Session 8A | Cervical Deformity & Early Onset Scoliosis Abstracts

Papers are listed in presentation order

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*

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 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.

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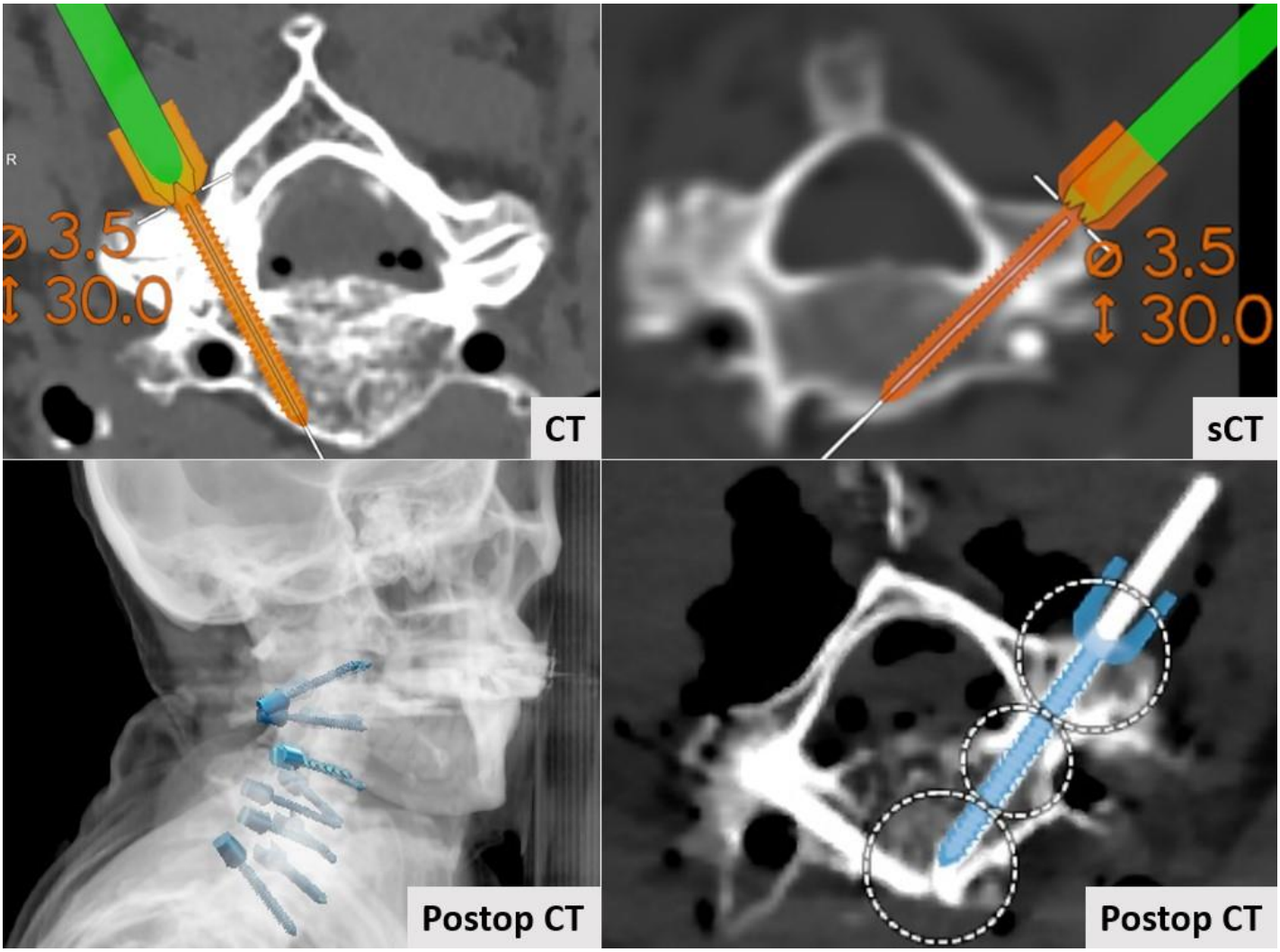

Screenshot of intraoperative screw planning on CT, sCT and postoperative screenshot of the virtual screws placed over k-wires.

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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

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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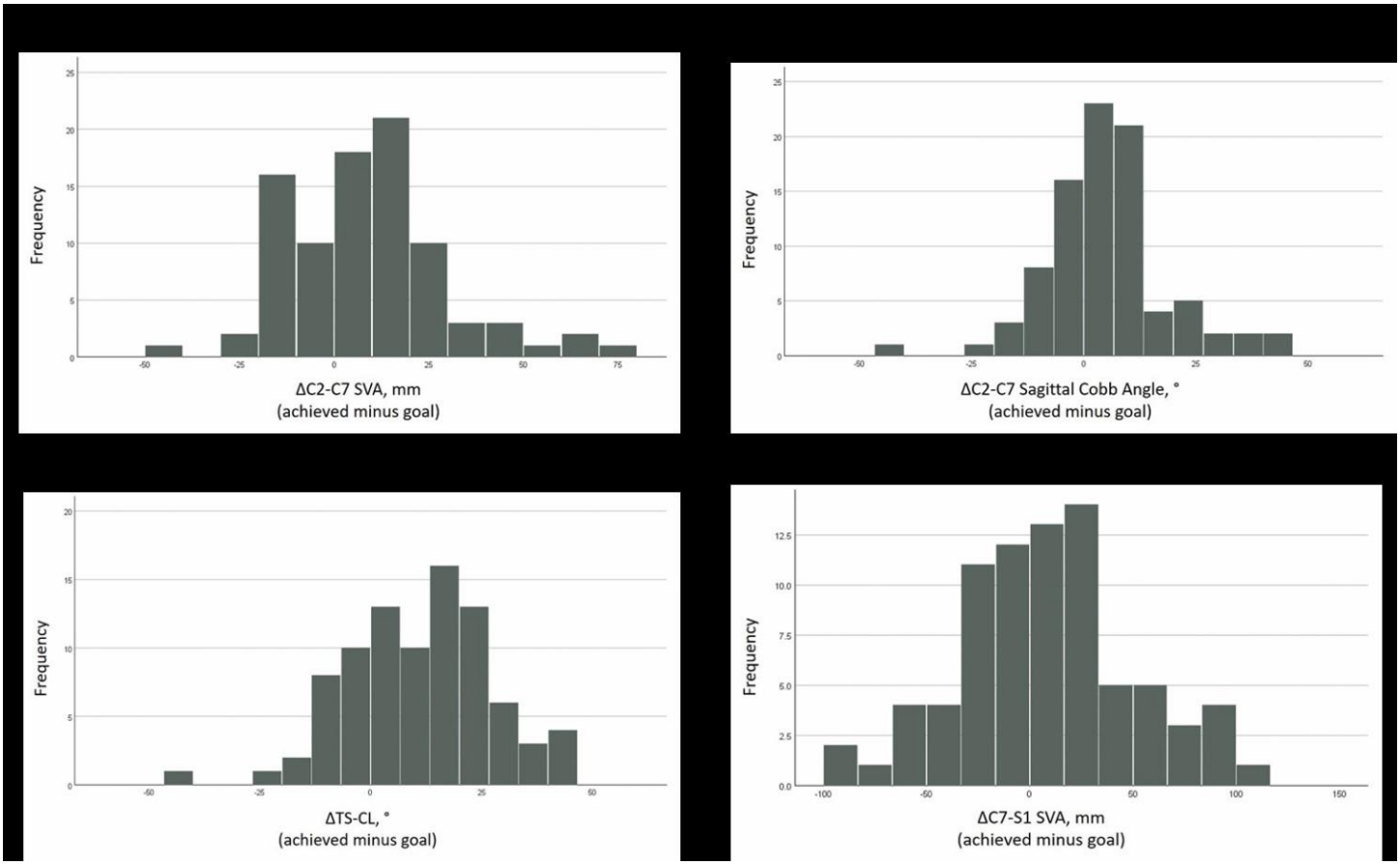

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Paper #106. Complications, Morbidity, and Mortality Following Corrective Surgery for Cervical Deformity Among Geriatric Cohorts

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

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.

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	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

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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*

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.

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.

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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

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

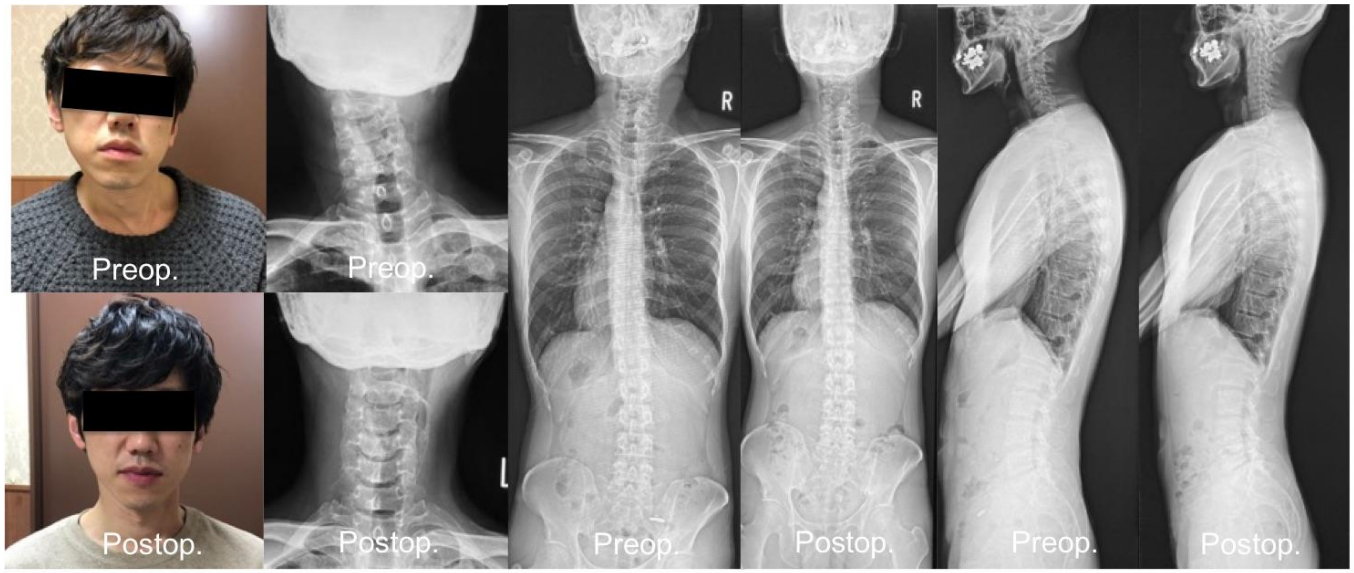
The inclusion criteria were as follows: the diagnosis of neglected CMT was confirmed by physical examination and imaging studies; symptomatic CMT that required surgical treatment; and age at surgery was over 20 years old. Radiographic parameters were evaluated including: cervicomandibular angle (CMA) 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.



Appearance and Radiograph

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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

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 $p \leq 0.05$.

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.

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		COL2			MPS		
		Nonoperative	Surgery	P-value	Nonoperative	Surgery	P-value
Demo-graphics	**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

Session 8A | Cervical Deformity & Early Onset Scoliosis Abstracts

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

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 development 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.

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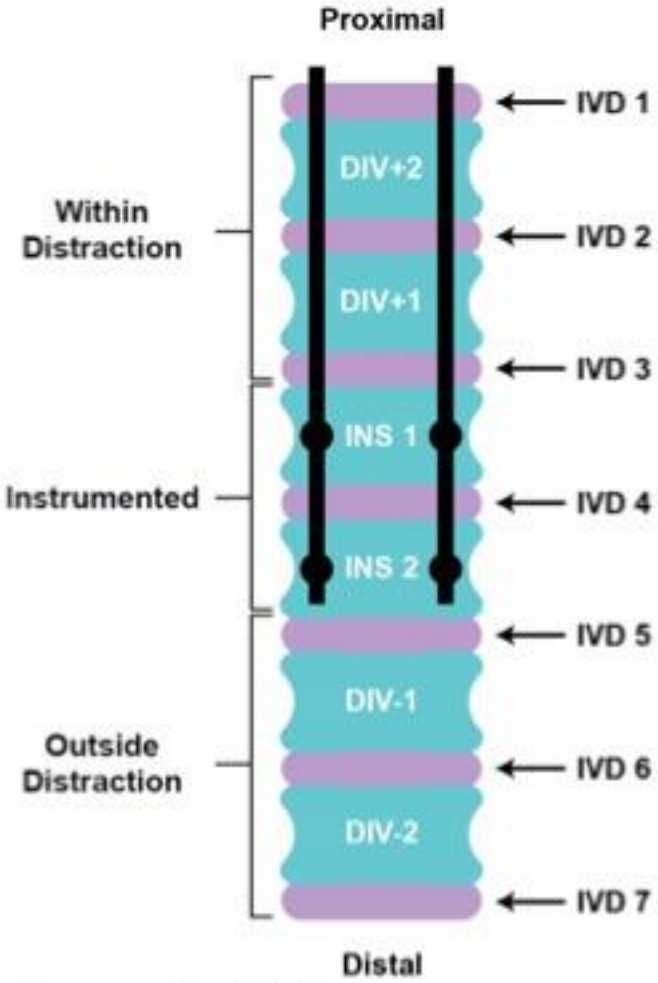

Figure 1. Evaluated levels
Two VBs and three IVDs within the growing system (within distraction or DIV+2/DIV+1). Two VBs and one IVD within the distal anchor (instrumented or INS). Two VBs and three IVDs distal to the distraction construct (outside distraction or DIV-1/DIV-2).

Session 8A | Cervical Deformity & Early Onset Scoliosis Abstracts

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*

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.

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.

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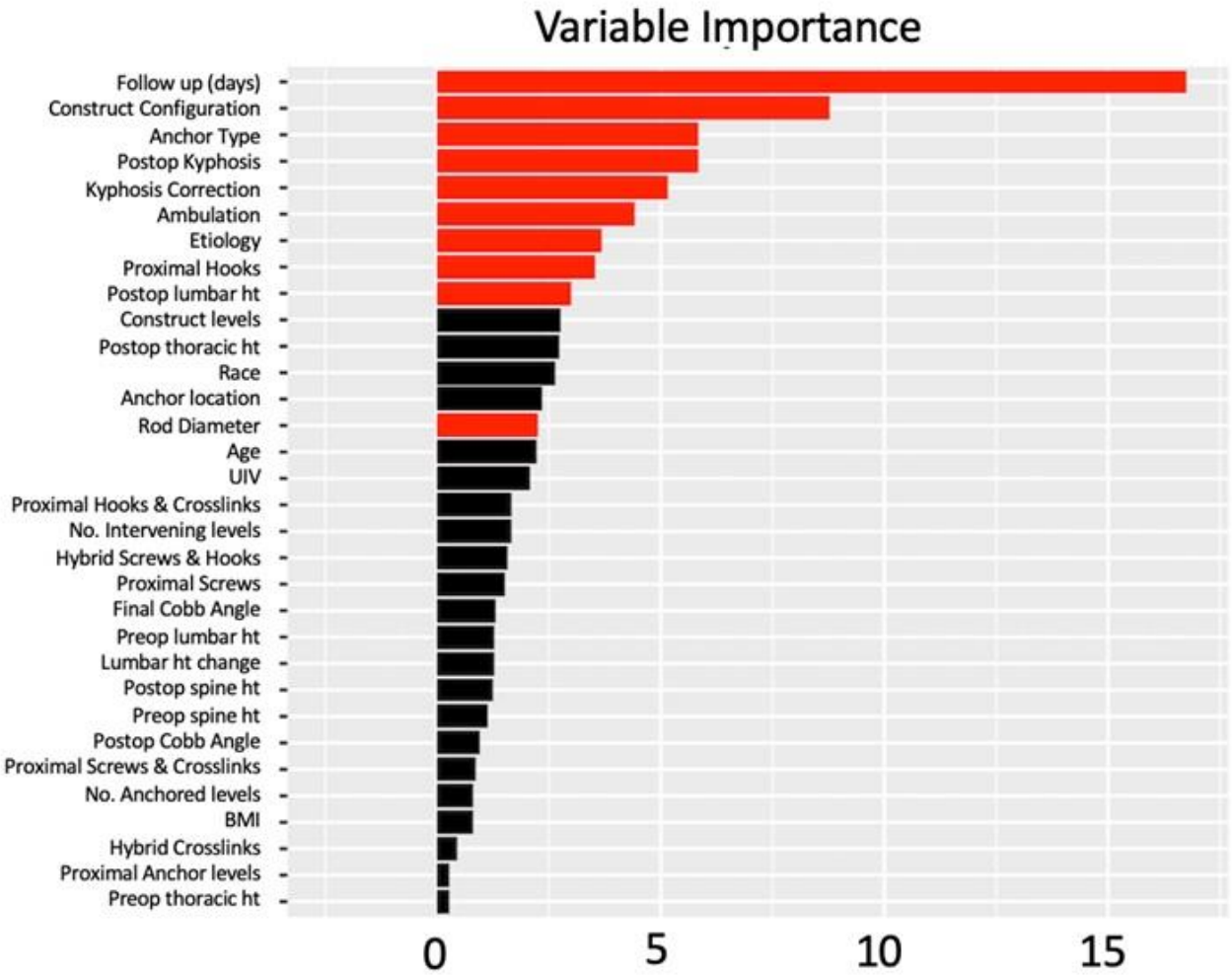

ML-based variable importance rankings. Significant variables are in red, with greater magnitudes indicating greater importance.

Session 8A | Cervical Deformity & Early Onset Scoliosis Abstracts

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

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 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.

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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.

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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*

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.

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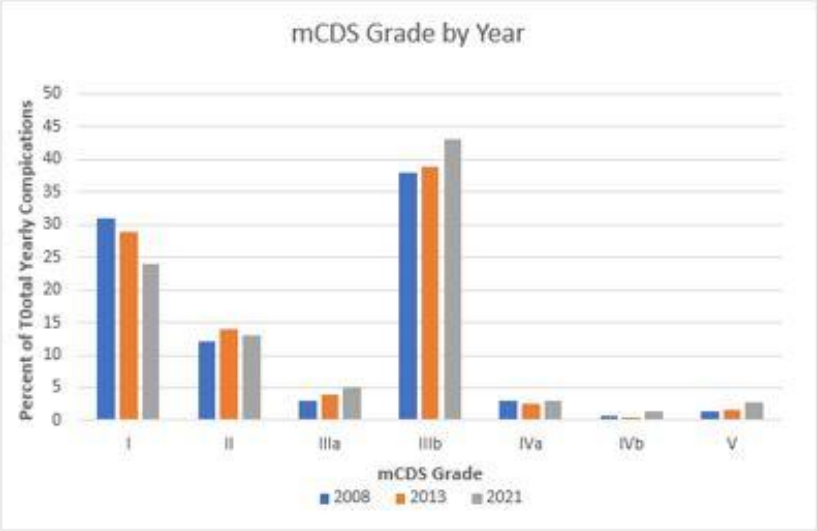

Figure 1. Distribution of mCDS-rated complications by year.

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)

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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

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.

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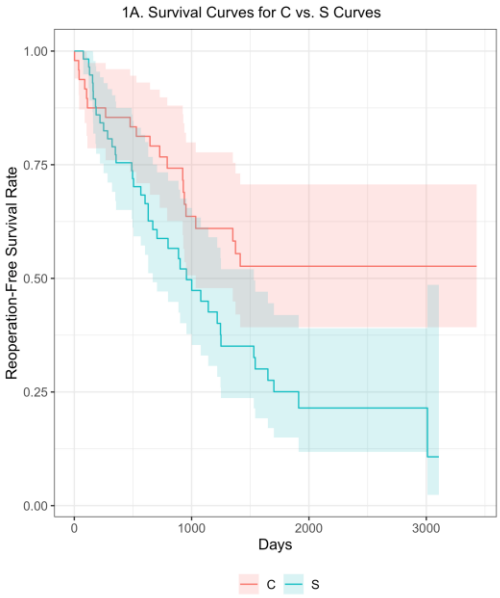

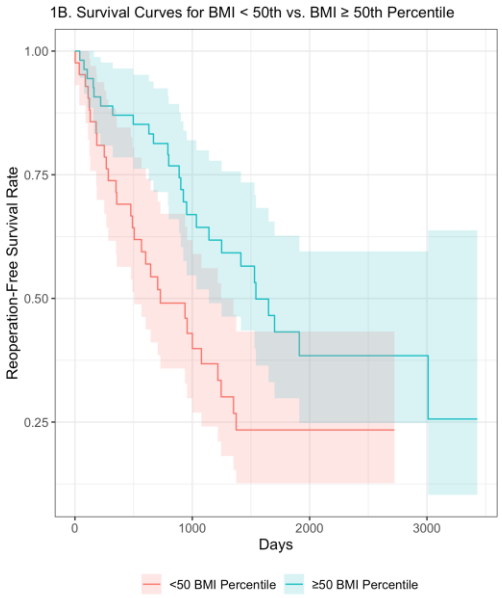

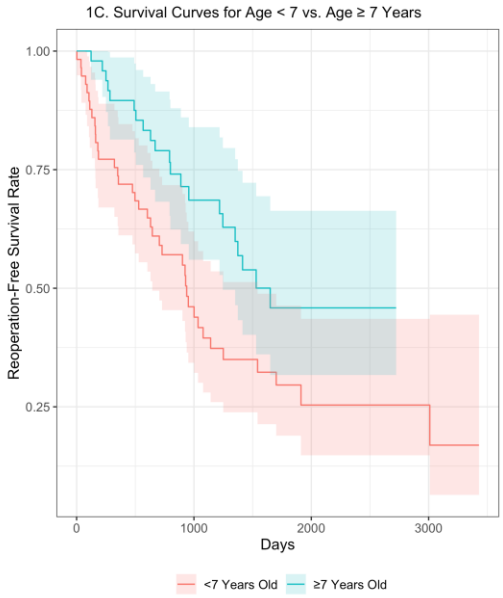

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Paper #115. Risk of Proximal Junctional Kyphosis After Revision of Growing Rod Constructs

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*

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

Session 8A | Cervical Deformity & Early Onset Scoliosis Abstracts

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

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.

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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

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 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.

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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

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.

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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