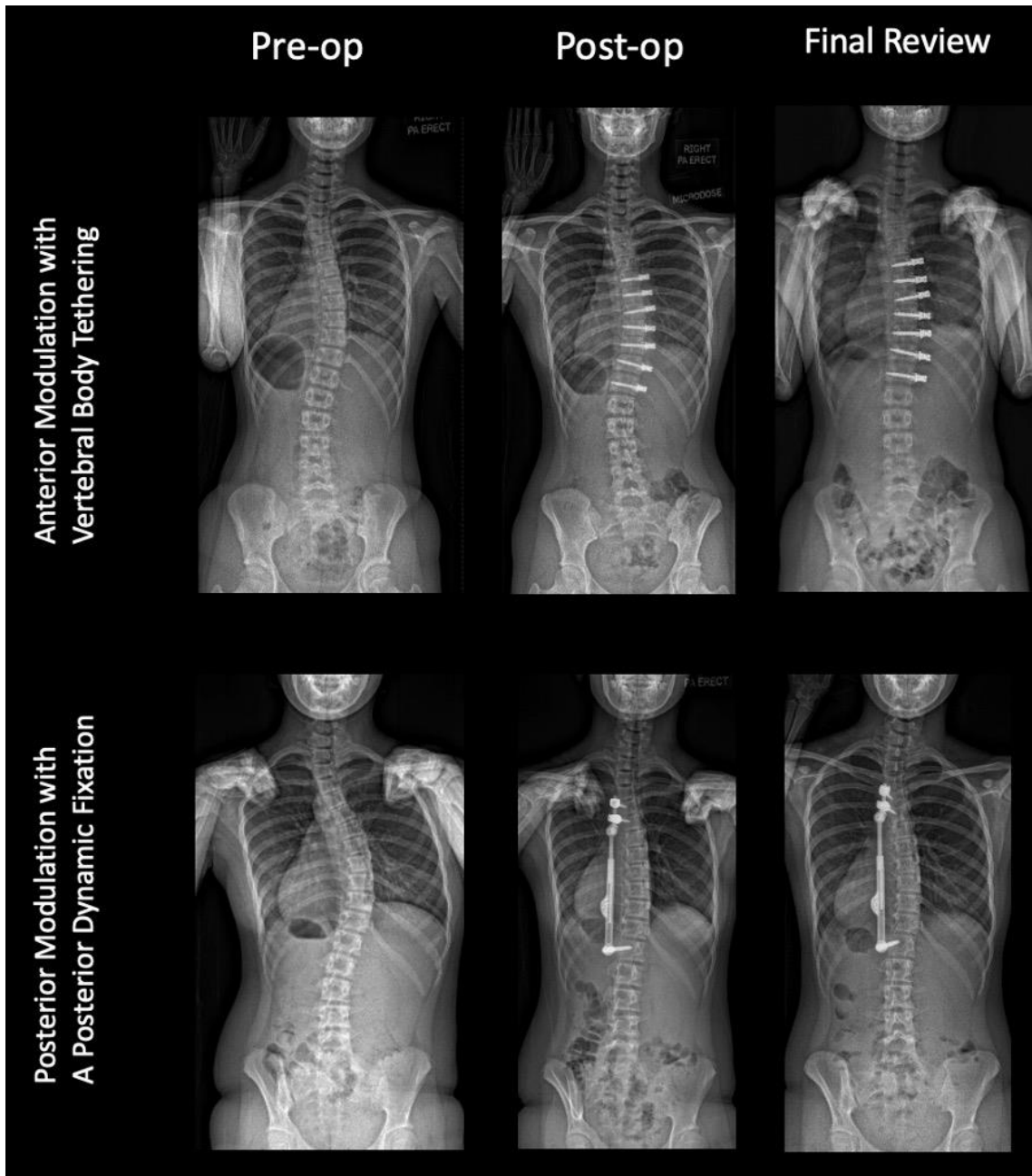
Radiographs of patients who underwent VBT (top) and PDF (bottom).

Paper #148. When is Growth the Greatest? Spine and Total Body Growth in Idiopathic Scoliosis Through Sanders Maturation Stages 2, 3A, 3B, and 4

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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.
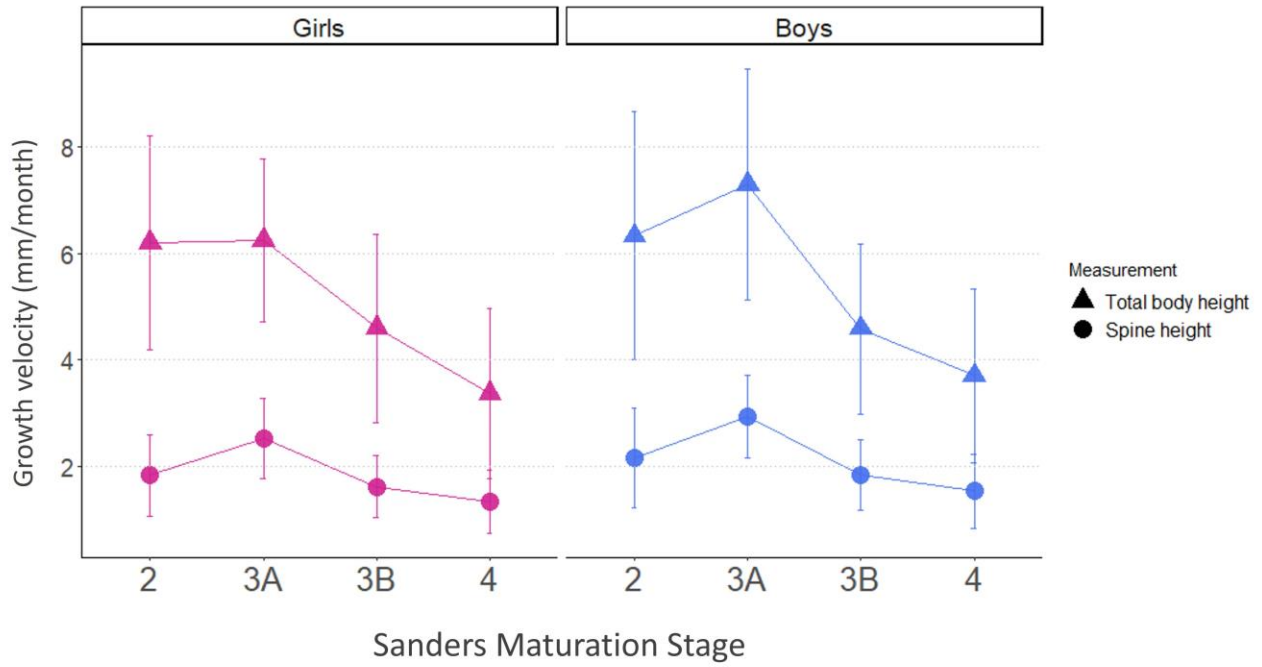
Growth velocity in spine and total body height through Sanders Maturation Stage 2, 3A, 3B, and 4. Dots indicate the mean value and error bars indicate standard deviation.