

200. Scoliosis After Repair of Congenital Diaphragmatic Hernia: A Study of Incidence and Associated Risk Factors

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Hypothesis:

The study hypothesized that scoliosis in congenital diaphragmatic hernia (CDH) survivors is driven more by disease severity and pulmonary compromise than by surgical tension from defect repair.

Design:

Single-Center Retrospective Cohort Study

Introduction:

Scoliosis is prevalent in CDH survivors, yet its etiology remains unclear. Conflicting theories attribute it to surgical mechanics (e.g., defect size, patch repair) or intrinsic disease severity (e.g., lung hypoplasia). This study aimed to determine the prevalence of scoliosis in long-term CDH survivors and identify independent risk factors by analyzing both surgical and patient-related variables.

Methods:

A retrospective review was performed on 376 patients who underwent CDH repair (1995–2021). Patients who died within 6 months were excluded. Survivors were screened for scoliosis (Cobb angle $\geq 10^\circ$ with rotation). Variables included demographics, defect size (length, area, Relative Defect Index), and treatment factors (patch use, ECMO, oxygen at discharge). Univariate and multivariate logistic regression analyses were conducted to identify predictors.

Results:

Of 335 survivors, 12 (3.6%) developed scoliosis. Defect size and area showed no significant difference between groups. Although patch repair ($p=0.036$) and revision for eventration ($p=0.048$) were more frequent in the scoliosis group in univariate analysis, they lost significance after adjustment. Multivariate analysis identified oxygen demand at discharge as the sole independent predictor (OR 8.036, $p=0.017$), while ECMO and patch repair were not significant.

Conclusion:

Scoliosis occurred in 3.6% of survivors. Surgical factors, such as defect size or patch repair, were not independent predictors of deformity. Instead, the requirement for supplemental oxygen at discharge—a surrogate for chronic respiratory insufficiency and lung hypoplasia—was the strongest risk factor. This suggests spinal deformity in CDH is linked to underlying disease severity rather than surgical mechanics. Long-term monitoring is warranted for these high-risk patients.

201. The Treatment of Severe Congenital Scoliosis Associated with Type I Split Cord Malformation: Is a Preliminary Bony Septum Resection Always Necessary? ±

Junlin Yang, MD, PhD; Zifang Huang, MD, PhD; Pan Zhou, PhD; Lei He, MD, PhD

Hypothesis:

To evaluate the safety and efficacy of a single-stage spine-shortening osteotomy in the treatment of severe congenital scoliosis associated with type I SSCM.

Design:

A retrospective study

Introduction:

Single-stage spine-shortening osteotomy without treating spinal cord malformations may have potential advantages for the treatment of severe congenital scoliosis (CS) with type I split spinal cord malformation (SSCM); however, the study of this technique was limited.

Methods:

A retrospective study was designed to compare two case series including 12 severe CS patients with type I SSCM and 26 patients with type A cord function (without spinal cord malformations, evoked potential abnormalities and neurological dysfunctions preoperatively) treated with a single-stage spine-shortening PVCR. Patients' demographic, clinical, operative and radiographic data were obtained and compared between groups.

Results:

The surgical procedure was successfully performed in both groups, and the patients were observed for an average of 44.9 months (range 25-78 months) after the initial surgery. The radiographic parameters, intraoperative data and new neurological deficits showed no difference, while deformity angular ratio (SSCM group : control group = 16.6 ± 3.6 : 20.1 ± 3.9 , $P=0.01$) and corrective rate (SSCM group : control group = 50% : 58%, $P=0.046$) of the main curve were statistically different between groups. All of the new neurological deficits recovered within one year.

Conclusion:

The single-stage spine-shortening PVCR with moderate correction could be applied to the treatment of CS associated with type I SSCM. This strategy can achieve safe spinal deformity correction while obviate the neurological complications brought by the detethering procedures, which merits further clinical investigation.

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

202. 10-Year CT Follow-up of Hemivertebra Resection: Block Vertebra-Like Morphology in Younger Children with Longer Constructs Despite Preserved Canal Dimensions

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Hypothesis:

10-year CT follow-up would provide detailed assessment of vertebral body morphology and spinal canal dimensions not readily evaluated by conventional radiographs in long-term follow-up.

Design:

Retrospective study

Introduction:

Early spinal fusion after hemivertebra resection may affect long-term growth. Prior studies rely primarily on AP radiographic parameters or have limited follow-up duration. Long-term CT morphometric data over 10 years quantifying vertebral body and canal changes have not been reported.

Methods:

Fifteen patients who underwent posterior hemivertebra resection with short-segment fusion (2-4 vertebrae) underwent CT at mean 12.4-year follow-up (range: 10.1-15.8 years). Mean age at surgery was 7.9 years (range: 2.4-15.1 years). Anterior concavity depth (ACD) was measured as maximum perpendicular distance from idealized anterior column to actual contour. Vertebral body parameters and spinal canal dimensions (AP diameter, lateral diameter, area) were measured at fused and adjacent levels. Patients were stratified by ACD severity and analyzed for age and fusion length correlations.

Results:

All patients demonstrated anterior concavity (mean ACD: 3.8 ± 2.1 mm, range: 1.2-8.9 mm). Five patients (33%) showed severe concavity (ACD >6 mm), all aged <4 years at surgery with 4-vertebra fusions. The most severe case was a 3-year-old with 4-level fusion showing ACD of 10.2 mm by CT, creating block vertebra-like morphology (Figure). Other vertebral parameters including pedicle dimensions and disc heights remained within normal ranges. Despite morphological changes, spinal canal dimensions remained within age-matched normal ranges at all levels in all patients (AP diameter: 14-22 mm, lateral diameter: 16-31 mm). Curve progression occurred in 2 patients (13.3%) with no other complications reported.

Conclusion:

This first 10-year CT morphometric study reveals a anterior growth restriction change forming block vertebra-like morphology, predominantly in patients fused before age 4 with 4-level constructs. While, other vertebral parameters and canal dimensions remain preserved, supporting safety of early fusion when indicated.

203. When Can a Pediatric Scoliosis MRI Be Performed Without Sedation? A Multicenter Study

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Hypothesis:

Contemporary MRI practices in pediatric scoliosis are associated with decreasing sedation rates over time

Design:

Retrospective review of prospectively collected multicenter data

Introduction:

MRI is frequently used in the evaluation of pediatric scoliosis but often requires sedation, particularly in younger patients. Despite advances in MRI techniques, there is no consensus regarding sedation practices or age thresholds for completing MRI without sedation. This study evaluates current MRI utilization, sedation trends, scan duration, and age-based thresholds for non-sedated MRI in a large multicenter pediatric scoliosis cohort.

Methods:

An international multicenter database was queried for pediatric scoliosis patients undergoing MRI between 01/01/2019 and 10/01/2024. Demographics, scoliosis etiology, MRI duration, sedation status, year of imaging, and availability of rapid-sequence MRI (RS-MRI) protocols were collected. Sedation rates were compared over time and by etiology using Chi2 and ANOVA. ROC curves were used to determine age cut-offs for MRI sedation using the Youden Index.

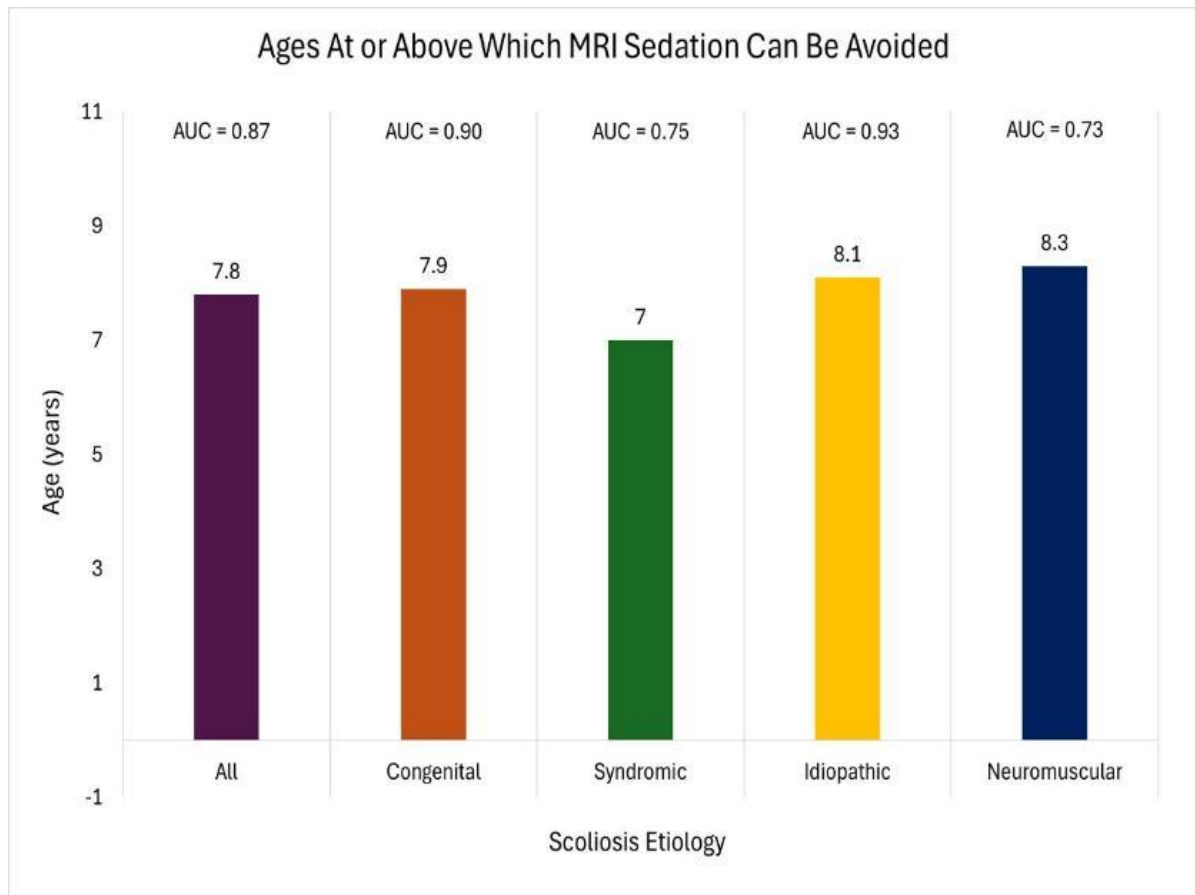
Results:

A total of 895 MRIs from 789 patients were analyzed (mean age 7.9 ± 4.6 y; 61.8% female). Idiopathic scoliosis was most common (45.2%). The overall MRI sedation rate was 50.6% and decreased significantly over time ($p < 0.001$), from 50.3% in 2019 to 39.3% in 2024. Idiopathic scoliosis patients had lower sedation rates (38.2%) than neuromuscular (61.8%), congenital (55.9%), and syndromic (69.2%) ($p < 0.001$). Sedated patients were younger than non-sedated patients (5.0 ± 3.4 vs 10.9 ± 3.7 y, $p < 0.001$) and had longer scan times (66.1 ± 30.6 vs 54.8 ± 27.2 min, $p < 0.001$). Mean MRI duration was 60.3 ± 29.5 min and did not vary by year ($p = 0.364$) or etiology ($p = 0.075$). RS-MRI duration was shorter than standard-sequence MRI (61.5 ± 29.0 vs 70.0 ± 29.0 min, $p = 0.018$). The age cut-off for sedation was 7.8 years, regardless of MRI sequence or diagnosis (AUC 0.87, $p < 0.001$).

Conclusion:

MRI sedation rates in pediatric scoliosis have decreased over time despite stable scan durations. RS-MRI protocols were associated with only modest reductions in scan time. Younger age and longer imaging time remain strongly associated with MRI sedation, with an 87% probability that patients aged 7.8 years and older can complete an MRI without sedation. These findings support age-based expectations for MRI tolerance and underscore the need for a standardized definition of rapid-sequence scoliosis MRI.

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant



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204. Do Magnetically Controlled Growing Rods Reach Their Intended Length? Construct-Level Outcomes in Early-Onset Scoliosis

Jeffrey T. Galla, BS; Kirsten Brouillet; Brian A. Kelly, MD; Scott J. Luhmann, MD

Hypothesis:

A majority of magnetically controlled growing rods (MCGR) will reach maximal length, while heavier, older patients are less likely to reach maximal actuator expansion prior to stall or failure.

Design:

Retrospective chart review

Introduction:

MCGRs are used to manage early-onset scoliosis (EOS) by correcting deformity while allowing for spinal growth with noninvasive lengthening. MCGRs reduce the need for repeated surgeries, but there is a higher up-front cost and they may not reach maximal expansion. This study evaluates MCGR construct outcomes, including rates of maximal expansion, stall, and failure, and identifies predictors of successful performance.

Methods:

EOS patients treated with MCGRs as their first intervention were reviewed at a single institution. Patients with care at outside centers were excluded. Stall was defined as failure to reach 95% maximal actuator capacity due to inability to lengthen, and failure was defined as complications requiring rod replacement. Radiographs were reviewed preoperatively, postoperatively, and at final follow-up. All subjects were followed for greater than 2 years and univariate analysis compared constructs reaching maximal expansion with those that did not.

Results:

43 patients (25 female) were analyzed. 24 constructs (55.8%) reached maximal expansion, 13 (30.2%) stalled, and 6 (14.0%) failed. Mean follow-up was 3.4 years, with time to reach maximal expansion 3.8 years and stall or failure 2.6 years. Stalled rods extended a mean of 61% of actuator capacity. Constructs not reaching maximal expansion were implanted in older patients (8.5 vs 7.4 years, $p=0.039$) with greater weight (26.6 vs 20.5 kg, $p=0.012$) and BMI (18.8 vs 15.4, $p=0.002$). Coronal deformity correction improved from preoperative to postoperative (33%, $p<0.001$) and final follow-up (38%, $p<0.001$). 10 patients (23%) received a 2nd MCGR, and 8 went on to fail ($p=0.0764$).

Conclusion:

Over half of MCGR constructs achieved maximal expansion, exceeding previously reported rates. Older age, greater weight, and increased BMI were associated with reduced likelihood of mechanical completion, and 2nd sets of MCGRs trended toward reduced likelihood. MCGRs provided durable coronal correction. These findings highlight the importance of patient selection and shared decision making when considering MCGRs for EOS management.

Variable	Overall	Maximally Expanded	Stalled or Failed	P value
Demographics				
No. Patients	43	24 (56%)	19 (44%)	-
No. Female	25 (58%)	15 (63%)	10 (53%)	-
Follow-up, yrs	3.41 ± 1.35	3.83 ± 1.37	2.61 ± 1.03	-
Age, yrs	7.9 ± 2.1	7.4 ± 2.2	8.5 ± 2.0	0.039
Height, cm	116 ± 14	114 ± 14	118 ± 13	NS
Weight, kg	23.2 ± 8.9	20.5 ± 7.2	26.6 ± 9.9	0.012
BMI, kg/m ²	16.9 ± 4.0	15.4 ± 2.3	18.8 ± 4.8	0.002
Radiographic Measurements				
Coronal Preop	66° ± 20°	68° ± 20°	64° ± 21°	NS
Sagittal Preop	49° ± 23°	49° ± 25°	50° ± 21°	NS
Coronal Preop to Postop Correction	33% ± 22% (p<0.001)	36% ± 18%	30% ± 26%	NS
Coronal Preop to Final Correction	38% ± 36% (p<0.001)	47% ± 31%	27% ± 41%	NS
Sagittal Preop to Postop Correction	4% ± 31% NS	-3% ± 37%	10% ± 21%	NS
Sagittal Preop to Final Correction	-6% ± 42% (NS)	-4% ± 47%	-7% ± 36%	NS

Table 1. Demographics and MCGR Construct Outcomes

205. Growing Rods Lead to Increased Collagen Accumulation and Enrichment of TGF- β Pathways in The Murine Intervertebral Disc

Lucas Budd, BS; Olanrewaju Akande, BS; Rachana S. Vaidya, PhD; Christian E. Gonzalez, BS; Simon Y. Tang, PhD; Blake K. Montgomery, MD

Hypothesis:

Mechanical loading mimicking growth rod treatment induces fibrotic matrix remodeling and transcriptomic changes in the murine juvenile intervertebral disc (IVD), contributing to spinal stiffening.

Design:

Experimental design murine study.

Introduction:

Early-onset scoliosis adversely affects quality of life and may shorten life expectancy. Distraction-based growing rods are used to increase thoracic height and correct deformity in skeletally immature patients but frequently lead to autofusion, occurring in up to 90% of patients. Autofusion limits thoracic growth which impairs pulmonary function and reduces quality of life. The biological response of the IVD to growing rods remains poorly understood.

Methods:

Six-week-old female C57BL/6 mice underwent growth rod instrumentation (n=8). Metal pins anchored 3D-printed washers connected by screws and springs to distract caudal spinal segments (Co7/8–Co12/13); adjacent segments served as non-distracted controls. Distraction force equaled twice body weight and was maintained for 20 weeks. Disc Height Ratio (DHR) was measured longitudinally. After sacrifice, contrast-enhanced microCT, dynamic compression testing, biochemical assays for sulfated glycosaminoglycans (sGAGs) and collagen (n=4), and bulk RNA sequencing (n=3) were performed. One-way ANOVA and paired t-tests were used.

Results:

The disc height was initially increased in distracted segments (DHR distracted = 0.525 vs non-distracted = 0.268, p < 0.0001) but subsequently declined. After 14 weeks the discs that were spanned by the growing rod were shorter than discs outside of the growing rod (DHR distracted = 0.226 vs non-distracted = 0.295, p = 0.0124). Discs that were spanned by the growing rod exhibited reduced volume and sGAG content, while collagen content trended higher, resulting in a reduced sGAG-to-collagen ratio. RNA sequencing demonstrated upregulation of genes associated with TGF- β signaling, inflammation, and collagen formation.

Conclusion:

Growth rod surgery induces structural, compositional, and transcriptional changes consistent with fibrotic remodeling of the juvenile IVD. Activation of TGF- β and inflammatory pathways provides a potential mechanistic link to spinal stiffening which may contribute to autofusion after growing rods are inserted in patients.

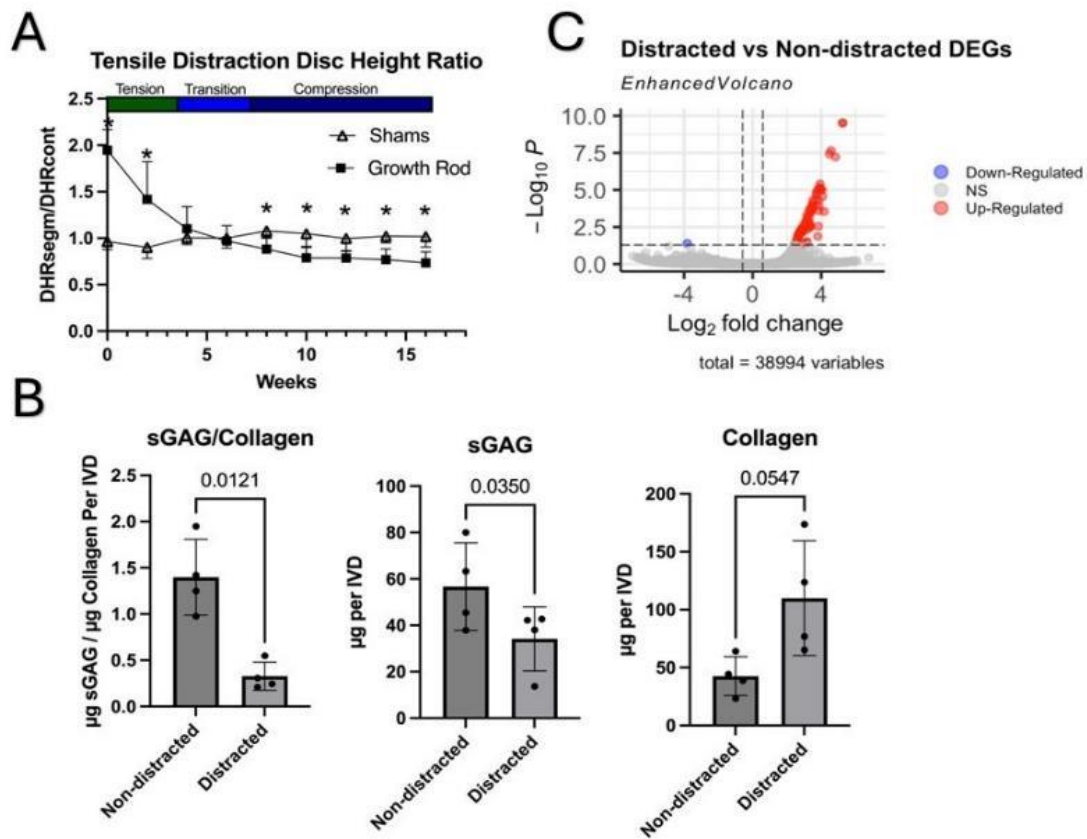


Figure 1: (A) Longitudinal DHR, (B) sGAG and collagen quantification, and (C) volcano plot of distracted vs non-distracted IVDs.

206. Radiographic Progression of Scoliosis After Triradiate Cartilage Closure in Non-Ambulatory Cerebral Palsy ±

Satoshi Takada, MD; Jason J. Howard, MD; Hiroshi Taneichi, MD, PhD; Alice Taylor, BS; Anuj Gupta, MD; M. Wade Shrader, MD

Hypothesis:

Non-ambulatory cerebral palsy (CP) patients with larger spinal curvature and pelvic obliquity at triradiate cartilage (TRC) closure are at increased risk for scoliosis progression after skeletal maturity.

Design:

Retrospective cohort study.

Introduction:

The natural history of scoliosis after skeletal maturity in non-ambulatory CP patients remains poorly understood, and evidence-based guidelines for radiographic surveillance are lacking. This study aimed to determine the prevalence and rate of scoliosis progression after TRC closure and identify risk factors for curve progression.

Methods:

Consecutive patients with spastic non-ambulatory CP (GMFCS IV-V) and minimum 2-year follow-up after TRC closure were included. Patients with prior spinal surgery before TRC closure were excluded. Radiographic parameters including major curvature, pelvic obliquity (PO), apical vertebral translation, and central sacral vertical line deviation were measured. Primary outcome was progression to major curvature $\geq 50^\circ$ or surgical intervention. Risk factors were analyzed using multivariate logistic regression and ROC curve analysis.

Results:

Eighty-one patients (47 males; mean age 14.6 years at TRC closure) were analyzed. Mean follow-up was 4.3 years. At TRC closure, mean major curvature was 31.5° and mean PO was 9.5° . Forty-eight patients (59.3%) experienced significant progression; 42 underwent surgery. Mean time to progression was 34 months. Multivariate analysis identified three independent risk factors: major curvature at TRC (OR 1.16, $p < 0.001$), PO (OR 1.12, $p = 0.02$), and epilepsy (OR 2.17, $p = 0.02$). ROC analysis identified major curvature $\geq 34^\circ$ as optimal threshold (sensitivity 72%, specificity 82%, AUC 0.76). PO $\geq 8^\circ$ showed moderate predictive value (AUC 0.69). Patients with prior hip surgery had significantly shorter progression-free survival ($p = 0.004$).

Conclusion:

Scoliosis progresses after TRC closure in nearly 60% of non-ambulatory CP patients. Major curvature $\geq 34^\circ$ at TRC closure, PO $\geq 8^\circ$, epilepsy, and prior hip surgery are significant risk factors. These thresholds support continued surveillance in high-risk patients after skeletal maturity.

207. Paediatric Patients with Complex Neuromuscular Scoliosis Do Not Require Routine Admission to ICU Following Scoliosis Surgery.

Hannah Phillips; Giuliana Antolovich, PhD, MBBS; Mia Percival; Moya Vandeleur, PhD; Katherine Frayman, PhD, MBBS; Donna Peachey, RN; Ingrid Sutherland, RN; Michael B. Johnson, MD, PhD; Tali Gadish, MD; Kristopher M. Lundine, MD

Hypothesis:

Not all patients with complex neuromuscular scoliosis require admission to PICU following their scoliosis surgery.

Design:

Retrospective Cohort Study

Introduction:

Paediatric patients with neuromuscular scoliosis represent a challenging population due to the severity of their spinal deformities and their medical comorbidities. Following scoliosis corrective surgery in this population, typical post-operative care across most paediatric institutions in Australia includes routine admission to the Paediatric Intensive Care Unit (PICU). PICU is an expensive and limited resource. Current practice at most paediatric centres across Australia is for routine admission to PICU following surgery for this population which can lead to prolonged surgical wait-times and day-of-surgery cancellations if a PICU bed is unavailable. At our institution, these patients are reviewed pre-operatively by a Multidisciplinary Team (MDT) and the Pre-Anaesthetic Resource Centre (PARC) to determine whether a post-operative PICU admission will be required. The purpose of this study was to assess the frequency of planned ICU admission, unplanned ICU admission and the main reasons for unplanned ICU admission to help optimize post-operative clinical care.

Methods:

Retrospective chart of review of all patients at a single paediatric institution with neuromuscular spinal deformity undergoing a pre-operative MDT review between January, 2019 and December, 2024 and subsequent spinal corrective surgery.

Results:

115 patients underwent scoliosis corrective surgery for their neuromuscular spinal deformity. Mean age was 14 years and most common primary diagnosis was Cerebral Palsy. 45 patients had a planned post-operative admission to PICU based on pre-op MDT and/or PARC review. Of the 70 patients that did not have a planned post-op PICU admission, 10 (14%) had an unplanned PICU admission. The most common reason for unplanned ICU admission was the need for post-operative respiratory support.

Conclusion:

Over half of patients (60/115) undergoing surgical correction for their neuromuscular scoliosis were safely managed post-operatively without the need for any PICU admission. Rate of unplanned PICU admission was 14% in patients deemed not to need PICU based on pre-operative assessment. Further research is needed to optimize pre-operative decision making to help guide clinical utilization of this limited resource.

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

208. Functional Response to Halo Gravity Traction (HGT) in Ambulatory Children with Severe Spine Deformity

Amareesa Robinson, BS; Amy L. McIntosh, MD; Charles E. Johnston, MD; Jaysson T. Brooks, MD; Tiffany Thompson, BS; Karina A. Zapata, PhD, DPT

Hypothesis:

Ambulatory children undergoing HGT will demonstrate improved physical and respiratory function.

Design:

Retrospective

Introduction:

HGT improves radiographic alignment in severe pediatric spine deformity, yet its impact on functional capacity remains uncertain. We evaluated changes in physical and pulmonary function during HGT in ambulatory children with spine deformity, with a subgroup analysis post-halo.

Methods:

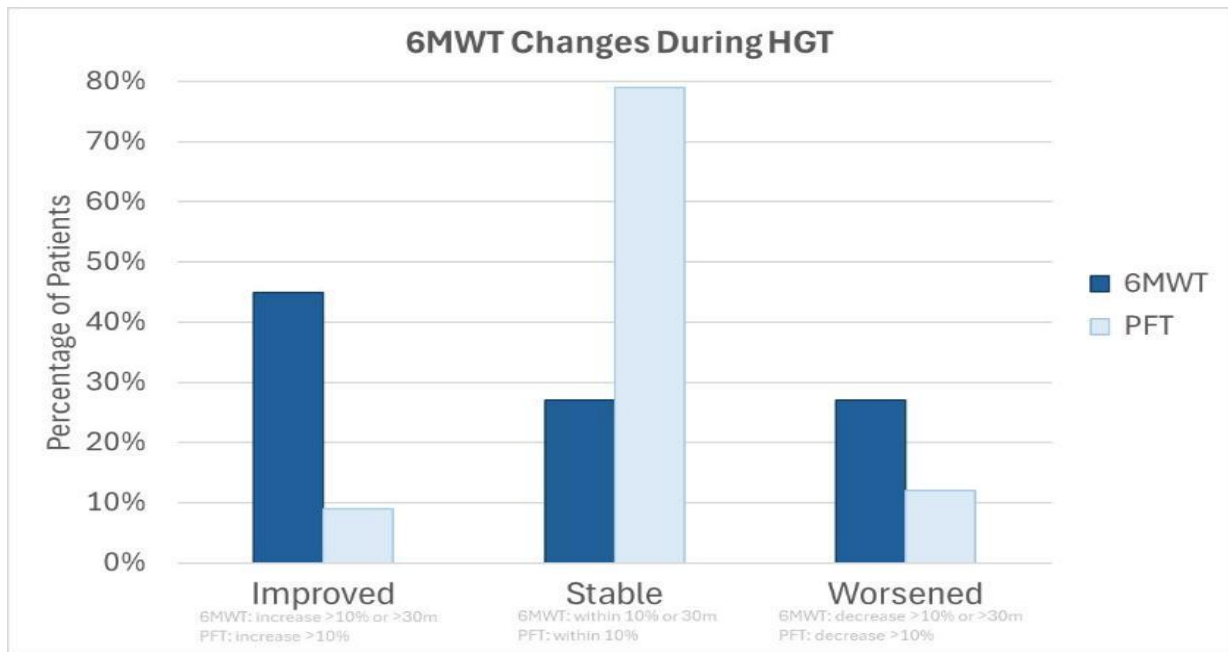
Children who underwent HGT completed six-minute walk tests (6MWT) and pulmonary function tests (PFT) pre- and during-halo. A subgroup completed 6MWT/PFT post-halo following definitive fusion. Clinically important 6MWT outcomes were defined as improved (increase >10% or >30 meters), stable (within 10% or 30 m), or worsened (decrease >10% or >30 m). PFT outcomes were defined as improved (FVC% >10%), stable (within 10%), or worsened (decrease >10%).

Results:

66 children (16 Congenital, 16 Idiopathic, 17 Neuromuscular, 17 Syndromic) averaging 11.2 ± 3.6 years completed pre- and during-halo 6MWT. In HGT, the coronal curves improved from $98 \pm 27^\circ$ to $76 \pm 27^\circ$, and thoracic kyphosis from $67 \pm 27^\circ$ to $51 \pm 25^\circ$. Median traction duration was 51 days, achieving $49 \pm 10\%$ body weight. Mean 6MWT distance remained stable ($405 \rightarrow 408$ m), though 45% of children demonstrated clinically important improvement; 27% worsened and 27% remained stable. The 30 pts with 6MWT improvement did not differ by etiology, age, curve magnitude, traction duration, traction body weight %, or pulmonary metrics ($p > .17$). Among 33 patients with spirometry, absolute FVC (1.2 L) and FEV1 (1.0 L) remained unchanged, with predicted values stable at FVC% $43 \rightarrow 42\%$ and 38%. Only 9% showed clinically important improvement in FVC%; 79% remained stable and 12% worsened. For the post-traction fusion group ($n=13$), 6MWT improved ($322 \rightarrow 404$ m, $p=.013$) after 3.5 ± 1.8 yr. However, this was unchanged compared to age- and sex-matched controls ($-4.1 \rightarrow -4.0$ SD, $p=.86$). Pulmonary function remained stable (FVC% $42\% \rightarrow 45\%$, $p=.33$).

Conclusion:

Nearly half of the ambulatory older children (mean age 11) undergoing HGT experienced clinically important improvements in physical function, independent of etiology, deformity magnitude, traction parameters, or spirometry. In fact, pulmonary spirometry revealed little or no change while in traction. In the post-fusion cohort, intermediate-term follow-up suggests gains in physical capacity, although unchanged from controls.



6MWT Changes in HGT

209. Deep Dive in DiGeorge: Spinal Deformities and Outcomes in Scoliosis Patients

Zachary Trotzky, BS; Alexa J. Karkenny, MD; Jacob F. Schulz, MD; Edina Gjonbalaj, BS; Leila Mehraban Alvandi, PhD; John (Jack) M. Flynn, MD; Pediatric Spine Study Group; Jaime A. Gomez, MD

Hypothesis:

The aim of this study was to provide preliminary radiographic, patient-reported, and clinical outcomes of operative and non-operative scoliosis treatment in children with DiGeorge syndrome.

Design:

Retrospective review of a multicenter database of patients with early-onset-scoliosis (EOS)

Introduction:

DiGeorge syndrome is the most common microdeletion syndrome, characterized by broad phenotypic variability. Patients frequently have cardiac anomalies, immunodeficiency, and musculoskeletal defects, with 50% of affected children developing scoliosis. Given its multisystem involvement, this disorder presents a unique challenge in scoliosis management and surgical decision-making. Current evidence on treatment of pediatric spinal deformity in this population is limited to case-level data.

Methods:

Children diagnosed with DiGeorge syndrome were identified. Patients were grouped based on treatment method: non-operative (brace), growth-friendly (GF) devices, or spinal fusion. Quality of life was measured using the 24-item Early Onset Scoliosis Questionnaire (EOSQ-24). Complications and unplanned returns to the operating room (UPRORs) were recorded.

Results:

This cohort included 75 patients (30 non-operative, 33 GF, and 12 fusion; mean 5 ± 3 -year follow-up). Among non-operative patients, major scoliosis curves progressed from 42 to 48° (Table 1). Surgical treatment decreased the major Cobb angle in the GF (69 to 48°) and fusion groups (66 to 44°). In the GF group, there were 47 complications (13 implant-related, 10 pulmonary) among 19 patients (58%), resulting in 16 UPRORs in 12 patients (36%). In the fusion group, there were 3 complications among 2 patients (17%), resulting in 0 UPRORs. Compared to baseline, mean EOSQ-24 scores improved in 8 of 12 domains in the non-operative group and in all domains in the GF and fusion groups.

Conclusion:

Non-operative treatment effectively maintained major Cobb angle while surgical intervention achieved curve correction. Improvements in quality of life were observed across all groups. Complication rates were higher in the GF group than the fusion group, particularly implant- and pulmonary-related events. Due to systemic comorbidities, children with DiGeorge syndrome may be at higher risk for complications, emphasizing the need for tailored treatment strategies.

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

Table 1. Characteristics and EOSQ-24 Scores of Non-Operative, Growth-Friendly, and Fusion Patients

Characteristic	Non-Operative (n=30)		Growth-Friendly (n=33)		Fusion (n=12)	
Demographic						
Age at baseline (years)*	5.9 ± 3.1		8.6 ± 2.9		12.1 ± 3.8	
Sex (female)	19 (63%)		20 (61%)		8 (67%)	
Baseline BMI (kg/m ²)*	16.6 ± 2.8		16.6 ± 3.0		19.6 ± 4.5	
Radiographic						
Major curve magnitude						
Baseline major Cobb (degrees)*	42.4 ± 17.7		68.5 ± 21.9		65.8 ± 20.5	
Most recent major Cobb (degrees)	47.9 ± 14.6		47.5 ± 18.0		44.3 ± 11.2	
Kyphosis magnitude						
Baseline kyphosis (degrees)	43.8 ± 10.6		49.9 ± 29.5		54.2 ± 10.5	
Most recent kyphosis (degrees)*	44.0 ± 23.7		57.9 ± 20.2		41.2 ± 10.0	
EOSQ-24 scores	Non-Operative		Growth-Friendly		Fusion	
	Baseline	Most Recent	Baseline	Most Recent	Baseline	Most Recent
General Health	55.6 ± 18.9	70.4 ± 20.9	68.3 ± 20.0	74.0 ± 16.9	64.3 ± 8.6	70.8 ± 15.1
Pain & Discomfort	83.3 ± 16.5	73.7 ± 19.0	68.3 ± 24.5	73.4 ± 20.0	55.4 ± 17.5	66.7 ± 31.3
Pulmonary Function	84.7 ± 21.4	86.2 ± 18.1	84.2 ± 14.5	85.4 ± 20.1	60.7 ± 34.1	95.8 ± 6.5*
Transfer	66.7 ± 39.5	75.0 ± 36.3	78.3 ± 24.8	86.5 ± 16.5	71.4 ± 22.5	83.3 ± 30.2
Physical Function	79.6 ± 33.9	76.9 ± 33.3	75.0 ± 26.0	77.1 ± 23.1	61.9 ± 29.2	79.2 ± 20.2
Daily Living	52.8 ± 38.9	61.1 ± 34.0	51.7 ± 30.2	64.6 ± 27.3	35.7 ± 29.3	64.6 ± 34.8
Fatigue & Energy Level	66.7 ± 32.5	81.9 ± 22.8	65.8 ± 29.3	67.2 ± 23.8	55.4 ± 34.5	75.0 ± 26.2
Emotion	86.1 ± 22.0	80.6 ± 22.4	69.2 ± 22.6	74.5 ± 23.5	64.3 ± 19.7	68.8 ± 22.0
Parental Impact	65.0 ± 19.5	73.5 ± 21.1	63.8 ± 25.1	77.1 ± 16.3	62.1 ± 25.3	88.3 ± 11.2*
Financial Impact	86.1 ± 22.0	86.8 ± 21.9	75.0 ± 31.0	78.1 ± 24.8	87.5 ± 30.6	91.7 ± 20.4
Child Satisfaction	80.6 ± 32.5	73.6 ± 18.1	62.5 ± 25.5	69.8 ± 22.1	53.6 ± 30.4	79.2 ± 24.6
Parent Satisfaction	63.9 ± 33.3	70.8 ± 23.1	61.7 ± 24.8	66.7 ± 22.9	53.6 ± 26.7	87.5 ± 13.7*

Data presented as Mean ± SD or n (%); *p < .05

210. Comparison of Traditional Bipolar Constructs and Bipolar Growing Rods (NEMOST) in Paediatric Non-Ambulatory Neuromuscular Scoliosis

Liam Rose, FRCS; Benjamin Prentice, MBBS; Kristopher M. Lundine, MD

Hypothesis:

NEMOST provides superior correction compared to standard bipolar with no further risk.

Design:

Retrospective comparative study

Introduction:

Bipolar constructs are a less invasive option for neuromuscular scoliosis, reducing operative time, blood loss, complications, and improving scoliosis and pelvic obliquity correction. NEMOST, a one-way self-expanding growing rod addition to the bipolar construct, is suitable for younger children requiring continued spinal growth. We compared outcomes of NEMOST versus traditional bipolar constructs.

Methods:

We retrospectively reviewed all children in the seven years since the technique's adoption in our unit, comparing preoperative parameters, blood loss, complications, and radiographic correction. Most had ≥ 2 years follow-up. An age-adjusted bipolar subgroup (<13 years old) was also analysed to account for a trend towards NEMOST in younger patients. Unpaired t-tests, Mann-Whitney-U and Fisher's exact tests assessed significance.

Results:

115 Bipolar patients were compared against 30 NEMOST patients, and an age-adjusted subgroup group of Bipolar ($n=35$). Preoperative Cobb angle and pelvic obliquity were similar (90.3 vs 96.5 , $p>0.2$; 25.2 vs 25.9 , $p>0.8$). Hb drop and transfusion rates were comparable, (34.8 vs 45.0 , $p=0.07$, and 17% vs 18.3%), especially when age-adjusted (17%). Surgical time, length of stay, ICU stay, and immediate postoperative Cobb and pelvic obliquity were similar across groups ($p > 0.05$ for all) in age-adjusted groups. At both one-year and two-years post-op, NEMOST achieved lower Cobb angles than the age-adjusted Bipolar group (42.5° vs 56.1° , $p = 0.007$ and 45.3 vs 58.3 , $p = 0.009$). In the age-adjusted Bipolar group, the Cobb angle increased at one (5.2°) and two years (7.3°) post op, whereas in NEMOST it was stable for one year (-0.4°) and increased slightly at two years (2.5°). There was no significant difference in pelvic obliquity. Hardware failure and return-to-theatre rates were similar in all groups ($p > 0.5$). 90-day mortality was low, with one death in the bipolar group.

Conclusion:

NEMOST showed superior Cobb angle correction up to two-years follow-and a lower risk of crankshafting, showing that there is value in a growing rod construct for younger patients. This did not come at the cost of increased complication rates, length of stay or return to theatre.

211. Index Complications and 30-Day Readmission Vary by Etiology After Posterior Spinal Fusion for Pediatric Neuromuscular Scoliosis

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Hypothesis:

Patients with different neuromuscular scoliosis etiologies experience distinct index complication patterns and 30-day readmission risk following posterior spinal fusion.

Design:

Retrospective cohort study

Introduction:

Neuromuscular scoliosis (NMS) comprises heterogeneous etiologies with differing perioperative risk after posterior spinal fusion (PSF).

Methods:

The 2016–2021 Nationwide Readmissions Database was queried using ICD-10 codes for patients <18 years undergoing posterior spinal fusion for scoliosis, stratified by neuromuscular etiology: cerebral palsy (CP), muscular dystrophy/myopathy, paralysis (paraplegia/quadriplegia, excluding CP), spinal muscular atrophy (SMA), and spina bifida/myelomeningocele (SB/MMC). Primary outcomes included index hospitalization complications, length of stay, and 30-day all-cause readmission. Survey weights generated national estimates. Groups were compared using design-adjusted tests (Rao–Scott χ^2 for categorical and design-based tests for continuous outcomes).

Results:

There were 2,511 admissions (weighted N=7,003). Age and sex differed by etiology (both $p<0.001$): Patients with SMA were youngest (9.99 ± 0.34 years) and myopathy oldest (13.28 ± 0.18), with female proportion lowest in myopathy (26.3%) and highest in SMA (62.2%). Length of stay did not differ ($p=0.112$). Any index complication differed across etiologies (CP 87.5%, paralysis 82.4%, SMA 75.6%, myopathy 66.9%, SB/MMC 65.8%; $p<0.001$). Neurologic complications were highest in CP and paralysis (66.2% and 50.7%) versus SMA and myopathy (6.2% and 9.5%; $p<0.001$). GI complications also varied (CP 43.2%, SMA 42.8% vs SB/MMC 20.1%; $p<0.001$), as did renal/metabolic complications (SMA 25.9% vs paralysis 13.7%; $p=0.038$). Pulmonary, hematologic/thrombotic, and infectious complications were similar across etiologies ($p>0.05$). Thirty-day readmission differed by etiology ($p=0.013$), highest in SB/MMC (18.1%) and paralysis (15.9%) and lowest in SMA (7.0%) and myopathy (7.5%).

Conclusion:

After PSF for scoliosis, different NMS etiologies are associated with distinct complication patterns and 30-day readmission risk. Complications are not uniform across NMS subtypes for neurologic, GI, and renal/metabolic domains, supporting etiology-specific perioperative optimization pathways.

Figure 1. Index complication rates by NMS etiology (survey-weighted). * $p < 0.05$, Rao–Scott adjusted.



Figure 1. Index complication rates by NMS etiology (survey-weighted %). * $p < 0.05$, Rao–Scott adjusted.

212. Efficacy of Halo-Gravity Traction in the Perioperative Treatment of Severe Scoliosis and Kyphosis: A Comparison of Adolescent and Adult Patients. ±

Zifang Huang, MD, PhD; Junlin Yang, MD, PhD; Pan Zhou, PhD; Lei He, MD, PhD

Hypothesis:

To evaluate and compare the efficacy of halo-gravity traction (HGT) as a perioperative management strategy for severe scoliosis and kyphosis in adolescent versus adult patients, specifically focusing on radiographic correction, pulmonary function improvement, and clinical complication rates.

Design:

A retrospective comparative study

Introduction:

Severe spinal deformities exceeding 100° present extreme surgical risks and compromised pulmonary function. Halo-gravity traction (HGT) serves as a vital perioperative adjunct by providing gradual correction and improving respiratory capacity. However, comparative evidence regarding HGT's efficacy across different age-related skeletal maturities remains limited.

Methods:

51 patients with severe scoliosis/kyphosis who underwent HGT followed by posterior spinal instrumented fusion were enrolled. Patients were divided into two groups: Adolescents (10–18 years, n=22) and Adults (>18 years, n=29). Standardized assessments included full-length spine radiographs (pre-traction, post-traction, and post-operation), pulmonary function testing (FVC% and FEV1%), and monitoring for neurological or traction-related complications over a minimum 2-year follow-up period.

Results:

We identified 29 adults (8 males and 21 females, mean age = 23.7 ± 8.7 years) and 22 adolescents (10 males and 12 females, mean age = 13.0 ± 4.5 years). In the adult group, the mean Cobb angle of the main curve before HGT was $141.7 \pm 18.2^\circ$, which improved to $126.4 \pm 8.6^\circ$ and $67.5 \pm 10.2^\circ$ after traction and operation, respectively. The kyphotic angle was corrected from $137.1 \pm 15.6^\circ$ before traction to $122.5 \pm 11.3^\circ$ after traction to $67.6 \pm 13.8^\circ$ after operation. The mean functional vital capacity% and forced expiratory volume in one second% were 43.1% and 37.5%, which improved to 46.7% and 41.7% after traction, respectively. In the adolescent group, the mean correction of the main curve improved from $139.3 \pm 12.6^\circ$ before traction to $112.1 \pm 8.3^\circ$ after traction to $59 \pm 13.1^\circ$ after surgical intervention. The kyphotic angle was corrected from $130.7 \pm 9.4^\circ$ before traction to $101.5 \pm 12.2^\circ$ after traction and then to $48.2 \pm 10.1^\circ$ after surgical intervention. Overall, patients in both groups showed significant improvement in their main scoliosis and kyphosis ($P < 0.05$), while the correction rate of the main curve and kyphosis was significantly higher in the adolescent group than that in the adult group ($P < 0.05$). The functional vital capacity% increased from 44.8% to 55.0% and the forced expiratory volume in one second% increased from 44.0% to 51.0% after using HGT. In terms of surgical outcomes, the incidence of postoperative neurological complications was 27.6% and 18.2% in the 2 groups, respectively.

Conclusion:

HGT is an effective and safe method to correct spinal deformities and improve lung function, especially in adolescent patients with severe scoliosis. In addition, it can potentially reduce the risk of neurological complications and the level of osteotomy in posterior spinal instrumented fusion surgery.

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

213. Sagittal Alignment in Scheuermann's Kyphosis Is Poorly Predicted by Pelvic Incidence Using Vertebral Pelvic Angles

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Hypothesis:

Sagittal alignment in Scheuermann's kyphosis (SK) follows a distinct vertebral pelvic angle (VPA) pattern that is not well predicted by pelvic incidence (PI) alone

Design:

Multicenter, retrospective study

Introduction:

In asymptomatic adults and AIS, VPA demonstrate strong, predictable relationships with PI. However, sagittal plane organization in Scheuermann's kyphosis (SK) has not been characterized using VPA.

Methods:

A multicenter and single-center registry was queried for adult and pediatric SK patients with min 2yr follow-up. Preop VPAs, including C2PA, L1PA, T4PA, and T4-L1PA mismatch, and PI were measured for all patients. Linear regression analyzed relationships between PI and VPAs. R² measured strength of model fit.

Results:

44 SK pts w/ ≥2yr follow-up were included. Mean age was 20.3±8.4yrs, 22.7% (n=10) were female. Mean TK and LL were 78.9±13.5 and 68.0±16.5 degrees, respectively. Mean C2 Tilt, C2PA, L1PA, T4PA, T4-L1PA mismatch, and PI were -5.2±7.65, 6.3±9.7, 4.4±13.4, 3.0±9.8, -1.4±9.7, and 38.9±12.9 degrees, respectively. When examining the relationship between VPAs and PI, L1PA demonstrated a weak but statistically significant relationship with PI (R²=0.15, p=0.0107), described by the equation: L1PA = 0.40·PI – 11.1 ±16.7° (80% prediction interval). Similarly, T4PA showed a weak yet significant association with PI (R²=0.16, p=0.0065): T4PA = 0.31·PI – 9 ±12°. In contrast, neither C2 Tilt (R²=0.01, p=0.6091), C2PA (R²=0.04, p=0.1706), nor T4–L1PA mismatch (R²=0.01, p=0.4335) demonstrated significant relationships with PI. Corresponding equations were C2 Tilt = 0.05PI – 7.01 ± 10.2°, C2PA = 0.16·PI + 0.18 ±12.7°, T4–L1PA = –0.10·PI + 2.1 ±12.9°.

Conclusion:

Vertebral pelvic angles in Scheuermann's kyphosis show weak coupling to pelvic incidence and wide variability, reflecting disruption of normal sagittal alignment rather than an alternative physiologic pattern. Unlike adolescent idiopathic scoliosis and asymptomatic adults, patients with Scheuermann's kyphosis exhibit malalignment in sagittal shape despite maintaining global balance. These findings support the use of vertebral pelvic angles to characterize sagittal deformity and reinforce restoration toward normal alignment targets as a biomechanical goal of correction.

214. Long-Term Assessment of Complications and Reoperations Following Posterior Spinal Fusion for Scheuermann's Kyphosis

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Hypothesis:

Patients undergoing spinal fusion for Scheuermann's kyphosis experience higher complication and reoperation rates in the early postoperative period, with lower incremental risk at longer-term follow-up.

Design:

Retrospective Database Study

Introduction:

Surgical treatment of Scheuermann's kyphosis has evolved with the development of pedicle screw-based segmental instrumentation, and deformity correction can provide reliable alignment correction and pain relief. However, the frequency and timing of complications and reoperations are incompletely defined. Therefore, this analysis leverages a large patient dataset to evaluate complication and reoperation rates after posterior fusion for Scheuermann's kyphosis.

Methods:

A national insurance claims database identified patients with Scheuermann's kyphosis who underwent index posterior spinal fusion spanning ≥ 7 levels with a minimum 2-year follow-up. Demographic and postoperative outcome data were collected and analyzed, including the following variables: Reoperations for revision or exploration of fusion, hardware removal, interbody fusion, and irrigation and debridement, and incidence of deep vein thrombosis, pneumonia or respiratory failure, urinary tract infection, sepsis, acute kidney injury, myocardial infarction, or stroke.

Results:

Two hundred fourteen patients were identified (59.3% male, mean follow-up ≥ 2 years). Pseudarthrosis occurred in 12 patients (5.6%) within 1 year. Reoperation rates were 7.0% at 1 year, 7.9% at 2 years, and 9.3% at 5 years, indicating that most reoperations occurred within the first postoperative year. Medical complications occurred in 7.5% of patients within 30 days and 7.9% within 90 days of surgery.

Conclusion:

Spinal fusion for Scheuermann's kyphosis is associated with moderate early reoperation rates, a slower increase in revision surgery risk beyond the first postoperative year, and low early medical complication rates. This suggests that posterior spinal fusion is a well-tolerated treatment for Scheuermann's kyphosis, but close surveillance is especially necessary during the first postoperative year.

215. Scheuermann's Kyphosis: Are Ponte Osteotomies Necessary?

Jesse P. Robinette, MD; Matthew Siebert, MD; Anna McClung-Booth, BSN; Megan Johnson, MD

Hypothesis:

Ponte osteotomies are not necessary for adequate deformity correction in Scheuermann's kyphosis.

Design:

Retrospective cohort study

Introduction:

Scheuermann's kyphosis (SK) is characterized by hyperkyphosis that often results in cosmetic dissatisfaction, and, rarely, neurologic compromise. While conservative measures are effective for many patients, surgical correction is indicated when symptoms persist. Posterior spinal fusion (PSF) with Ponte osteotomies is considered the gold-standard treatment; however, Ponte osteotomies increase operative time, blood loss, and neurologic risk. This study evaluates whether Ponte osteotomies are necessary to achieve adequate correction of SK.

Methods:

Single-institution retrospective chart review of patients with SK who had a PSF between 2006 and 2024. Patients with other forms of kyphosis and >2 hooks in their PSF construct were excluded. Demographic, radiographic and operative data were included.

Results:

77 patients (55 males, 22 females) were included. Age at surgery was 16.4 ± 2.1 yrs with max thoracic kyphosis of $87 \pm 9^\circ$, and average flexibility of $34 \pm 12\%$ on lateral bolster x-ray. 60 patients had Ponte osteotomies (P+) and 17 (P-) did not. There was no significant difference in age, BMI, pre-operative kyphosis, flexibility, and implant density between groups (Table 1). There was no significant difference in post-operative correction (P+ $27.8^\circ \pm 11.2^\circ$ vs. P- $27.0^\circ \pm 8.7^\circ$, $p=0.814$). The Ponte group had significantly greater EBL (P+ 877 ± 446 mL vs. P- 617 ± 363 mL, $p=0.003$) and operative time (P+ 339 ± 132 min vs. P- 292 ± 158 min, $p=0.018$). Four (7.3%) patients had IONM alerts in the P+ group vs. 0 in the P- group ($p=0.57$). The P+ group had significantly lower rates of radiographic proximal junctional kyphosis (defined as PJK $> 15^\circ$ at 2 year follow-up) than the P- group (13.3% vs. 41.2%, OR 0.18, 95% CI 0.04-0.74).

Conclusion:

In patients with SK undergoing PSF, Ponte osteotomies are not necessary to achieve adequate deformity correction. The use of Ponte osteotomies is associated with higher EBL and longer operative times. Patients who had Ponte osteotomies did, however, have lower rates of radiographic PJK at 2 years, suggesting that shortening the posterior column may have a protective effect against this complication.

	Ponte (n=60)	No Ponte (n=17)	p
Age (years)	16.5±2.0	15.9±2.4	0.407
BMI	28.5±7.2	28.1±7.1	0.771
Maximum Pre-operative Kyphosis(°)	85.9°±8.9°	93.1±7.2	0.0046
Pre-operative Flexibility Over Bolster (%)	35.8±11.8%	31.1±9.9%	0.206
Implant Density(n)	1.5±0.2	1.5±0.3	0.588
EBL (ml)	877±446	617±363mL	0.003
Operative Time (min)	339±132	292±158	0.018
IONM Alert	4	0	0.569
Immediate Post-op Kyphosis Correction (°)	27.8°±11.2°	27.0°±8.7°	0.814
Immediate Post-op Kyphosis Correction (%)	32±12 (3-65%)	29±9 (7-41%)	0.353
Maximum Immediate Post-Operative Kyphosis (°)	58.1°±9.88° (35-82°)	66.1°±9.3° (50-83°)	0.0057
Rate of Radiographic PJK (%)	13.3	41.2	0.008

Table 1

216. Instrumentation to the Sacrum/Pelvis Achieves Greater Sagittal Correction Compared to Shorter Instrumentation in Adult Spinal Deformity Patients with Thoracic Hyperkyphosis

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Hypothesis:

In pts with thoracic hyperkyphosis, fixation to the pelvis achieves greater correction of sagittal alignment compared to shorter instrumentation.

Design:

Retrospective cohort

Introduction:

Selection of the lowest instrumented vertebra (LIV) in adult spinal deformity (ASD) pts with thoracic hyperkyphosis is not completely understood. This study aims to characterize parameters influencing LIV selection and the respective post-operative outcomes.

Methods:

We reviewed all ASD pts with primary thoracic hyperkyphosis, defined as max kyphosis $\geq 60^\circ$ with major Coronal Cobb angle $< 30^\circ$, who underwent fusion extending from T4 or higher to a LIV in the lower thoracolumbar spine (T10 or lower) and had 2+ year follow-up. Proximal/Distal junctional kyphosis (PJK/DJK) were defined as post-operative proximal/distal junctional angle (PJA/DJA) $> 10^\circ$ that increased by 10° or more from baseline. Wilcoxon rank-sum test and Fisher's exact tests were used with significance set to $P < 0.05$.

Results:

20 pts were included (age 50.9 ± 18.0 years; 50% female). 11 pts were fused to the pelvis while 9 were fused shorter (range L1-L3). Pelvic fixation pts were older ($P = 0.019$), had higher BMIs ($P = 0.006$), and had lower L1 Hounsfield Units on computed tomography (CT, $P = 0.049$). At baseline, the pelvic fixation group had lower lumbar lordosis (LL, $P = 0.005$), greater pelvic tilt (PT, $P = 0.015$), greater T4 pelvic angle (T4PA, $P = 0.001$), greater T4-L1PA mismatch ($P = 0.004$), and greater sagittal vertical axis (SVA, $P = 0.002$). Post-operatively, thoracic kyphosis improved significantly in both groups ($P < 0.005$ at all timepoints). Post-operative alignment was comparable, but L1PA ($P = 0.03$) and SVA ($P = 0.02$) were greater in the pelvic fixation group at final follow-up. 4 (36%) pts in the pelvis group and 1 (11%) in the non-pelvis group had complications. Baseline Oswestry Disability Index (ODI) and Scoliosis Research Society (SRS) Function scores were worse in the pelvic fixation group, but all scores were comparable at 2-year follow-up.

Conclusion:

Compared to those fused short of the pelvis, adults with hyperkyphosis treated with pelvic instrumentation had greater baseline sagittal malalignment yet achieved statistically similar post-operative alignments, complication rates, and functional outcome improvements.

	LIV		P-value
	Non-Pelvis N = 9	Pelvis N = 11	
Age (years, mean, SD)	38.8 ± 19.0	60.8 ± 9.6	0.019
Female (N, %)	3 (33%)	7 (64%)	0.37
BMI (kg/m ² , mean, SD)	21.5 ± 3.0	29.0 ± 7.0	0.006
Comorbidities (N, %)			
Osteoporosis	2 (22%)	8 (73%)	0.07
Smoking History	0	1 (9%)	1.00
Prior Lumbar Decompression (N, %)	0	3 (27%)	0.22
Pre-Op L1 CT Hounsfield Units (mean, SD)	201 ± 51	150 ± 113	0.049
Fixation Including Stable Sagittal Vertebra (SSV) (N, %)	3 (33%)	-	
Fixation Including First Lordotic Vertebra (FLV) (N, %)	7 (77%)	-	
Radiographic Parameters (mean ± SD)			
<u>Baseline Pre-Operative</u>			
T2-T12 Thoracic Kyphosis (TK, °)	79.3 ± 15.3	74.2 ± 21.9	0.70
Maximum Kyphosis (°)	87.3 ± 11.6	89.9 ± 18.0	0.94
L1-S1 Lumbar Lordosis (LL, °)	67.1 ± 11.9	46.3 ± 17.1	0.005
Pelvic Incidence (PI, °)	47.3 ± 13.3	48.3 ± 15.6	0.88
Pelvic Tilt (PT, °)	12.5 ± 7.7	25.9 ± 12.5	0.015
T4 Pelvic Angle (T4PA, °)	0.2 ± 6.7	16.0 ± 12.8	0.001
L1 Pelvic Angle (L1PA, °)	0.8 ± 9.9	1.4 ± 13.6	0.82
T4-L1PA (°)	-0.5 ± 5.7	14.5 ± 10.4	0.004
C7 Sagittal Vertical Axis (SVA, mm)	-14.8 ± 18.0	41.9 ± 42.9	0.002
Proximal Junctional Angle (PIA, °)	0.2 ± 7.6	1.7 ± 14.1	0.73
Coronal Major Cobb Angle (°)	11.3 ± 7.7	14.0 ± 8.6	0.45
<u>Immediate Post-Operative</u>			
TK (°)	49.0 ± 7.0	48.6 ± 13.9	0.65
Max kyphosis (°)	49.9 ± 7.2	53.5 ± 12.6	0.29
LL (°)	40.1 ± 11.4	45.9 ± 9.6	0.40
PI (°)	47.7 ± 13.0	47.8 ± 14.0	0.94
PT (°)	21.1 ± 8.4	16.6 ± 10.0	0.36
T4PA (°)	13.3 ± 8.9	9.4 ± 9.6	0.45
L1PA (°)	10.3 ± 9.0	7.4 ± 9.0	0.60
T4-L1PA	3.0 ± 4.6	2.0 ± 3.8	0.65
SVA (mm)	25.7 ± 31.8	32.1 ± 48.5	0.70
PIA (°)	-4.2 ± 8.2	-1.8 ± 13.4	0.56
Coronal Major Cobb Angle (°)	6.0 ± 3.5	6.9 ± 3.9	0.60
<u>Final Follow-up</u>			
TK (°)	48.5 ± 5.6	48.7 ± 12.6	0.71
Max kyphosis (°)	52.5 ± 6.3	56.4 ± 11.9	0.49
LL (°)	50.8 ± 13.4	42.2 ± 12.4	0.22
PI (°)	49.2 ± 12.6	48.7 ± 11.6	1.00
PT (°)	16.1 ± 8.0	20.5 ± 9.5	0.22
T4PA (°)	4.9 ± 7.8	12.9 ± 9.5	0.10
L1PA (°)	3.4 ± 7.9	10.4 ± 7.6	0.03
T4-L1PA	1.5 ± 3.8	2.5 ± 4.3	0.49
SVA (mm)	-20.6 ± 20.2	26.2 ± 47.3	0.02
PIA (°)	0.2 ± 7.6	1.7 ± 14.1	0.73
Coronal Major Cobb Angle (°)	5.2 ± 3.5	6.2 ± 4.9	0.88
Complications (N, %)			
Proximal Junctional Kyphosis (PIK)	1 (11%)	1 (9%)	1.00
Distal Junctional Kyphosis (DIK)	0	0	1.00
Pseudoarthrosis	0	4 (36%)	0.09
Rod Fracture	0	3 (27%)	0.22
Vertebral Fracture	1 (11%)	0	0.45
Revision	1 (11%)	4 (36%)	0.32
Patient-Reported Outcomes (mean ± SD)			
<u>Baseline Pre-Operative</u>			
Oswestry Disability Index (ODI)	23.4 ± 10.6	38.5 ± 15.8	0.014
Scoliosis Research Society (SRS)	71.5 ± 15.6	60.4 ± 11.4	0.15
Function	3.7 ± 0.8	2.8 ± 0.6	0.01
Pain	3.0 ± 1.1	2.9 ± 0.9	0.80
Self-Image	2.8 ± 0.7	2.2 ± 0.7	0.11
Mental Health	3.6 ± 1.1	3.2 ± 0.8	0.48
<u>2-Year Post-Operative</u>			
ODI	7.2 ± 6.7	13.2 ± 10.4	0.27
SRS	99.2 ± 8.2	92.0 ± 7.0	0.22
Function	4.6 ± 0.4	4.2 ± 0.5	0.32
Pain	4.5 ± 0.5	4.1 ± 0.5	0.15
Self-Image	4.6 ± 0.4	4.1 ± 0.5	0.05
Mental Health	4.2 ± 0.6	4.2 ± 0.5	0.32

Table 1: Patient Characteristics and Outcomes Stratified by Lowest Instrumented Vertebra (LIV).

217. The Influence of Patient–Physician Concordance on Bracing Adherence in Adolescent Idiopathic Scoliosis: A Multicenter Prospective Cohort Study ‡

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Hypothesis:

Patients with similar demographic characteristics as their physicians will demonstrate greater adherence to treatment recommendations.

Design:

Retrospective review of a multicenter prospective study.

Introduction:

Patient-provider concordance (PPC) is associated with increased patient satisfaction in orthopaedic care. However, its impact on patient adherence to treatment recommendations remains unclear. Given the potential behavioral malleability of adolescent patients with idiopathic scoliosis (AIS), this study aimed to determine if PPC in age, gender, or race influences bracing adherence in this population.

Methods:

This study included patients >10 years old who initiated bracing for AIS between 2021-2025. Patient demographics and clinical information were obtained from the EHR. Physician demographics were collected via survey. Patients without brace sensor data within one year of brace initiation were excluded. Adherence, calculated as average brace wear divided by prescribed wear time, was treated as both a continuous and binary variable using 80% as a threshold. Mann-Whitney tests and univariate regressions were used for statistical analysis.

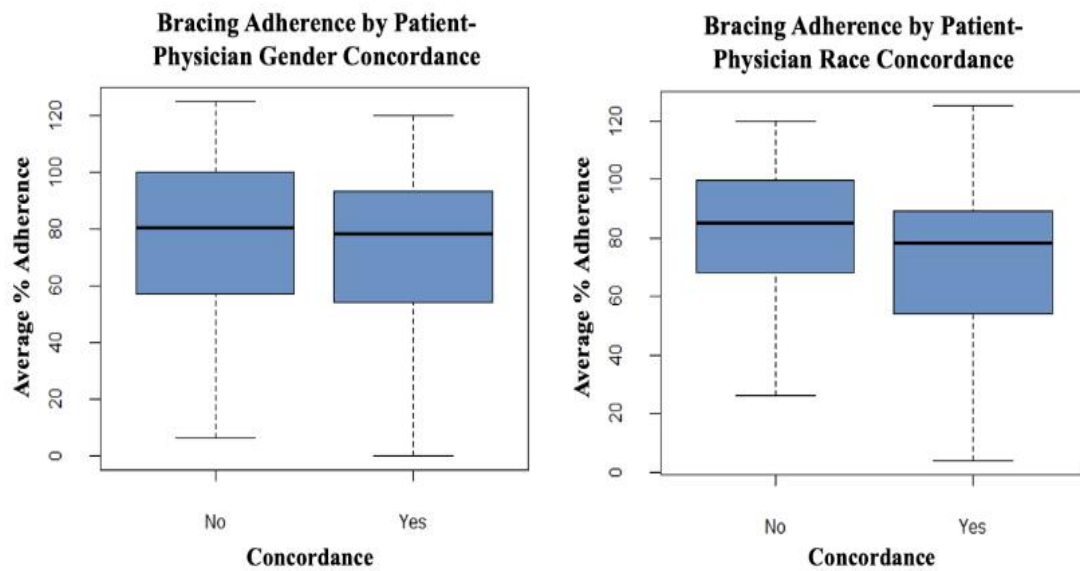
Results:

This study included 122 patients (mean age 13.0±1.5 years, 76% female, 68% white) and 16 physicians (mean age 51.6±11.0 years, 19% female, 81% white). Patients initially presented with an average major Cobb angle of 29.8°±7.0°. Six months after bracing initiation, the median adherence rate for all patients was 80% (range: 0-125%). When controlling for curve severity, Sanders score, and brace type, adherence was not related to PPC in age, gender, or race. Furthermore, there was no statistically significant relationship between PPC and patient progression to either successful nonoperative treatment or surgical intervention.

Conclusion:

In this study, PPC did not influence bracing adherence or outcomes in patients with AIS. These results suggest that alternative factors such as brace discomfort, parental involvement, or social pressures may be more influential. Furthermore, concordance may have a more substantial impact on subjective outcomes – including trust and perception of care – than objective behaviors. Further investigation into the role of the patient-physician relationship in shaping treatment adherence is warranted.

‡ Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant



Comparison of bracing adherence between groups stratified by patient-physician concordance

Comparison of bracing adherence between groups stratified by patient-physician concordance.

218. Brace Adherence Is Not the Whole Story: High Rate of Curve Progression Despite Hyper-adherence in Idiopathic Scoliosis

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Hypothesis:

Curve progression in patients who are hyper-adherent with bracing will be influenced by curve magnitude and in-brace correction.

Design:

Single institution retrospective review

Introduction:

Some patients with idiopathic scoliosis experience curve progression despite being hyper-adherent with brace wear, suggesting that brace adherence is just one of many factors influencing brace success. This study aims to assess the rate of curve progression in a cohort of idiopathic scoliosis (IS) patients who were hyper-adherent with brace wear and to evaluate additional factors associated with curve progression in this population.

Methods:

IRB approved review was conducted of IS patients who were braced between 2015-2024. Patients were included if $\geq 80\%$ of their treatment was monitored by a temp. sensor and their brace adherence averaged $\geq 100\%$ (Providence: ~ 8 hrs/day; TLSO: ~ 18 hrs/day) for the entire duration of bracing. Progression was defined as major curve Cobb progression $\geq 6^\circ$, major curve Cobb $\geq 45^\circ$ at discontinuation, or progression to surgery. Patients who progressed and those who did not were compared using χ^2 tests and Mann-Whitney/t tests, as appropriate, with significance set at $p < 0.05$

Results:

112 patients were included (86% Female). Average age for the cohort was 12.0 ± 1.6 yrs. Overall wear time for patients treated with a TLSO and Providence was 20.4 ± 1.3 and 9.3 ± 0.9 hrs/day, respectively. 22 patients (19.6%) progressed during treatment. There was no difference in age, sex, menarche, or skeletal maturity between patients who progressed vs. those who did not. Patients who progressed had significantly larger pre brace major curve Cobbs (33° vs 27° , $p=0.01$) and demonstrated less in brace correction (52% vs 84%, $p<0.01$). Patients treated with a TLSO were more likely to progress than those prescribed a Providence ($p<0.01$). 10 patients in the TLSO group had curves $\geq 45^\circ$ at brace discontinuation and 8 patients progressed to surgery vs. no patients in the Providence group for either outcome ($p<0.01$).

Conclusion:

Curve progression for patients with idiopathic scoliosis remains problematic even in patients who are hyper-adherent with brace wear. In this population, larger baseline curves, worse in brace correction and use of a TLSO vs. Providence were associated with curve progression. These findings may help guide patient discussions at the time of brace initiation and throughout brace treatment.

Table 1. Comparison of Curve Progression vs. Non-Progression in Patients Who Are Hyper-adherent with Bracing

Variable		Overall			TSLO			Providence		
		No Progression N=90	Progression N=22	P	No Progression N=33	Progression N=17	P	No Progression N=57	Progression N=5	P
Sex	Female	79 (88%)	17 (77%)	0.2	30 (91%)	13 (77%)	0.2	49 (86%)	4 (80%)	0.6
	Male	11 (12%)	5 (33%)		2 (9%)	4 (23%)		8 (14%)	1 (20%)	
Brace Type	Anterior TLSO	6 (7%)	3 (14%)	<0.01	6 (18%)	3 (18%)	0.6			
	Posterior TLSO	27 (30%)	14 (64%)		27 (82%)	14 (82%)				
	Providence	57 (63%)	5 (22%)							
Pre-Brace Menarche Status	Pre	52 (56%)	11 (55%)	0.9	20 (67%)	9 (69%)	0.6	32 (55%)	2 (50%)	0.5
	Post	27 (34%)	6 (35%)		10 (33%)	4 (31%)		17 (35%)	2 (50%)	
Pre-Brace Risser	Risser 0-2	78 (87%)	21 (95%)	0.2	31 (94%)	16 (94%)	0.7	47 (83%)	4 (80%)	0.6
	Risser 3-5	12 (13%)	1 (5%)		2 (6%)	1 (6%)		10 (17%)	1 (20%)	
Progression ≥ 6°	No	90 (100%)	2 (9%)	<0.01	33 (100%)	2 (12%)	<0.01	57 (100%)	-	<0.01
	Yes	-	20 (91%)		-	15 (88%)		-	5 (100%)	
≥45° at Discontinuation	No	90 (100%)	12 (55%)	<0.01	33 (100%)	7 (41%)	<0.01	57 (100%)	5 (100%)	-
	Yes	-	10 (45%)		-	10 (59%)		-	-	
Surgery	No	90 (100%)	14 (63%)	<0.01	33 (100%)	9 (53%)	<0.01	57 (100%)	5 (100%)	-
	Yes	-	8 (36%)		-	8 (47%)		-	-	
Age		12.01 ± 1.6 (7.7 - 16.17)	12.0 ± 1.41 (8.95 - 14.19)	1.0	11.63 ± 1.6 (7.7 - 15.18)	11.88 ± 1.5 (8.95 - 14.19)	0.6	12.23 +/- 1.56 (8.57 - 16.17)	12.38 +/- 1.05 (11.1 - 13.74)	0.8
Pre-Brace Major Curve Cobb (°)		26.64 ± 6.67 (17 - 46)	32.64 ± 9.45 (19 - 47)	0.01	31.85 ± 7.1 (20 - 46)	34.94 ± 9.16 (20 - 47)	0.2	23.63 +/- 4.09 (17 - 34)	24.8 +/- 5.85 (19 - 31)	0.8
In-Brace Correction (%)		83.6 ± 43.06 (-195 - 0)	51.95 ± 38.87 (-195 - 3)	<0.01	47.52 ± 18.75 (-85 - 0)	39.65 ± 18.37 (-70 - 3)	0.2	104.49 +/- 39.17 (-195 - 30)	93.8 +/- 61.21 (-195 - 30)	0.6
Discontinuation Major Curve Cobb (°)		22.23 ± 8.75 (3 - 44)	43.0 ± 10.54 (27 - 61)	<0.01	26.67 ± 9.77 (5 - 44)	45.0 ± 10.88 (28 - 61)	<0.01	19.67 +/- 7.0 (3 - 36)	36.2 +/- 5.89 (27 - 41)	<0.01
Brace Duration (months)		22.26 ± 9.43 (7 - 49)	25.91 ± 8.83 (11 - 50)	0.036	23.64 ± 8.77 (12 - 40)	25.12 ± 9.4 (11 - 50)	0.6	21.46 +/- 9.77 (7 - 49)	28.6 +/- 6.66 (21 - 37)	0.04
Percent of Treatment Covered by Sensor (%)		97.64 ± 5.25 (80.67 - 100.0)	97.58 ± 4.76 (84.43 - 99.9)	0.4	96.77 ± 6.18 (81.01 - 99.92)	97.1 ± 5.31 (84.43 - 99.9)	0.7	98.15 +/- 4.61 (80.67 - 100.0)	99.24 +/- 1.42 (96.7 - 99.9)	0.2
Average Compliance (hours)		13.26 +/- 5.42 (7.98 - 22.46)	18.1 +/- 4.97 (8.57 - 22.9)	<0.01	20.21 +/- 1.29 (17.39 - 22.46)	20.65 +/- 1.33 (18.46 - 22.9)	0.3	9.24 +/- 0.89 (7.98 - 11.67)	9.41 +/- 0.61 (8.57 - 9.88)	0.5

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

219. 30% of Brace-Compliant Patients with Idiopathic Scoliosis End Treatment with Smaller Curves when Treated with a Modern 3D Brace

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Hypothesis:

Idiopathic scoliosis patients with good in-brace correction and high brace compliance can achieve significant curve improvement at skeletal maturity.

Design:

Single-center retrospective review

Introduction:

While historically the aim of bracing was to simply halt progression, many patients now complete their treatment with modern 3D bracing with a smaller deformity than at treatment initiation. There is little to no published evidence documenting the frequency of this new outcome, so we lack the information needed to counsel families regarding curve improvement.

Methods:

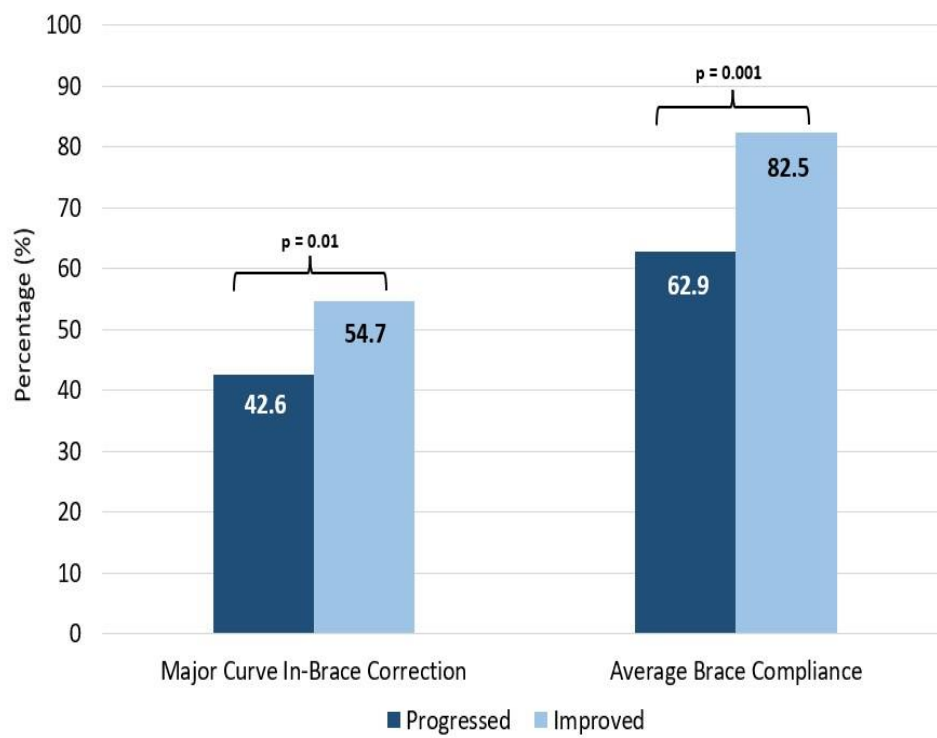
A retrospective single-center brace compliance database was queried for patients 18y/o and under who completed brace treatment for idiopathic scoliosis and had at least 6 months of post-bracing follow-up. Every patient reached skeletal maturity and had data on their heat-sensitive brace compliance monitor, Cobb angle, and in-brace coronal curve correction. Patients were classified based on if their curve progressed ($\text{change} \geq 6^\circ$), remained stable ($-5^\circ \leq \text{change} \leq 5^\circ$), or improved ($\text{change} \leq -6^\circ$). The data were analyzed using descriptive statistics and Wilcoxon rank sum test.

Results:

170 patients were included. At the most recent follow-up, 42 (25%, 31 F) patients' curves progressed, 89 (52%, 76 F) remained stable, and 39 (23%, 34 F) improved. When comparing patients with curve progression vs. improvement, there was no statistically significant difference in age (12.7 v. 12.9 years, $p=0.802$), BMI (18.9 v. 18.0, $p=0.075$), or primary curve magnitude (30° v. 29° , $p=0.955$) at bracing initiation. Patients whose curves improved had significantly greater in-brace correction (54.7% v. 42.6%, $p=0.010$) and greater brace compliance (82.5% v. 62.9%, $p=0.001$) than their peers whose curves worsened. Of patients who braced at least 85% of hours prescribed, 30% ended treatment with a smaller curve.

Conclusion:

23% of idiopathic scoliosis patients treated with a 3D correction brace, and 30% of those who wore their brace at least 85% of the prescribed time, concluded treatment with a deformity smaller than at presentation. Age and major curve magnitude at brace initiation were not significant predictors of curve improvement. We now have evidence to counsel families that a modern 3D correction brace can significantly reduce curve magnitude.



Major curve in-brace correction and average brace compliance in patients with curve progression vs. improvement.

220. Full-time Bracing versus Hybrid Bracing in Adolescent Idiopathic Scoliosis: A Randomized Trial

Adam Yiu Chung Lau, FRCS; Stephanie Tsz Ping Chong; Ho Man Kee, MS; Kenneth Guangpu Yang, PhD, MBBS; Cheuk Kin Kwan, MD; Alec Lik Hang Hung, FRCS; Wayne YW Lee, PhD; M S Wong, PhD; Jack Chun Yiu Cheng, MD; Tsz Ping Lam, FRCS

Hypothesis:

A hybrid bracing protocol combining a daytime underarm brace and a nighttime lateral bending brace can enhance in-brace correction in AIS patients with thoracolumbar or lumbar curves

Design:

A prospective randomized parallel-group trial

Introduction:

Fulltime bracing, such as underarm Brace (UAB), is indicated for skeletally immature adolescents with idiopathic scoliosis (AIS) with Cobb angle $>20^\circ$. Another bracing system is a nighttime Lateral Bending Brace (LBB), which is designed in a bending position opposite to the convexity of the curve, resulting in overcorrection. Previous studies have reported that in-brace correction (IBC) is an important determinant of brace effectiveness. To enhance IBC, we propose a hybrid bracing protocol (HyBP) combining daytime UAB use and nighttime LBB use. The primary objective was to determine whether the HyBP Group achieves superior IBC when compared with the conventional fulltime brace group.

Methods:

102 skeletally immature female AIS patients (baseline mean age 12.3 ± 0.9 years, Cobb angle $25.1 \pm 5.0^\circ$) with a single thoracolumbar or lumbar curve newly prescribed bracing were randomly allocated to the HyBP Group or the Conventional Brace Group (CB Group) ($n = 51$ per group). There were no statistically significant baseline differences between the groups in age, BMI, Risser grade, menarche status, or initial Cobb angle. In-brace correction was measured at 2 weeks after first brace fitting and at three and 18 months.

Results:

At first visit, the in-brace correction was comparable between the HyBP and CB group ($29.1 \pm 27.2\%$ vs $32.2 \pm 18.7\%$, $p = 0.503$). The hybrid brace group maintained better in-brace correction at three and 18 months ($28.4 \pm 28.2\%$, $24.3 \pm 22.2\%$) while the IBC progressively decreased in CB group ($22 \pm 18.6\%$, $16.8 \pm 24.5\%$). However, the change in Cobb angle from first fitting to 18 months did not differ significantly between the two groups (HyBP: $5.4 \pm 9.5^\circ$, CB: $0.44 \pm 9^\circ$, $p=0.09$).

Conclusion:

Hybrid bracing enhances in-brace correction compared with conventional fulltime bracing but does not significantly alter Cobb angle at 18 months. Longer follow up until skeletal maturity is required to determine the effect of improved IBC on final curve outcomes.

Figure 1A: The rigid underarm brace (Conventional Brace) used in this study



Figure 1B: Key pressure areas with paddings and the 3-point control system

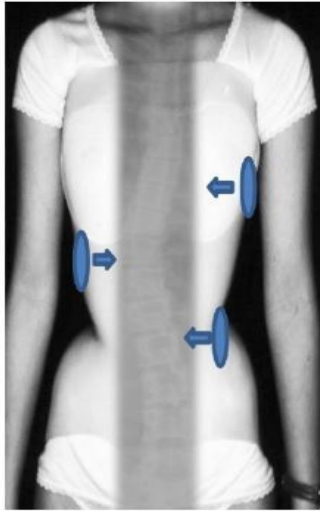


Figure 2A: Before bracing



Figure 2B: x-ray taken with Lateral Bending Brace (LBB)



221. Same-Day In-brace X-rays Result in Better Curve Correction Than Break-in Period X-rays for AIS

Karina A. Zapata, PhD, DPT; Ann Kramer, MS; Grace Dietz, MS; Sara Martinson, MS, CPO; Amy L. McIntosh, MD; Jaysson T. Brooks, MD; Megan Johnson, MD

Hypothesis:

In-brace correction (IBC) for adolescent idiopathic scoliosis (AIS) will be equivalent between same-day x-rays and break-in period x-rays.

Design:

retrospective cohort

Introduction:

It is standard practice to obtain an IB x-ray after brace fitting to evaluate the amount of IBC achieved during brace treatment for AIS, but the ideal timing is unknown. This study compares IBC, brace adherence, curve magnitude changes, and quality-of-life (QOL) changes between patients who undergo IB radiographs the same day as brace fitting and patients who utilize a 1-month break-in period prior to IB radiographs.

Methods:

Single institution review of patients with AIS, Risser 0-2 or Sanders stage <6, curves 20°-45° prescribed custom anterior-opening thoracolumbosacral orthoses from 2022-2024. IBC was calculated by comparing radiographs at brace prescription to IB radiographs. Brace adherence was monitored with temperature sensors. QOL was evaluated with the following PROs: PROMIS Anxiety, Mobility, and Pain Interferences. IBC, brace adherence, QOL changes, and curve magnitude changes were compared between 2 groups (same-day versus break-in) after 6 months.

Results:

118 (same-day=45, break-in=73) patients were included with an average age of 12.4 ± 1.3 and curve magnitude of $29^\circ \pm 6^\circ$ at brace prescription. The groups did not differ by age, sex, curve magnitude, Risser grade, Sanders stage, triradiate cartilage status, and curve pattern. The same-day group required less surgeon clinic visits after brace delivery until their 6-month follow-up visit (1.0 vs. 2.0, $p < .001$) while receiving more orthotist clinic visits (3.3 vs. 2.8, $p = 0.002$) than the break-in group. The same-day group had significantly greater IBC at $58\% \pm 30\%$ than the break-in group at $40\% \pm 23\%$ ($p = 0.002$). There were no significant differences between the same-day and break-in groups for brace adherence (13.8 h vs. 12.8 h, $p = 0.57$), curve progression (-1° vs. 0° , $p = 0.36$), or PROs ($p > 0.5$) after 6 months.

Conclusion:

Same-day IB radiographs show superior IBC compared to IB radiographs taken after a break-in period. Brace adherence, curve magnitude, and PROs are not impacted after 6 months. Same-day IB radiographs also increase clinic availability for providers and improve efficiency by shifting patients' visits to orthotists for brace wear optimization and counseling.

	Nighttime brace	Full-time brace	p-value
Total Sample	n=265	n=255	
Female Sex	78% (n=208)	84% (n=215)	0.088
Initial age (yrs)	12.6±1.3	12.3±1.2	0.023
Initial curve type			<0.001
Thoracic	14%	86%	
Thoracolumbar/Lumbar	86%	14%	
Initial curve magnitude (°)	24.4±3.3	26.9±4.0	<0.001
Initial Risser grade			0.210
0	75%	75%	
1	11%	15%	
2	14%	10%	
Open TRC status	47%	56%	0.027
Initial BMI	18.3±2.9	19.2±3.5	0.003
Years braced	2.2±0.9	2.0±1.0	<0.001
Avg brace wear (h)	7.0±2.3	12.1±5.8	<0.001
Growth (cm)	9.7±6.0	9.0±5.8	0.166
Final curve magnitude (°)	26.7±10.8	33.5±12.7	<0.001
Total curve progression (°)	2.3±10.1	6.6±11.7	<0.001
Curve improvement ≥6°	21%	11%	0.002
Curves stable (-5° to 5°)	48%	44%	0.317
Curve progression ≥6°	31%	45%	<0.001
Progression to surgery	6%	20%	<0.001
Matched thoracic pairs	n=37	n=37	
Open TRC status	51%	51%	1.00
Initial curve magnitude (°)	23.5±2.6	23.5±2.6	0.969
Final curve magnitude (°)	26.2±10.5	27.9±11.9	0.581
Curve improvement ≥6°	17%	13%	0.562
Curve progression ≥6°	24%	32%	0.439
Progression to surgery	5%	11%	0.674
Matched thoracolumbar/lumbar pairs	n=32	n=32	
Open TRC status	59%	59%	1.00
Initial curve magnitude (°)	26.7±3.9	26.7±3.9	1.00
Final curve magnitude (°)	30.5±12.6	31.0±10.3	0.925
Curve improvement ≥6°	14%	7%	0.670
Curve progression ≥6°	31%	28%	0.784
Progression to surgery	13%	9%	1.00

*Bold indicates p<0.05. TRC=triradiate cartilage. Initial=time of brace prescription; Final=skeletal maturity or progression to surgery.

222. Adolescents with Idiopathic Scoliosis Show Less Functional Improvements After Physical Therapy For Low Back Pain

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Hypothesis:

Adolescents with non-specific low back pain (NSLBP) with idiopathic scoliosis (+IS) will have worse functional improvement after outpatient physical therapy (PT) than those without IS (-IS).

Design:

Retrospective cohort

Introduction:

The effectiveness of PT for children with NSLBP +IS compared to -IS is unknown. We compare improvements in functional disability due to outpatient PT between adolescents with NSLBP +IS and NSLBP -IS.

Methods:

All patients treated with outpatient PT for back pain at a pediatric orthopedic institution from 1/2021-3/2024 were reviewed. Functional disability was assessed using the Oswestry Disability Index (ODI-9); 0-20%=minimal disability and 21-40%=moderate disability. Inclusion criteria were a diagnosis of NSLBP and ODI-9 completion at both PT evaluation and discharge. Secondary diagnoses (e.g. non-IS or spondylolisthesis) were excluded. Patients with NSLBP were grouped by + and - IS. Outcomes were defined by % change in ODI-9 scores: improved ($\geq 50\%$ decrease), stable (change between -49% and +49%), or worsened ($\geq 50\%$ increase).

Results:

76 patients with NSLBP (34 +IS, 42 -IS) ages 15.0 ± 2.4 were included. Median back pain duration was 403 days (IQR: 222–1049), with no differences between groups ($p=.52$). In the +IS group, curves averaged $27^\circ \pm 16^\circ$, and most were near skeletal maturity (94% Risser stage ≥ 3 /80% Sanders stage ≥ 6). Patients attended an average of 8.1 PT sessions over 11.3 weeks, similar between groups ($p>.43$). At PT evaluation, mean ODI-9 scores were lower (better) in the +IS group than -IS group (18% vs 24%, $p=.029$). At PT discharge, ODI-9 scores were similar (13% +IS vs 11% -IS, $p=.52$). However, functional improvement in the +IS group was smaller than the -IS group (6% vs 13%, $p=.009$). Fewer in the +IS group achieved $\geq 50\%$ improvement (35% vs 59%, $p=.035$) and more experienced $\geq 50\%$ worsening (18% vs 2%, $p=.042$), indicating a lower rate of clinically meaningful functional gains among those with IS.

Conclusion:

Patients with NSLBP and IS seek outpatient PT despite having relatively low levels of disability. Although PT generally improves function in NSLBP, children with IS experience smaller gains than their peers without IS. These findings suggest that IS may limit the effectiveness of standard PT approaches, highlighting the need for tailored rehabilitation approaches to optimize outcomes in this population.

	NSLBP + IS	NSLBP - IS	P-value
Age (years)	15.9±2.1	14.6±2.7	0.035
Female Sex	79%	76%	0.738
Race			0.677
White	66%	62%	
Black	24%	21%	
Asian	8%	2%	
Other	6%	7%	
Ethnicity			0.002
Hispanic	26%	62%	
Non-Hispanic	74%	38%	
Language			0.024
English	91%	67%	
Spanish	9%	33%	
Insurance			0.028
Private	44%	19%	
Public	29%	57%	
Self-pay	27%	24%	
Body Mass Index (kg/m ³)	21.9±5.3	24.3±6.7	0.934
AIDI State Decile	4.4±2.5	5.0±2.4	0.351
<i>Initial PROs</i>			
ODI-9 Total (%)	18.3±11.1	24.3±12.1	0.029
PROMIS Pain Score	55.3±8.9	57.1±7.5	0.575
PROMIS Mobility Score	45.7±9.5	39.4±7.8	0.002
PROMIS Anxiety Score	48.8±10.3	49.5±10.6	0.892
<i>Final PROs</i>			
ODI-9 Total (%)	12.8±9.3	11.4±9.5	0.521
Change ODI-9 %, Initial – Final	-6%	13%	0.009
ODI Worse (>50% increase)	18%	2%	0.042
ODI Stable (-49% to +49% change)	47%	39%	0.414
ODI Improved (>50% decrease)	35%	59%	0.045
PROMIS Pain	52.8±9.0	57.5±10.5	0.093
PROMIS Mobility	46.8±9.6	41.9±9.3	0.050
PROMIS Anxiety	45.7±10.5	46.4±10.4	0.769

Pt Characteristics and Outcomes

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

223. Factors That Influence Pain Trajectories After Anterior Vertebral Tethering (AVT) for AIS

Charles Culata, BS; John T. Braun, MD; John T. Braun, MD; Sofia Federico; Brian E. Grottkau, MD

Hypothesis:

Multiple factors will contribute to post-operative pain after AVT.

Design:

Prospective 2021-2024

Introduction:

Though pain is a relatively common complaint in AIS patients, few studies have analyzed pre-operative factors associated with the occurrence, persistence, or resolution of pain after AVT. We prospectively analyzed multiple pre-operative factors in a consecutive series of AIS patients treated with AVT to determine the potential association with post-operative pain.

Methods:

Sixty-seven AIS patients consecutively treated with AVT had ≥ 2 years follow-up. Pain was prospectively evaluated pre-operatively and post-operatively (6 weeks, 12 weeks, 6 months, 12 months, and 24 months) using a Visual Analog Scale, SRS-22r Patient Questionnaire, and patient charts. Pain was categorized by severity, location, duration, and timing. Pain resolution was defined as a VAS of 0 at 1 and 2 years. Standard X-rays were used for scoliosis analysis.

Results:

Sixty-seven AIS patients with 96 curves (27 T, 11 TL, 29 Double) measuring 50.5° were treated with AVT at 14.2 years and Sanders 5.1. Pain was present in 63% of pre-operative patients and 45% of post-operative patients with 80% of post-operative pain representing persistent pain and 20% new pain ($p \leq 0.04$). Persistent pain was more likely in patients with severe pain and less likely in patients with mild to moderate pain or intermittent pain. New pain was more likely in patients with larger curves (57°) and greater maturity (Sanders 6.5). Pain was absent in 37% of pre-operative patients with 76% of these remaining pain-free post-operatively. The difference in the occurrence of post-operative pain between patients with and without pre-operative pain (36% vs 9%) demonstrated a trend toward significance.

Conclusion:

In this prospective analysis of 67 AIS patients with 63% pre-operative pain, 45% had post-operative pain associated with the presence and severity of pre-operative pain as well as with greater curve magnitude and skeletal maturity.

224. Growth Modulation After Vertebral Body Tethering Results in Similar Axial Correction to a Posterior Spinal Fusion

Melanie E. Boeyer, PhD; Dustin Kress, BS; Stefan Parent, MD, PhD; Peter O. Newton, MD; Burt Yaszay, MD; Harms Study Group; Dan Hoernschemeyer, MD

Hypothesis:

We hypothesize that: (1) postoperative axial rotation correction would be significantly better after Posterior Spinal Fusion (PSF) than Vertebral Body Tethering (VBT), regardless of whether growth modulation occurred postoperatively.

Design:

Retrospective, multi-center.

Introduction:

Adolescent Idiopathic Scoliosis is a complex three-dimensional deformity characterized by significant axial rotation, particularly at the apex. Though PSF has been shown to significantly reduce apical rotation in the axial plane, no studies have conducted a head-to-head comparison with VBT, particularly when accounting for curve type, deformity magnitude, and lowest instrumented vertebra.

Methods:

We included 86 patients treated with either PSF (n = 43) or VBT (n = 43), all of whom had at least two years of follow-up and the required postoperative radiographic data. Patients were matched one- to-one based on sex, curve type (Lenke 1A/B), main thoracic deformity magnitude ($\pm 5^\circ$), and lowest instrumented vertebra (± 1). Those included were required to have three-dimensional full spine reconstructions preoperatively and at all postoperative timepoints. We quantified raw measures of apical vertebral rotation in the axial plane as well as main thoracic Cobb angle over time. Clinical axial rotation was evaluated using a scoliometer. We defined postoperative growth modulation as $\geq 6^\circ$ of deformity correction from First Erect to Two Years in patients treated with VBT (i.e., VBT-GM). Statistical differences were assessed with either a paired or unpaired, two-sided t-test.

Results:

We observed a significant decrease in main thoracic deformity measures for all patients, with the greatest initial correction being in patients treated with a PSF ($11.8 \pm 7.3^\circ$ vs. $29.2 \pm 11.0^\circ$; $p < 0.001$), followed by continued deformity correction in only VBT-GM ($16.3 \pm 9.5^\circ$ [n = 18] vs. $31.8 \pm 9.4^\circ$ [n = 25]; $p < 0.001$). Those treated with a PSF exhibited better three-dimensional axial correction ($3.8 \pm 8.0^\circ$ vs. $10.8 \pm 8.7^\circ$; $p < 0.001$) at Two Years compared to all VBT; however, no differences were observed between PSF and VBT-GM ($2.3 \pm 8.7^\circ$ vs. $7.3 \pm 9.1^\circ$; $p = 0.166$). We also found no differences in clinical rotation at any timepoint for PSF vs. VBT or PSF vs. VBT-GM.

Conclusion:

Our data indicate that axial correction after VBT is similar to that of PSF when growth modulation occurs. If postoperative growth modulation is unlikely, PSF outcomes are superior.

Table 1. Comparison of Deformity and Axial Rotation Characteristics between VBT vs. PSF and VBT-GM vs. PSF Patients at Relevant Timepoints: values represented as the mean $\pm$ standard deviation; statistical comparisons performed using an unpaired or paired two-sided t-test.

Characteristic	Preoperative			First Erect			Two Years		
	VBT	PSF	P-Value	VBT	PSF	P-Value	VBT	PSF	P-Value
N	43	43	---	43	42	---	43	43	---
Proximal Thoracic	24.0 $\pm$ 6.9	24.6 $\pm$ 7.7	= 0.713	18.9 $\pm$ 7.5	10.1 $\pm$ 4.4	< 0.001	15.5 $\pm$ 9.1	10.6 $\pm$ 4.9	= 0.002
Main Thoracic	50.5 $\pm$ 11.8	51.5 $\pm$ 9.7	= 0.684	29.2 $\pm$ 11.0	11.8 $\pm$ 7.3	< 0.001	25.3 $\pm$ 12.1	16.0 $\pm$ 6.1	< 0.001
Thoracolumbar	32.5 $\pm$ 8.0	35.3 $\pm$ 8.9	= 0.145	21.8 $\pm$ 8.3	14.4 $\pm$ 7.8	< 0.001	18.5 $\pm$ 11.9	14.1 $\pm$ 7.2	= 0.068
Apical Axial Rotation	-13.8 $\pm$ 8.1	-10.7 $\pm$ 10.6	= 0.165	-9.9 $\pm$ 7.5	-2.4 $\pm$ 8.8	< 0.001	-10.8 $\pm$ 8.7	-3.8 $\pm$ 8.0	< 0.001
Scoliometer	14.3 $\pm$ 3.8	15.3 $\pm$ 5.2	= 0.094	9.4 $\pm$ 4.6	5.8 $\pm$ 3.0	= 0.904	10.5 $\pm$ 5.0	6.1 $\pm$ 4.1	= 0.348
Characteristic	VBT-GM			PSF			VBT-GM		
	VBT-GM	PSF	P-Value	VBT-GM	PSF	P-Value	VBT-GM	PSF	P-Value
N	18	18	---	18	17	---	18	18	---
Proximal Thoracic	23.0 $\pm$ 7.2	24.3 $\pm$ 6.9	= 0.609	17.9 $\pm$ 6.2	10.5 $\pm$ 5.5	< 0.001	12.7 $\pm$ 7.8	11.3 $\pm$ 5.5	= 0.558
Main Thoracic	49.1 $\pm$ 9.2	50.3 $\pm$ 8.9	= 0.730	29.1 $\pm$ 10.6	12.9 $\pm$ 5.8	< 0.001	16.3 $\pm$ 9.5	14.5 $\pm$ 4.8	= 0.538
Thoracolumbar	32.3 $\pm$ 7.0	34.3 $\pm$ 7.0	= 0.272	22.8 $\pm$ 10.3	15.3 $\pm$ 8.3	= 0.029	16.0 $\pm$ 14.7	12.4 $\pm$ 8.1	= 0.398
Apical Axial Rotation	-11.8 $\pm$ 9.7	-10.2 $\pm$ 13.5	= 0.682	-7.1 $\pm$ 8.8	0.8 $\pm$ 9.0	= 0.059	-7.3 $\pm$ 9.1	-2.3 $\pm$ 8.7	= 0.166
Scoliometer	12.6 $\pm$ 3.5	14.7 $\pm$ 4.8	= 0.231	9.4 $\pm$ 6.8	5.2 $\pm$ 3.3	= 0.618	7.6 $\pm$ 4.1	6.0 $\pm$ 3.7	= 0.350

* Note: Scoliometer Data at First Erect was Missing for a Large Portion of the Sample: 19 PSF and 18 VBT Patients; All Other Relevant Data were Available at this Timepoint.

Table 1.

225. Biomechanically Optimized Intraoperative Correction in Lumbar Vertebral Body Tethering ± ‡

Marine Gay; Nikita Cobetto, PhD; Christiane Caouette, PhD; A Noelle Larson, MD; Isabelle Villemure, PhD; Melanie E. Boeyer, PhD; Dan Hoernschemeyer, MD; Ahmet Alanay, MD; Ron El Hawary, MD, MSc; Carl Eric Aubin, PhD, P.Eng

Hypothesis:

Patient specific optimization of intraoperative correction in lumbar vertebral body tethering (VBT) will yield satisfactory scoliosis correction at the end of the clinically meaningful growth period.

Design:

Biomechanical study using a validated patient-specific physics-based finite element model (FEM) of pediatric lumbar scoliosis to include spinal growth.

Introduction:

Lumbar VBT is increasingly adopted in adolescent idiopathic scoliosis (AIS) to preserve growth and motion. Surgeons can directly impact intraoperative correction, whereas subsequent growth modulation is biologically driven and challenging to predict. Due to a lack of predictive tools, under and over correction remains a common cause of reoperation and suboptimal results in VBT .

Methods:

Fifteen AIS cases (mean lumbar Cobb 48°, range 40°-59°) were used to build validated 3D patient-specific FEMs (mean 2-yr prediction accuracy: 3°; 90% statistical power). Models were calibrated using preoperative Sanders score (SS), spine flexibility, and body weight. VBT simulations were performed in the lateral decubitus position incorporating actual upper (T10-T12) and lower (L2-L4) instrumented vertebrae. Intra-operative correction levels (50% to 90%) were tested under four alternate growth remaining scenarios (SS 3A, 3B, 4, and 5). Growth and growth modulation were simulated over 2 years. The targeted result was a curve around 10° at 2 year follow-up.

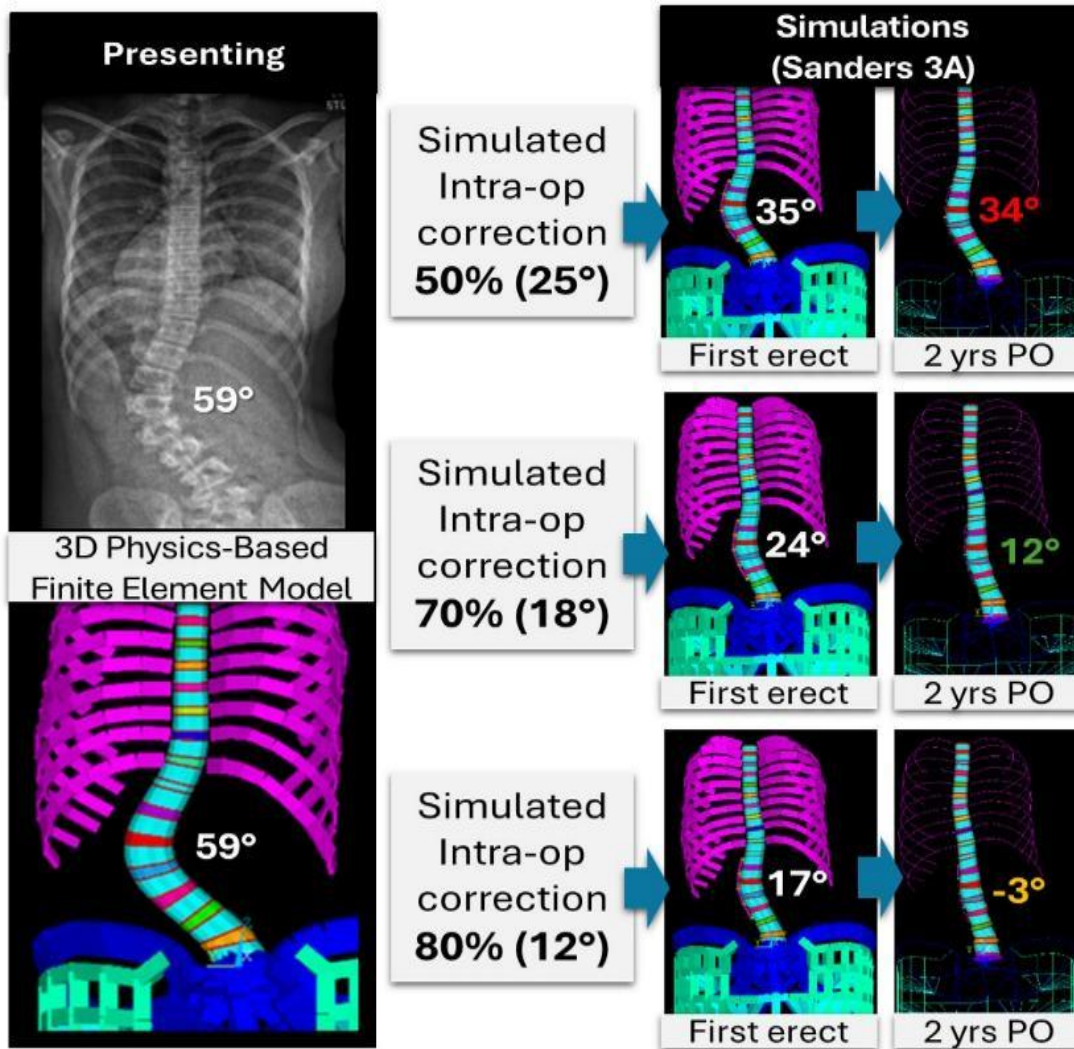
Results:

Achieving a 10 degrees curve at 2 years follow-up required significantly lower intraoperative correction in SS 3A than in all other SS groups (p<0.01). No significant difference was found among SS 3B, 4, and 5. Corresponding intraoperative correction targets were 65% (53%–75%), 72% (60%–80%), 73% (60%–80%), and 73% (68%–80%). Spine flexibility, body weight, and their interactions significantly influenced required correction targets in SS 3A and 3B (p<0.05).

Conclusion:

Optimal intraoperative correction in lumbar VBT depends on growth remaining, patient weight, and curve flexibility. In skeletally immature patients, spine flexibility and body weight should also guide correction target selection. The planning tool presents a pathway forward to develop precise, individualized intraoperative correction strategies to improve the reliability of VBT surgery.

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant



Example of three simulations for a single case with varying intraoperative correction.

226. Multi-Modal PA and Lateral Whole-Spine Radiographs for Predicting Pulmonary Function in Adolescent Idiopathic Scoliosis

Yuanpeng Zhu, MD; Xiangjie Yin, MD; Guilin Chen, MD; Guozhuang Li, MD; Jianguo T. Zhang, MD; Nan Wu, MD

Hypothesis:

A deep learning model that fuses standing PA and lateral whole-spine radiographs can accurately predict spirometric lung function (FEV1 and FVC) in AIS patients, and incorporation of basic clinical covariates will further improve predictive performance compared with imaging-only or clinical-only models.

Design:

Retrospective study

Introduction:

AIS can impair lung function, yet spirometry is not always feasible. Routine standing PA and lateral whole-spine radiographs may enable image-based estimation of FEV1 and FVC for screening and follow-up.

Methods:

We included 1,300 AIS patients with paired standing PA and lateral whole-spine radiographs acquired near the time of spirometry. The dataset was split 8:2 into training and held-out testing sets. Images were standardized with rescaling, centered cropping, and augmentation. A dual-branch convolutional encoder extracted view-specific features from PA and lateral images, followed by attention-based late fusion to generate a unified representation. Age, sex, and BMI were encoded via a small multilayer perceptron and concatenated with fused imaging features. The network was trained as a multi-task regressor to jointly predict FEV1 and FVC. Model performance was evaluated using MAE, RMSE, R^2 , and Pearson correlation (r). Comparator models included: (1) imaging-only PA+lateral fusion, (2) single-view models, and (3) clinical-variables-only baselines. Saliency maps (Grad-CAM) were used for interpretability.

Results:

On the test set, the multi-modal fusion model achieved strong agreement with measured spirometry. For FEV1 prediction, MAE was approximately 0.20 L, RMSE 0.27 L, and R^2 0.79 ($r \approx 0.89$). For FVC prediction, MAE was approximately 0.24 L, RMSE 0.33 L, and R^2 0.76 ($r \approx 0.87$). Adding clinical covariates improved R^2 by ~ 0.04 – 0.07 over imaging-only fusion. Dual-view fusion outperformed single-view models by ~ 0.06 – 0.12 in R^2 , while clinical-only baselines showed modest performance ($R^2 \approx 0.45$ – 0.55). Grad-CAM highlighted the thoracic cage contour, thoracic spine curvature, and costovertebral regions as key contributors to predictions.

Conclusion:

A deep learning model using paired PA and lateral whole-spine radiographs can predict FEV1 and FVC in AIS, with further improvement from basic clinical covariates. This low-cost tool may support pulmonary risk stratification and follow-up, pending external validation.

227. Integrated Spatial and Single-Nucleus Transcriptomics Uncovers Molecular Drivers of Muscle Fiber Transition: a new player in Adolescent Idiopathic Scoliosis

Gen Tang, PhD; Wayne YW Lee, PhD; Jack Chun Yiu Cheng, MD; Adam Yiu Chung Lau, FRCS; Tsz Ping Lam, FRCS

Hypothesis:

We hypothesized that specific cellular drivers within paraspinal muscles are key regulators of mechanical sensing and muscle fiber transition that drive the initiation and progression of AIS.

Design:

This study integrates human snRNA-seq and spatial transcriptomics with in vitro validation and two in vivo mouse models.

Introduction:

Current AIS therapies target symptoms rather than the unknown etiology. While paraspinal muscle asymmetry is evident in AIS and increased lean mass reduces risk, it remains unclear whether these phenotypes drive deformity. To identify the cellular mechanisms of this remodeling, we integrated single-nucleus RNA sequencing (snRNA-seq) and spatial transcriptomics (ST), aiming to uncover novel diagnostic and therapeutic targets.

Methods:

We constructed a spatially resolved transcriptomic atlas from AIS patient multifidus muscles using snRNA-seq and ST. Validation included in vitro Gene A knockdown and two in vivo models: a mechanical restrainer to simulate loading, and an AAV-mediated Gene A knockdown in wild-type mice to demonstrate independent causality of curvature initiation.

Results:

Trajectory analysis of the transcriptomic atlas identified a novel myogenic precursor population—situated between satellite cells and mature fibers—defined by Gene A and Gene C expression. Clinical validation confirmed significant upregulation of both genes in the convex side. In vitro, Gene A knockdown suppressed Gene C and MYH7, triggering a Type I-to-II fiber transition. In the thoracic restrainer mouse model, we demonstrated that Genes A and C are modulated by mechanical loading, mirroring clinical asymmetry. Crucially, AAV-mediated knockdown of Gene A in wild-type mice was sufficient to induce significant right thoracic curvature by 7 weeks, with mean Cobb angle progression increasing from 2.6° to 15.5°.

Conclusion:

We present the first spatially resolved transcriptomic atlas of AIS paraspinal muscles, identifying 'Gene A+' precursors as regulators of mechanical sensing and fiber transition. Crucially, Gene A knockdown in wild-type mice was sufficient to induce curvature, proving this deficit drives AIS initiation. This finding establishes a new target for non-surgical, biological intervention.

228. Hybrid Fixation is Superior to Bilateral Vertebral Body Tethering for AIS Patients with Double Curves

Amer F. Samdani, MD; Alexander J. Schupper, MD; Joshua M. Pahys, MD; Emily Nice, BS; Sanaa Jackson, BS; Terrence G. Ishmael, MBBS; Steven W. Hwang, MD

Hypothesis:

The hybrid (H) approach (thoracic fusion/contralateral lumbar tether) will provide similar results to bilateral vertebral body tethering (bVBT).

Design:

Retrospective review of prospective single institution data.

Introduction:

In skeletally immature patients with AIS, VBT is a viable option, but with limited correction and a high reoperation rate. The hybrid technique offers a novel approach for patients with double curves but lacks data assessing its efficacy. We sought to determine how the hybrid technique compares with bVBT in patients with AIS.

Methods:

We identified all patients treated with either the hybrid technique or bVBT with a minimum 2-year f/u. Clinical and radiographic data, including reoperations and outcomes, were compared using Student's t-test and Fisher's exact testing where appropriate.

Results:

130 patients were identified (H=27, bVBT=103). Patients were predominantly female (H=70.4%, bVBT=88.3%), with similar age at surgery (H=13.3±1.4 years, bVBT= 12.8±1.3 years, p=0.080). Mean follow-up was H=33.3±8.4 and bVBT=56.5±21.7 months. Both groups were skeletally immature (Sanders median H= 4, bVBT= 3, p<0.01). Hybrid patients had significantly larger pre-op curves compared to bVBT patients (T: 64.0±12.6° vs. 52.9±9.3°, p<0.01; L: 60.1±10.0° vs. 50.9±8.3°, p<0.01). On FE, the hybrid cohort had smaller thoracic curves (15.9±6.5° vs. 29.8±8.7°, p<0.01), and similar lumbar curves (18.1±9.3° vs. 20.7±10.5°, p=0.3). At 2 years, the hybrid cohort had smaller thoracic (17.1±7.0° vs. 23.4±9.7°, p<0.01) and lumbar 12.2±7.3° vs. 17.7±11.6°, p<.01) curves, but with significantly greater % correction (T: H=73.6%, bVBT=55.1%: p<0.01, L: H=79.7%, bVBT= 65.7%, p<0.01). At latest follow-up, all hybrid patients had thoracic curves <30°, with 1 patient (3.7%) having a lumbar curve >30°. In contrast, 56 (54.3%) bVBT patients had a thoracic curve >30°, and 26 (25.2%) had a lumbar curve >30°. Both groups had similar reoperation rates (H=33.3%, bVBT= 28.2%, p=0.64), but 17 (16.5%) bVBT patients received a fusion, with none in the hybrid group.

Conclusion:

Hybrid fixation provides markedly better correction than bVBT for AIS patients with double curves. A successful outcome (curve <30°) was achieved in 96% (26/27) of hybrid patients but in only 43.7% (45/103) of bVBT patients. For most patients with double curves, the hybrid approach is the more reliable option.

Demographics	Hybrid	Bilateral	p-value
Total # VBT	27	103	
Female	19 (70.4%)	91 (88.3%)	0.4906
Follow-up (months)	33.3 ± 8.4	56.5 ± 21.7	<0.0001
Age at index procedure (years)	13.3 ± 1.4	12.8 ± 1.3	0.0795
Radiographic Information			
Pre-op thoracic Cobb	64.0 ± 12.6	52.9 ± 9.3	<0.0001
Pre-op lumbar Cobb	60.1 ± 10.0	50.9 ± 8.3	<0.0001
Pre-op Sanders score (median)	4	3	<0.0001
Pre-op Risser grade (median)	1	0	<0.0001
First erect thoracic Cobb angle (°)	15.9 ± 6.5	29.8 ± 8.7	<0.0001
First erect lumbar Cobb angle (°)	18.1 ± 9.3	20.7 ± 10.5	0.2756
2-year thoracic Cobb angle (°)	17.1 ± 7.0	23.4 ± 9.7	<0.0001
2-year lumbar Cobb angle (°)	12.2 ± 7.3	17.7 ± 11.6	0.0004
Latest thoracic Cobb angle (°)	13.6 ± 6.3	28.8 ± 11.2	<0.0001
Latest lumbar Cobb angle (°)	12.8 ± 8.4	22.8 ± 12.4	<0.0001
Latest thoracic Cobb angle >30°	0 (0)	56 (54.4)	<0.0001
Latest lumbar Cobb angle >30°	1 (3.7)	26 (25.2)	<0.0001
2-year % correction thoracic	73.6 ± 10.5	55.1 ± 17.2	<0.0001
2-year % correction lumbar	79.7 ± 11.0	65.7 ± 22.4	0.0087
Reoperations			
Number of patients requiring reoperations	9 (33.3%)	29 (28.2%)	0.6378
Total number of reoperations	9	41	
Months from index	23.6 ± 6.2	33.7 ± 22.7	0.2246
Conversion to fusion	0 (0)	17 (16.5)	<0.0001

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

229. Automated Alpha Angle Calculation for Adolescent Idiopathic Scoliosis Surgery Planning Using Deep Learning Pose Model

Shun Herng Tan, MBBS; Saturveithan Chandirasegaran, MBBS, MSOrth; Chee Kidd Chiu, MBBS, MSOrth; Chris Yin Wei Chan, MD, MSOrth; Mun Keong Kwan, MBBS, MSOrth

Hypothesis:

An artificial intelligence–based model can accurately and reliably automate Alpha Angle calculation, providing an objective and patient-specific target for LIV tilt.

Design:

Retrospective diagnostic validation study.

Introduction:

Accurate selection of lowest instrumented vertebra (LIV) tilt is essential to prevent distal adding-on in adolescent idiopathic scoliosis. We previously showed that achieving an intraoperative LIV tilt (β) $\geq$ preoperative Alpha Angle (α) from supine left side-bending radiographs reduced adding-on to 10%. This study aimed to develop an AI model to automate Alpha Angle calculation and provide an objective, patient-specific LIV tilt target.

Methods:

This study included 249 AIS patients (Lenke 1–6) undergoing posterior spinal fusion. Supine left side-bending radiographs were divided into training (n=199) and validation (n=50) sets. A YOLOv11-pose CNN was trained to identify T11–L4 vertebrae and the pelvis to calculate the Alpha Angle. Performance was validated against expert consensus using ICC, mean absolute error, clinical success rates ($\pm 3^\circ$ and $\pm 5^\circ$), and mean average precision.

Results:

The AI system achieved robust technical performance on the validation set, with a bounding box mAP50 of 99.4% and pose estimation mAP50 of 97.6%. In clinical validation, the model demonstrated excellent reliability with an ICC of 0.931 (95% CI: 0.89–0.96). The Mean Absolute Error was 1.68° , with negligible systematic bias (-0.12° ; $p=0.78$). The AI achieved a clinical success rate of 92.0% within a 5° threshold and 80.0% within a 3° threshold. AI–surgeon agreement rate at 3° was 80.0%, and at 5° was 94.0%. There was no significant difference in X-angle, Alpha angle, and adjusted Alpha angle between surgeon consensus and AI. For the Y-angle, the AI measured a significantly lower displacement ($p\text{-value}<0.001$). Stratified analysis showed robust accuracy from T11 to L1, though reliability decreased at the L2 level (ICC=0.39).

Conclusion:

This study introduces the first AI system to automate Alpha Angle calculation for AIS surgical planning, demonstrating expert-level reliability (ICC >0.93) and accuracy exceeding inter-surgeon variability. With 92% of measurements within 5° of expert consensus, it provides a rapid and consistent alternative to manual measurement, bridging complex modeling and practical clinical application.

230. Effect of Upper Instrumented Vertebra Selection on Sagittal Contour and Proximal Junctional Alignment in Adolescent Idiopathic Scoliosis

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Hypothesis:

In Adolescent Idiopathic Scoliosis (AIS) patients undergoing posterior spinal fusion, selection of a more proximal upper instrumented vertebra (T3) results in improved postoperative thoracic sagittal contouring and moderation of proximal junctional kyphosis (PJK) magnitude compared with more caudal fixation (T4–T5), even with baseline differences in proximal junctional morphology, without a predictable reduction in short-term PJK incidence.

Design:

AIS patients (11–18 years) undergoing primary posterior spinal fusion with UIV at T3 (n=48), T4 (n=62), or T5 (n=35) were retrospectively reviewed.

Introduction:

Selection of the upper instrumented vertebra (UIV) in AIS patients is frequently influenced by concern for PJK and sagittal alignment control. Extension to T3 optimizes thoracic contouring and junctional behavior despite increased surgical extent, yet evidence supporting improved junctional outcomes is limited.

Methods:

Radiographic parameters included thoracic sagittal alignment, shoulder balance, and PJK angle assessed preoperatively, immediately postoperatively, and through 2-year follow-up. PJK was defined as a $>10^\circ$ increase between the lower endplate of the UIV and upper endplate of UIV+2.

Results:

Baseline deformity features were comparable across groups, except for PJK angle, which was significantly greater in T5 constructs than T3 (10.9° vs 5.7° , $p<0.001$). T3 fixation increased surgical extent: greater fusion length and operative time ($p<0.001$). Across immediate and early follow-up, more caudal UIV selection displayed consistently higher absolute PJK angles, with T5 constructs exceeding mean values of 13° by 3 months, while T3 constructs maintained lower junctional magnitudes ($p<0.05$ through 1 year). Although 2-year PJK incidence differed in significantly among groups, junctional kyphosis magnitude and sagittal alignment trajectories favored more proximal fixation.

Conclusion:

More proximal UIVs were associated with improved control of PJK magnitude and early sagittal contouring, despite baseline differences in junctional morphology. While extension to T3 did not significantly reduce 2-year PJK incidence, it moderated junctional kyphosis severity during early and mid-term follow-up. These findings support individualized UIV selection based on sagittal morphology and junctional alignment goals rather than binary prevention of PJK.

231. The Impact of Multiple Indications-related Learning Curves on Complications and Additional Procedures after Anterior Vertebral Tethering (AVT) for AIS

John T. Braun, MD; John T. Braun, MD; Sofia Federico; Charles Culata, BS; Brian E. Grottkau, MD

Hypothesis:

Multiple indications-related learning curves will impact outcomes after AVT for AIS.

Design:

Retrospective 2010-2024

Introduction:

While AVT has been proposed as an alternative to fusion surgery for AIS, the earliest reported outcomes for this new procedure have been disappointing. Though a relatively high rate of complications and additional procedures is likely related to multiple factors, an analysis of the indications-related learning curves necessary to improve outcomes for this novel procedure has yet to be accomplished.

Methods:

One hundred ninety-nine AIS patients consecutively treated with AVT had >2 year F/U. Patients were divided into 3 groups depending on the time period in which they were treated: early (2010-2014), middle (2015-2019), and late (2020-2024). Charts and radiographs were reviewed to identify complications and additional procedures for each of the groups.

Results:

Of 199 AIS patients consecutively treated with AVT over 15 years, 14 were in the early group, 38 in the middle group, and 147 in the late group. Complications in the early group: 42% tether rupture/21% overcorrection/7% kyphosis progression with 7% revision/21% fusion. Complications in the middle group: 39% tether rupture/8% inadequate correction with 8% revision/8% fusion. Complications in the late group: 33% tether rupture/5% inadequate correction/2% overcorrection. Overcorrection and kyphosis progression were essentially eliminated after the early time period due to a change in indications ($p<0.05$). Inadequate correction decreased after the middle time period due to a change in indications ($p<0.05$). Tether rupture decreased over time but not significantly. Adding-on and progression of an adjacent curve were not encountered.

Conclusion:

In this study, complications and additional procedures decreased over time due to a better understanding of the indications for AVT. The learning curves for overcorrection and kyphosis progression were short and essentially allowed the elimination of these two complications after the early time period due to the avoidance of small curves, excessive immaturity, and kyphosis. The learning curve for inadequate correction was longer but allowed a significant decrease in this complication after the middle time period due to avoidance of large, stiff curves. Unfortunately, we were unable to identify a learning curve for tether rupture.

232. Just “A Small Tune-up”? Do VBT Revisions Have More Perioperative Complications Than Index Procedures?

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Hypothesis:

Revision thoracic vertebral body tethering (VBT) has similar 90-day peri-operative complication rates compared with index VBT procedures.

Design:

Multicenter retrospective cohort study using an international pediatric spine registry

Introduction:

Revision VBT procedures are becoming more common. Surgeons anecdotally report pleural adhesions and scarring during repeat thoracic approaches that may increase perioperative risk; however, outcomes remain poorly defined. This study compared 90-day complications after index and revision thoracic VBT.

Methods:

An international, multicenter pediatric spine registry was queried for scoliosis patients with index or revision thoracic VBT performed between 2013-2025 and ≥ 30 days of follow-up. Revision cases underwent review of case details and radiographs to confirm procedure and approach. Demographics, clinical data, surgical data, and 90-day complications were compared between index and revision cases.

Results:

We identified 362 patients receiving index VBT and 15 that underwent revisions. Surgical approach was confirmed to be repeat endoscopic thoracic approach for 13/15 (87%) of patients, though could not be verified in the remaining 2 patients. Eight patients (53%) underwent selective tether ligation or removal for overcorrection, while 7/15 (47%) underwent tether replacement for curve progression and/or suspected rupture. Revision patients were younger at time of surgery than index (11.4 vs. 12.8 years; $p=0.019$). Procedure time was shorter for revisions (184 vs 233 min; $p=0.047$). There was no significant difference in overall 90-day complications between index and revision procedures (24.0% vs 20.0%; $p=1.00$; Table 1). Pulmonary complications requiring intervention occurred in 9 (2.5%) index and 1 (6.7%) revision ($p=0.34$). Repeat interventions under anesthesia were required in 15 (4.1%) index vs. 1 (6.7%) revision complication patients ($p=0.46$).

Conclusion:

Complications of revision thoracic approaches for VBT were previously unknown. This study indicates that revision endoscopic thoracic approaches for VBT are feasible and may be performed without increased perioperative complication risk compared with index surgery. This study is limited by a small number of revision procedures. Future analysis with more revisions will further define these risks. This data remains valuable for surgical decision-making and patient counseling.

Surgical Data				
	Index Tether (N= 362)	Revision Tether (N=15)	P-value	
LOS (days) (average (SD))	5.1 (1.7)	4.1 (2.1)	p = 0.21	
Procedure Time (minutes) (average (SD))	233 (84)	184 (89)	p = 0.047	
EBL (cc) (average (SD))	183.13 (176.1)	181.40 (113.3)	p = 0.44	
Thoracic Approach			Note: 3 Revisions had additional open lumbar approaches	
Endoscopic	307 (85%)	13 (87%)		
Open	9 (2.5%)	0 (0%)		
Unknown	46 (13%)	2 (13%)		
Complications				
	Index Tether (N= 362)	<u>Revision</u> (N=15)	P-value	Intervention and outcome
All complications n (%)	87 (24.0%)	3 (20%)	p = 1.00	-
Neurologic	6 (1.7%)	1 (6.7%) a	p = 0.25	Temporary sensory or motor def. – all resolved
CSF leak	3 (0.83%)	0 (0%)	p = 1.00	Blood patch (2), Lumbar drain, screw revision (1)
Wound	8 (2.2%)	0 (0%)	p = 1.00	Deep SSI: debridement (2) Keloid – scar revision (1)
Pulmonary ^b	9 (2.5%)	1 (6.7%)	p = 0.34	-
Pneumothorax/Hemothorax	5 (1.4%)	1 (6.7%)	p = 0.22	Drain placement (5) Repeat Exploration (1)
Pleural Effusion	4 (1.1%)	0 (0%)	p = 1.00	Drain placement (4) Antibiotics (2)
Other (Pain, GI, prolonged LOS)	62 (17%)	1 (6.7%)	p = 0.48	-
Required intervention under anesthesia	15 (4.1%)	1 (6.7%)	p = 0.48	-
LOS = Length of Stay, EBL = Estimated Blood Loss, CSF = Cerebrospinal Fluid, GI = Gastrointestinal, SSI = Surgical Site Infection. Categorical variables were compared using Fisher's exact test; continuous variables were compared using independent-samples t-tests. ^a One revision patient experienced thigh numbness/weakness which resolved with time. ^b Pulmonary complications (pneumothorax, hemothorax, pleural effusion) were only included if they required additional treatment.				

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

233. The Law of Diminishing Returns: Is There an Optimal Implant Density for Outcomes in Spinal Fusion for Adolescent Idiopathic Scoliosis?

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Hypothesis:

Increasing implant density (ID) will only yield better outcomes up until a certain threshold.

Design:

Single center retrospective

Introduction:

In spinal fusion for adolescent idiopathic scoliosis (AIS), prior literature analyzed if ID affected outcomes in a binary fashion (high ID [HID] vs. low ID [LID]). However, ID was seldom analyzed as a continuous variable, and the type of relationship (linear or quadratic) between ID and outcomes is underexplored. By extension, there is a sparsity in literature on whether an optimal ID (OID) exists. Therefore, we investigated [1] if simply increasing ID yielded better outcomes, [2] if this relationship was linear or quadratic, and [3] if there was an OID.

Methods:

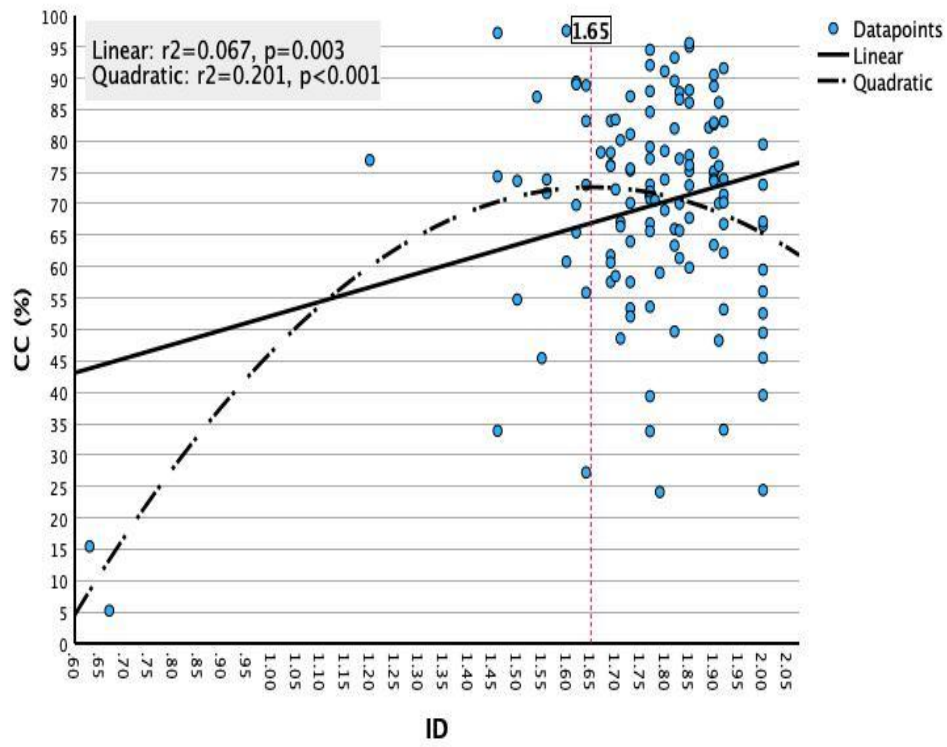
Patients who underwent spinal fusion for AIS from 2019-2025 were reviewed at a single academic center. Demographics, ID, Coronal Cobb Correction at 4 weeks (CC) and estimated blood loss per level fused (EBL) were analyzed. [1] The effect of ID on outcomes was assessed by linear regression in unadjusted and adjusted (controlling for age, sex, BMI, and pre-op Cobb angle) analysis. [2] For outcomes significantly affected by ID, curve analysis was done to determine if the relationship between ID and outcome was linear or quadratic (whichever had a higher r^2 fit the data better). [3] If the relationship was linear, OID of 2 was assumed; if the relationship was quadratic, then vertex analysis was done to calculate OID.

Results:

There were 128 patients (14.4 ± 2.2 yo, 66% F, 1.76 ± 0.20 ID). Increasing ID was associated with increased CC (unadjusted and adjusted $p < 0.031$) but not EBL (unadjusted and adjusted $p > 0.18$). For CC, a quadratic curve fit the data better compared to a linear curve (r^2 0.20 vs. 0.07). In vertex analysis, OID was 1.65 for CC.

Conclusion:

This is the first study to find ID quadratically affecting CC (with an OID). Increasing ID had better CC up until 1.65 ID. Beyond this, CC slightly declined, suggesting diminishing returns. Though the OID could change with greater sample size, due to the significant quadratic relationship found in this study, we think this diminishing return phenomena will be generalizable. Higher number of implants could be expensive while increasing the total risk of malpositioned screws. Taken together with prior literature showing similarity in outcomes between LID and HID, this study highlights the diminishing returns of using ID beyond 1.65.



± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

234. Patient-Perceived Recovery After Posterior Spinal Fusion: Evaluating Minimum Clinically Important Difference (MCID) in Adolescents with Idiopathic Scoliosis

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Hypothesis:

Lower preoperative SRS-22r scores will predict greater likelihood of achieving anchor-based minimum clinically important difference (MCID) following posterior spinal fusion (PSF) in adolescents with idiopathic scoliosis (AIS).

Design:

Retrospective analysis of a prospectively collected AIS surgical registry

Introduction:

AIS is the most common pediatric spinal deformity requiring surgical correction, yet postoperative recovery varies widely. The SRS-22r assesses multidimensional patient-reported outcomes (PROs), but the ability of preoperative scores to predict clinically meaningful improvement remains unclear. Identifying predictive domains may improve risk stratification and guide targeted perioperative interventions.

Methods:

AIS patients who underwent PSF (2012–2022) with ≥ 2 -year follow-up were included. Exclusions were non-idiopathic scoliosis and anterior fusion. SRS-22r scores were collected preoperatively and at 6 weeks, 6 months, 1 year, and ≥ 2 years. Anchor-based MCID thresholds (pain 0.6, function 0.3, self-image 1.3, mental health 0.3) were applied. Demographics, surgical variables, and Child Opportunity Index (COI) were recorded. Multivariable logistic regression identified independent predictors of MCID achievement.

Results:

A total of 161 AIS patients were analyzed (mean age 15.3 ± 2.2 years; 65.8% female; 78.9% residing in very low/low COI areas). Median preoperative Cobb angle was 56° . At 1 year, MCID was achieved in 35% (pain), 36% (function), 30% (self-image), and 43% (mental health). By ≥ 2 years, pain (26%) and self-image (23%) declined, while function (44%) and mental health (35%) were sustained. Lower preoperative SRS-22r scores predicted MCID across all domains ($p < 0.05$). Independent predictors included poorer baseline mental health for pain and mental health MCID, lower baseline function for functional MCID, lower self-image plus male sex for self-image MCID, and younger age for functional recovery.

Conclusion:

Preoperative SRS-22r profiles are strong predictors of clinically meaningful improvement following PSF in AIS. Patients with worse preoperative pain, function, mental health, or self-image demonstrate the greatest capacity for postoperative improvement. Integrating baseline PROs into preoperative counseling and risk stratification may support targeted perioperative interventions and optimize long-term outcomes.

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

Table 1. Number and Percentage of Patients Who Did and Did Not Pass Bago et al.'s anchor-based MCID thresholds (Across SRS-22r Domains) (A indicates anchor based)

SRS-22r Domains	MCID Achievement Status n (%)	MCID Threshold
Mental Health (1 Year Postoperative)		0.3
Not Achieved	47 (56.6)	
Achieved	36 (43.4)	
Mental Health (≥ 2 Years Postoperative)		0.3
Not Achieved	39 (65.0)	
Achieved	21 (35.0)	
Pain (1 Year Postoperative)		0.6
Not Achieved	53 (65.4)	
Achieved	28 (34.6)	
Pain (≥ 2 Years Postoperative)		0.6
Not Achieved	63 (74.1)	
Achieved	22 (25.9)	
Function and Activity (1 Year Postoperative)		0.3
Not Achieved	53 (63.9)	
Achieved	30 (36.1)	
Function and Activity (≥ 2 Years Postoperative)		0.3
Not Achieved	53 (55.9)	
Achieved	26 (44.1)	
Self-Image (1 Year Postoperative)		1.3
Not Achieved	58 (68.9)	
Achieved	25 (30.1)	
Self-Image (≥ 2 Years Postoperative)		1.3
Not Achieved	44 (77.2)	
Achieved	13 (22.8)	

Table 2. Significant Predictors of MCID Achievement Across SRS-22r Domains in AIS Patients Undergoing Posterior Spinal Fusion

SRS-22r Domain	Significant Predictor	Exp(B) [95% CI]	p-value
Mental Health (1 year)	Pre-op Mental Health	0.161 [0.057-0.460]	<0.001
Mental Health (more than 2 years)	Pre-op Mental Health	0.184 [0.070-0.488]	<0.001
Pain (1 year)	Pre-op Pain	0.019 [0.002-0.143]	<0.001
	Pre-op Mental Health	4.813 [1.110-20.843]	0.034
Pain (more than 2 years)	Pre-op Mental Health	0.082 [0.023-0.294]	<0.001
	Sex (M)	0.135 [0.026-0.698]	0.017
Function (1 year)	Pre-op Function	0.060 [0.014-0.255]	<0.001
Function (more than 2 years)	Pre-op Function	0.125 [0.033-0.480]	0.002
	Age	0.640 [0.45-0.909]	0.013
Self-Image (1 year)	Pre-op Self-Image	0.019 [0.003-0.135]	<0.001
	Sex (M)	6.141 [1.018-37.032]	0.048
Self-Image (more than 2 years)	Pre-op Self-Image	0.056 [0.009-0.370]	0.003
	Pre-op Pain	0.235 [0.056-0.992]	0.049

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

235. The Role of Caudal Screw Fixation in Outcomes of Posterior Dynamic Distraction Device for Adolescent Idiopathic Scoliosis

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Hypothesis:

Caudal screw parameters influence rates of mechanical failure, revision, and curve correction in patients treated with the Posterior Dynamic Distraction Device (PDDD).

Design:

Retrospective multicenter cohort study

Introduction:

Non-fusion options, such PDDD for adolescent idiopathic scoliosis (AIS), aims to correct deformity and preserve motion. PDDD has 2 pedicle screws cranially but only one caudal screw. This study evaluated caudal screw parameters on mechanical failure, revision surgery, and construct breakage.

Methods:

A review of AIS patients from a multicenter registry who underwent PDDD with ≥ 2 -year follow-up was performed. Caudal screw depth, rod-to-caudal screw angle, and caudal screw-to-upper endplate angle was measured. Mechanical failure was defined as breakage in any component. Revisions for non-mechanical reasons (infection and max actuator length) were excluded.

Results:

A total of 156 patients (mean age 15 yrs, range 10-25 yrs; 75% female) were included, mean f/u of 2.3 years. Mean initial coronal deformity was 45.5°, and 21.5° at final. Construct breakage occurred in 14.4%, and overall mechanical failure in 23.5%. Revisions for mechanical failure occurred in 12.3%. Patients with mechanical failure had a significantly greater final coronal deformity (27.5° vs 19.7°, $p = 0.002$). Revisions, breakage, and mechanical failure were all correlated with more convergent, negative, initial screw-to-upper endplate angle (2.2° vs -1.4°, $p = .009$, 2.2 vs -1.7, $p = .02$, and 2.7° vs -1.6°, $p = .0002$, respectively). Mechanical failure was also correlated with lower initial and final caudal screw depth (78 vs 72, $p = .0331$; 75 vs 68.8, $p = .0320$, respectively), lower initial rod-to-caudal screw angle (87.9 vs 84.4, $p = .009$), and initial and final convergent screw-to-upper endplate angulation (2.7° vs -1.6°, $p < .001$; 1.2° vs -2.2°, $p = .004$, respectively). BMI, Sanders score, and curve flexibility were not correlated with complications. At the final follow-up, 116 patients retained the device, 26 had the device removed, and 14 were converted to PSF.

Conclusion:

PDDD achieved meaningful curve correction, but with notable mechanical failure rates. Caudal screw sagittal position and depth of insertion, but not screw diameter, were associated with suboptimal outcomes, emphasizing the importance of sagittal screw trajectory and depth to maximize outcomes and minimize reoperations.

236. Supercrit-processed allograft reduces pedicle screw loosening at the last instrumented levels in AIS posterior fusion

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Hypothesis:

The addition of supercritical CO2 processed allograft to local autograft enhances distal fusion and reduces the incidence of pedicle screw (PS) loosening at the lowest instrumented levels (LIV) in adolescent idiopathic scoliosis (AIS) surgery.

Design:

Single center retrospective study.

Introduction:

Achieving solid posterior fusion in long constructs remains challenging, even in children, especially at both extremities submitted due to high mechanical loads. The identification of radiolucent halos around distal PS indicate residual micromotion and can lead to revision. Supercritical CO2 sterilization is an innovative process used to prepare allograft, preserving bone matrix's structural integrity, but its safety and efficacy have not been investigated in pediatric PSF.

Methods:

A total of 360 consecutive AIS patients who underwent non-selective PSF (>9 levels) were reviewed, with a minimum 2-year follow-up. Group 1 (n=180, before 2021) received local autograft alone, while a combination of autograft and 250cc of supercrit-processed allograft chips were used in group 2 (n=180, after 2021). Radiological and clinical outcomes were evaluated, and the rates of PS loosening were compared.

Results:

Groups were comparable regarding age, flow-up duration, preoperative deformity magnitude and correction rates (67-69%). The incidence of PS loosening was 6.4% in the entire cohort, only located at LIV and LIV-1, and was significantly reduced in group 2 (2.8% vs 10%, p=0.001). All halos appeared progressively and were not visible before 1 year follow-up. In Group 1, loosening led to 2 unplanned revisions and 5 cases of LIV screw fracture, while no complication was reported in group 2.

Conclusion:

The incidence of PS loosening is not negligible after AIS PSF, especially at distal levels. The combination of supercritical CO2 processed allograft with local autograft, associated with thorough distal decortication, significantly reduces the occurrence of distal radiolucency and implant failure.

237. Sagittal Alignment Stabilizes at 3-Months Postoperatively in Pediatric Idiopathic Scoliosis

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Hypothesis:

Sagittal plane maturation occurs by 3 months postoperatively

Design:

Retrospective, single institution cohort

Introduction:

In pediatric spinal deformity, postoperative standing alignment emerges from surgically established anatomy and compensatory adaptive responses of the non-instrumented segments. Identifying the point of radiographic maturation—where sagittal alignment reaches a stable, durable state—is critical for postoperative monitoring and determining when further concern regarding sagittal balance is warranted. This study evaluates the longitudinal stability of vertebropelvic angles (VPAs) to define the timeframe of definitive sagittal maturation following surgical intervention for Juvenile and Adolescent Idiopathic Scoliosis (JIS, AIS).

Methods:

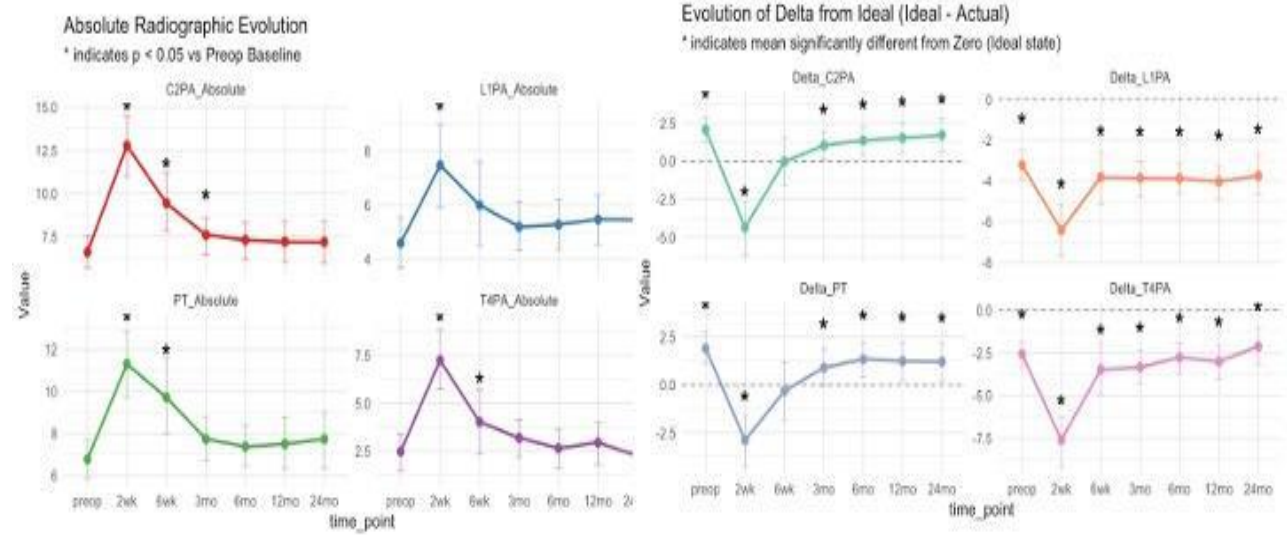
251 patients with JIS and AIS who underwent spinal instrumentation and fusion (posterior, anterior, or combined approaches) were reviewed. Standing lateral radiographs were analyzed preoperatively and postoperatively at 2 weeks, 6 weeks, 3 months, 6 months, 1 year and 2 years. VPAs (C2PA, PT, T4PA, L1PA) were plotted absolutely and compared against proposed ideal parameters ($\Delta VPA = VPA_{ideal} - VPA_{actual}$); ideal PT was assumed from Le Huec 2019 and ideal VPAs from MEANS results.

Results:

Preoperatively, mean ΔPT and $\Delta C2PA$ were positive (+2.0 and +2.1, respectively), indicating a pelvic anteversion relative to the proposed ideal. Following surgery, acute significant shifts occurred at 2 weeks, with mean absolute values peaking (C2PA: 12.8; PT: 11.3) and ΔVPA values crossing zero to reach a nadir ($\Delta C2PA$: -4.3; ΔPT : -2.8), representing initial over-correction/retroversion. Beginning at 3 months, all VPAs demonstrated definitive stabilization. From 3 to 24 months, mean absolute values and ΔVPA deviations remained statistically stable ($p < 0.05$), with final $\Delta C2PA$ and ΔPT settling at +1.7 and +1.2.

Conclusion:

In AIS/JIS, the sagittal plane radiographically stabilized at 3 months postoperatively. This was maintained through 24 months, suggesting that radiographs obtained at the 3-month mark accurately reflect the patient's final compensated balance state. While final parameters often deviate from proposed ideals, the system organizes into a stable, patient-specific equilibrium. These findings indicate that surgeons can trust that sagittal alignment has stabilized by 3 months until at least 24 months postoperatively.



VPAs stabilize by 3 months postoperatively up to 2 years

238. Balancing Motion and Correction: Mid-Term Outcomes of Hybrid Fixation in Adolescent Idiopathic Scoliosis

Feyzi Kilic, MD; Altug Yucekul, MD; Gokhan Ergene, MD; Sahin Senay, MD; Elif Gizem Carus, MS; Tais Zulemyan, MS; Caglar Yilgor, MD; Ahmet Alanay, MD

Hypothesis:

To report the mid-term radiographic, patient-reported, pulmonary, and implant-survival outcomes for a consecutive cohort of patients undergoing hybrid fixation for scoliosis.

Design:

A retrospective analysis of a single-center, consecutive patient cohort.

Introduction:

Vertebral body tethering (VBT) is a motion- preserving scoliosis treatment. For complex curves, a hybrid approach combining thoracic posterior fusion with thoracolumbar/lumbar VBT balances correction and mobility. This study reports mid-term outcomes for this technique, as comprehensive series are limited.

Methods:

Prospectively maintained data from a single center were retrospectively analyzed. Outcomes included upper thoracic (UT), main thoracic (MT), and thoracolumbar/lumbar (TLL) Cobb angles; SRS-22 patient-reported outcomes; and percent-predicted pulmonary function tests (FVC, FEV1). Complications and implant survival were also recorded.

Results:

Twenty-five patients (mean age 13.9 ± 2.5 years; 84% female) were analyzed with a median follow-up of 27.2 months [24.2–29.2]. Lenke types were: Type 1: 43.5%, Type 2: 17.4%, Type 4: 4.3%, Type 5: 26.1%, and Type 6: 8.7%; lumbar modifiers: A: 4.3%, B: 26.1%, C: 69.6%. Preoperative flexibility was $48.8 \pm 20.5\%$ for UT, $56.8 \pm 20.5\%$ for MT, and $80.7 \pm 18.9\%$ for TLL. UT, MT, and TLL Cobb angles were $36.0 \pm 11.1^\circ$, $61.8 \pm 17.3^\circ$, and $50.9 \pm 13.9^\circ$ preoperatively; improved to $8.1 \pm 5.0^\circ$, $7.8 \pm 5.0^\circ$, and $12.8 \pm 6.6^\circ$ at first erect; and measured $8.8 \pm 6.3^\circ$, $11.0 \pm 8.7^\circ$, and $12.3 \pm 8.3^\circ$ at latest follow-up. SRS-22 self-image improved significantly ($\Delta +0.84$, $p < 0.001$), with 67% of patients achieving MCID. Other SRS-22 domains (Function, Pain, Mental Health) and pulmonary function tests remained unchanged (all $p > 0.05$). Two mechanical complications occurred (tether break in 8% of patients), and no readmissions or reoperations were recorded.

Conclusion:

In this cohort with over two years of follow-up, hybrid fixation provided substantial and maintained correction of all curves. Patient self-image improved while pulmonary function was preserved. The technique showed a favorable mid-term safety profile with low mechanical complication rates, supporting its use as a promising motion- preserving alternative, warranting confirmation in larger cohorts with longer follow-up.

239. Hybrid Fixation vs Bilateral VBT in AIS: Striking the Balance Between Durability and Motion

Altug Yucekul, MD; Feyzi Kilic, MD; Fedde Weenink, MD; Gokhan Ergene, MD; Sahin Senay, MD; Elif Gizem Carus, MS; Tais Zulemyan, MS; Caglar Yilgor, MD; Ahmet Alanay, MD

Hypothesis:

To compare outcomes of hybrid fixation vs. bilateral VBT for AIS in the first matched, follow-up–equalized analysis.

Design:

A retrospective analysis of prospectively collected data for a 1:1 matched cohort.

Introduction:

Hybrid fixation and bilateral VBT are motion- preserving options for adolescent idiopathic scoliosis (AIS). Hybrid constructs provide durable correction in the thoracic spine while preserving lumbar mobility. Bilateral VBT offers flexibility across both regions but may carry higher risks of tether-related complications. To date, no direct comparison between these two approaches has been reported.

Methods:

A 1:1 matched cohort (15 pairs) was created from prospective data based on preoperative Cobb angle and skeletal maturity. Analyses were capped at the shorter follow-up for each pair (median 25.3 months). Cobb angles, SRS-22 scores, pulmonary function, complications, and implant survival were compared.

Results:

The matched cohort (15 pairs) had mean ages of 13.3 ± 1.3 yrs (Hybrid) and 12.9 ± 2.0 yrs (Bilateral). Preoperative Cobb angles (Hybrid vs. Bilateral) were: UT $36.8^\circ \pm 10.5^\circ$ vs $29.9^\circ \pm 9.6^\circ$ ($p=0.152$); MT $62.1^\circ \pm 17.5^\circ$ vs $59.7^\circ \pm 10.2^\circ$ ($p=0.678$); and TLL $50.4^\circ \pm 8.5^\circ$ vs $49.9^\circ \pm 8.6^\circ$ ($p=0.080$). At the first- erect, differences in correction were: UT -12.5° ($p=0.0017$), MT -20.0° ($p<0.001$), and TLL -5.5° ($p=0.049$). At the latest follow-up, differences were: UT -10.1° ($p=0.020$), MT -17.1° ($p<0.001$), and TLL -9.7° ($p=0.014$). The difference in SRS-22 score change ($\Delta\Delta$, Hybrid–Bilateral) was significant for the Function domain: -0.47 ($p=0.014$). Other SRS-22 $\Delta\Delta$ were: Pain -0.17 ($p=0.539$), Self-image $+0.39$ ($p=0.298$), and Mental Health -0.51 ($p=0.113$). Changes in pulmonary function (FVC, FEV1) were not significant: FVC -4.0 ($p=0.561$) and FEV1 -1.5 ($p=0.802$). Tether breaks occurred in 2 Hybrid vs. 9 Bilateral patients ($p=0.023$). Kaplan- Meier survival free of a tether break for Hybrid vs. Bilateral was 1.00 vs. 0.857 at 12 months, and 0.825 vs. 0.455 at 24 months (log-rank $p=0.015$) (Fig 1).

Conclusion:

In this first matched, follow-up–equalized comparison, Hybrid fixation provided better radiographic correction and implant survival. Bilateral VBT showed superior improvement in the SRS-Function domain. Results suggest Hybrid fixation offers greater durability, while Bilateral VBT may have functional advantages. Longer-term studies are needed.

240. Incidence of Proximal Thoracic Major Scoliotic Curves and its Significance: An Analysis of 970 Patients
Chee Kidd Chiu, MBBS, MSOrth; Ying Ying Thum, MBBS; Saturveithan Chandirasegaran, MBBS, MSOrth; Chris Yin Wei Chan, MD, MSOrth; Mun Keong Kwan, MBBS, MSOrth

Hypothesis:

We hypothesized that proximal thoracic major scoliotic curves are significantly associated with a higher prevalence of non-idiopathic scoliosis compared with main thoracic (MT) and thoracolumbar/lumbar (TL/L) major curves.

Design:

Retrospective study

Introduction:

Proximal thoracic major scoliotic curves can be found among individuals with scoliosis. As defined by the Lenke classification, these curves have an apex at T3, T4 or T5. The proximal thoracic is major when it had the largest Cobb angle. This study aimed to determine the prevalence and clinical significance of proximal thoracic major curves.

Methods:

We analyzed 970 patients diagnosed with scoliosis in the outpatient clinic from 2012 to 2018. Included were all patients with lateral spine curves exceeding 10° in the coronal plane. Whole spine AP standing radiographs were obtained for major curve and type analysis. Clinical and radiological data of all patients, including age, gender, presenting symptoms and signs, comorbidities, family history and MRI/CT findings, were then collected and analyzed.

Results:

Among the 970 patients, aged 2 to 41 years, 779 (80.3%) were females and 191 (19.7%) males. The incidence of proximal thoracic major curves was 2.6%, while the incidence of main thoracic major curves and TL/L major curves were 54.4% and 43%, respectively. Within the proximal thoracic major curve group, 84% had left-sided curves, and 16% had right-sided curves. Notably, the prevalence of non-idiopathic scoliosis was significantly higher in the proximal thoracic major curve group (64%), compared to the MT major group (16.5%) and TL/L major curve group (18.5%). All patients with right-sided proximal thoracic major curve had non-idiopathic scoliosis, while 57.1% of those with left-sided proximal thoracic major curves were non-idiopathic. The proximal thoracic major curves had a higher proportion of males compared to females (72% vs 28%). Neural axis abnormalities (43.8%) were identified as the most common cause of non-idiopathic scoliosis in this group.

Conclusion:

Proximal thoracic major scoliotic curves comprised of 2.6% of cases and show a high prevalence of non-idiopathic causes (64%), with neural axis abnormalities being the most common. Right-sided curves were exclusively non-idiopathic, emphasizing the need for detailed evaluation and imaging in this group.

241. Safety and Efficacy of VBT at 5-year Follow-up: How to Optimize Outcomes

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Hypothesis:

Long term clinical and radiographic outcomes of VBT are favourable at 5-yrs post-op

Design:

Retrospective, multicentre

Introduction:

Vertebral body tethering (VBT) is a growth friendly potential surgical alternative to spinal fusion. Safety and efficacy of VBT has been primarily reported out to 2-yr f/u, however, longer term f/u beyond 2-yrs remains sparse. Our aim was to report on the clinical, radiographic, and complication profile of VBT at min 5-yr f/u.

Methods:

A retrospective, multicentre non-fusion database identified all consecutive patients who underwent a VBT procedure with min 5-yr f/u. Data was collected at preop, first erect (FE), 2-yrs, and 5-yrs post-op. Demographic, clinical, radiographic, and complication data were analyzed. Success was defined a priori as major tethered coronal Cobb $<30^\circ$ at most recent f/u. Univariate and multivariate regression attempted to identify predictors of success.

Results:

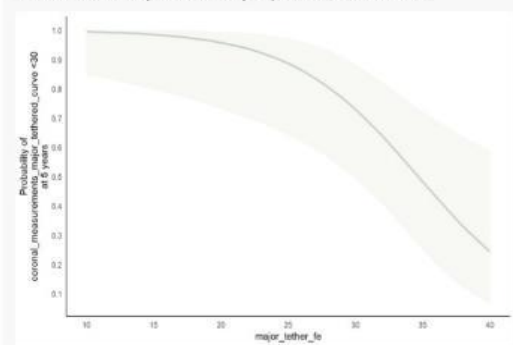
Total of 84 patients (83.1% female, 16.9% male), mean age of 12.2 ± 1.7 yrs, and min 5-yr f/u were reviewed. Most curves were Lenke 1 (57.4%), 2 (22.1%) and 5 (8.8%). Majority of patients were Sanders 3 (53.7%) and 81.2% were Risser 0. Avg preop height was 155.8 ± 10.1 cm increasing to avg 169.2 ± 8.5 cm at 5 yrs. Median preop major Cobb was 46° [IQR: 42, 56; Range: 30-81] correcting to median 27° [IQR: 20, 33.8; Range: 5-49] at FE with further correction to median 22.5° [IQR: 13.8, 31.5; Range: 1-55] at 5-yr f/u. Thoracic rib hump improved from mean $14 \pm 5.3^\circ$ to $9.5 \pm 6.3^\circ$ and lumbar hump from mean $6.7 \pm 4.8^\circ$ to $4.4 \pm 4.3^\circ$. 72% of patients had clinical success at 5-yr f/u with major tethered coronal Cobb $<30^\circ$. Univariate analysis identified preop height ($p=0.03$) and major tethered coronal Cobb at FE ($p=0.02$) to be predictors of success which remained significant in the multivariate regression model ($p=0.04$; $p=0.01$). With each unit increase in preop height, Sanders, Risser, and major tethered Cobb at FE, the odds of successful outcome decreased by 12%, 37%, 60%, and 19%, respectively. There were 53 reported complications in 29 patients with a reoperation rate of 16.7%: 9.5% conversion to fusion; 7.1% revision VBT.

Conclusion:

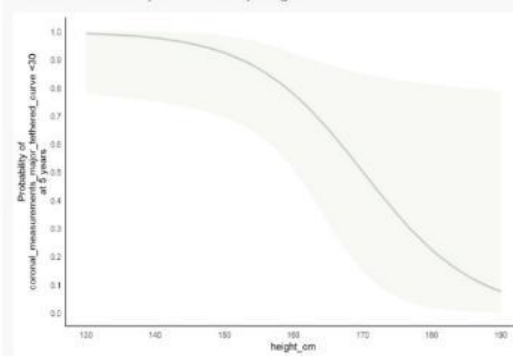
This is the largest min 5-yr f/u multicenter study showing VBT remains a safe and effective treatment option in idiopathic scoliosis. Success was noted in 72% of patients with the odds of successful outcome strongly associated with preop height, Sanders, Risser, and major tethered Cobb at FE. A 16.7% reoperation rate should alert surgeons to continue to optimize patient selection.

Patient Demographics		Preop	FE	2-yr	5-yr
Mean age(yrs)		12.2+/-1.7			
Gender (%)		M=16.9 F=83.1			
Sanders (%)		1(7.4); 2(18.5); 3(53.7); 4(5.6); 5(5.6); 6(7.4); 7(1.9)			
Mean Height (cm)		155.8+/-10.1	157.1+/-10.4	165.6+/-9.5	166.3+/-21.8
Mean BMI		18.6+/-3	18.1+/-2.5	20.6+/-3.1	22.1+/-4.1
Risser 0 (%)		81.2	79.4	17.5	1.5
Risser 1 (%)		4.3	7.4	8.8	0
Risser 2 (%)		8.7	7.4	19.3	1.5
Risser 3 (%)		5.8	5.8	31.6	16.2
Risser 4 (%)		0	0	22.8	38.2
Risser 5 (%)		0	0	0	42.6
PeriOp Outcomes					
Mean ORT (minutes)		357.1+/-352.8			
Mean EBL (cc)		194.1+/-127.5			
Mean LOS (d)		4.9+/-2.2			
Mean No. of Levels Instrumented		7.7+/-1.8			
Outcome Variable (Median [IQR])		Preop	FE	2-yr	5-yr
Thoracic Rib Prominence (°)		14 [10.5,17]	8 [6,11]	7 [5,11.3]	9.5 [3,14]
Lumbar Prominence (°)		5 [4.8,5]	4 [5,0.5]	4 [1.6,6.5]	4 [1,7]
Major Tethered Cobb (°)		46 [42,56]	27 [20,33.8]	19 [10,31]	22.5 [13.8,31.5]
Upper Thoracic Cobb (°)		26 [22,34]	20 [16,27]	18 [10,24]	17 [9.5,23.5]
Main Thoracic Cobb (°)		45 [42,56]	30 [23.5,35.5]	26.5 [17,39]	28 [21,38.3]
T/L / Lumbar Cobb (°)		33 [24,40]	22 [17,30]	23 [15.8,30]	24 [17,31]
T2-T12 Sagittal Cobb (°)		26 [20,34]	27 [19,33]	27.5 [19.3,38.5]	26 [19,34]
T5-T12 Sagittal Cobb (°)		10 [4.3,17]	19 [12,3.25]	21 [13.3,28]	21.5 [14,26]
T10-L2 Sagittal Cobb (°)		-2 [-7.3,6]	0 [-6.8,7]	1 [-4.9,8]	-1 [-8.3,8]
Multivariate Regression (Success <30° Major Tethered Cobb at 5yrs)		Odds Ratio	95% CI	P-value	
Age (yrs)		1.28	0.73, 2.35	0.4	
Height (cm)		0.88	0.77, 0.98	0.04*	
Preop Sanders		0.63	0.22, 1.64	0.35	
Preop Risser		0.40	0.07, 1.72	0.24	
Major Tethered Cobb FE (°)		0.81	0.67, 0.92	0.006*	
Complications N (%)					
Suspected Broken Tether		20 (23.8)			
Overcorrection >10°		4 (4.8)			
Loss of Correction >10°		4 (4.8)			
Reoperation - Fusion		8 (9.5)			
Reoperation - Revision VBT		6 (7.1)			
Instrumentation		3 (3.6)			
Medical		1 (1.2)			
Pulmonary		1 (1.2)			
Neurologic		1 (1.2)			
Pain		5 (6)			

Predicted Probability of Success by Major Tethered Cobb at FE



Predicted Probability of Success by Height



± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

243. Proximal Femur Maturity Index is a Viable Assessment of Skeletal Maturity in Adolescent Idiopathic Scoliosis

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Hypothesis:

Proximal femur maturity index (PFMI) can be used to assess skeletal maturity in adolescent idiopathic scoliosis (AIS) patients.

Design:

Retrospective multicenter cohort

Introduction:

Cheung et al (2022) developed PFMI as an alternative assessment of skeletal maturity based on the radiographic appearance of the femoral head, greater trochanter, and triradiate cartilage on full posteroanterior (PA) spine radiographs without the need for additional hand imaging. This study seeks to externally validate the reliability of PFMI and its correlation with Sanders and Risser scoring and peak growth.

Methods:

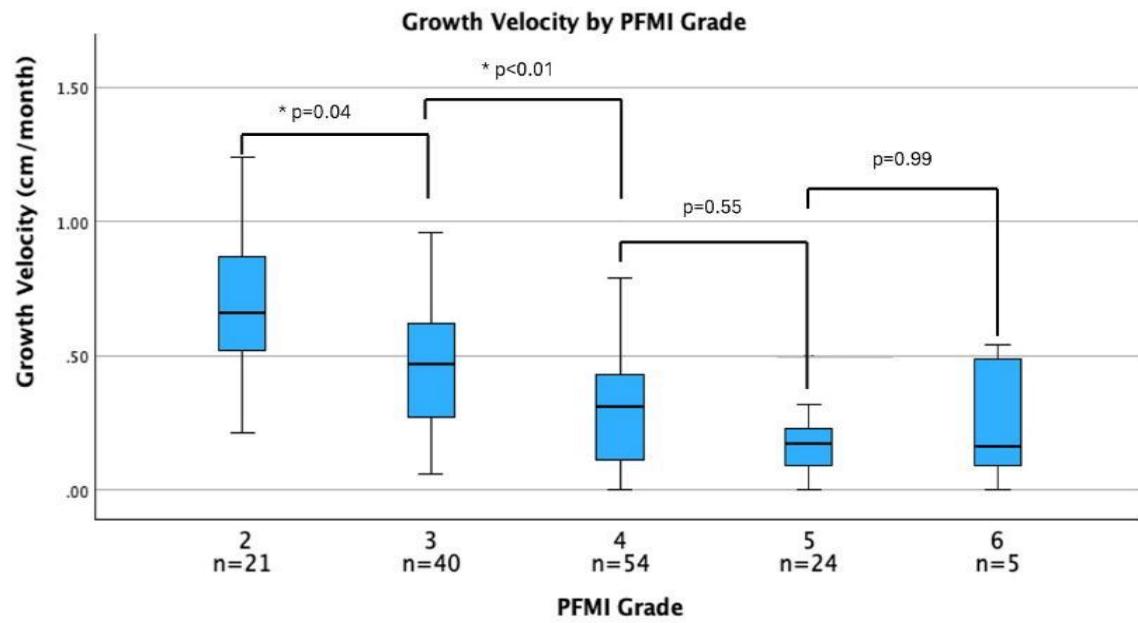
Longitudinal spine and hand radiographs after thoracic vertebral body tethering (VBT) from first erect (FE: defined baseline standing height) to 2 years postop, were assessed for skeletal maturity with PFMI, Sanders, and Risser. Longitudinal standing heights were recorded in tandem to detect peak growth (cm/month) with minimum 6-month interval between visits. PFMI reliability was graded on 200 PA spine radiographs by three experienced reviewers two weeks apart.

Results:

144 AIS patients (121 females/23 males) were included. PFMI moderately correlated with age (Kendall Tau-b (τ_b)=0.43) ($p<0.001$). The largest growth rate occurred at PFMI 2 (0.70 ± 0.26 cm/mo) followed by PFMI 3 (0.49 ± 0.31 cm/mo) and decreasing to PFMI 6 (0.25 ± 0.24 cm/mo) with growth cessation.(Fig 1) Moderate correlations were found between PFMI and Sanders ($\tau_b=0.70$) and Risser ($\tau_b=0.59$), $p<0.001$. Excellent intrarater reliability (weighted kappa: 0.74 to 0.9) and good interrater reliability (weighted kappa=0.66) were observed for PFMI amongst the three reviewers. Mean thoracic curve magnitude decreased from FE to 2 years postop (25° to 20° , $p<0.001$).

Conclusion:

This is the first study to externally validate the reliability of PFMI and its correlation with traditional maturity markers and peak height growth. PFMI demonstrated good to excellent inter- and intra-rater reliability as well as a moderate correlation with Sanders and Risser scoring comparable to previous reports. Peak height growth was demonstrated at PFMI grade 2 and progressively decelerated to growth cessation at PFMI grade 6. PFMI grades correlated with respective established growth velocity grades for Sanders and Risser. Thus, PFMI is a viable alternative assessment of skeletal maturity that can be measured on routine PA spine radiographs without the need for additional imaging.



± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

244. Risk of Curve Progression Among Children with Positive Scoliosis Screening but Radiographic Cobb Angle Below 10 Degrees

Cheuk Kin Kwan, MD; Kenneth Guangpu Yang, PhD, MBBS; Tsz Ping Lam, FRCS; Adam Yiu Chung Lau, FRCS; Jack Chun Yiu Cheng, MD; Alec Lik Hang Hung, FRCS; Wayne YW Lee, PhD

Hypothesis:

Children with positive scoliosis screening but radiographic cobb angle below 10 degrees have a high risk of curve progression to scoliosis

Design:

Cohort study

Introduction:

Screening for scoliosis facilitates early identification and timely intervention. Data from our Student Health Service in Hong Kong indicate approximately 15% of children are screened positive among whom only about 10% are subsequently diagnosed with scoliosis defined by a radiographic Cobb angle of $\geq 10^\circ$. The risk of disease progression for the remaining 90% with Cobb angles $< 10^\circ$ remains poorly understood. This study aims to evaluate their risk of subsequent progression to scoliosis (Cobb angle $\geq 10^\circ$) and to the bracing threshold.

Methods:

This retrospective cohort study including children with positive axial trunk rotation (ATR) and Moiré topography screening but initial radiographic Cobb angle $< 10^\circ$. Data included demographics, Cobb angle, and skeletal maturity markers, with follow-up to skeletal maturity. Outcomes were progression to scoliosis threshold (Cobb $\geq 10^\circ$) and bracing initiation. Analyses comprised Kaplan–Meier survival curves and logistic regression modelling.

Results:

Of 218 patients (mean age 12.5 years, mean Cobb angle 7° , mean follow-up 2.0 years), 120 (55.0%) progressed to AIS threshold (Cobb $\geq 10^\circ$), and 11 (5.0%) initiated bracing. Kaplan–Meier analysis showed 50% reaching threshold by age 15 and 55% by final follow-up (Figure 1). Logistic regression identified baseline Cobb angle and Risser grade as predictors for progression to scoliosis (AUC 0.73). No statistically significant predictors were identified for progression to bracing threshold.

Conclusion:

Although 15% of children screen positive for ATR, 90% have initial Cobb angles $< 10^\circ$. This study shows 50% of these children progress to scoliosis (Cobb $\geq 10^\circ$), with 5% requiring bracing. Baseline Cobb angle and skeletal immaturity (Risser grade) independently predicted progression to scoliosis. These findings support targeted monitoring and potential preventive interventions for this high-risk preclinical group. Future research may also focus on identifying additional predictors of scoliosis progression and bracing need.

245. Assessment of Medial Shoulder, Neck, And Lateral Shoulder Balance Following Posterior Spinal Fusion (PSF) in Lenke Type 1 And 2 Adolescent Idiopathic Scoliosis (AIS) Patients: A Multicenter Asia Pacific Spine Society (APSS) Collaborative Study

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Hypothesis:

Lenke 1 and 2 AIS is associated with postoperative medial shoulder, lateral shoulder, and neck imbalance prior to PSF surgery

Design:

Retrospective study

Introduction:

Few multicentre studies have investigated postoperative medial shoulder, neck, and lateral shoulder balance in patients with Lenke type 1 and 2 adolescent idiopathic scoliosis AIS

Methods:

A total of 253 patients with ≥ 2 -year follow-up from six centers were included. Medial shoulder balance was assessed by T1 tilt (balanced: -3° to 3°), lateral shoulder balance by clavicle angle (-2° to 2°), and neck balance by cervical axis (-3° to 3°)

Results:

The cohort was predominantly female (88.5%), with a mean age of 15.2 ± 3.5 years. 72% of patients were classified as Lenke type 1. The mean main thoracic (MT) Cobb angle was $58.8 \pm 14.9^\circ$. The prevalence of postoperative positive medial shoulder imbalance (+ve MI) at final follow-up was 36%, with a mean T1 tilt of $2.4 \pm 5.1^\circ$. The prevalence of positive neck imbalance (+ve NI) was 24% at the final follow-up, with a mean CA of $1.6 \pm 3.0^\circ$. Positive lateral shoulder imbalance (+ve LI) was observed in 17% at the final follow-up, with a mean Cla-A of $0.7 \pm 2.2^\circ$. The most significant factors associated with the final follow-up T1 tilt were preoperative T1 tilt, final follow-up PT Cobb angle, and final follow-up UIV tilt angle. For CA, the significant factors were the final follow-up PT Cobb, final follow-up MT Cobb, and preoperative thoracolumbar kyphosis. For Cla-A, the factors included preoperative lumbar Cobb, preoperative MT Cobb, and final follow-up MT Cobb. UIV selection did not significantly influence these outcomes. Patients with neck imbalance reported significantly lower postoperative satisfaction (4.27 vs. 4.47, $p = 0.031$) at the final follow-up

Conclusion:

At final follow-up, medial shoulder, neck, and lateral shoulder imbalance were present in 36%, 24%, and 17% of patients, respectively. Preoperative T1 tilt, postoperative UIV tilt angle, and residual PT and MT Cobb angles were significantly associated with medial shoulder imbalance. Neck imbalance was associated with lower SRS satisfaction scores

246. Screw Trajectory Matters: UIV Screw Angulation as a Modifiable Risk Factor for Proximal Junctional Kyphosis

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Hypothesis:

Cranially-oriented UIV screw angulation and reduced screw-to-superior endplate distance increase the risk of proximal junctional kyphosis (PJK) following adult spinal deformity surgery

Design:

Retrospective cohort study

Introduction:

PJK is a common complication following adult spinal deformity (ASD) surgery. While implant density and construct stiffness have been implicated, the influence of upper instrumented vertebra (UIV) screw positioning remains poorly characterized. This study evaluates UIV screw trajectory and depth as risk factors for PJK following ASD fusion terminating at the thoracolumbar junction.

Methods:

Adults with ASD undergoing fusion (2010–2017) at a single institution with UIV between T10–L2 and minimum 2-year follow-up were identified. UIV screw position was quantified by screw-to-superior endplate (sEP) distance and screw angle (Cobb angle between screw trajectory and sEP; positive = cranially oriented). PJK was defined as $\geq 10^\circ$ increase in proximal junctional angle from immediate postoperative measurements.

Results:

Among 150 patients (median age 68.0 years; 53.3% female), 47 (31.1%) developed PJK at median 24 months. Patients with PJK had lower UIV+1 Hounsfield units (111 vs 150, $p < 0.001$), shorter screw-sEP distance (4.4 vs 7.5 mm, $p = 0.002$), and more cranial screw angulation (3.0° vs 0.8° , $p < 0.001$). ROC analysis identified optimal thresholds: screw angle $\geq 3.8^\circ$ (PJK 62.9% vs 21.1%; AUC 0.68; specificity 87%) and screw-sEP < 4.6 mm (PJK 52% vs 21%; AUC 0.66). On multivariable Cox regression, higher UIV+1 HU (HR 0.98/HU, $p < 0.001$) and more caudal screw angulation (HR 1.07/degree for cranial angulation, $p = 0.005$) independently predicted PJK risk. Screw-sEP distance was not significant on multivariable analysis ($p = 0.43$).

Conclusion:

More caudal UIV screw angulation and better bone integrity appear protective against PJK following ASD fusion terminating at the thoracolumbar junction. Screw tips positioned closer to the UIV superior endplate may also increase PJK risk, but this was not predictive on multivariable analysis. These findings suggest screw trajectory may represent a more important modifiable factor than screw depth at the proximal junction.

247. Effective Indirect Decompression Despite Psoas Muscle Injury Following Lateral Lumbar Interbody Fusion in Adult Spinal Deformity

Dong-Gune Chang, MD, PhD; Per D. Trobisch, MD

Hypothesis:

The indirect decompression effect following lateral lumbar interbody fusion (LLIF) showed satisfactory radiological results in patients with adult spinal deformity (ASD), despite substantial psoas muscle injury.

Design:

A retrospective cohort study.

Introduction:

Indirect decompression effects after LLIF may be identified by increased intervertebral disc space. However, morphological changes in disc height, spinal canal, intervertebral foramen, and psoas major muscle are unclear in patients with ASD after LLIF.

Methods:

We retrospectively assessed 58 patients with ASD who underwent LLIF comprising 149 lumbar interbody levels. Radiological changes of intervertebral disc height, stenosis grade, and left psoas major muscle were retrospectively evaluated using preoperative and postoperative plain radiographs and magnetic resonance imaging (MRI). The cross-sectional area (CSA) and fatty infiltration (FI) of left psoas muscles were calculated from axial T2-weighted MRI at the involved interbody levels by manual tracing in ImageJ software.

Results:

All radiological parameters including Cobb's angle (12.5° to 4.5° , $P < 0.001$) and pelvic incidence (PI) – lumbar lordosis (LL) (29.6° to 4.5° , $P < 0.001$) were significantly improved after LLIF. The mean anterior ($\Delta = 7.1\text{mm}$), middle ($\Delta = 6.0\text{mm}$), and posterior ($\Delta = 3.2\text{mm}$) disc heights were significantly increased after LLIF (all P s < 0.001). The stenosis grades of the central canal and both foramina were significantly improved after LLIF, and the change in foraminal stenosis grade was significantly associated with posterior disc height ($P = 0.016$). The mean CSA and FI significantly increased by 1.6-fold and 3.2-fold after OLIF, respectively (all P s < 0.001). Regarding the spinopelvic parameters in LLIF, anterior height at L2-3 was significantly associated with the correction of LL ($P = 0.013$) and PI– LL mismatch ($P = 0.007$).

Conclusion:

The indirect decompression effect following LLIF was satisfactory on postoperative MRI in patients with ASD, despite substantial psoas muscle injury. The surgical treatment of ASD through LLIF should focus on posterior disc height to alleviate the stenotic symptoms and the anterior disc height of the upper lumbar lesion to achieve proper correction of the spinopelvic parameters.

248. Ten-Year Outcomes After Elderly Adult Spinal Deformity Surgery: Postoperative Coronal Imbalance Predicts Late Rod Fracture and Reduced Revision-Free Survival

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Hypothesis:

Postoperative coronal imbalance (CIB) after long-segment adult spinal deformity (ASD) correction independently increases the risk of late rod fracture and revision, and satellite-rod reinforcement mitigates this risk.

Design:

Retrospective cohort study with minimum 10-year follow-up.

Introduction:

Residual coronal malalignment is increasingly recognized as a driver of late mechanical complications after ASD surgery, yet its independent contribution to rod fracture—separate from baseline coronal severity—and the potential preventive role of satellite-rod reinforcement remain incompletely defined.

Methods:

Consecutive patients aged ≥ 65 years who underwent long-segment ASD correction with pelvic fixation (2010–2020) were reviewed. Postoperative CIB was defined as C7 plumb line–CSVL >3 cm on early standing radiographs. Mechanical outcomes included rod fracture and revision surgery. To address baseline confounding, we performed (1) multivariable logistic regression to test whether postoperative CIB was influenced by preoperative coronal parameters (C7–CSVL and coronal Cobb angle), and (2) multivariable logistic regression for rod fracture including postoperative CIB and clinically relevant covariates (age, three-column osteotomy, bone mineral density, and satellite-rod use). Revision-free survival was assessed using Kaplan–Meier and Cox models.

Results:

Postoperative CIB was present in 20.2% of patients. Rod fracture (45.2% vs 28.3%) and revision surgery (37.3% vs 19.8%) occurred more frequently in the CIB group. In the rod-fracture model, postoperative CIB was an independent risk factor (OR 2.95; 95% CI 1.45–11.25; $p=0.007$), whereas satellite-rod use was independently protective (OR 0.16; 95% CI 0.06–0.39; $p<0.001$). Revision-free survival was reduced in the CIB group (HR 1.8; 95% CI 1.0–4.0; log-rank $p=0.041$).

Conclusion:

In elderly ASD correction with pelvic fixation, postoperative CIB is a strong independent predictor of rod fracture and reduced revision-free survival. Satellite-rod reinforcement shows a robust protective association, supporting an actionable strategy: optimize coronal balance and consider reinforcement when residual CIB risk is high.

249. Predictors of Root Level Intraoperative Neuromonitoring (IONM) Changes in Adult Spinal Deformity (ASD) Surgery

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Hypothesis:

Age, loss of lordosis, PI-LL mismatch, sagittal imbalance, deformity angular ratio, and three-column osteotomy predict root level IONM changes in ASD surgery.

Design:

Retrospective cohort study

Introduction:

Recent studies have clarified risk factors for cord level IONM changes in ASD. Risk factors for root level changes are less well known.

Methods:

A retrospective cohort of ASD patients who underwent posterior only based spine fusion with a single surgeon between 2015 and 2023 was reviewed. Primary outcome was root level IONM change as defined by 75% decrement in motor evoked potential (MEP) in any muscle group. Secondary outcome was new motor deficit on postoperative day (POD) 1. Univariate logistic regression was performed to assess association between clinical variables and root level IONM change. Variables demonstrating univariate $p < 0.20$ were considered potential predictors and entered into an initial multivariable logistic regression model. Predictors with ≤ 10 events were excluded. Model was refined using backward elimination based on highest p-value with refitting after each removal until remaining predictors demonstrated $p < 0.05$. Key demographic variables were retained regardless of p-value due to clinical relevance. Odds ratios (OR) with 95% confidence intervals (CI) were reported. Statistical significance was defined as $p < 0.05$.

Results:

551 ASD patients were included. 116 (21.1%) had root level changes; of these, 29 (25%) developed a new motor deficit. Study-wide, 37 patients (6.7%) experienced new motor deficit. While multiple potential predictors demonstrated statistically significant univariate association with root level change, only body mass index [BMI] (OR 1.072217, CI 1.010072-1.138187, $p = 0.022$), preoperative lower extremity motor deficit (OR 2.712647, CI 1.249272-5.890196, $p = 0.012$), pelvic tilt (OR 1.044434, 1.0165-1.073135, $p = 0.0021$), Type III spinal cord (OR 5.436050, 1.876682-15.746220, $p = 0.002$), and estimated blood loss [liters] (OR 2.182416, 1.307783-3.641994, $p = 0.003$) remained significant in the final multivariable model (Table 1).

Conclusion:

In the largest study of nerve root monitoring to date, we found that BMI, poor baseline nerve and spinal cord health (weakness, Type III cord), evidence of compensation for sagittal imbalance (PT), and intraoperative blood loss (potential ischemia), are predictive of root level IONM changes during ASD surgery.

Univariate logistic regression of potential predictors of root level IONM change				
Potential Predictor	OR	95% CI	p-value	
Age	1.005473	0.993883	1.017192	0.356
BMI	1.028047	0.993442	1.063858	0.113
Female gender	0.632225	0.534402	1.296027	0.416
Type of deformity				
Any scoliosis	2.412376	1.006394	5.782585	0.048*
Kyphosis	1.397617	0.923620	2.114865	0.113
Coronal malalignment	1.382353	0.904747	2.112081	0.134
Sagittal malalignment	1.752228	1.131484	2.713518	0.012*
Idiopathic scoliosis	0.603252	0.396300	0.913667	0.017*
Degenerative scoliosis	0.722768	0.511094	1.168414	0.222
Congenital	0.712727	0.266841	1.905187	0.500
Scheuermann kyphosis	0.420000	0.124515	1.418699	0.162
Neuromuscular	3.714851	1.736766	7.945873	0.001*
Syndromic	1.614425	0.793492	3.284080	0.186
Post XRT	1.458407	0.279254	7.610554	0.635
Post-laminectomy	1.998755	0.825598	4.838945	0.125
Listhesis	1.995780	0.960937	4.145054	0.064
ASA Score				
1	Reference	-	-	-
2	2.335185	1.280987	4.204386	0.007*
3	1.784257	0.872792	3.647572	0.113
4	21.857140	2.124283	224.892200	0.019*
Charlston Comorbidity Index				
0	Reference	-	-	-
1	1.576840	0.931225	2.670057	0.090
2	1.116736	0.635165	1.963424	0.701
3	1.114625	0.545210	2.278733	0.766
4	0.743083	0.244557	2.257852	0.600
5	1.424242	0.278043	7.295511	0.671
Comorbidities				
Any cardiac history	1.246142	0.793806	1.956235	0.339
HTN	1.243697	0.782763	1.977320	0.357
HLD	1.818937	1.116588	2.963073	0.016*
MI	0.747826	0.086514	6.464238	0.792
CHF	1.682610	0.169215	20.945090	0.607
PVD	2.283188	0.537568	9.697287	0.263
Stroke / TIA	1	-	-	-
COPD	5.142857	1.134627	23.310726	0.034*
Connective tissue disease	0.741071	0.246261	2.212131	0.591
PUD / GERD	0.472728	0.190528	1.137096	0.094
Liver disease	0.618421	0.196456	2.809898	0.533
DM	1.094777	0.511103	5.590393	0.390
Hypothyroidism	1.211560	0.672604	2.181732	0.523
CKD	2.729380	1.015850	7.334615	0.047*
Cancer	0.721154	0.373941	1.390782	0.329
PE / DVT	0.704082	0.236858	2.092949	0.528
Preop IVC Filter	0.935288	0.259464	3.371281	0.919
Preop lower extremity motor deficit	2.535750	1.621942	3.964400	<0.001*
Preop myelopathy	2.927864	1.457751	5.880559	0.003*
Preop radiculopathy	1.424448	0.940788	2.158758	0.095
SVA (cm)	1.115723	1.068911	1.164585	<0.001*
CVA (absolute value, cm)	1.007929	0.906244	1.019752	0.184
Tk (T2-T12)	0.998706	0.990492	1.008987	0.759
Lumbar lordosis	0.998574	0.988342	1.008912	0.786
Pelvic incidence	1.025827	1.010658	1.041225	0.001*
PI-LL	1.010492	1.001441	1.019624	0.023*
Pelvic tilt	1.043576	1.023124	1.064437	<0.001*
Max coronal Cobb angle	1.002399	0.993827	1.011250	0.593
Sagittal DAR	1.038892	1.005387	1.073513	0.023*
Coronal DAR	1.054396	1.016638	1.093557	0.004*
Total DAR	1.032486	1.011212	1.054268	0.003*
Spinal Cord Type				
I	Reference	-	-	-
II	1.195602	0.643294	2.222103	0.572
III	4.534749	2.525911	8.141201	<0.001*
Preop Hgb	0.990634	0.938775	1.045357	0.732
Lowest intraop Hgb	0.870620	0.761207	0.995761	0.043
Change in Hgb	1.002140	0.967115	1.038434	0.906
Estimated blood loss (L)	3.164784	2.240930	4.469511	<0.001*
Intraoperative transfusion (L)	3.205854	2.011358	5.109732	<0.001*
Durotomy	2.648829	1.517900	4.622372	0.001*
Three Column Osteotomy				
None	Reference	-	-	-
PSO	4.347826	2.274583	8.310794	<0.001*
VCR	2.903226	1.544902	5.455829	0.001*
PSO + VCR	9.999979	0.895411	111.680100	0.061
Number of decompressions	1.621640	1.332686	1.973246	<0.001*
Number of PCOs	1.062813	1.000447	1.129068	0.048*
Number of TLIFs	1.460888	1.190875	1.792425	<0.001*
UIV				
Cervical	1.040000	0.304101	3.555717	0.950
Upper Thoracic	0.628506	0.215064	1.825086	0.391
T5 to T9	1.536364	0.445364	5.301155	0.497
T10 to T12	0.800000	0.236765	2.703098	0.719
Lumbar	Reference	-	-	-
LIV				
Thoracic	-	-	-	-
Lumbar	Reference	-	-	-
Ilium	1.805555	1.085285	3.003846	0.023*
Multivariable logistic regression of potential predictors of root level IONM change				
Potential Predictor	OR	95% CI	p-value	
Age	0.802980	0.968579	1.017954	0.577
BMI	1.072217	1.010972	1.139187	0.022*
Gender				
Male	Ref	-	-	-
Female	1.028124	0.944000	0.474170	0.474
Preop lower extremity motor deficit	2.712647	1.249272	5.890196	0.012*
Pelvic tilt	1.044434	1.016500	1.073135	0.002*
Spinal cord type				
I	Ref	-	-	-
II	0.953874	0.368329	2.470282	0.923
III	5.436050	1.876682	15.746226	0.002*
Estimated blood loss (L)	2.182416	1.307783	3.641994	0.003*

Table 1: Logistic regression

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

250. Prediction of proximal junctional kyphosis and failure after S2AI fixation in adultspinal deformity : Is Pedicle Bone Mineral Density More Critical?

Ze Zhang Zhu, MD, PhD; Zhen Liu, MD, PhD; Yong Qiu, PhD; Saihu Mao, MD; Xiaodong Qin, PhD; Xing Sun, MD

Hypothesis:

Measuring both pedicle and vertebral bone density simultaneously is more beneficial in providing important guidance for surgical decision-making in patients with DSD.

Design:

Retrospective analysis of medical records of 164 patients with degenerative spinal deformities who underwent pelvic fixation using S2AI screw fixation technique. Patients were divided into a PJK group and a control group based on whether PJK occurred.

Introduction:

Exploring the predictive value of pedicle bone density for postoperative proximal junctional kyphosis (PJK) in patients with degenerative spinal deformities fixed with second sacral iliac screws (S2AI).

Methods:

Retrospective analysis of medical records of 164 patients with degenerative spinal deformities who underwent pelvic fixation using S2AI screw fixation technique in our hospital from March 2017 to November 2022. Patients were divided into a PJK group (38 cases) and a control group (126 cases) based on whether PJK occurred. Measure the HU values of UIV vertebrae and pedicle on preoperative CT, and measure the VBQ scores of UIV vertebrae and pedicle on preoperative MRI. Preoperative and postoperative measurements of the following imaging parameters: thoracic kyphosis (TK), lumbar lordosis (LL), sacral slope (SS), pelvic tilt (PT), pelvic incidence angle (PI), mismatch between PI and LL (PI-LL), sagittal vertical axis (SVA).

Results:

There was no statistically significant difference in the number of fixed segments and follow-up time ($P>0.05$). The HU values of vertebral bodies and pedicle in the PJK group were significantly lower than those in the control group, while the VBQ scores of vertebral bodies and pedicle were significantly higher than those in the control group. Compared with vertebral HU and VBQ scores, pedicle HU and VBQ scores have higher AUC values in predicting PJK, but the difference is not statistically significant ($p>0.05$). In patients with low vertebral bone density, the incidence of PJK was significantly lower in patients with higher pedicle bone density than in patients with lower pedicle bone density (15% vs 32%, $p<0.05$).

Conclusion:

Individual vertebral bone density is not sufficient to accurately assess the risk of PJK occurrence. Therefore, measuring both pedicle and vertebral bone density simultaneously is more beneficial in providing important guidance for surgical decision-making in patients with DSD.

251. Artificial Intelligence-Based Quantification of Total Paraspinal Muscle Fatty Infiltration Predicts Proximal Junctional Failure following Thoracolumbar Spinal Fusion for Adult Spinal Deformity

Pearce B. Haldeman, MD; Thaddeus Woodard, MD, BS; Robert K. Eastlack, MD; Gregory M. Mundis Jr, MD; Bahar Shahidi, PhD

Hypothesis:

Total lumbar paraspinal muscle fatty infiltration (FI) measured using artificial intelligence is associated with proximal junctional failure (PJF).

Design:

Retrospective analysis of a prospective cohort.

Introduction:

PJF remains a significant complication following long-segment posterior spinal fusion (PSF) for adult spinal deformity (ASD). Prior studies have linked paraspinal muscle quality to PJF risk; however, most rely on manual segmentation and extrapolate global lumbar muscle quality from single-level measurements. This study evaluates automated, multi-level paraspinal muscle FI in patients with and without PJF following thoracolumbar PSF.

Methods:

A prospective ASD cohort was queried for patients undergoing PSF to the pelvis with available preoperative thoracolumbar MRI. Demographics, surgical variables, and 3-month postoperative sagittal alignment parameters were collected. L1PA error was calculated as measured L1PA minus goal L1PA (goal L1PA=0.5*PI-19). PJF was defined as revision surgery for pathology at the proximal junction. Automated MRI analysis quantified FI of the erector spinae (ES), multifidus (M), psoas (P), and quadratus lumborum (QL). Multivariate regression assessed the association between FI and PJF, adjusting for sagittal alignment. Significance was set at $p < 0.05$.

Results:

Forty-five patients met inclusion criteria with a minimum 2-year follow-up (mean=41 months); 10 patients (22%) developed PJF. Mean time to PJF was 12 ± 8.6 months. There were no differences in age, sex, BMI, DEXA T-score, or number of levels fused between groups. Postoperative L1PA, T4PA, and C2PA were greater in the PJF group ($p < 0.03$), though L1PA error and T4PA–L1PA mismatch did not differ. M FI was greater in the PJF group ($p = 0.043$). Multivariate analysis adjusting for C2PA, T4PA, and L1PA demonstrated that increased M FI was independently associated with PJF (OR=1.09, 95% CI 1.02–1.16).

Conclusion:

Increased lumbar multifidus FI is independently associated with PJF after long-segment PSF, with an approximately 9% increased risk per 1% FI increase after accounting for sagittal alignment. These findings support the validity of single-level lumbar FI as a surrogate for global lumbar muscle quality in the ASD population and highlight the utility of high-throughput, AI-based muscle characterization in ASD risk stratification.

Variable	No PJF (n=35)	PJF (n=10)	p-value
Demographics / Clinical			
Age (years)	67.9±8.9	72.2±5.1	0.064
Female Sex	18 (51%)	8 (80%)	0.154
BMI (kg/m ²)	26.4±4.8	26.7±7.6	0.916
DEXA T-score	-1.66±0.9	-1.66±0.9	0.989
Primary surgery	20 (57%)	6 (60%)	1
Levels fused	8.5±1.0	8.7±1.0	0.544
Sagittal Alignment (3-month postop)			
L1PA (°)	6.4±6.6	10.7±4.5	0.03
T4PA (°)	10.4±7.5	17.2±3.4	<0.001
C2PA (°)	17.5±7.9	25.3±3.9	<0.001
L1PA Error	-1.5±4.7	0.7±5.0	0.221
T4PA-L1PA mismatch	3.9±3.9	6.6±3.9	0.082
Paraspinal Muscle Fatty Infiltration (%)			
Multifidus FI	40.7±10.3	50.3±12.4	0.043
Erector spinae FI	29.0±8.7	36.0±13.5	0.149
Psoas FI	15.3±5.3	18.2±13.6	0.521
Quadratus lumborum FI	27.4±8.2	30±8.7	0.431

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

252. Weakness Of Trunk And Knee Extensors Might Hinder the Ability To Maintain Compensatory Mechanisms While Walking

Abir Massaad, PhD; Rami Rachkidi, MD, MS; Jean-Pierre Saad; Yamen Beyh; Josef Lattouf; Michel Al Ammouri; Frederic Maatouk; Mohamad Hajj Youssef; Ibrahim Hamati; Moustapha Rteil; Virginie Lafage, PhD; Ismat Ghanem, MD, MS; Ayman Assi, PhD

Hypothesis:

ASD with increased pelvic tilt and weak trunk and knee extensors fail to maintain pelvic retroversion while walking.

Design:

Retrospective study on prospectively collected data.

Introduction:

Recent findings in the functional evaluation of ASD have shown that some patients maintain pelvic retroversion during walking, while others adopt a normal or anteverted pelvis. Therefore, the aim was to investigate the underlying mechanisms that enable certain patients to maintain compensatory mechanisms while walking.

Methods:

96 ASD patients, presenting with sagittal malalignment and $PT > 25^\circ$, underwent biplanar X-rays with the calculation of 3D spinopelvic parameters and filled QOL questionnaires (SF36, VAS for pain). Trunk and lower limb muscle forces were captured using a handheld dynamometer. They all underwent 3D gait analysis from which spine, pelvis and lower limbs kinematics were calculated. Patients were classified depending on their dynamic pelvic tilt behavior relatively to a normative database of 150 controls: anteverted (Antev-dynPT $< -17^\circ$), normal (-17 to -6°) or retroverted (Retro-dynPT $> -6^\circ$, Fig1.A). Comparisons were computed between groups.

Results:

19 ASD were classified as Antev-dynPT (-20°), 44 as normal-dynPT (-10°) and 33 as Retro-dynPT (1°). Radiographic spinopelvic parameters were similar between the 3 groups (PI: 54° , PT: 31° , SVA: 75mm). Patients in the Antev-dynPT group walked with a forward shifted trunk (dynSVA: 177 vs 122mm) and exhibited a reduced trunk and knee extensors forces compared to the Retro-dynPT group (108 vs 235N, 157 vs 265N resp., all $p < 0.001$; Fig1.B). Patients in the Antev-dynPT group reported more deteriorated QOL scores (VAS: 8.2 vs 6.5, physical component SF36: 32 vs 37 in the Retro-dynPT group, both $p < 0.05$).

Conclusion:

Despite comparable radiographic sagittal malalignment, ASD patients with weak trunk and knee extensors tend to walk with an anteverted pelvis and increased trunk flexion. In contrast, patients with preserved muscle capacity appear to maintain their static compensatory mechanisms during gait. Personalized muscle strengthening programs may restore patients' ability to utilize compensatory mechanisms while walking, thereby enhancing surgical and non-surgical outcomes.

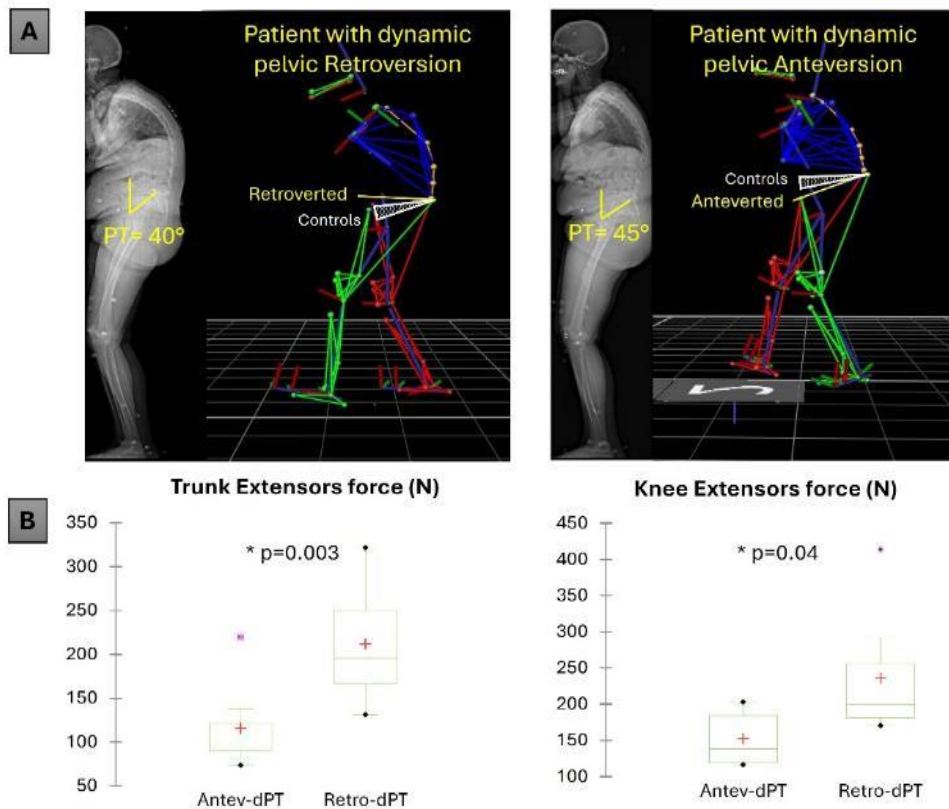


Fig.1: A) examples of patients with retroverted and anteverted dynamic pelvic tilt and comparable radiographic profiles. B) Trunk and knee extensors force.

253. Putting to Use A New Classification System for Distal Junctional Failure After Adult Spinal Deformity Surgery: An In-Depth Dual Institution Study

Benjamin D. Elder, MD, PhD; Scott Zuckerman, MD; Pawel P. Jankowski, MD; Byron F. Stephens, MD; Harsh Jain, MBBS; Advith Sarikonda, BS, BA; Robert K. Eastlack, MD; Peter G. Passias, MD; Kari Odland, DAT, ATC; David W. Polly Jr, MD

Hypothesis:

A new classification system of distal junctional failure (DJF) after adult spinal deformity surgery (ASD) will help predict reoperation for spinopelvic complications.

Design:

Retrospective cohort

Introduction:

DJF and spinopelvic complications after ASD surgery total \$1 billion over 5-years and occur in approximately 25% cases. In a dual-institution study, we sought to use the classification system to: 1) describe spinopelvic complications from two centers and 2) determine which complications require reoperation.

Methods:

A dual-institution, retrospective cohort study (2009-23) was undertaken for patients undergoing ASD surgery. Inclusion criteria were: ≥ 5 -level fusion, fused to pelvis, sagittal/coronal deformity, and 2-year follow-up. Primary outcome was spinopelvic failure, defined as L4-S1 rod fractures/pseudarthrosis, S1/ilium screw failure, iliac set plug dislodgment, iliac screw loosening/prominence, and sacroiliac joint (SIJ) pain. The classification system trichotomized failures into: 1) instrumentation, 2) osseous and 3) clinical failure. Descriptive/bivariate statistics were performed.

Results:

Of 311 patients, spinopelvic failure occurred in 74 (23.8%) patients, with 60/74 (81.1%) requiring reoperation. The classification was successfully implemented; 45 (60.8%) had one complication mode only, whereas 19 (25.7%) had 2 failure modes, and 10 (13.5%) had all 3 failure modes. Instrumentation failure was most common (62, 83.7%), followed by bony (28, 37.8%) and clinical (23, 31.1%). Rod fractures occurred in 39 (52.7%), most commonly at L4/5 (28, 71.8%), followed by L5/S1 (10, 25.6%), and S1/ilium (2, 5.1%). Pelvic screw haloing occurred in 33 (44.6%), S1 screw haloing occurred in 7 (9.5%), distal bone fracture occurred in 3 (4.1%), painful screw prominence in 3 (4.1%), and SIJ pain in 16 (21.6%). Patients with bony failures had the highest reoperation rates (89.2%), followed by clinical (87.0%) and instrumentation failures (77.4%). Rod fracture was significantly associated with reoperation compared to patients without rod fracture (91.4% vs. 71.8%, $p=0.031$).

Conclusion:

Using the novel classification system to report spinopelvic failures, a more granular description can be utilized to gain additional insight into DJF and spinopelvic complications after ASD surgery. Rod fractures from L4-ilium were significantly associated with reoperation.

254. Routine Practices in Anesthesiology for Spine Deformity Surgery: A Multi-Centre Comparison

Chloe Cadieux, MD, FRCS(C); Kyle Rogan, MD, FRCS(C); So Kato, MD, PhD; Saumyajit Basu, MS (Ortho), DNB (Ortho), FRCS (Ed); Yashar Javidan, MD; Sultan Aldebeyan, MD; Eric O. Klineberg, MD; Jeffrey M. Hills, MD; Sigurd H. Berven, MD; Serena S. Hu, MD; Zeeshan M. Sardar, MD; Brian J. Neuman, MD; Alisson R. Teles, MD; Anastasios Charalampidis, MD; Robert Ravinsky, MD, FRCSA, MPH; Kenny Y. Kwan, BMBCh(Oxon), FRCSEd; Kristen E. Jones, MD; Ahmed Shawky Abdelgawaad, MD, PhD; Jonathan N. Sembrano, MD; Mauricio Campos Daziano, MD; Reuben CC Soh, MBBS, FRCS; Arthur Sackeyfio, MD; Bhavuk Garg, MS; Aaron J. Buckland, MBBS, FRCSA; Nelson Astur, MD; Stephen J. Lewis, MD, FRCS(C); Michael P. Kelly, MD; Justin S. Smith, MD, PhD; Fred H. Nicholls, MD

Hypothesis:

Agreement will be seen in anesthesia practices across deformity centres.

Design:

Survey

Introduction:

Despite the critical role anaesthesiologists play in the care of spinal deformity patients, there remains vast variability in practice patterns. We compared routine perioperative practices in anesthesiology across high volume deformity centres to help highlight best-practice protocols specific for spinal deformity surgery.

Methods:

A 103 question survey was designed in collaboration between surgeons and anesthesiologists to assess routine perioperative anesthesia practices in spinal deformity surgery. Basic demographic and professional characteristics were collected. Subsequent sections focused on anesthesia practices in pre-operative, intra-operative, and post-operative care. The survey was distributed to the AO Spine Knowledge Forum Deformity membership for completion by either an adult or pediatric anesthesiologist at their home centre.

Results:

Thirty-six survey responses were collected, representing 15 different countries. Of these, 63% were based on adult and 37% were based on paediatric practices. The majority of respondents had additional fellowship training (67%) and 53% worked at centres that performed >100 major deformity cases per year. Vast differences in routine practices were seen between centres in all phases of care. Considerable variation was seen in pre operative evaluation and optimization; only 56% of sites had a dedicated subspecialty anaesthesia team and only 39% referred patients to a local blood management program. On the day of surgery, significant differences were seen in routine medications prescribed pre-operatively. Intra-operatively, MAP targets used during surgery ranged greatly between 60-80 mmHg and Hb transfusion thresholds between 60-110. Fluid management was highly variable, with only 39% of respondents indicating an attempt to limit crystalloid usage for volume replacement. Post-operatively, major differences included analgesia modalities commonly used and routine involvement of an acute pain service.

Conclusion:

Despite strong evidence in the literature, substantial heterogeneity in nearly all aspects of peri-operative anesthesia care in spinal deformity surgery persists. The variability in this international survey highlights the need for standardized protocols and guidelines, and the results provide insight into simple targets for optimization.

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

Question	% Respondents
Strong agreement across survey responses	
Do you routinely use tranexamic acid?	97.2% reported “yes”
How do you routinely administer antibiotics for SSI prophylaxis?	91.7% reported intermittent bolus
What do you routinely use to maintain anesthesia during deformity procedures when evoked potentials are being used?	88.8% reported TIVA with propofol
What thromboprophylaxis strategies do you use intra-operatively, if any?	75% reported sequential compressive devices (SCDs)
Strong disagreement across survey responses	
Does your program routinely pursue pre-operative opiate reduction?	30.5% reported “yes”
Are patients routinely screened for malnutrition (low BMI or muscle mass)?	38.8% reported “yes”
Does your anesthesia group have a standardized anesthetic protocol for major spine deformity procedures?	42% reported “no”
What is the routine disposition for patients undergoing major deformity procedures?	50% reported ICU (extubated)
Are patients who smoke routinely counselled on smoking cessation without nicotine replacement?	58.3% reported “yes”
Is intra-operative cell salvage routinely used at your institution?	52.7% reported “yes”
Do you attempt to limit crystalloid administration during cases (i.e. additional volume replacement done via colloid and/or blood product administration)?	61.2% reported “no”

Example summary of practice agreement

255. Postoperative Bracing following Adult Thoracolumbar Spinal Deformity Surgery

Anthony L. Mikula, MD; Nikita Lakomkin, MD; Justin K. Scheer, MD; Scott Zuckerman, MD; Jay D. Turner, MD, PhD; Jeffrey Mullin, MD; Breton Line; Renaud Lafage, MS; Virginie Lafage, PhD; Khaled M. Kebaish, MD; Eric O. Klineberg, MD; Gregory M. Mundis Jr, MD; Alan H. Daniels, MD; Robert K. Eastlack, MD; Stephen J. Lewis, MD, FRCS(C); Richard Hostin, MD; Jeffrey Gum, MD; Byron F. Stephens, MD; Brandon B. Carlson, MD; Thomas Buell, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Munish C. Gupta, MD, MBA; Han Jo Kim, MD; Michael P. Kelly, MD; Lawrence G. Lenke, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Christopher P. Ames, MD; Shay Bess, MD; International Spine Study Group

Hypothesis:

Postoperative bracing is protective against reoperation for mechanical complications following adult thoracolumbar spinal deformity surgery.

Design:

Retrospective review of a prospective multicenter adult spinal deformity (ASD) database.

Introduction:

The benefits of postoperative bracing in preventing mechanical complications following adult spinal deformity surgery are not well understood.

Methods:

Patients undergoing adult spinal deformity surgery with constructs extending from the thoracic spine to the pelvis were included. Minimum follow up was one year to maximize study power as the benefits of short duration postoperative bracing in preventing mechanical complications >1 year is unlikely. Patients who underwent postoperative bracing were compared against those who did not, using two primary outcome measures: radiographic complications and reoperation for mechanical complications. Multivariable logistic regression analysis controlled for factors significant on the univariable analysis, including number of rods, rod configuration, rod material, and body mass index.

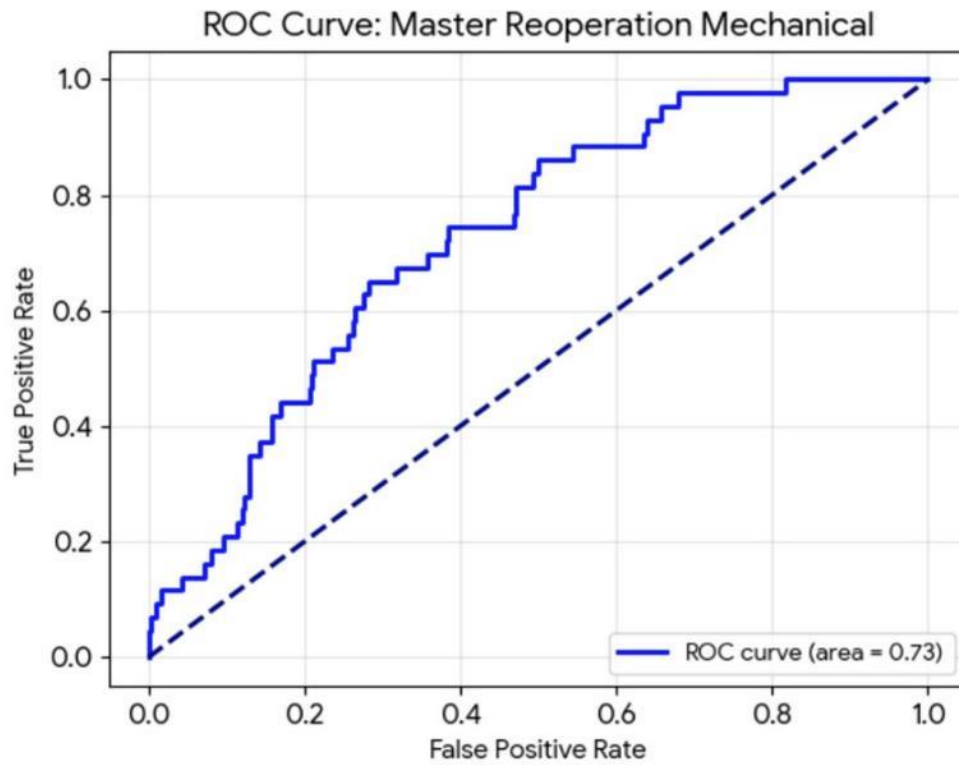
Results:

A total of 520 patients were included, with a mean age of 65 years and 72% of the cohort was female. Postoperative bracing was utilized by 293 patients (56%), with a thoracolumbar sacral orthosis being the most common (n=211, 72%), with a median brace duration of 12 weeks. Radiographic complications occurred in 257 patients (49%), including PJK (n=224), rod fracture (n=18), and pseudarthrosis (n=15). Reoperation for mechanical complications occurred in 45 patients (9%), with indications including proximal junctional kyphosis (n=22), pseudarthrosis (n=17), implant failure (n=16), junctional fracture (n=10), and distal junctional failure (n=2). On the multivariable analyses, the use of postoperative bracing was not protective against radiographic complications (p=0.82), but it was independently protective against reoperation for mechanical complications (p=0.02, OR = 0.39) in addition to four rod constructs (p=0.04, OR = 0.38).

Conclusion:

The use of postoperative bracing was independently associated with decreased odds of reoperation for mechanical failure following adult thoracolumbar spinal deformity surgery. Surgeons should consider the use of postoperative bracing following adult thoracolumbar deformity surgery.

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant



± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

256. A Nomogram for Predicting Postoperative Neurological Deficits in Spinal Deformity Surgery: A Multicenter Study.

Jiahao Zhang, MD; Jiale Zhu, MS; Yan Zeng, MD

Hypothesis:

A nomogram integrating key preoperative radiographic and clinical factors including preoperative neurological status, apex location, sagittal Cobb angle, and total deformity angular ratio (T-DAR) can effectively predict the risk of postoperative neurological deficits (PONDs) in patients underwent spinal deformity surgeries.

Design:

Retrospective multicenter comparative analysis.

Introduction:

Corrective surgery for spinal deformity carries a significant risk of PONDs, a serious complication that impacts patient outcomes. Current risk assessment relies on individual surgeon experience and isolated radiographic parameters, lacking a comprehensive, quantitative predictive tool. This study aimed to develop and validate a clinically practical nomogram model to predict the probability of PONDs.

Methods:

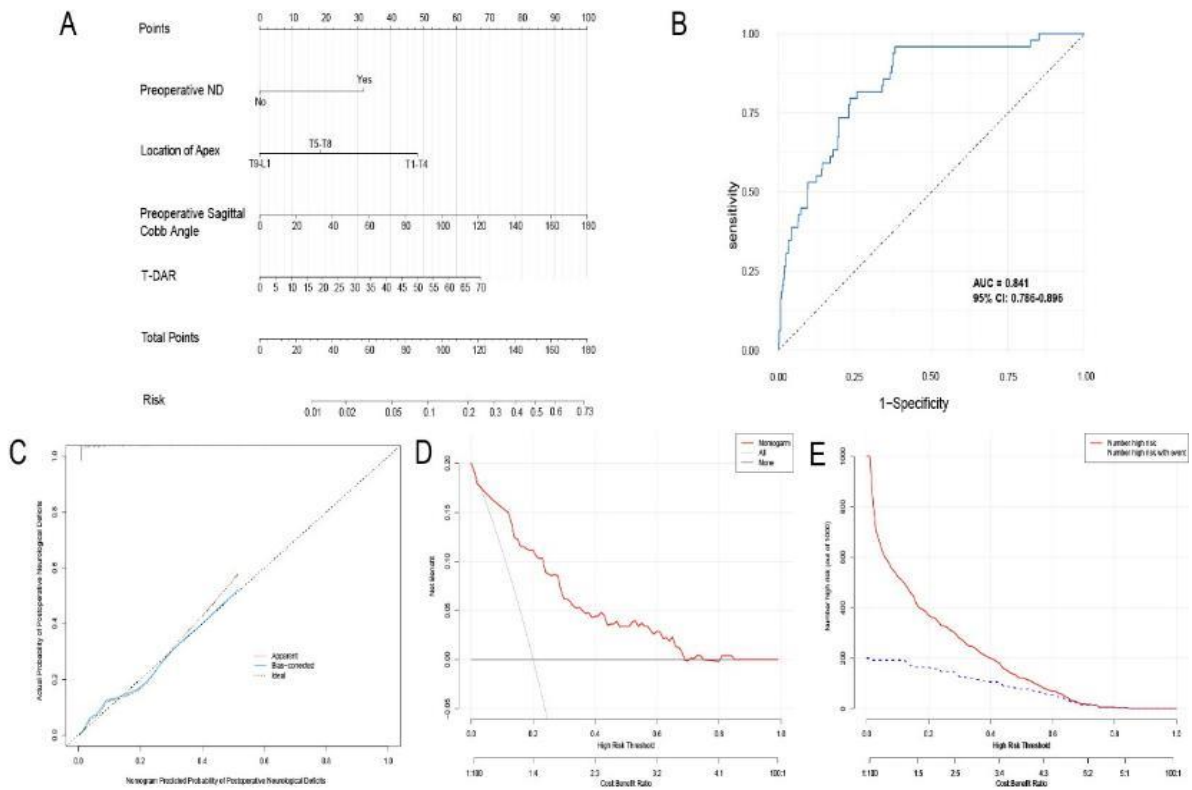
A consecutive series of 598 patients from three centers with spinal deformity who underwent corrective surgery between April 2010 and June 2025 were included in our study. Relevant measurements, including the Cobb angle, deformity angular ratio, and location of the apex were assessed and calculated using x-ray imaging. To identify independent risk factors associated with PONDs, we employed univariate analysis, followed by stepwise multivariate logistic regression analysis. A nomogram was established based on the identified independent risk factors to predict the likelihood of PONDs in patients underwent spinal deformity surgeries.

Results:

The mean age of the 598 patients was 26.0 (14.0–53.0) years, with an observed incidence of PONDs at 8.2%. The stepwise multivariate logistic regression analysis indicated that preoperative neurological deficits, location of apex, preoperative sagittal Cobb angle, and T-DAR were independent predictors of PONDs. Utilizing these independent risk factors, we constructed a nomogram model to estimate the probability of PONDs. The concordance index of the model was 0.841 (95% CI: 0.786–0.896), indicating a satisfactory level of accuracy in predicting the likelihood of PONDs.

Conclusion:

The predictive factors for PONDs include preoperative neurological deficits, location of apex, preoperative sagittal Cobb angle, and T-DAR. We developed a nomogram model to predict PONDs, which could be useful for patient counseling and facilitating treatment-related decision-making.



A: the nomogram; B: ROC curve for the model; C: calibration curve; D: DCA curve; E: CIC curve.

257. What Do Patients Hope to Regain from Adult Spinal Deformity Surgery? Cross-Cultural Differences in Expectations and Patient-Reported Outcomes Between the United States and Japan

Jean-Christophe A. Leveque, MD; Takeshi Fujii, MD, PhD; Philip K. Louie, MD; Aiyush Bansal, MD, MASc; Venu M. Nemani, MD, PhD; Jean-Christophe Leveque, MD; Kento Yamanouchi, MD; Kazuki Takeda, MD, PhD; Satoshi Suzuki, MD, PhD; Rajiv K. Sethi, MD, PhD; Kota Watanabe, MD, PhD

Hypothesis:

Expectations and baseline patient-reported outcomes (PROs) for adult spinal deformity (ASD) surgery differ between the United States (US) and Japan (JP) and are associated with self-image.

Design:

Prospective cohort study.

Introduction:

Patient expectations may potentially influence a patient's perception of their clinical outcomes. In addition, cultural differences in daily activities may shape what patients hope to regain following ASD surgery. This study aims to evaluate cross-cultural differences in patient expectations for ASD surgery and to assess the association between expectations and baseline PROs.

Methods:

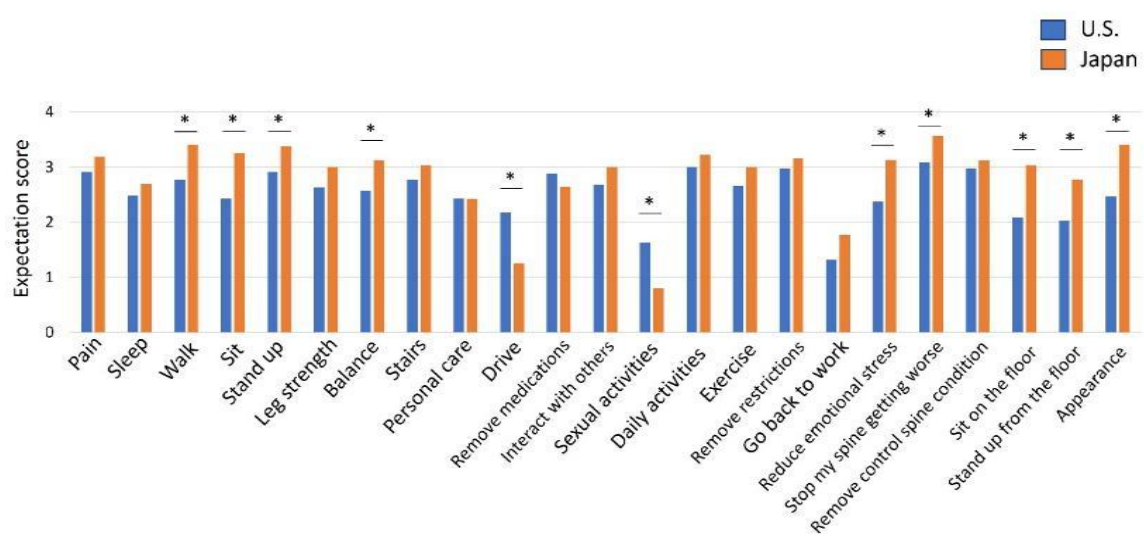
Patients ≥ 50 years undergoing ASD correction with ≥ 5 -level fusion were prospectively enrolled (2024-2025). Expectations were measured using a modified Hospital for Special Surgery Lumbar Spine Surgery Expectations Survey. PROs were assessed with SRS-22 and the Lumbar Stiffness Disability Index (LSDI). Preoperative expectations, PROs, and radiographic deformity were compared between surgical patients in the US and JP, and correlations between expectations and SRS-22 domains were analyzed.

Results:

Eighty-two patients were included (67.3 ± 8.1 years; 41 US, 41 JP); age and fused levels were similar. Overall expectations were comparable; JP patients more strongly expected improvement in walking ($p=0.01$) and floor-sitting ($p=0.03$), whereas US patients prioritized driving ($p=0.04$). JP had worse deformity: coronal balance 42.6 ± 35.6 vs 20.8 ± 25.2 mm, SVA 51.0 ± 14.9 vs 35.8 ± 14.3 mm, and PI-LL mismatch $33.6 \pm 17.0^\circ$ vs $21.1 \pm 15.0^\circ$ (all $p<0.01$). Despite this, LSDI was lower in JP (18.7 ± 17.8 vs 34.2 ± 20.3 , $p=0.01$). SRS-22 function and pain scores were higher, while self-image and mental health scores were lower in JP. Expectations correlated negatively with SRS-22 self-image ($p<0.01$).

Conclusion:

Japanese ASD surgical patients showed greater radiographic severity yet lower stiffness-related disability and better function/pain, with worse self-image/mental health and culture-specific expectations. These findings indicate that patient-centered targets for ASD surgery differ across cultures (walking/floor-sitting vs driving) and that expectations are linked to self-image. Culturally informed counseling and studies linking expectations to postoperative satisfaction and PRO change are warranted.



Preoperative Patient Expectations

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

258. Machine Learning–Based Prediction of Rod Fracture After Long-Segment Fusion: The Role of Construct Design and Segmental Lordosis Distribution

JungHee Lee, MD, PhD; Ki Young Lee, MD; Hong-Sik Park, MD; Woo-Jae Jang, MD

Hypothesis:

We hypothesized that predictive performance would differ among machine learning (ML) models for rod fracture (RF) after long-segment fusion for adult spinal deformity (ASD) surgery and that surgical construct design and segmental lordosis distribution would contribute more substantially to RF risk.

Design:

Retrospective cohort study.

Introduction:

RF remains a frequent mechanical complication after long-segment fusion for ASD. Although global sagittal alignment has been emphasized, RF is influenced by multiple interacting anatomical and surgical factors. ML techniques may improve risk prediction; however, comparative model performance and the relative importance of contributing variables remain unclear. This study aimed to compare ML models for RF prediction and to clarify the roles of construct strategy and alignment parameters using SHapley Additive exPlanations (SHAP).

Methods:

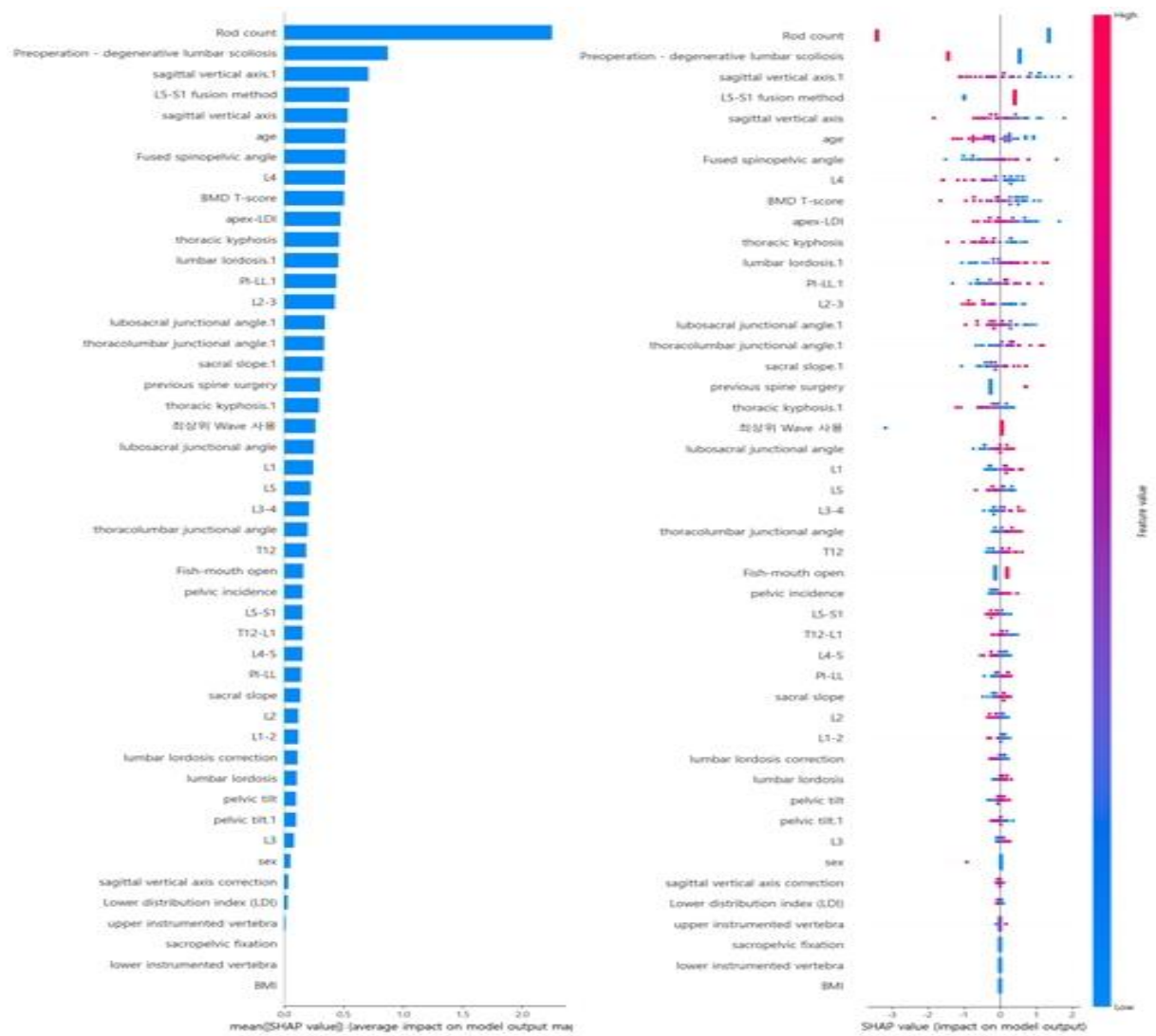
Patients who underwent lateral lumbar interbody fusion combined with posterior column osteotomy for ASD were retrospectively reviewed. Patients were classified into RF (n=29) and non-RF (n=122) groups. Logistic regression (LR), random forest, XGBoost, and LightGBM models were developed. Model performance was evaluated using AUROC, accuracy, sensitivity, and specificity. SHAP analysis was used to quantify the contribution and directionality of anatomical, surgical, and radiographic variables.

Results:

LR demonstrated the most consistent predictive performance, showing superior AUROC and balanced accuracy compared with tree-based ensemble models. SHAP analysis identified surgical construct design and segmental alignment distribution as the primary contributors to RF prediction. Use of a four-rod construct showed a strong protective effect. Larger L2–3 intervertebral angles, higher apex lordosis distribution index, and greater postoperative lumbar lordosis (LL) were also associated with reduced RF risk. Global alignment parameters showed comparatively lower contributions.

Conclusion:

LR provided the most reliable and interpretable model for predicting RF after long-segment fusion for ASD. Surgical construct design and segmental alignment distribution play a more important role in RF risk than global alignment parameters alone. Emphasizing multi-rod constructs and a harmonious distribution of LL with a more proximal apex may help reduce mechanical failure after long-segment fusion for ASD.



SHAP plot

259. Synthetic CT from Diagnostic Spine MRI: a Multi-Center Approach for Radiation-Free Bone Visualization*

Ryan Pollitt; Tom P. Schlosser, MD, PhD; Marijn van Stralen, PhD; **René M. Castelein, MD, PhD**; Wilbert Bartels, PhD; Peter R. Seevinck, PhD

Hypothesis:

An AI model trained on a large multi-center dataset can generalize to new, unseen centers, generating synthetic CT from routine diagnostic spine MRI with performance equivalent to models trained on the new center's data.

Design:

In this prospective, multicenter study, paired spinal MR and CT scans were collected in nine different centers and used in a technical validation.

Introduction:

Synthetic CT (sCT) generation from MRI promises radiation-free 3D bone visualization. Current methods are limited by single-center validation, a need for dedicated scans, or low-resolution outputs. This study aimed to develop and validate an sCT method from diagnostic spine MRI that overcomes these limitations.

Methods:

Using paired MRI/CT scans from 199 patients across nine centers spanning a wide range of spinal pathologies, anatomical regions and MRI sequences, we trained a Multi-Center Network on data from eight centers. Its performance on an unseen ninth center was compared to two benchmarks: a Single-Center Network (trained only on that center's data) and an All-Centers Network (trained on all center's data). The sCTs and CTs were compared using image intensity-based metrics and the mean surface distance between automatic vertebra segmentations.

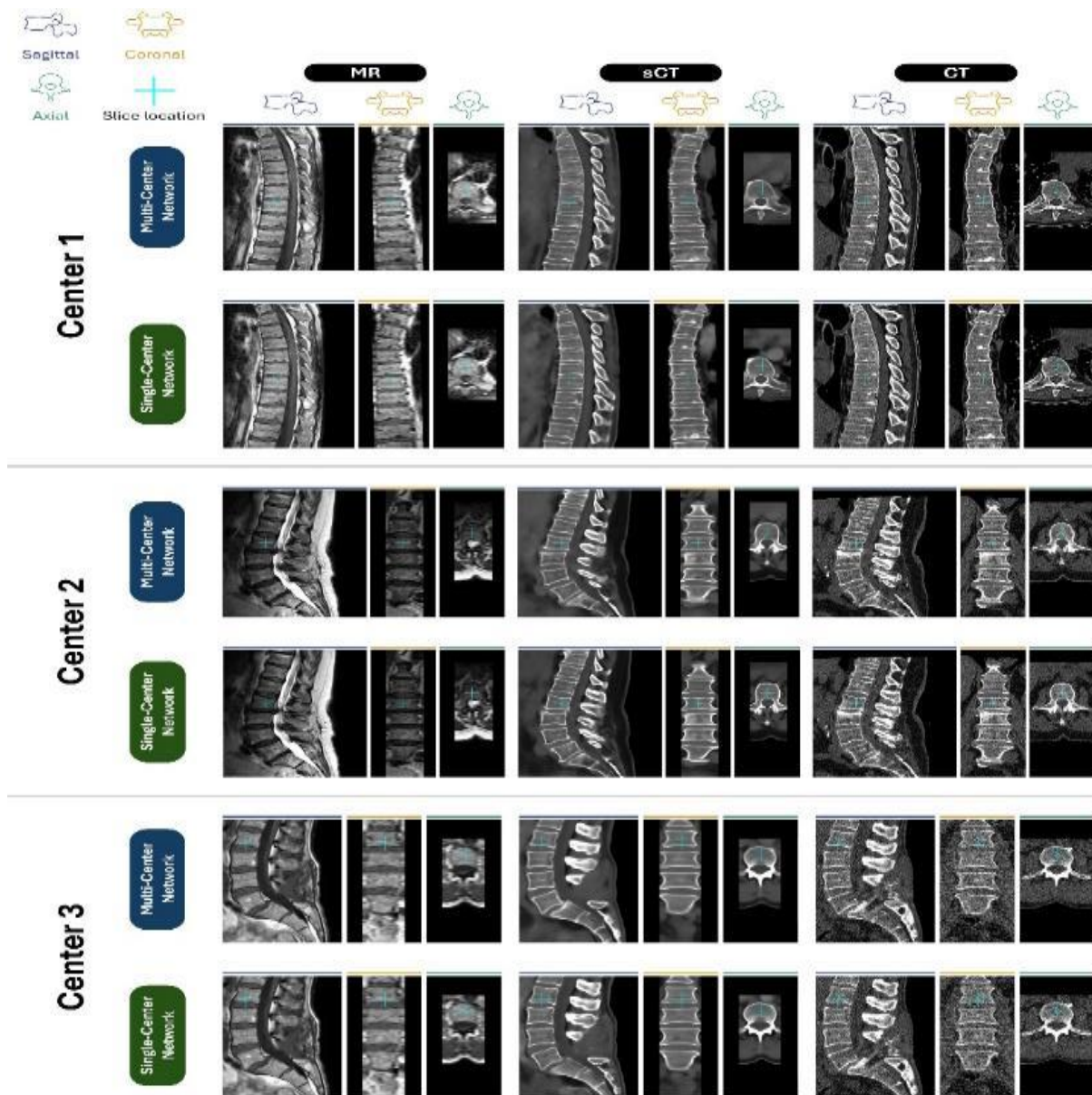
Results:

The Multi-Center Networks (trained without the test center's data) performed equally to the Single-Center Networks (trained with the test center's data) as shown qualitatively in Fig. 1. The Multi-Center Networks also achieved similar performance to the All-Centers Network with non-significant differences in 74% of comparisons and an average of only 1.5% difference in metric values. This performance was consistent across different MRI scan types and all three test centers.

Conclusion:

An AI model trained on a large, diverse multi-center dataset, can successfully generate (sub)millimeter resolution 3D sCTs from diagnostic MRI from new unseen centers, performing similarly to networks trained on data from that center. This demonstrates an important step towards radiation-free bone visualization from diagnostic MR scans across diverse imaging centers, supporting broader clinical and surgical applications.

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant



Qualitative examples of sCTs predicted by the Multi-Center Networks and Single-Center Networks per center. The MR inputs were sagittal 2D acquired scans with original slice spacings of 3.3-4.4 mm.

260. Lactoferrin-Anchored Tannylated Mesoporous Silica Nanomaterials-Induced Bone Fusion in a Rat Model of Lumbar Spinal Fusion *

Sung Hyeon Noh, MD, PhD

Hypothesis:

We suggest that TA-MSN-LF is a potent material for spinal bone fusion.

Design:

Prospective study

Introduction:

Lactoferrin (LF) is a potent antiviral, anti-inflammatory, and antibacterial agent found in cow and human colostrum which acts as an osteogenic growth factor. This study aimed to investigate whether LF-anchored tannylated mesoporous silica nanomaterials (TA-MSN-LF) function as a bone fusion material in a rat model.

Methods:

In this study, we created TA-MSN-LF and measured the effects of low (1 µg) and high (100 µg) TA-MSN-LF concentrations in a spinal fusion animal model. Rats were assigned to four groups in this study: defect, MSN, TA-MSN-LF-low (1 µg/mL), and TA-MSN-LF-high (100 µg/mL).

Results:

Eight weeks after surgery, a greater amount of radiological fusion was identified in the TA-MSN-LF groups than in the other groups. Hematoxylin and eosin staining showed that new bone fusion was induced in the TA-MSN-LF groups. Additionally, osteocalcin, a marker of bone formation, was detected by immunohistochemistry, and its intensity was induced in the TA-MSN-LF groups. The formation of new vessels was induced in the TA-MSN-LF-high group. We also confirmed an increase in the serum osteocalcin level and the mRNA expression of osteocalcin and osteopontin in the TA-MSN-LF groups. TA-MSN-LF showed effective bone fusion and angiogenesis in rats.

Conclusion:

We suggest that TA-MSN-LF is a potent material for spinal bone fusion.

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

261. Radiological Features and Postoperative Outcomes in Patients of Degenerative Lumbar Scoliosis with Pelvic Obliquity: the Application of a Novel Classification *

Junyu Li, MD; Liangyuan Wang; Yongqiang Wang, MD; Zhuoran Sun, MD; Miao Yu, MD; Weishi Li, MD

Hypothesis:

A novel classification system for pelvic obliquity (PO) in degenerative lumbar scoliosis (DLS) can distinguish between two distinct types with different biomechanical implications. The preoperative categorization can guide surgical strategy and predict outcomes for pelvic balance restoration.

Design:

Retrospective cohort study

Introduction:

Pelvic obliquity (PO) is common in Degenerative Lumbar Scoliosis (DLS) and significantly impacts quality of life. However, its definition and impact on surgical planning are poorly studied. This study proposes and evaluates a novel classification of PO to guide corrective surgery.

Methods:

Patients with DLS and PO (Pelvic Obliquity Angle, POA $\geq 3^\circ$) were classified into two types based on the relationship between the C7 Plumb Line (C7PL) and the higher iliac crest: Type I: The C7PL deviates toward the higher side of the pelvis. Type II: The C7PL deviates toward the lower side of the pelvis. Radiological parameters (Cobb angle, C7PL-CSVL distance [CVA], Apical Vertebral Translation [AVT], Sacral Obliquity Angle [SOA], POA) and surgical outcomes (fixation levels, PO persistence/recurrence) were compared pre- and post-operatively and between types.

Results:

90/290 patients (31%) had significant PO (48 Type I, 42 Type II). Type I PO Recovery: Associated with better correction of coronal deformity (lower postoperative AVT). Sacral fixation was not mandatory for PO correction. Type II PO Recovery: Dependent on adequate intraoperative SOA correction. Sacral fixation was crucial for preventing long-term PO recurrence. Poor Outcomes: Persistent/recurrent PO was linked to insufficient correction of the primary deformity (AVT in Type I) or failure to address sacral obliquity/fuse to the sacrum (in Type II).

Conclusion:

The proposed PO classification (Type I vs. Type II) is clinically relevant. It suggests distinct surgical strategies: Type I PO correction focuses on overall coronal balance (Cobb, AVT), while Type II PO correction requires specific attention to the sacrum (SOA correction, sacropelvic fixation). This classification can help tailor surgery, potentially avoiding unnecessary fusion to the sacrum in Type I cases.

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

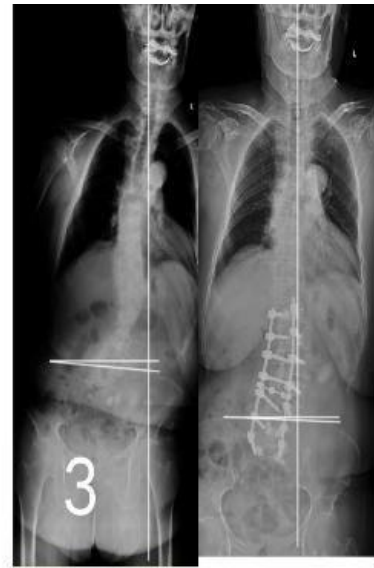
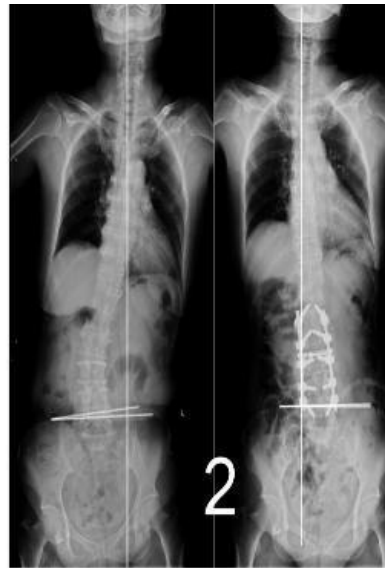


Fig.1: Methods for measuring radiological parameters. Fig.2: Type I pelvic obliquity in a DLS patient, pre- and post-op. Fig.3: Type II pelvic obliquity in a DLS patient, pre- and post-op.

262. The Two Distinct Functional Lordoses of the Lumbar Spine *

David Gadoin, MD; Ayman Assi, PhD; Claudio Vergari, PhD; Anas Venard, MD; Pierre Guigui, MD, PhD; Olivier Gille, MD, PhD; Wafa Skalli, PhD; Virginie Lafage, PhD; Emmanuelle Ferrero, MD, PhD; Marc Khalife, MD, PhD, MS

Hypothesis:

Lumbar lordosis may consist of two distinct functional arcs (proximal and distal), each with its own set of contributing spinopelvic parameters, challenging current uniform curvature models

Design:

Prospective observational and analytical study

Introduction:

Lumbar lordosis (LL) is a key component of sagittal spinal balance, yet its definition and measurement remain debated. Recent evidence suggests that LL is not a uniform curvature but a composite structure with proximal and distal arcs exhibiting distinct biomechanical roles. This study aimed to analyze the relationships of these arcs with spinopelvic parameters and determine how their distribution varies with pelvic incidence (PI).

Methods:

This multicentric study included 642 healthy volunteers (mean age 37.6±16.3 years) without spinal deformities. Full-body stereoradiographs were used to measure spinopelvic parameters, including maximum lumbar lordosis (LLmax), proximal lordosis (LLprox, from the thoracolumbar inflection point to the lumbar apex), and distal lordosis (LLdist, from the lumbar apex to the sacral plateau). Correlations between these arcs and spinopelvic parameters were sought. Subjects were stratified into five PI groups using Jenks' natural breaks optimization method, to determine lordosis distribution variation with PI in terms of angle and number of vertebrae included in curvature.

Results:

LLdist strongly correlated with pelvic parameters, particularly sacral slope (SS, $r=-0.83$, $p<0.001$) and PI ($r=-0.54$, $p<0.001$), but not with thoracic alignment. In contrast, LLprox correlated with both pelvic and thoracic parameters, including SS ($r=-0.31$, $p<0.001$) and thoracic kyphosis (TKmax, $r=-0.35$, $p<0.001$). As PI increased, the contribution of LLdist to LLmax rose from 55±12% to 66±8% ($p<0.001$), while the number of vertebrae in the distal arc increased from 1.52±0.50 to 2.32±0.59 ($p<0.001$). LLprox's proportional contribution decreased from 45±12% to 34±8% ($p<0.001$), despite a stable vertebral extent.

Conclusion:

Lumbar lordosis comprises two functionally distinct arcs: a pelvic-driven distal arc and a compensatory proximal arc influenced by thoracic alignment. As PI increases, the distal arc of LL becomes preponderant. These findings advocate for a segmental approach in clinical assessment and surgical planning, emphasizing the need to consider both arcs independently to optimize sagittal balance and reduce complications such as PJK.

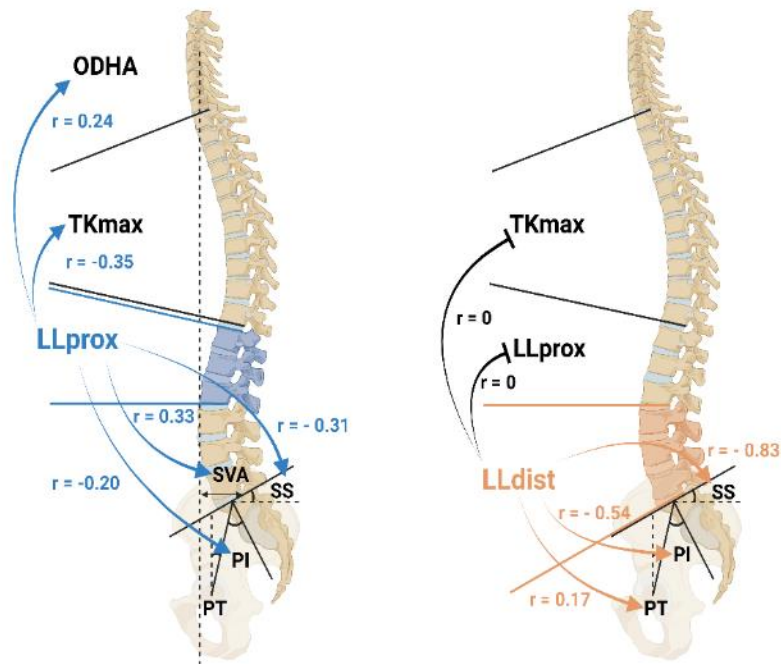


Figure : Functional Duality of Lumbar Lordosis

263. Unilateral Segmental Artery Ligation Induces Asymmetric Vertebral Growth and Vertebral Wedging in Immature Swine

Jie Xiao, MD; Jingming Xie; Jin Zhou, MD; Yingsong Wang, MD; Zhi Zhao, MD; Tao Li, MD; Zhiyue Shi, MD; Tingbiao Zhu, MD; Wei Zhao, MD; Xiaobing Tian, MD

Hypothesis:

Unilateral segmental artery ligation in immature swine diminishes ipsilateral vertebral growth plate perfusion, resulting in asymmetric vertebral growth, increasing vertebral wedging, and scoliosis.

Design:

Prospective randomized controlled study.

Introduction:

Vascular injury to one side of a limb growth plate can disrupt symmetric growth and produce angular deformity, but whether targeted vascular disruption can modulate vertebral growth is not well defined. We investigated unilateral segmental artery disruption as a growth-modulating stimulus, hypothesizing that reduced unilateral vertebral blood supply alters the local growth environment and induces asymmetric vertebral development and scoliosis.

Methods:

Thirty 6-week-old piglets (9–11 kg) were randomized to Experimental (n=10), Sham (n=10), or Control (n=10). Left segmental arteries from T12 to L1 were ligated at their origin and intervertebral foramina and electrocoagulated in the Experimental group. A left paramedian approach exposed the rib bed and costotransverse joints, ligated posterior intercostal vessels/nerves, and removed a 2cm segment of T12–15 ribs and the L1 transverse process to expose target arteries. Sham animals underwent identical exposure without ligation; Controls had no surgery. Monthly radiographs assessed curve progression; axial CT at 4, 8, and 12 weeks quantified vertebral morphology and side-to-side height asymmetry using vertebral height ratio (VHR = ligation-side height/non-ligation-side height).

Results:

The Experimental group developed scoliosis with convexity contralateral to the surgical side, progressing Cobb angles of $11.87 \pm 2.07^\circ$ (4 W), $13.94 \pm 2.59^\circ$ (8 W), and $16.49 \pm 2.22^\circ$ (12 W). Sham group had milder scoliosis with ipsilateral convexity and Cobb angles of $9.62 \pm 1.47^\circ$, $11.23 \pm 1.34^\circ$, and $12.48 \pm 1.64^\circ$ at the same time points. CT demonstrated wedge-shaped vertebral deformation in the Experimental group, with early T12–L1 side-to-side height asymmetry at 1 month (VHR 0.929–0.951) that progressed by 3 months (VHR 0.856–0.868), indicating increasing growth imbalance on the ligated side.

Conclusion:

Unilateral disruption of segmental arterial supply induces asymmetric vertebral growth and progressive vertebral wedging, producing scoliosis in immature swine. These results suggest a vascular role in spinal growth modulation and offer a platform to research targeted vascular treatments to reduce asymmetric growth in EOS.

264. Does Adding Uncovertebral Foraminotomy to Anterior Cervical Discectomy and Fusion Improve Patient Outcomes? A 5-Year Propensity Score–Matched Analysis of MCID and Mechanical Complications

San Kim, MD; Hyuk-joon Sohn, MD; Kihyun Kwon, MD; Dong-Ho Lee, MD, PhD; Dong Ki Ahn, MD, PhD; ByungSuk Kim, MD; Jiseon Ahn, MD

Hypothesis:

The study investigated whether adding uncovertebral foraminotomy (UVF) to anterior cervical discectomy and fusion (ACDF) affects long-term patient outcomes, specifically the achievement of the minimum clinically important difference (MCID) and the incidence of mechanical complications

Design:

A 5-Year Propensity Score–Matched (PSM) Analysis

Introduction:

The study aimed to evaluate long-term patient outcomes and mechanical complications over a minimum five-year follow-up in patients undergoing ACDF with or without UVF

Methods:

From a pool of 253 patients who underwent one- to three-level ACDF between 2006 and 2020, a propensity score-matched (PSM) analysis was conducted. Patients were matched 1:1 into UVF (n = 85) and No UVF (n = 85) groups based on variables including age, sex, BMI, bone quality (CT HU), and surgical levels. Outcome measures included the Neck Disability Index (NDI), visual analogue scale (VAS) for neck and arm pain, and radiographic assessments for pseudarthrosis, cage subsidence, and loss of lordosis. Both absolute and relative MCID achievement rates were analyzed

Results:

In the matched cohort, NDI and neck pain VAS showed no significant differences between the two groups at any time point. While the UVF group reported significantly higher arm pain VAS at the two-year mark compared to the No UVF group (3.54 ± 2.91 vs. 2.35 ± 2.57 ; $p = 0.006$), this difference was no longer significant at the final follow-up. There were no statistical differences in MCID achievement rates for any clinical metric between groups. Radiographically, C2–C7 lordosis and SVA were similar between the groups. Although the overall rate of mechanical complications did not differ significantly in the matched cohort, subanalysis revealed that bilateral UVF was associated with a higher incidence of pseudarthrosis compared to the No UVF group (17.9% vs. 5.5%; $p = 0.017$)

Conclusion:

Adding UVF to ACDF does not provide additional long-term clinical benefits or improve MCID achievement. Furthermore, it may increase early postoperative arm pain and the risk of pseudarthrosis, particularly when performed bilaterally. Surgeons should carefully weigh the potential for increased mechanical complications against the lack of long-term clinical superiority when considering UVF

Characteristics		UVF (n = 85)	No UVF (n = 85)	P-value
Radiographic outcomes				
C2–7 lordosis	Preoperative	5.43 ± 12.37	5.66 ± 10.89	0.897
	Postoperative	7.05 ± 10.94	6.90 ± 8.04	0.914
	Final	9.88 ± 10.21†,‡	8.90 ± 10.13†,‡	0.529
C2–7 SVA	Preoperative	17.78 ± 10.08	19.62 ± 9.53	0.223
	Postoperative	18.46 ± 8.14	20.07 ± 9.16	0.228
	Final	18.35 ± 10.21	20.09 ± 9.41	0.250
Complications				
Pseudarthrosis	Final	6 (7.1%)	6 (7.1%)	1.000
Subsidence	Final	1 (1.2%)	6 (7.1%)	0.117
Loss of lordosis	Final	13 (15.3%)	17 (20.0%)	0.547
Revision	After final	4 (4.7%)	5 (5.9%)	1.000
Patients with any mechanical complication		20 (23.5%)	25 (29.4%)	0.487

UVF, uncovertebral foraminotomy; SVA, sagittal vertical axis;

* Statistically significant difference between the two groups (p <0.05).

† Statistically significant change compared to the preoperative measurement.

‡ Statistically significant change compared to the postoperative measurement.

Radiographic outcomes

265. Comparison of Clinical and Radiographic Outcomes between Subaxial Pedicle Screws and Lateral Mass Screws in Cervical Deformity Surgery

Anthony L. Mikula, MD; Rahul Kumar, MD, PhD; Darryl Lau, MD; Jeffrey Mullin, MD; Nikita Lakomkin, MD; Justin K. Scheer, MD; Renaud Lafage, MS; Virginie Lafage, PhD; Khaled M. Kebaish, MD; Eric O. Klineberg, MD; Gregory M. Mundis Jr, MD; Alan H. Daniels, MD; Robert K. Eastlack, MD; Richard Hostin, MD; Jeffrey Gum, MD; Brandon B. Carlson, MD; Peter G. Passias, MD; Themistocles S. Protopsaltis, MD; Munish C. Gupta, MD, MBA; Han Jo Kim, MD; Michael P. Kelly, MD; Lawrence G. Lenke, MD; Christopher I. Shaffrey, MD; Shay Bess, MD; Justin S. Smith, MD, PhD; Christopher P. Ames, MD; International Spine Study Group

Hypothesis:

Subaxial pedicle screws are associated with a greater magnitude of radiographic correction compared to lateral mass screws without a difference in perioperative complications.

Design:

Retrospective review of a prospective multicenter cervical adult spinal deformity database.

Introduction:

The impact of subaxial pedicle screws on radiographic outcomes and perioperative complications compared to lateral mass screws for cervical deformity surgery is not well understood.

Methods:

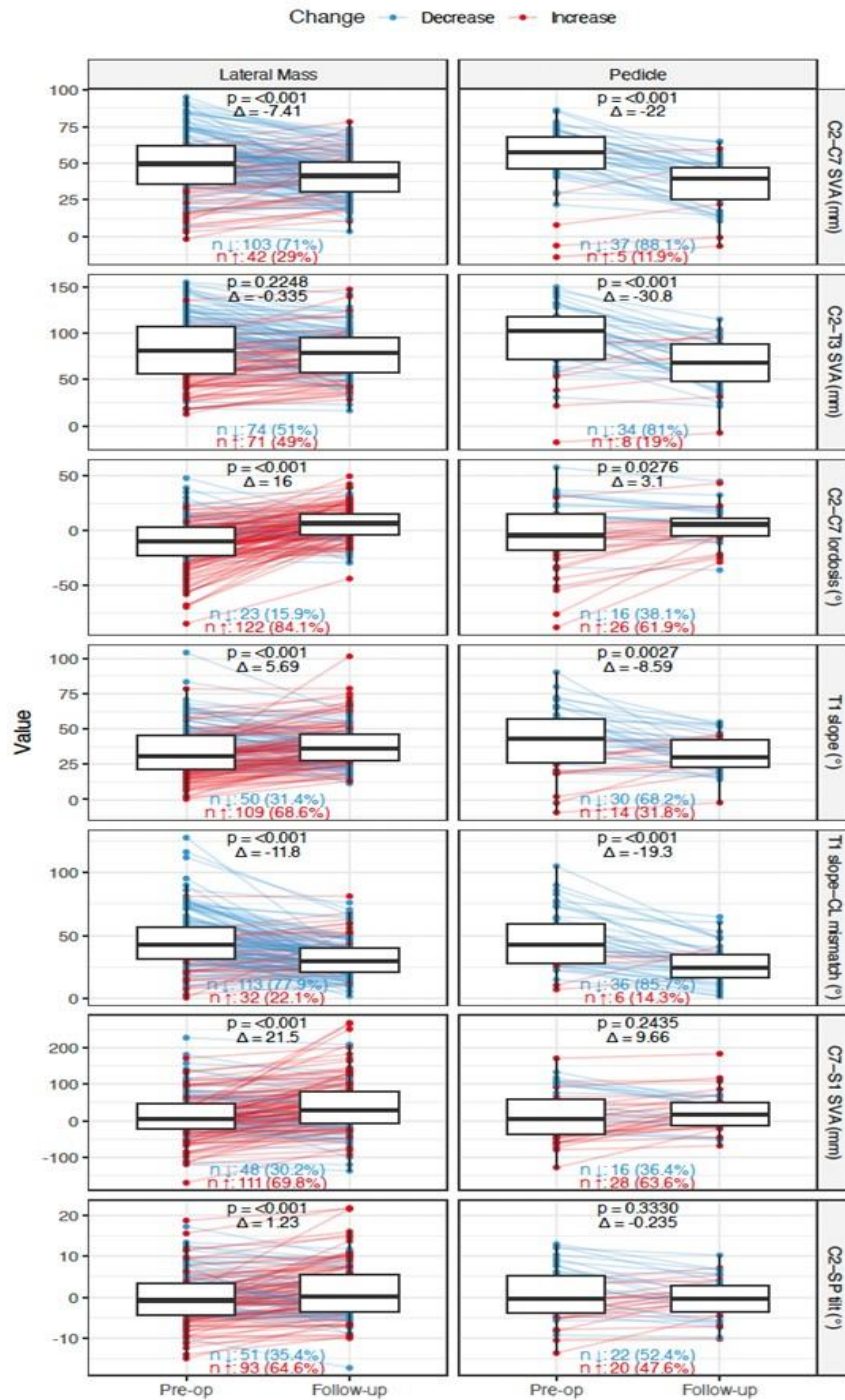
Patients undergoing cervical deformity surgery with subaxial pedicle screws placed at the C3-C6 levels were compared to those who had lateral mass screws. Patients who had a mix of both screw types from C3-C6 were excluded. The primary outcome measures were radiographic parameters at first follow up and complications. Analysis of covariance controlled for key covariates to isolate the impact of subaxial pedicle screws versus lateral mass screws. No minimum follow-up period was required to capture all screw-placement related complications.

Results:

A total of 232 patients were included, with a median age of 65 and 55% were female. Fifty-one patients (22%) underwent subaxial pedicle screw placement. After controlling for baseline radiographic parameter value, construct length, three column osteotomy, posterior column osteotomy, previous cervical spine surgery, and surgical approach, subaxial pedicle screws resulted in a greater degree of radiographic correction including C2 tilt by 2° ($p=0.02$), C2-C7 sagittal vertical axis (SVA) by 6mm ($p=0.01$), C2-T3 SVA by 10mm ($p=0.01$), C7-S1 SVA by 20mm ($p=0.03$), and T1 slope by 6° ($p=0.01$). There was no difference between subaxial pedicle screw and lateral mass screw patients in any of the complications, including instrumentation failure, neurologic deficit, operative complications, and radiographic complications. Specifically, subaxial pedicle screw placement did not cause any strokes or vascular injuries.

Conclusion:

Subaxial pedicle screws are associated with a greater magnitude of radiographic correction compared to lateral mass screws without a difference in complication rate. Cervical deformity surgeons should consider subaxial pedicle screws for cases that demand a high degree of sagittal plane correction.



± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

266. Clinical Efficacy of Concave-Side Distraction in the Treatment of Congenital Cervical Scoliosis

Dazhao Tie, MD; Feifei Zhou, MD

Hypothesis:

Concave-side distraction (CSD) provides effective, durable correction of congenital cervical scoliosis (CCS) while reducing neurovascular risk; corrective efficiency is highest at the craniovertebral junction (CVJ).

Design:

Retrospective study of CSD-based strategies applied at two anatomic regions (CVJ and subaxial/CTJ)

Introduction:

CCS correction is limited by vertebral artery proximity and the morbidity of extensive osteotomy or hemivertebra resection. We developed a “valley-fill” strategy that restores concave-side length using patient-specific spacers. This represents the largest known surgical cohort of congenital cervical scoliosis worldwide.

Methods:

We retrospectively reviewed 69 consecutive patients who underwent surgical correction for congenital cervical scoliosis (CCS) at a single tertiary referral center between December 2009 and January 2023. Inclusion criteria were CCS with a coronal Cobb angle $>10^\circ$ and definitive surgery. The CVJ cohort included 25 patients who underwent concave-side distraction (CSD)-based procedures, with outcomes focused on the CVJ structural Cobb angle (SCA). The subaxial/cervicothoracic (CTJ) cohort comprised 44 patients treated with subaxial CSD.

Results:

In the CVJ cohort, concave-side distraction achieved substantial and durable coronal correction, with the structural Cobb angle (SCA) improving from $30.75^\circ \pm 13.09^\circ$ preoperatively to 4.30° early postoperatively (84% correction) and to 3.00° at final follow-up (88% correction). Mean operative time was 473.74 ± 134.29 minutes, and mean estimated blood loss was 336.11 ± 166.52 mL. In the subaxial and cervicothoracic (CTJ) cohort, mean SCA improved from $33.7^\circ \pm 14.1^\circ$ to $12.8^\circ \pm 11.4^\circ$ postoperatively (66.7% correction) and was maintained at final follow-up ($12.5^\circ \pm 11.0^\circ$). Mean operative time and estimated blood loss were 466.6 ± 118.5 minutes and 321.1 ± 209.8 mL, respectively. Across both cohorts, the most common complication was transient C5 palsy (CVJ: 5; subaxial/CTJ: 4), with full recovery within six months. Two cases of CVJ spacer subsidence occurred without neurological sequelae and were managed conservatively, with no impact on final radiographic outcomes.

Conclusion:

Concave-side distraction offers a reconstructive alternative to resection-based CCS correction, enabling concave-side length restoration and coronal realignment with low catastrophic neurovascular risk.

267. The Improvement of 3D-printed Titanium Cage Used in Atlantoaxial Lateral Joints on Cervical Realignment in Atlantoaxial Dislocation

Qixin Liu, MS; Junlong Zhong, MD, PhD; Zhenhai Zhou, MD, PhD; Qin Wu, MS; Kai Cao, MD, PhD

Hypothesis:

Three D-printed cage used in the atlantoaxial lateral joint can improve the cervical sagittal realignment in atlantoaxial dislocation.

Design:

Cohort study.

Introduction:

This study is to investigate the effects of using 3D-printed titanium cage in the atlantoaxial lateral joints on cervical sagittal realignment in atlantoaxial dislocation surgery compared with conventional Harms rod-screw system without cage.

Methods:

Seventeen atlantoaxial dislocation Pts treated with 3D-printed cage (Cage group) with a 1:1 matched Pts without cage (Non-cage group) were collected during the same period. Preoperative, last follow-up cervical upright lateral radiographs were collected. Cervical sagittal parameters including slope of Frankfort horizontal line (sFH), orbital tilt (OrT), occipital incidence (OI), occipital slope (OS), cervical sagittal vertical axis (cSVA), occiput-C1 Cobb angle (O-C1 CA), occiput-C2 Cobb angle (O-C2 CA), C1-C2 Cobb angle (C1-C2 CA), C2-7 Cobb angle (C2-7 CA), T1 slope (T1s), thoracic inlet angle (TIA), and neck tilt (NT) were measured and compared between two groups.

Results:

Total 34 Pts were included in this study with 1:1 matched in two groups. The average operative time and blood loss were more in cage group but with no significant difference. The gender, age, hospital stay, all preoperative cervical sagittal parameters and intraoperative complications were not significant different between two groups. Solid bone fusion could be observed in all Pts in 3 mons after surgery. Cervical alignments were improved in all Pts at two groups after surgery, However, OrT, O-C1 CA, O-C2 CA, C2-7 CA and T1S were significantly improved more in cage group. The values of Δ sFH, Δ OrT, Δ O-C1 CA, Δ O-C2 CA, Δ C2-7 CA reflecting the postoperative improvement of cervical alignments compared with the preoperative also significantly changed more in cage group.

Conclusion:

In the surgical treatment of atlantoaxial dislocation, the placement of a 3D-printed titanium cage between the atlantoaxial lateral mass joints did not increase the surgery related complications. However, it did significantly realign the cervical spine better compared to the conventional Harm screw-rod system without cage through improving the value of atlantoaxial regional alignment.

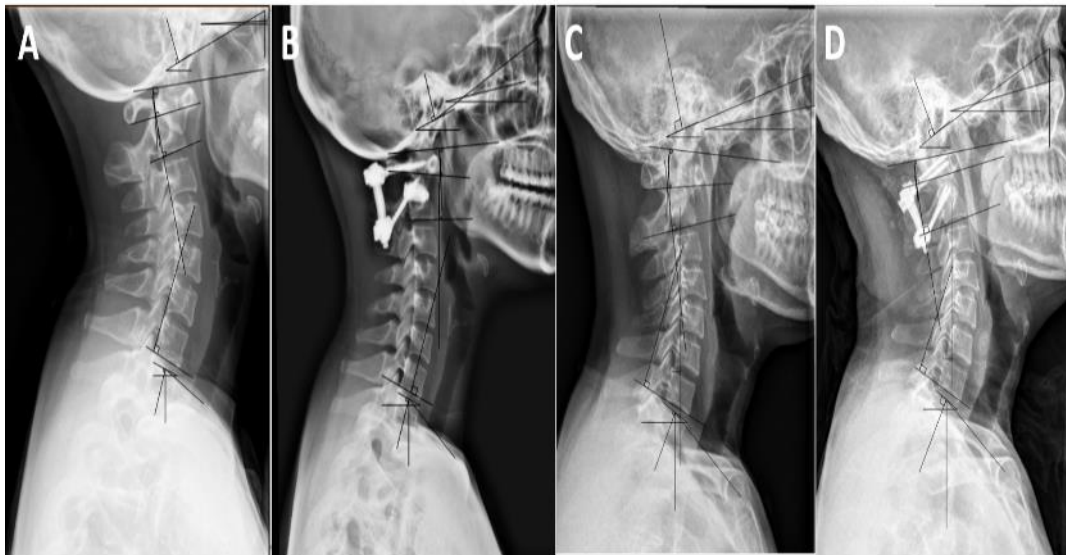


Fig.1, Lateral X-rays of Pts with atlantoaxial dislocation at preop. (A,C) and at final F/U with 3D-printed cage (B) or without (D).

267. The Improvement of 3D-printed Titanium Cage Used in Atlantoaxial Lateral Joints on Cervical Realignment in Atlantoaxial Dislocation

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Results:

Total 34 Pts were included in this study with 1:1 matched in two groups. The average operative time and blood loss were more in cage group but with no significant difference. The gender, age, hospital stay, all preoperative cervical sagittal parameters and intraoperative complications were not significant different between two groups. Solid bone fusion could be observed in all Pts in 3 mons after surgery. Cervical alignments were improved in all Pts at two groups after surgery, However, OrT, O-C1 CA, O-C2 CA, C2-7 CA and T1S were significantly improved more in cage group. The values of Δ sFH, Δ OrT, Δ O-C1 CA, Δ O-C2 CA, Δ C2-7 CA reflecting the postoperative improvement of cervical alignments compared with the preoperative also significantly changed more in cage group.

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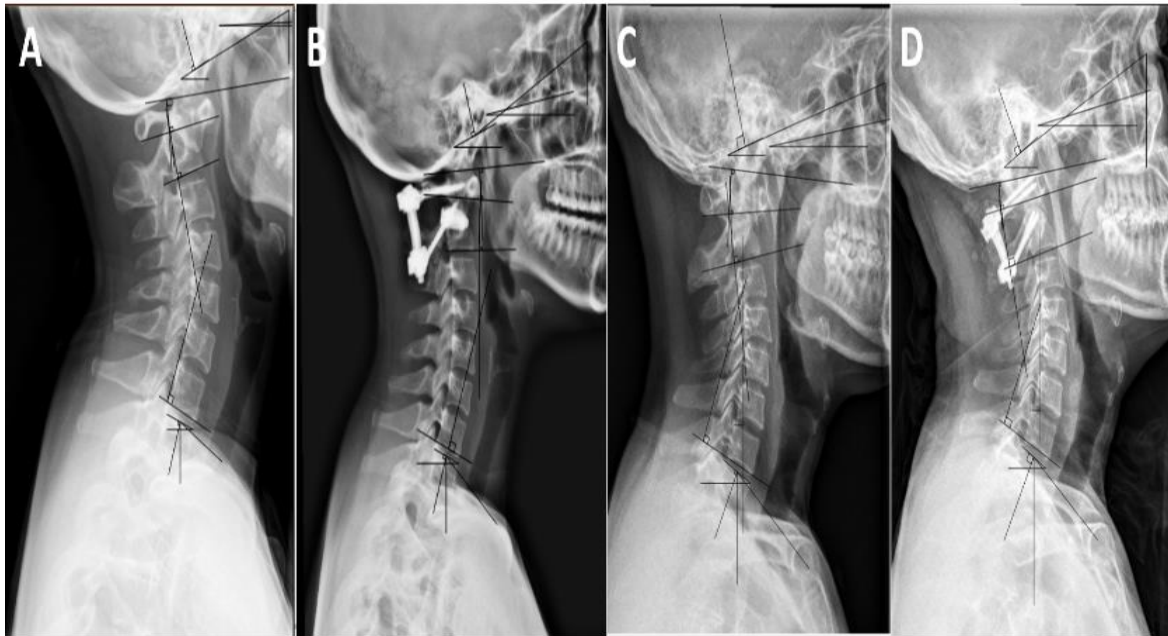


Fig.1, Lateral X-rays of Pts with atlantoaxial dislocation at preop. (A,C) and at final F/U with 3D-printed cage (B) or without (D).

268. Beyond the Cervicothoracic Junction: Proximal Thoracic Lower Instrumented Vertebra Optimizes Sagittal Balance in Adult Cervical Deformity Patients

James Y. Chen, BA; Justin L. Reyes, MS; Thomas Hunt, BA; Jacob Okulewicz, BS; Demetrius Bryson, BS; Shonik Ganjoo, BS; Hamzah Abbas, BS; Kenji Kaproth, BS; Joseph M. Lombardi, MD; Ronald Lehman Jr, MD; Daniel Riew, MD; Zeeshan M. Sardar, MD

Hypothesis:

Compared to patients fused to the cervicothoracic junction (CTJ), those fused to the proximal thoracic spine (PTS) have more significant baseline deformities but comparable outcomes.

Design:

Retrospective comparative cohort

Introduction:

Prior studies on the selection of the lowest instrumented vertebra (LIV) in adult cervical deformity have primarily compared fusion lengths with respect to the CTJ (C7-T1). Few studies have characterized the factors influencing LIV selection, particularly to the CTJ or the PTS.

Methods:

We reviewed all adult cervical deformity patients with 2+ year follow-up who underwent 4+ levels of posterior cervical fusion (PCF, with or without anterior fusion) at a single center. We included patients with: C2-C7 sagittal vertical axis (cSVA) > 30 mm, T1 slope (T1S) > 30°, and/or cervical mismatch (T1S+CSA [cervical sagittal angle]) > 25°. Patients were divided into CTJ (C7-T1 LIV) and PTS (T2-T4 LIV) groups. Wilcoxon rank-sum test and Fisher's exact tests were used with significance set to P<0.05.

Results:

26 patients were included (mean age 58.5±15.4 years; 35% female), with 13 in the CTJ group and 13 in the PT group. Compared to the CTJ group, preoperatively, the PTS group had more kyphotic cervical spines (CK; CSA +18.8° vs. -3.0°, P=0.046), greater C2 slope (C2S; 51.9° vs. 33.1°, P=0.016), and greater cSVA (59.9 vs. 42.9 mm, P=0.040). Immediate post-operative T1S was greater in the CTJ group (35.6° vs. 24.8°, P=0.027), while the PTS group had greater correction in C2S (-33.1° vs. -11.3°, P=0.018) and cSVA (-27.3 vs. -6.1 mm, P=0.006). At final follow-up, cSVA correction remained greater in the PTS group while the CTJ group had slight worsening of alignment (-19.4 vs. 2.0 mm, P=0.012). Rates of complications, mechanical failures, and revisions were similar post-operatively.

Conclusion:

Patients fused to the proximal thoracic spine (PTS) had greater pre-operative cervical kyphosis (CK) and greater cervical sagittal imbalance than those fused to the cervicothoracic junction (CTJ), yet the PTS group achieved better maintenance of cervical alignment at final follow-up. This is the first single-center study supporting longer fusion constructs terminating in the PTS for these complex cervical deformities.

	LIV Anatomical Region		P-value
	CTJ (C7-T1) N = 13	PTS (T2-T4) N = 13	
Age (years, mean ± SD)	62.7 ± 9.2	54.2 ± 19.3	0.46
Female (N, %)	5 (38%)	4 (31%)	1.00
BMI (kg/m², mean ± SD)	29.5 ± 7.8	28.3 ± 6.5	0.83
Comorbidities (N, %)			
Osteoporosis	1 (7.7%)	1 (7.7%)	1.00
Smoking History	8 (62%)	4 (31%)	0.24
Prior Cervical Fusion (N, %)	9 (69%)	5 (38%)	0.24
Posterior Levels Fused (mean ± SD)	5.2 ± 0.9	6.5 ± 1.6	0.021
Anterior-Posterior Fusion (N, %)	8 (62%)	8 (62%)	1.00
Surgical Time (minutes, mean ± SD)	248.3 ± 82.6	309.2 ± 162.1	0.031
Estimated Blood Loss (mL, mean ± SD)	175.0 ± 77.7	309.2 ± 110.0	0.003
Complications (N, %)			
Wound Complications	0	1 (7.7%)	1.00
Any Mechanical Complications	0	2 (15%)	0.48
Proximal Junctional Kyphosis (PJK)	0	0	1.00
Distal Junctional Kyphosis (DJK)	0	0	1.00
Pseudoarthrosis	1 (7.7%)	1 (7.7%)	1.00
Revision	2 (15%)	1 (7.7%)	1.00
Radiographic Parameters (mean ± SD)			
<u>Baseline Pre-Operative</u>			
C2-C7 Cervical Sagittal Angle (CSA, °)	-3.0 ± 14.6	18.8 ± 27.8	0.046
C2 Slope (C2S, °)	33.1 ± 15.5	51.9 ± 21.6	0.016
T1 Slope (T1S, °)	34.8 ± 10.0	30.8 ± 13.3	0.58
T1S+CSA (°)	34.8 ± 15.3	48.4 ± 22.0	0.11
C2-C7 Sagittal Vertical Axis (cSVA, mm)	42.9 ± 15.3	59.9 ± 20.3	0.040
<u>Immediate Post-Operative</u>			
CSA (°)	-9.4 ± 13.7	-6.8 ± 15.1	0.81
Δ CSA (°)	-9.4 ± 18.1	-24.9 ± 26.4	0.15
C2S (°)	22.2 ± 12.0	18.8 ± 13.7	0.72
Δ C2S (°)	-11.3 ± 14.2	-33.1 ± 24.0	0.018
T1S (°)	35.6 ± 10.5	24.8 ± 11.0	0.027
Δ T1S (°)	0.7 ± 11.1	-3.3 ± 10.1	0.31
T1S+CSA (°)	24.5 ± 11.7	18.4 ± 12.6	0.37
Δ T1S+CSA (°)	-13.3 ± 15.6	-27.7 ± 29.3	0.22
cSVA (mm)	37.9 ± 12.6	32.3 ± 19.0	0.57
Δ cSVA (mm)	-6.1 ± 12.8	-27.3 ± 18.2	0.006
<u>Final (2+ Year) Follow-up</u>			
CSA (°)	-11.9 ± 13.9	-4.6 ± 9.7	0.22
Δ CSA (°)	-11.6 ± 17.6	-22.7 ± 27.9	0.47
C2S (°)	25.3 ± 12.2	24.0 ± 15.1	0.94
Δ C2S (°)	-8.1 ± 14.6	-27.8 ± 28.6	0.05
T1S (°)	36.6 ± 6.8	32.0 ± 16.3	0.77
Δ T1S (°)	2.2 ± 9.5	3.0 ± 13.3	0.98
T1S+CSA (°)	24.7 ± 10.8	26.3 ± 15.4	0.25
Δ T1S+CSA (°)	-7.5 ± 16.9	-22.4 ± 32.1	0.36
cSVA (mm)	45.9 ± 13.9	40.2 ± 19.5	0.76
Δ cSVA (mm)	2.0 ± 12.3	-19.4 ± 23.5	0.012

Table 1: Patient Characteristics and Outcomes Stratified by LIV Anatomical Region

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

268. Beyond the Cervicothoracic Junction: Proximal Thoracic Lower Instrumented Vertebra Optimizes Sagittal Balance in Adult Cervical Deformity Patients

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Hypothesis:

Compared to patients fused to the cervicothoracic junction (CTJ), those fused to the proximal thoracic spine (PTS) have more significant baseline deformities but comparable outcomes.

Design:

Retrospective comparative cohort

Introduction:

Prior studies on the selection of the lowest instrumented vertebra (LIV) in adult cervical deformity have primarily compared fusion lengths with respect to the CTJ (C7-T1). Few studies have characterized the factors influencing LIV selection, particularly to the CTJ or the PTS.

Methods:

We reviewed all adult cervical deformity patients with 2+ year follow-up who underwent 4+ levels of posterior cervical fusion (PCF, with or without anterior fusion) at a single center. We included patients with: C2-C7 sagittal vertical axis (cSVA) > 30 mm, T1 slope (T1S) > 30°, and/or cervical mismatch (T1S+CSA [cervical sagittal angle]) > 25°. Patients were divided into CTJ (C7-T1 LIV) and PTS (T2-T4 LIV) groups. Wilcoxon rank-sum test and Fisher's exact tests were used with significance set to P<0.05.

Results:

26 patients were included (mean age 58.5±15.4 years; 35% female), with 13 in the CTJ group and 13 in the PT group. Compared to the CTJ group, preoperatively, the PTS group had more kyphotic cervical spines (CK; CSA +18.8° vs. -3.0°, P=0.046), greater C2 slope (C2S; 51.9° vs. 33.1°, P=0.016), and greater cSVA (59.9 vs. 42.9 mm, P=0.040). Immediate post-operative T1S was greater in the CTJ group (35.6° vs. 24.8°, P=0.027), while the PTS group had greater correction in C2S (-33.1° vs. -11.3°, P=0.018) and cSVA (-27.3 vs. -6.1 mm, P=0.006). At final follow-up, cSVA correction remained greater in the PTS group while the CTJ group had slight worsening of alignment (-19.4 vs. 2.0 mm, P=0.012). Rates of complications, mechanical failures, and revisions were similar post-operatively.

Conclusion:

Patients fused to the proximal thoracic spine (PTS) had greater pre-operative cervical kyphosis (CK) and greater cervical sagittal imbalance than those fused to the cervicothoracic junction (CTJ), yet the PTS group achieved better maintenance of cervical alignment at final follow-up. This is the first single-center study supporting longer fusion constructs terminating in the PTS for these complex cervical deformities.

	LIV Anatomical Region		P-value
	CTJ (C7-T1) N = 13	PTS (T2-T4) N = 13	
Age (years, mean ± SD)	62.7 ± 9.2	54.2 ± 19.3	0.46
Female (N, %)	5 (38%)	4 (31%)	1.00
BMI (kg/m ² , mean ± SD)	29.5 ± 7.8	28.3 ± 6.5	0.83
Comorbidities (N, %)			
Osteoporosis	1 (7.7%)	1 (7.7%)	1.00
Smoking History	8 (62%)	4 (31%)	0.24
Prior Cervical Fusion (N, %)	9 (69%)	5 (38%)	0.24
Posterior Levels Fused (mean ± SD)	5.2 ± 0.9	6.5 ± 1.6	0.021
Anterior-Posterior Fusion (N, %)	8 (62%)	8 (62%)	1.00
Surgical Time (minutes, mean ± SD)	248.3 ± 82.6	309.2 ± 162.1	0.031
Estimated Blood Loss (mL, mean ± SD)	175.0 ± 77.7	309.2 ± 110.0	0.003
Complications (N, %)			
Wound Complications	0	1 (7.7%)	1.00
Any Mechanical Complications	0	2 (15%)	0.48
Proximal Junctional Kyphosis (PJK)	0	0	1.00
Distal Junctional Kyphosis (DJK)	0	0	1.00
Pseudoarthrosis	1 (7.7%)	1 (7.7%)	1.00
Revision	2 (15%)	1 (7.7%)	1.00
Radiographic Parameters (mean ± SD)			
<u>Baseline Pre-Operative</u>			
C2-C7 Cervical Sagittal Angle (CSA, °)	-3.0 ± 14.6	18.8 ± 27.8	0.046
C2 Slope (C2S, °)	33.1 ± 15.5	51.9 ± 21.6	0.016
T1 Slope (T1S, °)	34.8 ± 10.0	30.8 ± 13.3	0.58
T1S+CSA (°)	34.8 ± 15.3	48.4 ± 22.0	0.11
C2-C7 Sagittal Vertical Axis (cSVA, mm)	42.9 ± 15.3	59.9 ± 20.3	0.040
<u>Immediate Post-Operative</u>			
CSA (°)	-9.4 ± 13.7	-6.8 ± 15.1	0.81
Δ CSA (°)	-9.4 ± 18.1	-24.9 ± 26.4	0.15
C2S (°)	22.2 ± 12.0	18.8 ± 13.7	0.72
Δ C2S (°)	-11.3 ± 14.2	-33.1 ± 24.0	0.018
T1S (°)	35.6 ± 10.5	24.8 ± 11.0	0.027
Δ T1S (°)	0.7 ± 11.1	-3.3 ± 10.1	0.31
T1S+CSA (°)	24.5 ± 11.7	18.4 ± 12.6	0.37
Δ T1S+CSA (°)	-13.3 ± 15.6	-27.7 ± 29.3	0.22
cSVA (mm)	37.9 ± 12.6	32.3 ± 19.0	0.57
Δ cSVA (mm)	-6.1 ± 12.8	-27.3 ± 18.2	0.006
<u>Final (2+ Year) Follow-up</u>			
CSA (°)	-11.9 ± 13.9	-4.6 ± 9.7	0.22
Δ CSA (°)	-11.6 ± 17.6	-22.7 ± 27.9	0.47
C2S (°)	25.3 ± 12.2	24.0 ± 15.1	0.94
Δ C2S (°)	-8.1 ± 14.6	-27.8 ± 28.6	0.05
T1S (°)	36.6 ± 6.8	32.0 ± 16.3	0.77
Δ T1S (°)	2.2 ± 9.5	3.0 ± 13.3	0.98
T1S+CSA (°)	24.7 ± 10.8	26.3 ± 15.4	0.25
Δ T1S+CSA (°)	-7.5 ± 16.9	-22.4 ± 32.1	0.36
cSVA (mm)	45.9 ± 13.9	40.2 ± 19.5	0.76
Δ cSVA (mm)	2.0 ± 12.3	-19.4 ± 23.5	0.012

Table 1: Patient Characteristics and Outcomes Stratified by LIV Anatomical Region

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

269. A Novel Morphology-Based Classification for Congenital Cervical Scoliosis: Development, Reliability, and Surgical Application

Feifei Zhou, MD

Hypothesis:

A classification system based on deformity-driving anatomical units can reliably characterize congenital cervical scoliosis (CCS) and guide surgical strategy.

Design:

Retrospective cohort study with reliability analysis.

Introduction:

Congenital cervical scoliosis (CCS) is a rare and surgically challenging deformity. Unlike thoracolumbar congenital scoliosis, CCS lacks a dedicated classification that reflects its unique anatomy and informs surgical planning. Existing systems are not designed for the cervical spine and provide limited guidance for operative decision-making. Using the largest surgical CCS cohort to date, we developed a morphology-based classification focused on deformity-driving units and evaluated its reliability and clinical utility.

Methods:

Seventy-five patients undergoing surgical correction for CCS were retrospectively reviewed. A deformity-driving unit was defined as a malformed vertebra or fused vertebral complex responsible for a coronal Cobb angle $>10^\circ$. Based on the number and composition of these units, CCS was classified into three types and five subtypes. Ten fellowship-trained spine surgeons independently classified all cases twice, with a three-week interval. Interobserver and intraobserver reliability were assessed using Fleiss' and Cohen's kappa, respectively. Surgical strategies included convex-side resection or concave-side distraction. Radiographic correction, operative data, and complications were analyzed.

Results:

Thirteen patients were classified as Type 1, 17 as Type 2a, 25 as Type 2b, 9 as Type 3a, and 11 as Type 3b. Interobserver reliability was substantial (mean $\kappa = 0.79$), as was intraobserver repeatability (mean $\kappa = 0.81$). Mean operative time was 472 ± 126 minutes, longest in Type 3b ($P < 0.05$). Median estimated blood loss was 400 mL without significant intergroup differences. Median Cobb angle improved from 27.5° preoperatively to 8.3° postoperatively and 8.1° at final follow-up ($P < 0.001$). Correction rates differed significantly among subtypes, with Type 1 achieving the highest correction.

Conclusion:

The PUTH classification is the first morphology-based system specifically developed for CCS. It demonstrates high reproducibility and provides a practical framework for surgical decision-making based on deformity-driving anatomy.

270. Difference of Characteristics and Outcomes Between the Advanced Cervical Deformity: Global Cervical Kyphosis vs. Preserved Cervical Lordosis Morphotypes based on the Subaxial Cervical Alignment

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Hypothesis:

Advanced cervical deformity (CD) has different clinical characteristics and surgical outcomes depending on the subaxial cervical spine alignment.

Design:

Retrospective analysis of a multicenter prospective CD database.

Introduction:

Subaxial cervical spine is not always kyphotic in advanced CD. Global Cervical Kyphosis (GK) and Preserved Lordosis (PL) type are distinct morphotypes but comparative data remain limited.

Methods:

Adults undergoing CD surgery were grouped as PL(T1 slope(T1S) > C2 Slope(C2S), T1S> 35°) vs GK(T1S < C2S). Focal or compensated deformity with C2-7 SVA <4cm were excluded. Demographics, surgical characteristics, radiographic parameters, patient reported outcomes (PROs), and complications were compared.

Results:

The cohort included 110 patients (PL n=55; GK n=55). At baseline, PL showed preserved cervical lordosis (CL:18 vs -22°), higher thoracic kyphosis (TK:54 vs 38°), higher T1S (56 vs 23°), more prior thoracolumbar (TL) fusion (51 vs. 25%) and greater sagittal malalignment (C2-7 SVA 54 vs 46 mm; C2 pelvic angle 26 vs 20°; all p<0.01), but lower T1S-CL (38 vs 44°, p=0.04) than GK. GK more often had upper cervical UIVs (65 vs 94%) and PL more often had mid or lower thoracic LIVs (81 vs 23%, both p<0.01). PL also had more three-column osteotomies (55 vs 25%, p<0.01) and higher EBL (1000 vs 400mL, p=0.01). There was no significant differences in baseline, 6-month, or 1-year PROs. Overall surgical complications and revision rates were similar, while distal junctional kyphosis (DJK) was higher in GK (38vs 15%, p<0.01) after excluding cases fused to the pelvis. On multivariable analysis, deformity type was not associated with surgical complications (OR 1.3, p=0.71) or revisions (OR 1.5, p=0.63).

Conclusion:

Advanced CD can be categorized with subaxial cervical alignment. GK and PL are distinct subtypes with different baseline alignment and operative strategies. The PL demonstrated greater baseline TL malalignment and surgical magnitude, and the GK showed greater cervical malalignment. Revisions and complications were similar, while DJK was more common in GK. These findings need to be considered in preoperative planning and patient counselling.

Table 1: Comparison of baseline radiographic data, surgical characteristics and complications between patients with Preserved Lordosis deformity versus Global Cervical Kyphosis deformity

Baseline	Preserved Lordosis (n=55)	Global Cervical Kyphosis (n=55)	P value
C2-C7 Coronal Cobb	3.51 ± 8.8	2.06 ± 10.5	0.459
PI-LL Mismatch	4.07 ± 17.1	3.12 ± 13.7	0.755
T4-T12 Kyphosis	-53.62 ± 18.1	-37.70 ± 13.8	<0.001
C7-S1 SVA	37.16 ± 72.7	-19.57 ± 58.6	<0.001
T4 Pelvic Angle	14.13 ± 11.7	11.28 ± 9.1	0.166
T1 Pelvic Angle	19.15 ± 11.8	14.33 ± 9.3	0.024
C2 Pelvic Angle	26.49 ± 11.7	20.26 ± 9.0	0.005
C2-C7 Sagittal Cobb Angle	18.26 ± 16.3	-21.54 ± 18.7	<0.001
T1S-CL mismatch	37.96 ± 13.8	44.06 ± 17.0	0.041
C2-C7 SVA	54.07 ± 13.2	46.48 ± 14.3	0.005
T1 Slope	56.22 ± 13.6	22.52 ± 9.0	<0.001
C2 Slope	37.66 ± 13.9	44.28 ± 16.3	0.024
McGregor Slope	5.00 ± 13.9	2.66 ± 10.4	0.395
Surgical Variables	Preserved Lordosis (n=55)	Global Cervical Kyphosis (n=55)	P value
Estimated Blood Loss, cc	1000 (375–1400)	400 (200–1200)	0.014
Operative time, minutes	352 (245–520)	368 (247–473)	0.507
Levels fused	11 (8–15)	7 (7–9)	<0.001
Length of stay, days	6 (4–9)	6 (4–8)	0.569
Approach			<0.001
Posterior only	44 (80.00)	21 (38.18)	
Anterior - posterior	8 (14.55)	27 (49.09)	
Three column osteotomy	30 (54.55%)	14 (25.45%)	0.003
Complications	Preserved Lordosis (n=55)	Global Cervical Kyphosis (n=55)	P value
Surgical Complications	18 (32.73)	23 (41.82)	0.324
Medical Complications	13 (23.64)	7 (12.73)	0.138
Neurologic Complications	11 (20.00)	9 (16.36)	0.621
Revision Surgery	7 (12.73)	8 (14.55)	0.781
Deep Surgical Site Infection	2 (3.64)	1 (1.82)	>0.99
Superficial Surgical Site Infection	2 (3.64)	1 (1.82)	>0.99
C5 Motor Deficit	0 (0.00)	3 (5.45)	0.243
Sensory Deficit	3 (5.45)	2 (3.64)	>0.99
Radiculopathy	2 (3.64)	3 (5.45)	>0.99
Spinal Cord Injury	1 (1.82)	0 (0.00)	>0.99
Motor Deficit	7 (12.73)	4 (7.27)	0.527
Dural Tear	0 (0.00)	3 (5.45)	0.243
Adjacent Segment Disease	1 (1.82)	0 (0.00)	>0.99
Distal Junctional Kyphosis	8 (14.55)	21 (38.18)	0.005

Values represent mean ± SD, median (IQR) or n (%). PI-LL: Pelvic Incidence -Lumbar Lordosis; SVA: Sagittal Vertical Axis; T1S-CL: T1 Slope-Cervical Lordosis.

271. Cervical Motion Imbalance Is Associated with Postoperative Cervical Kyphosis Progression After Posterior Decompression: A Prospective Cohort Study

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Hypothesis:

Preoperative flexion-extension imbalance and anterior sagittal translation (C2-C7 and C7-S1 SVA) increase the risk of postoperative cervical kyphosis progression.

Design:

Prospective cohort study

Introduction:

Posterior decompression is effective for degenerative cervical disease, yet postoperative cervical kyphosis progression remains a clinically relevant complication. The contribution of whole-spine sagittal alignment, beyond cervical alignment and motion, remains unclear.

Methods:

A total of 131 patients who underwent posterior decompression with ≥ 2 -year follow-up were prospectively enrolled. Kyphotic deformity progression was defined as a $\geq 5^\circ$ decrease in the neutral C2–7 angle at 2 years postoperatively. Preoperative cervical parameters included the C2–7 angle, flexion and extension range of motion (ROM), C2–7 SVA, and T1 slope. Global sagittal parameters included T2-5 TK, T5-12 TK, T2-12 TK, SS, PT, PI, LL, PI-LL, C7 SVA. Patients were divided into progression (K) and non-progression (N) groups. Radiographic parameters were compared, and multivariate logistic regression was performed.

Results:

Kyphotic deformity progression was observed in 31 patients (24%); one patient required revision surgery for kyphosis correction. There were no differences in age, sex, diagnosis, surgical procedure, or number of decompressed levels between two groups. The K group showed greater preoperative flexion ROM ($27 \pm 9^\circ$ vs. $23 \pm 10^\circ$, $p=0.03$), smaller extension ROM ($11 \pm 6^\circ$ vs. $14 \pm 8^\circ$, $p=0.01$), and larger C2–7 SVA (33 ± 18 mm vs. 24 ± 14 mm, $p<0.01$). The K group also demonstrated a larger preoperative C7 SVA (44 ± 46 mm vs. 25 ± 46 mm, $p=0.049$), while other global sagittal parameters were not different between two groups. Multivariate analysis identified flexion and extension ROM as independent risk factors.

Conclusion:

In this prospective cohort, cervical kyphosis progression occurred in 24% at 2 years after posterior decompression. A flexion-dominant, extension-limited preoperative motion pattern independently predicted progression; adding dynamic cervical radiographs to standing full-length sagittal assessment may improve risk stratification and surgical planning.

272. Early Treatment of Cervical Myelopathy with Multilevel Fusion Achieves a Greater Clinically Meaningful Improvement Compared to Delayed Treatment

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Hypothesis:

Longer preoperative symptom duration is associated with delayed achievement of clinically meaningful improvement after ≥ 3 -level fusion for cervical spondylotic myelopathy (CSM).

Design:

Post hoc analysis of a prospective multicenter study involving 1,085 patients with >80% follow-up at 5 years.

Introduction:

Multilevel cervical fusion for CSM improves patient-reported outcomes; however, recovery timing varies. While many patients improve early, others experience delayed recovery. Identifying determinants of recovery kinetics may inform counseling and operative decision-making.

Methods:

We prospectively collected data on 1,085 patients undergoing surgical treatment for CSM through a multicenter study group. Patients undergoing ≥ 3 -level cervical fusion (anterior and/or posterior) with baseline and longitudinal Neck Disability Index (NDI) follow-up were included (N=267, 98.6% follow-up at 5 years). Meaningful improvement was defined using established NDI minimal clinically important difference (MCID) thresholds. Early improvement was defined as MCID attainment by 3 months postoperatively and late improvement as attainment between 3 months and 5 years. Multivariable logistic regression identified factors independently associated with late improvement.

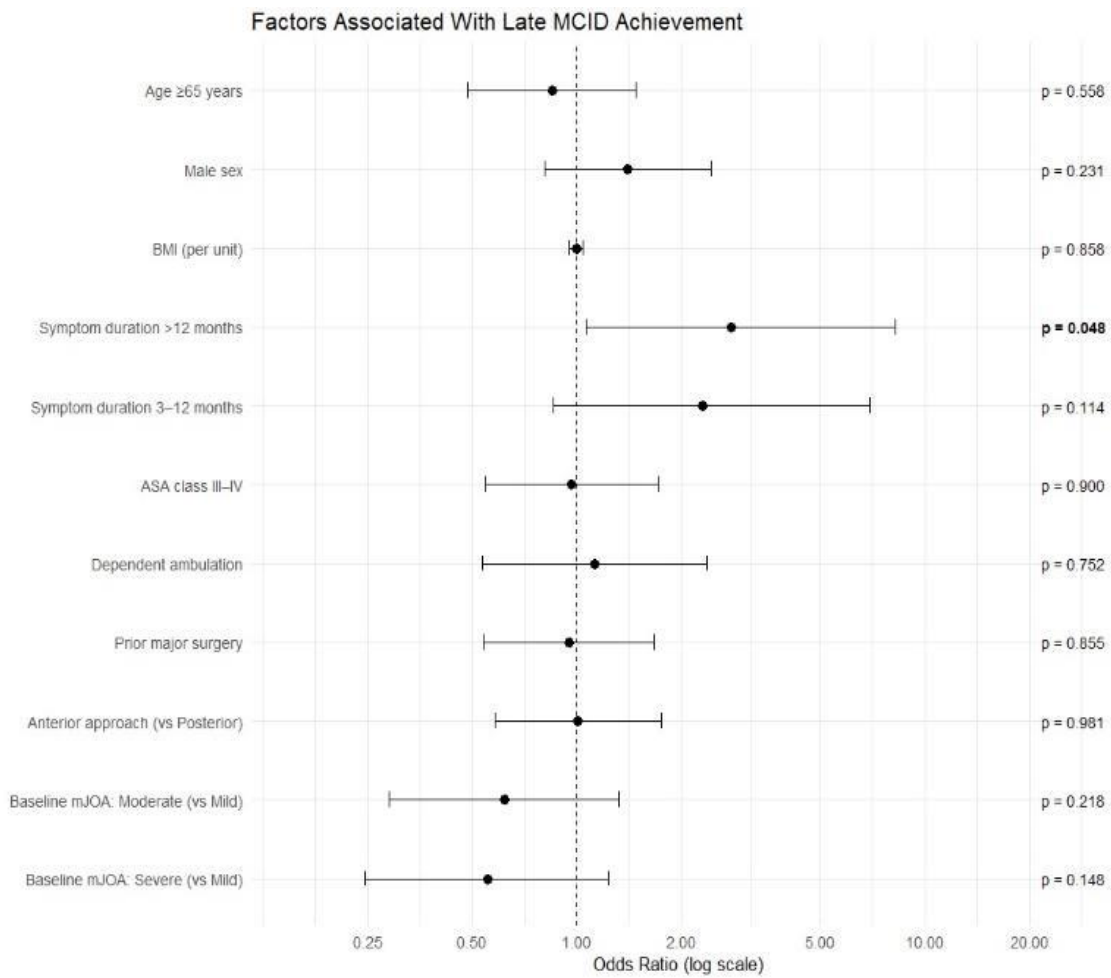
Results:

Among patients achieving MCID after ≥ 3 -level cervical fusion (N=267), early (≤ 3 months) and late (> 3 months through 5 years) recovery patterns were observed. Baseline demographic, clinical, and surgical characteristics were similar between groups. On multivariable analysis, myelopathy symptoms ≤ 12 months was associated with reaching MCID for NDI by 3 months postoperatively whereas symptom duration > 12 months was associated with delayed improvement (mean 25 ± 18 months; OR 2.77, 95% CI 1.06-8.22; $p=0.048$). Age, baseline mJOA, ambulatory status, comorbidity burden, and surgical approach were not associated with delayed recovery.

Conclusion:

Among patients achieving clinically meaningful improvement following multilevel cervical fusion for CSM, intervention within 12 months of myelopathy symptoms is associated with earlier recovery (MCID for NDI by 3 months postop). Patients with symptoms for > 12 months required, on average, 2 years to reach MCID. Surgery soon after myelopathy symptom onset improves recovery kinetics.

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant



Factors Associated with Late MCID Achievement

273. Benefits to Subaxial Cervical Pedicle Screws for Cervical Deformity Surgery: Assessment of Correction, Mechanical Failure and Revision Surgery

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Hypothesis:

Use of subaxial cervical pedicle screws in cervical deformity (CD) is associated with improved correction and lower revision rates

Design:

Retrospective review

Introduction:

Strength of posterior cervical fixation is often the limiting factor when trying to perform corrective maneuvers especially with lateral mass screws. Pedicles screws have proven to be stronger but there are inherent risks. This study aims to assess the utility of subaxial pedicle screws for primary CD and multiregional CD.

Methods:

A multicenter prospective database of adult CD patients was queried. Patients were split into two groups: primary CD (T1 slope<30° and C2 slope>20°) and multiregional CD (C2 slope>20° and T1 slope≥30°). The utility of subaxial pedicle screw utilization on correction, mechanical failure (pseudarthrosis, junctional or instrumentation), and revision surgery was examined using univariate analysis.

Results:

A total of 201 patients were identified: 75 (37.3%) primary CD and 126 (62.7%) multiregional CD, 50 (24.9%) with pedicle screws and 151 (75.1%) with lateral mass screws. Primary CD preoperative alignment: cSVA (4.1 cm), CL (24.8°), C2-slope (40°), and T1-slope (18.7°) and multiregional CD preoperative alignment: cSVA (6.0 cm), CL (4.8°), C2-slope (53.6°), and T1-slope (49.3°). With similar preoperative deformity, use of pedicle screws (vs. lateral mass screws) for both CD subtypes was significantly associated with shorter operative time (primary CD: 260 vs 459 min, p<0.001 and multiregional CD: 280 vs 471 min, p<0.001), less anterior surgery (primary CD: 18.8% vs. 72.9%, p<0.001 and multiregional CD: 0.0% vs. 33.7%, p<0.001), and fewer anterior interbodies (primary CD: 0.5 vs 2.5, p=0.003 and multiregional CD: 0 vs 1.6, p<0.001). Similar correction was achieved when comparing anterior-posterior surgery vs. posterior-only with pedicle screws. Overall rate of mechanical failure and revision at 1-year were as follows: primary CD (10.7% and 6.7%) and multiregional CD (5.6% and 6.3%). Pedicle screws were not associated with mechanical complications or revision surgery for both groups.

Conclusion:

Regardless of CD subtype, subaxial cervical pedicle screws may offer the ability to achieve adequate correction with decreased need for additional anterior approaches and without compromise of long-term outcomes.

274. PROMIS Anxiety Scale is Reflective of Suicide Risk in Adolescents with Spine Concerns

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Hypothesis:

Elevated Patient-Reported Outcomes Measurement Information System (PROMIS) Anxiety is associated with a positive Ask-Suicide Screening Questions (ASQ) score.

Design:

cross-sectional survey

Introduction:

The relationship of suicide risk with anxiety in adolescents with spine concerns is unknown. The 4-item ASQ assesses suicide risk in youth. We evaluated 1) the responsiveness of PROMIS Anxiety with the ASQ and 2) predictors of suicide risk in adolescents with spine concerns.

Methods:

8,089 adolescents (5,068 girls, 3,021 boys) ages 10-18 referred to a pediatric orthopedic institution for spine concerns who completed both the ASQ and PROMIS Pediatric Anxiety were retrospectively reviewed from 4/2021-6/2023. Positive ASQ scores (+ASQ: ≥ 1 yes response for suicide risk) were compared to negative ASQ scores (-ASQ). Elevated PROMIS anxiety was defined as scores ≥ 51 indicating $\geq$ mild severity, a clinically meaningful distinction. Logistic regression followed by ROC analysis determined the PROMIS Anxiety threshold.

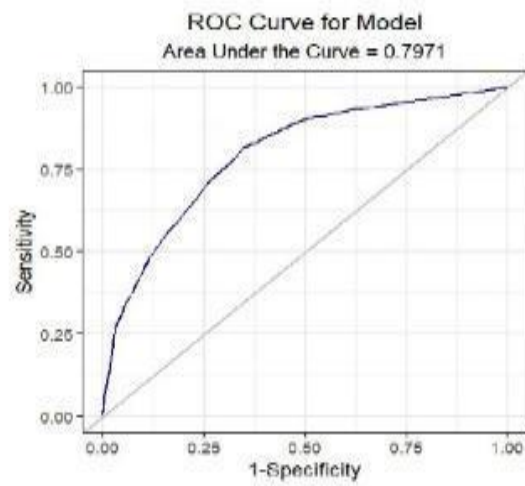
Results:

4.2% of adolescents with spine concerns had +ASQs (338/8,089). PROMIS Anxiety averaged mild severity (54) for +ASQs versus within normal limits (41) for -ASQs. Children with elevated ($\geq$ mild severity) PROMIS Anxiety scores had a 6-fold risk of a +ASQ than those with PROMIS Anxiety scores within normal limits (OR 6.35, 95% CI 5.07-7.99). Scoliosis was not associated with a +ASQ (4.4% with scoliosis [196/4,489]; 3.9% [98/2,528] with no structural diagnosis). However, larger coronal curves were associated with a +ASQ (OR 1.010, 95% CI 1.003-1.017). Multivariate analysis revealed older age (OR 1.09, 95% CI 1.03-1.15), female sex (OR 1.61, 95% CI 1.22-2.14), English vs Spanish speakers (OR 2.30, 95% CI 1.48-3.74), public vs private insurance type (OR 1.42, 95% CI 1.10-1.84), and increased PROMIS Anxiety scores (OR 1.11, 95% CI 1.10-1.12) were associated with a +ASQ. A PROMIS anxiety threshold of 44.5 (AUC=0.80) was associated with a +ASQ.

Conclusion:

Increased anxiety is clearly associated with suicide risk in youth with spine concerns, resulting in an acceptable AUC. PROMIS anxiety may be a readily available and useful clinical predictor of suicide risk in clinical settings that don't routinely screen for suicide risk, especially for girls who are disproportionately affected by scoliosis and stressful life events. Early intervention can potentially improve PROMIS anxiety scores, reflecting lower suicide risk.

ROC curve of Positive ASQ versus PROMIS Anxiety



± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

275. Home-Based Halo Gravity Traction for Severe Pediatric Spinal Deformities Using a Novel Protocol

Lucas Piantoni, MD, PhD; Carlos A. Tello, MD, PhD; Eduardo Galaretto, MD; Rodrigo G. Remondino, MD

Hypothesis:

A home-based HGT management protocol would facilitate this preoperative stage without increasing complication rates, while achieving satisfactory correction and reducing costs.

Design:

Prospective cohort study

Introduction:

Conventional halo-gravity traction (HGT) for severe pediatric spinal deformities is usually performed in the hospital setting. After developing a structured protocol for preoperative home-based traction, we evaluated the safety and efficacy of this home HGT approach in children with severe spinal deformity.

Methods:

A treatment protocol for preoperative home-based HGT was developed for children with severe spinal deformity submitted to posterior spinal fusion. The protocol comprises two phases. Phase 1 (hospital, 3–5 days) includes halo placement and structured family training on pin-site care, weight progression, and neurological monitoring. Phase 2 (home) involves a gradual traction increase of weight, weekly clinical, neurological, nutritional, respiratory, and radiological assessments. We assessed: duration of traction, Cobb angle, complications, and adherence to the protocol. All variables were recorded by two specialist spine surgeons. The protocol was implemented and evaluated in a prospective cohort of patients with kyphoscoliosis > 90° (2020-2024). Inclusion criteria were age 5 to 18 years, adequate cultural and economic family support, and the ability to attend scheduled follow-up visits at the hospital.

Results:

Forty-three patients were initially evaluated; 40 completed the home-based HGT protocol. The mean age at the start of HGT was 12 years $\pm$ 2 months (5-18), and 67.5% were female. The mean pre-HGT scoliosis angle was 106°, with a mean angular correction of 25°. The mean duration of HGT was 14.7 weeks. Complications occurred in seven patients (17.5%), including six cases requiring halo or pin repositioning procedures (15%) and one superficial infection (2.5%). All patients were able to maintain their usual educational and social activities, and families continued their work routines.

Conclusion:

The home-based HGT protocol proved effectiveness, achieving results comparable to those in literature. It appears to be safe, and may provide psychosocial advantages together with a potential reduction in both hospital and family-associated costs. We recommend its use in carefully selected patients with adequate family support and sufficient educational and cultural resources.

276. Single-Stage En Bloc Spondylectomy via Rotated Prone Lateral Surgery: Bridging Anterior-Posterior Access Without Repositioning

Yu-Cheng Yeh, MD; Yung-Hsueh Hu, MD; Tsung-Ting Tsai, MD, PhD; Po-Liang Lai, MD

Hypothesis:

Rotated prone lateral surgery (RPLS) allows for a seamless transition from staged surgeries to a single-stage en bloc spondylectomy by bridging the anterior and posterior corridors without patient repositioning.

Design:

Retrospective case series and technical note.

Introduction:

En bloc spondylectomy for complex thoracolumbar tumors (WBB type 3/5) traditionally requires staged procedures or cumbersome intraoperative repositioning to manage the diaphragm, great vessels, and nerve roots. This study demonstrates how the rotated prone lateral technique bridges the gap between anterior release and posterior reconstruction, facilitating a transition toward a more efficient, single-stage surgical paradigm.

Methods:

We retrospectively reviewed 10 consecutive patients who underwent en bloc spondylectomy for metastatic thoracolumbar tumors (L1-L4) using the RPLS approach. Patients were positioned prone on a radiolucent Jackson table rotated 45 degrees, utilizing gravity to retract peritoneal contents. This orientation provides simultaneous access to the retroperitoneal corridor for vessel mobilization and the posterior column for instrumentation. Surgical metrics, margins, and complications were analyzed.

Results:

The cohort included 10 patients (mean age: 59.7 ± 9.3 years) with oligoprogression metastatic thoracolumbar tumors. The procedures involved levels from L1 to L4, requiring WBB type 3 or 5 resections. All patients successfully underwent single-stage en bloc resection without intraoperative repositioning. The mean operative time was 7 hours 19 minutes $\pm$ 2 hours 55 minutes, and the mean estimated blood loss was 1117 ± 899 ml. The rotated prone position allowed for simultaneous approach and manipulation for en bloc resection of the spinal tumor. No major approach-related complications (e.g., bowel injury, major vascular injury) occurred, though one patient experienced root injury.

Conclusion:

Rotated prone lateral surgery represents a significant transition in complex tumor surgery. By bridging the anterior and posterior surgical corridors in a single stage, this technique eliminates the risks associated with repositioning and staged procedures. It offers a safe and ergonomic alternative for WBB type 3 and 5 tumors, reflecting the evolution toward integrated, simultaneous access in oncological spine surgery.

$\pm$ Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

277. Robotic-Assisted Direct Pars Repair: An Innovative Minimally Invasive Technique

Vivien Chan, MD, MS; Samantha Snyder, BS; Paal Nilssen, BS; Prudhvi Kodali, BA; James Caruso, MD; Christopher Mikhail, MD; Kenneth D. Illingworth, MD; Corey T. Walker, MD; David L. Skaggs, MD, MMM

Hypothesis:

Robotic-assisted direct pars repair is safe and effective technique for treating spondylolysis

Design:

Case Series

Introduction:

Spondylolysis is the most common cause of low back pain in young athletes. Direct repair with robotic-assisted surgery could be less invasive and more precise than traditional techniques.

Methods:

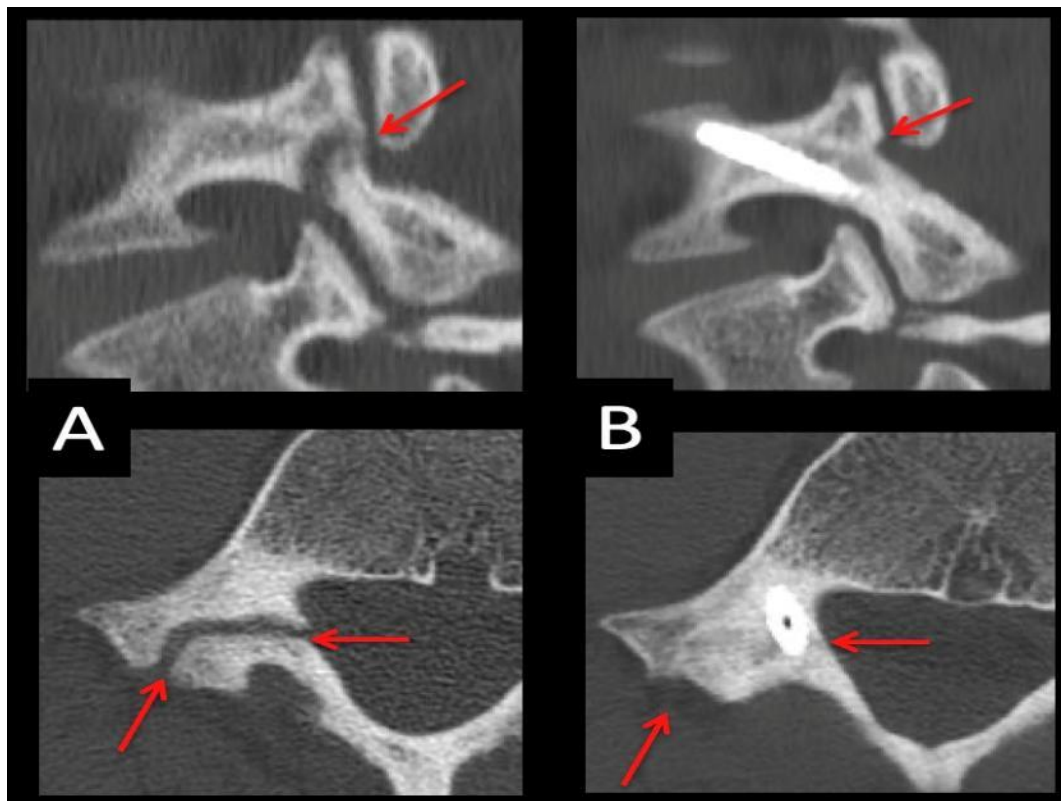
We performed a single-center retrospective review of all patients with spondylolysis who underwent robotic-assisted direct pars repair from 2023-2025. The technique evolved to placing a reference array on the spinous process of the affected vertebra through a <2 cm midline incision, and screws were placed through a separate <2cm midline incision. Hydroxyapatite screws, usually 4.5mm x 40mm, were planned with navigation software. Screw position was confirmed with intra-operative fluoroscopy and EMG, and postoperative CT.

Results:

There were 32 patients (mean age 16 years, range 10-23) with 63 pars fractures. Mean spondylolysis gap size was 1.5 mm (range 0.0-7.7). Mean bilateral repair operative time was 138 minutes, and 28 patients (84%) were discharged same-day. Ten patients had bone grafting at initial surgery, and three patients (T2 STIR negative) underwent reoperation with bone grafting. Four cases (13%) had minor perioperative complications which resolved without intervention (guidewire breakage, anterior thigh pain/tightness, bilateral numbness/tingling/pain, seroma). There were no major complications or neurological injuries. At first post-operative follow-up (mean 22 days), 27 (84%) patients had resolution of pre-operative pain, 4 (12%) had improved pain, and 1(3%) had persistent pain. CT demonstrated complete union in 35 (60%), partial union in 23 (40%), no case of non-union, and correct screw location as planned 100%. Excluding one patient with an endplate fracture, 29 of 30 patients who were at least 10 weeks post-op were pain free and allowed to return to sports.

Conclusion:

This represents the largest reported case series of robotic-assisted direct pars repair for spondylolysis. The technique appears safe and effective, with high rates of pain resolution, accurate screw placement, and early return to athletics.



CT Scans: A. Pre-op, pars fracture (red arrows) B. 12 weeks post-op healed fracture. Professional dancer returned to dance, shared with patient consent.

278. Evaluation of the Subaxial Cervical Spine Injury Classification Score in a Pediatric Population

Satchi Metaxas, BA; Mohammed Abbas, MD; Ian Fletcher, MD; Jacquelyn N. Valenzuela-Moss, MPH; Tyler Tetreault, MD; Michael J. Heffernan, MD; Lindsay M. Andras, MD

Hypothesis:

SLIC treatment recommendations for pediatric spinal injuries will closely predict treatment decisions in a spinal practice.

Design:

Single center, retrospective

Introduction:

The Subaxial Cervical Spine Injuries Classification (SLIC) score is commonly used to provide guidance on surgical versus conservative treatment in adults but remains largely unvalidated in the pediatric population.

Methods:

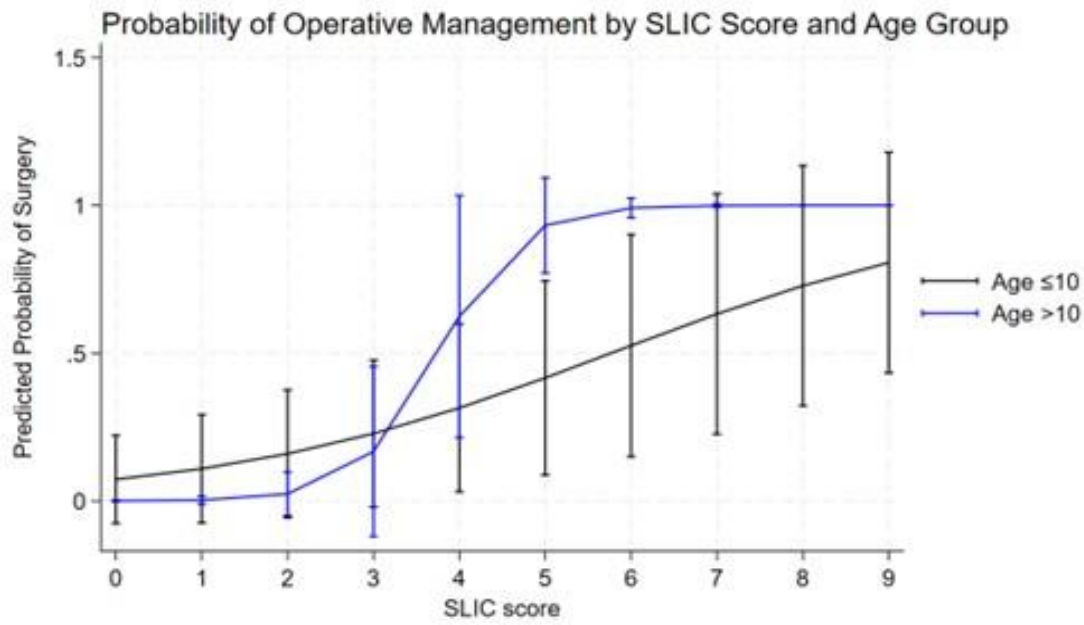
Retrospective study of patients under the age of 18 at a pediatric level one trauma center evaluated for traumatic subaxial cervical spinal injury between January 1, 2012, and June 1, 2025. Injuries were graded using the SLIC score. Agreement between SLIC score recommendations and management patients received was assessed. Overall agreement was calculated using misclassification rate, defined as the proportion of discordant cases. Median SLIC scores were compared between treatment groups using Wilcoxon rank-sum tests.

Results:

70 patients with mean age of 13.5 met the inclusion criteria. 20/70 (28.6%) were treated operatively, and 50/70 (71.4%) were treated nonoperatively. The overall median SLIC score was 1.5 (IQR 5), with the operative cohort showing a median of 6 (IQR 2) and the nonoperative cohort showing a median of 1 (IQR 2) ($p < 0.001$). There was a misclassification rate of 5.7%. Overall agreement was high at 94.3%. SLIC sensitivity was 94.4% (95% CI, 72.7-99.9%) and specificity was 94.2% (95% CI [84.1-98.8%]), with strong rule-in and rule-out performance ($LR+ = 16.4$; $LR- = 0.06$; $OR = 277.7$). The PPV was 85.0% (95% CI, 62.1-96.8%) and the NPV was 92.5% (95% CI, 81.8-97.9%). For the patients aged >10 years (54/70), operative management closely aligned with SLIC recommendations, with sensitivity of 100% (95% CI, 75.3-100%) specificity of 95% (95% CI, 83.5-99.4%), and 96.3% accuracy. Discordance more often reflected SLIC recommending operative management when nonoperative treatment was ultimately chosen (3/5 cases). For the patients ≤ 10 years (16/70), SLIC sensitivity was 80% (95% CI, 28.4-99.5%), with a specificity of 91% (95% CI, 58.7-99.8%), and 87.5% accuracy. Discordance was uncommon in this group (2 cases) and split between one over-recommendation of surgery and one under-recommendation.

Conclusion:

The SLIC scoring system demonstrated strong concordance with treatment decisions made at a major pediatric spine center and supports the use of SLIC as an adjunct in guiding management of pediatric patients.



± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

279. Robotic-Assisted Revision Spinal Deformity Surgery in Adult and Paediatric Patients: Accuracy, Safety, and Early Outcomes

Vidyadhara Srinivasa, MD, MS; Balamurugan Thirugnanam, MS; Abhishek Soni, MD, MS; Dinesh Iyer, MS

Hypothesis:

The established accuracy of robotic guidance in primary spine surgery extends to the more complex scenario of revision spinal deformity surgery in both adult and paediatric populations.

Design:

Prospective observational study

Introduction:

Revision spinal deformity surgery is complicated by distorted anatomy, prior instrumentation, and abnormal pedicle morphology. Robotic guidance has proven accurate in primary cases, but its utility in revision deformity involving both adults and children is not well established.

Methods:

Twenty-six consecutive patients (18 adults, 8 paediatric) undergoing revision spinal deformity surgery with robotic-assisted instrumentation were prospectively enrolled. Pedicle screw accuracy was evaluated using the Gertzbein–Robbins classification. Secondary outcomes included screw-related reoperation, 90-day complications, and three-month functional outcomes (ODI/VAS for adults; SRS-22/VAS for paediatric patients).

Results:

A total of 342 pedicle screws were placed. Clinically acceptable accuracy (Grade A+B) was achieved in 97.7% of screws. Two screws (0.58%) required revision; no permanent neurological injury occurred. The 90-day complication rate was 15.4%. At three months, adults demonstrated significant improvement in ODI (54.3% to 30.2%) and VAS (7.1 to 3.3), while paediatric patients improved in SRS-22 (2.8 to 4.0) and VAS (6.3 to 2.9) (all $p < 0.001$).

Conclusion:

Robotic guidance provides excellent screw accuracy with minimal revision rates in revision spinal deformity surgery, supporting its role as a valuable adjunct in complex deformity reconstruction across all age groups.

Parameter	Result
Total patients	26
Adults / Paediatric	18 / 8
Mean age (years)	42.3 ± 19.6
Female / Male	15 / 11
Total screws placed	342
Screws per patient	13.1 ± 3.2
Clinically acceptable accuracy (Grade A+B)	97.7%
Screw-related revision rate	0.58%
Permanent neurological injury	0
Mean operative time (minutes)	331 ± 62
Blood loss – adults (mL)	880 ± 310
Blood loss – paediatric (mL)	580 ± 190
Fluoroscopy time (seconds)	18.4 ± 5.9
90-day complication rate	15.4%
Adult ODI (pre → post)	54.3% → 30.2% (p<0.001)
Adult VAS (pre → post)	7.1 → 3.3 (p<0.001)
Paediatric SRS-22 (pre → post)	2.8 → 4.0 (p<0.001)
Paediatric VAS (pre → post)	6.3 → 2.9 (p<0.001)

Table: Summary of Key Findings

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

280. Lost in Translation: Interpreter Need Identifies Socioeconomic Risk in Pediatric Spinal Deformity

Judy-Mae Lima, BS; David C. Thornberg, BS; John Patrick Rathbun, BS; Aisha Analil, BSA; Hannah Shreiner, BA; Brandon A. Ramo, MD; Amy L. McIntosh, MD; Megan Johnson, MD; Jaysson T. Brooks, MD

Hypothesis:

Hispanic/Latino pediatric spinal deformity patients requiring interpreters will have worse socioeconomic indicators and PROMIS scores.

Design:

Retrospective Study

Introduction:

Hispanic/Latino (H/L) children are a rapidly growing US population while encountering barriers to care. Although disparities across ethnic groups are documented, less is known about how primary language shapes disparities within the same ethnic community. This study evaluates how language and interpreter request affects socioeconomic status using both self-reported and proxy-reported measures among patients within the same ethnic background.

Methods:

An IRB-approved review identified spine deformity patients seen over 1 year at a pediatric orthopedic hospital. Included patients identified as H/L and Caucasian, spoke Spanish or English, had a geocodable address, and completed a Social Determinants of Health (SDOH) survey. Addresses were used to assign Area Deprivation Index (ADI) and Child Opportunity Index (COI) scores. COI domains (Overall, Education, Health/Environment (H/E), and Social/Economic (S/E)) were categorized as Low or High Risk. Lower ADI and higher COI scores represent less disadvantage. SDOH subdomains included Food Insecurity (FI), Housing Stability (HS), Caregiver Education/Work (CEW), Transportation Needs (TN), and Financial Resource Strain (FRS). PROMIS scores were collected when available.

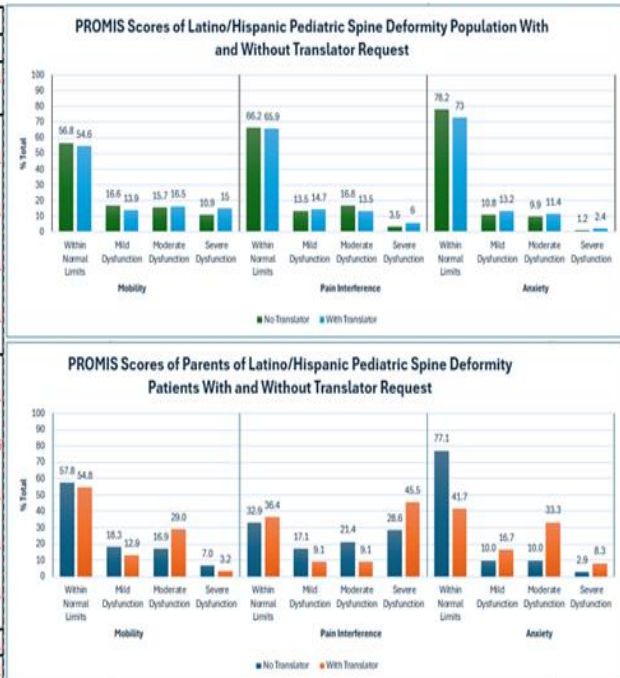
Results:

Of 1667 patients, 561 (37%) required an interpreter. Interpreter need was associated with lower COI scores and higher High-Risk proportions in Education (40% v 24%), H/E (82% v 62%), and S/E subdomains (50% v 29%) (all $p < 0.0001$). Interpreter-using families had higher SDOH risk across CEW (72% v 17%), FRS (24% v 6.6%), HS (24% v 16.7%), TN (10.8% v 6.1%), and FI (51% v 24%) (all $p < 0.01$). ADI was worse among interpreter users (65 ± 19 v 57 ± 22 , $p < 0.0001$). However, PROMIS mobility, pain interference, and anxiety scores did not clinically differ.

Conclusion:

Despite similar ethnic backgrounds, families requiring interpreter services had worse self-reported and proxy SES markers as measured by SDOH, ADI, and COI. Despite these disparities, PROMIS domain scores were similar, suggesting comparable patient-reported health status at presentation. Acknowledging interpreter requirements may help clinics identify at-risk families and connect them to supportive resources to improve equity.

Table 1: Interpreter Use in the Latino/Hispanic Pediatric Spine Deformity Population (n=1667)					
		Interpreter Use	No Interpreter Use	p-value	
Preferred Language	English	0 (0%)	1106 (100%)	<0.0001	
	Spanish	561 (100%)	0 (0%)		
COI National					
Overall National	Low Risk	222 (40.7%)	711 (65.5%)	<0.0001	
	High Risk	323 (59.3%)	374 (34.5%)		
Education	Low Risk	328 (60.2%)	825 (76.0%)	<0.0001	
	High Risk	217 (39.8%)	260 (24.0%)		
Health & Education	Low Risk	98 (18.0%)	411 (37.9%)	<0.0001	
	High Risk	447 (82.0%)	674 (62.1%)		
Social & Economic	Low Risk	273 (50.1%)	775 (71.4%)	<0.0001	
	High Risk	272 (49.9%)	310 (28.6%)		
SDOH					
Caregiver Education/Work	Low Risk	148 (28.5%)	839 (82.7%)	<0.0001	
	High Risk	372 (71.5%)	175 (17.3%)		
Housing Stability	Low Risk	396 (76.0%)	849 (83.4%)	0.0006	
	High Risk	125 (24.0%)	169 (16.6%)		
Financial Resource Strain	Low Risk	376 (76.0%)	920 (93.4%)	<0.0001	
	High Risk	119 (24.0%)	65 (6.6%)		
Transportation Needs	Low Risk	456 (89.2%)	933 (93.9%)	0.0021	
	High Risk	55 (10.8%)	61 (6.1%)		
Food Insecurity	Low Risk	247 (49.3%)	736 (76.2%)	<0.0001	
	High Risk	254 (50.7%)	230 (23.8%)		
% of SDOH as High Risk		36.1% ± 24.2%	14.1 ± 20.2%	<0.0001	
National ADI		N= 3395	64.9 ± 19.3	57.0 ± 22.3	<0.0001



Interpreter Use in Latino/Hispanic Spine Deformity Pop.

281. TiLiPA - Towards a Universal Spinal Alignment Metric: Regional Landmarks Outperform Fixed Vertebral Points Across the Pelvic Incidence Spectrum *

Sléiman Haddad, MD, PhD, FRCS; Lluis Vila Castillo, MD; Anika Pupak, PhD, BS; Susana Nunez Pereira, MD, PhD; Michael P. Kelly, MD; Jeffrey M. Hills, MD; Javier Pizones, MD, PhD; Alejandro Gomez-Rice, MD, PhD; Frank Kleinstuck, MD; Ahmet Alanay, MD; Ibrahim Obeid, MD; Ferran Pellise, MD, PhD; Yann Phillippe Charles, MD, PhD; European Spine Study Group ESSG

Hypothesis:

While the fixed T4-L1 model remains a valid tool for spinal assessment, a regional approach based on individual anatomical inflection points will demonstrate superior stability and predictive accuracy across the pelvic incidence (PI) spectrum

Design:

Cross-sectional analytical study of 236 asymptomatic adults

Introduction:

The T4-L1 Hip axis model (Hills) is a validated and effective method for assessing global spinal alignment. However, its reliance on fixed vertebral landmarks (T4, L1) may reduce precision in patients with significant anatomical variations. This study evaluates whether determining regional landmarks based on individual curve inflection points offers a more stable and accurate alternative to fixed vertebral references.

Methods:

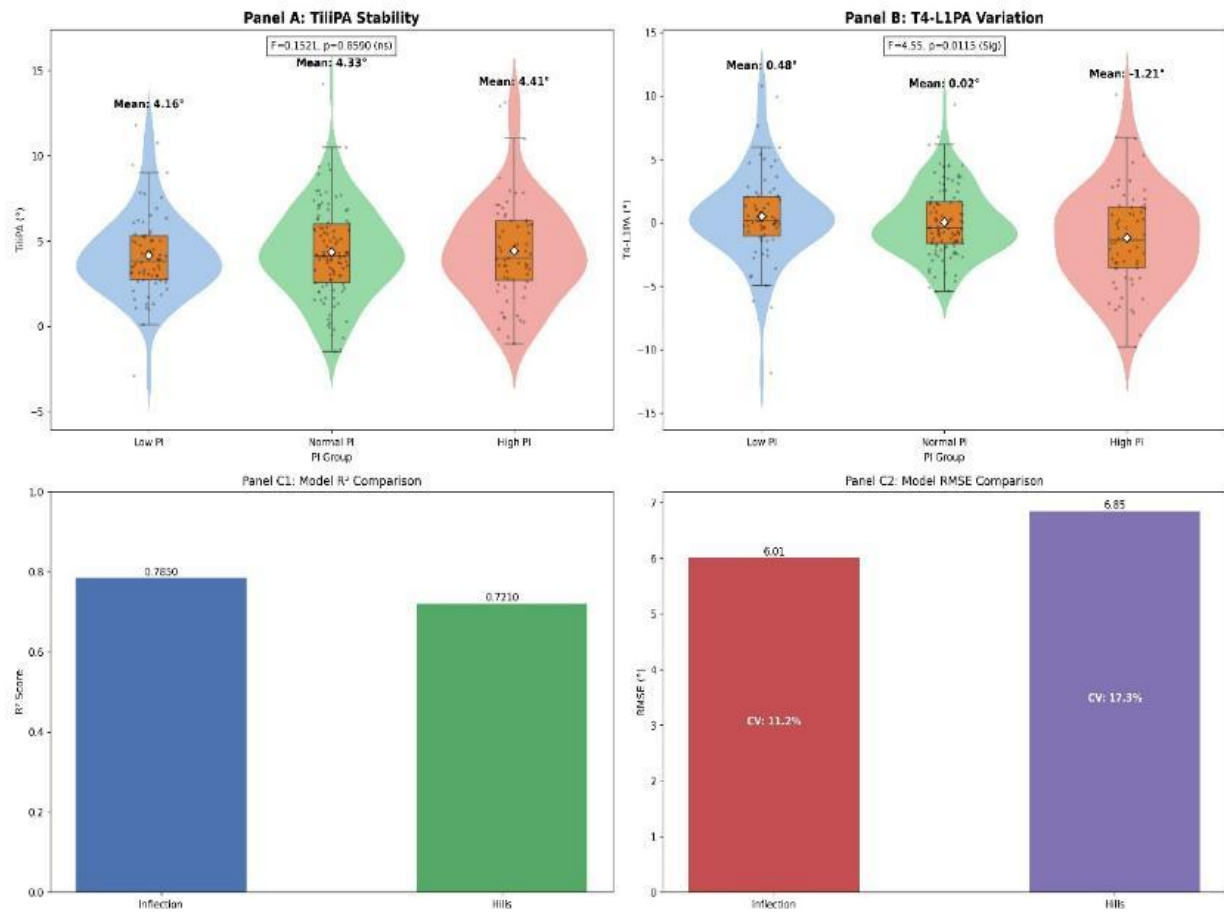
We analyzed 236 asymptomatic adults (35.7 ± 10.1 years) with complete EOS imaging. Patients were stratified by PI: Low ($<45^\circ$, $n=67$), Normal ($45-60^\circ$, $n=108$), and High ($>60^\circ$, $n=61$). The primary outcome was the stability of TiLiPA (Thoracic - Lumbar Inflection pelvic angle) across groups. Secondary outcomes included validation of the Hills model (T4L1PA), predictive modeling for lumbar lordosis (LL), and correlation analyses using ANOVA, Pearson correlations, linear regression, and Bland-Altman tests.

Results:

TiLiPA demonstrated remarkable stability across PI groups ($p=0.864$), with mean values ranging only from 4.17° (Low PI) to 4.42° (High PI), unlike fixed vertebral parameters which showed significant variation ($p<0.001$). Although the T4-L1PA model predicted LL well ($R^2=0.721$), it suffered from systematic bias (1.15°) and significant proportional error ($p<0.001$) in PI extremes. Conversely, the inflection-based approach offered superior lumbar predictive accuracy ($R^2=0.785$, $RMSE=6.01^\circ$) and greater stability across the PI spectrum ($CV=6.3\%$ vs. 11.7% for Hills).

Conclusion:

This study confirms the validity of the T4-L1 fixed landmark model for general assessment but provides evidence that a regional, inflection point-based approach offers superior precision. While the Hills model remains a useful standard, TiLiPA demonstrates universal applicability without the systematic bias found in fixed models. These findings support utilizing valid fixed models for general screening while adopting regional inflection points for personalized, high-precision surgical planning



± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

282. Development, Calibration, and Clinical Validation of a Deployable PROMIS-Based Adaptive Assessment Tool (PROMIS-CAT) for Real-Time Patient-Reported Outcomes in Spine Care ±

Devender Singh, PhD; Eeric Truumees, MD; Matthew Geck, MD; *Aiyana Adams, BS*; Swara Kale, BS; John Stokes, MD

Hypothesis:

A locally deployable Patient-Reported Outcomes Measurement Information System-computer (PROMIS)-based computer adaptive testing engine can accurately reproduce standard PROMIS T-scores across physical, pain, fatigue, and psychosocial domains using fewer questions, without requiring server connectivity, while maintaining clinical interchangeability with PROMIS Short Forms.

Design:

Instrument development & validation

Introduction:

To develop a Patient-Reported Outcomes Measurement Information System-computer adaptive test (PROMIS-CAT) capable of estimating PROMIS T-scores using fewer questions by applying adaptive item selection & machine-learning-based calibration.

Methods:

Three sequential datasets (development n = 2,000; calibration n = 900; validation n = 887) were used. The final system adaptively measured six PROMIS domains (Physical Function, Pain Interference, Fatigue, Anxiety, Depression, & Ability to Participate in Social Roles). After each response, the tool computes a provisional ability estimate (θ) using a graded response model & selects the next question predicted to produce maximal statistical information at θ . The adaptive loop continues until measurement precision meets the PROMIS-CAT threshold. To convert θ into standard PROMIS T-scores, linear calibration models were applied to Physical Function, Pain Interference, Fatigue, & Social Roles. For Anxiety & Depression, isotonic monotonic regression calibration was required to eliminate systematic underestimation in emotional health.

Results:

In the 887-patient validation cohort, our PROMIS-CAT engine demonstrated high accuracy relative to PROMIS Short Forms. Physical Function, Pain Interference, Fatigue, & Social Roles met all a priori interchangeability criteria, achieving mean absolute errors (MAEs) less than 3 T-score points & negligible bias. Anxiety & Depression, initially inaccurate (MAE ~ 12), improved dramatically after isotonic calibration (MAE ~ 4), with bias eliminated.

Conclusion:

Our PROMIS-CAT engine estimates PROMIS T-scores with dramatically fewer questions without relying on PROMIS servers, enabling real-time scoring within mobile apps, patient portals, & EMR environments. This instrument supports efficient, accurate, & clinically actionable outcome measurement in routine spine care.

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

283. Intraoperative Wound Bed Cultures in Pediatric Spinal Deformity Surgery: Incidence, Risk Factors, and Clinical Implications of *Cutibacterium acnes*

Gabriel Piza Vallespir, MD, PhD; Ignacio Sanpera Triqueros, MD, PhD

Hypothesis:

Positive intraoperative wound bed cultures (IWBCs) are common and are not independently associated with deep surgical site infection (SSI); frequent *Cutibacterium acnes* recovery may guide prophylactic strategies.

Design:

Single-center retrospective cohort study.

Introduction:

The incidence, microbiology, and clinical significance of IWBCs in pediatric spinal deformity surgery remain unclear, particularly when results suggest contamination.

Methods:

We reviewed pediatric spinal deformity procedures in which IWBCs were obtained. At our center, when a heterologous graft is used, a wound bed specimen (and a separate graft specimen) is routinely collected to monitor potential graft contamination. Organisms and growth were recorded; scant growth or growth only in enrichment broth was considered probable contamination. Demographic and surgical variables were collected. Superficial and deep SSIs were identified clinically. Associations were evaluated with univariate analyses.

Results:

115 patients were included (76% female; mean age 15.7 years). IWBCs were positive in 53/115 cases (46.1%), yielding 61 isolates, most commonly *C. acnes* and coagulase-negative staphylococci; 79% were classified as probable contaminants. IWBC positivity was not associated with demographics, diagnosis, or surgical variables. Eight infections occurred (7.0%), including six deep SSIs requiring debridement (5.2%). Deep SSI was more frequent in neuromuscular/syndromic deformity and in older patients, but was not associated with IWBC positivity, even after excluding probable contaminants. *C. acnes* was recovered in 2/6 deep SSI debridement cultures (both polymicrobial) and was present in the IWBC in 2 cases, although not in the same patients.

Conclusion:

Positive IWBCs are frequent, and most isolates show low-burden growth consistent with contamination rather than true infection. IWBC positivity was not independently associated with deep SSI. However, frequent *C. acnes* isolation and its recovery in some polymicrobial deep infections suggest considering this organism when refining perioperative prevention strategies (systemic prophylaxis selection, skin preparation and/or topical antibiotics).

284. Comparative Analysis of Patient Radiation Exposure Across Five CT-based Imaging Systems Used in Spinal Surgery

Matthew C. Gernon, BS; Nicholas Swarts, BA; Damon Mar, PhD, MS, BS; Brandon B. Carlson, MD

Hypothesis:

We hypothesize that different intraoperative CT-based imaging systems differ significantly in radiation exposure under controlled conditions.

Design:

Controlled, phantom-based dosimetry study.

Introduction:

Intraoperative computed tomography (CT) imaging is increasingly used in spinal surgery to enable navigation platforms and facilitate minimally invasive instrumentation techniques. The radiation profiles remain an important concern due to dose-dependent risks associated with ionizing radiation (IR), which has been linked to an increased risk of malignancy. Although prior studies have reported radiation exposure for individual intraoperative CT systems, direct comparisons among multiple imaging platforms in a controlled setting are limited.

Methods:

Radiation exposure was measured in a controlled operating room (OR) environment at a university hospital using an anthropomorphic phantom positioned prone on a radiolucent Jackson table. Calibrated Thermoluminescent Dosimeters (TLDs) were placed on the posterior surface of the phantom centered at the L3 vertebral level. Environmental radiation exposure was simultaneously measured using pressurized-ion-chamber dosimeters positioned at standardized surgeon and radiology technologist positions. Intraoperative CT systems with both high- and low-dose exposure protocols were evaluated in comparison with a standard CT. One-way analysis of variance (ANOVA) was used to compare the different mean radiation doses.

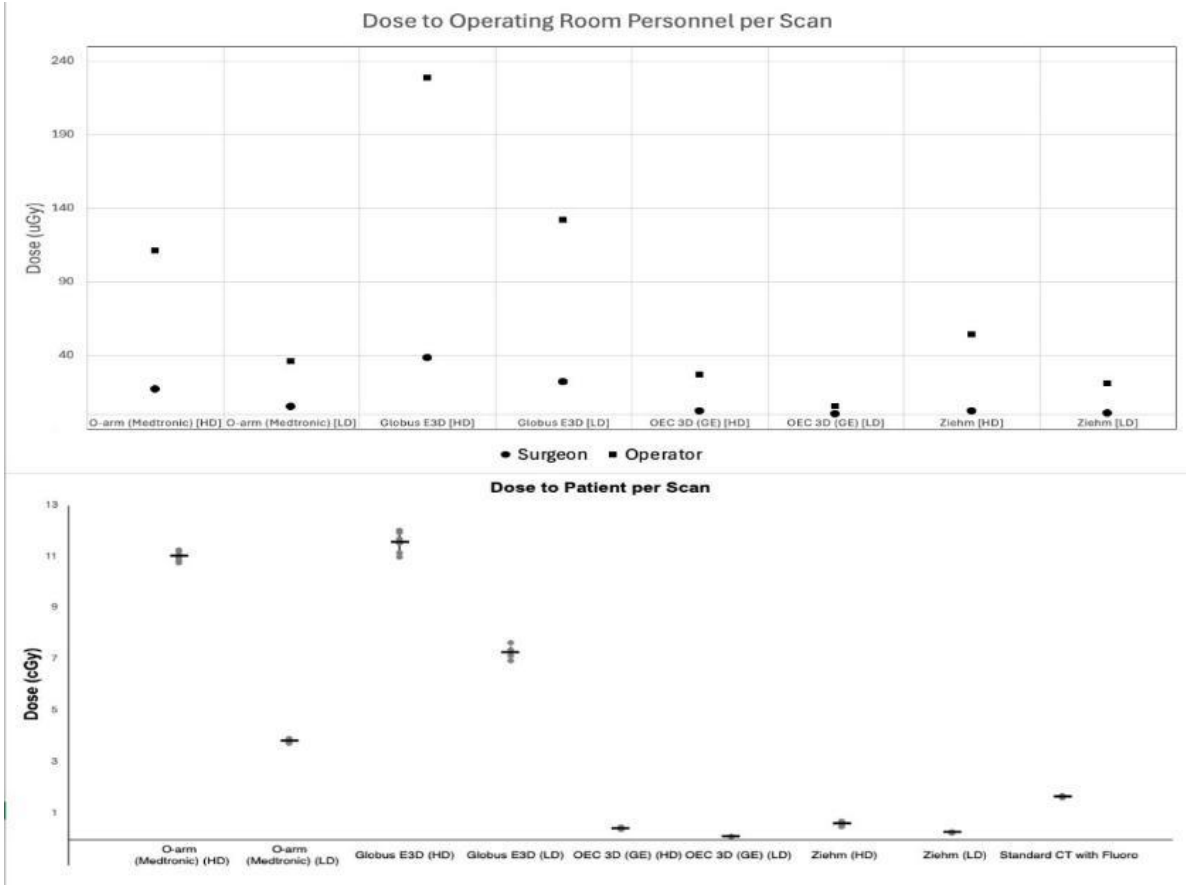
Results:

Significant differences were seen in patient and OR personnel radiation exposure across imaging systems under high and low-dose protocols ($p < .001$). Post-hoc pairwise comparisons identified multiple significant differences. Across all imaging systems, OR personnel radiation exposure scaled proportionally to patient radiation dose (Figure 1).

Conclusion:

In a controlled setting, radiation exposure to patient and OR personnel differed significantly across CT-based navigation systems in spine surgery. Given the cumulative dose-dependent risk factors surrounding IR, the inter-system differences observed in this study are clinically meaningful for understanding occupational risk exposure. These findings emphasize that system selection and dose-protocol optimization provide opportunities to reduce radiation exposure without compromising intraoperative navigation.

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant



Radiation dose to OR personnel and patient.

± Louis A. Goldstein Best Clinical Research E-Point Presentation; * John H. Moe Best Basic Research E-Point Presentation; ‡ SRS Funded Research Grant

285. Bridging The Gap Between Patient Priorities And Clinical Outcome Measures: A Qualitative Analysis Of The Reddit Scoliosis Community

Chuck H. Lam, BSc; Conor T. Boylan, MBChB, MSc, BSc, MRCS Ed; David S. Marks, MBBS, FRCS; Morgan Jones, FRCS, MBChB; David L. Skaggs, MD, MMM

Hypothesis:

Patients' priorities expressed in an online scoliosis community extend beyond domains captured by commonly used PROMs (e.g., SRS-22), particularly around navigating care, understanding diagnosis, and exercise safety.

Design:

Cross-sectional qualitative content analysis of an online health community.

Introduction:

Patient-reported outcome measures (PROMs) such as the SRS-22 are widely used to assess quality of life in scoliosis, and these instruments were developed through expert consensus rather than direct patient input. Online health communities offer an unfiltered window into what patients themselves prioritise. This study analysed patient-generated content from the Reddit scoliosis community (r/scoliosis) to characterise patient concerns and evaluate their alignment with existing outcome measures.

Methods:

We conducted a cross-sectional qualitative analysis of posts from r/scoliosis over 12 months (May 2024–May 2025). Question-type posts were extracted and coded using a 14-category codebook developed through iterative review of 300 posts. Categories included diagnosis and severity assessment, pain experiences, treatment decisions, mental health and emotional impact, body image, healthcare navigation, exercise and physical therapy, and daily function.

Results:

A total of 4,683 posts met the inclusion criteria. The most prevalent themes were diagnosis and severity assessment (53.6%), pain experiences (39.0%), healthcare navigation (37.6%), peer support (30.6%), and exercise safety guidance (29.7%). Exercise safety guidance and healthcare navigation were discussed more frequently than mental health (21.4%) and body image (21.3%). Posts frequently addressed multiple concerns, with a mean of 3.4 themes per post. Diagnosis and healthcare navigation commonly co-occurred (25.1%), suggesting patients simultaneously struggle to understand their condition and access appropriate care.

Conclusion:

Patient-generated content reveals patient priorities that are incompletely captured by current scoliosis outcome measures. While mental health and body image are incorporated into commonly used PROMs, concerns such as healthcare navigation, exercise safety guidance, and diagnostic understanding—which were frequently discussed in patient forums—are not. These findings support the development of more patient-centred outcome measures and targeted educational resources.

286. Does Surgeon Gender and Size Affect Muscle Exertion During Spine Surgery?

Joshua Abrams, BS; Zoe Cauthen, BS; Lyles Addy, BS; Robert F. Murphy, MD; Sara Van Nortwick, MD

Hypothesis:

Standard spinal instrumentation disproportionately increases muscle exertion and ergonomic strain among surgeons of smaller stature, particularly female surgeons, during spinal fusion tasks.

Design:

Prospective cross-sectional experimental study

Introduction:

Work-related musculoskeletal injuries are common among spine surgeons, yet ergonomic research in spine surgery remains limited compared to other surgical fields. As the surgical workforce becomes increasingly diverse in gender and body size, reliance on one-size-fits-all instrumentation may contribute to ergonomic inequities. This study evaluates muscle activation and perceived exertion during simulated posterior spinal fusion tasks to assess whether surgeon gender and size influence ergonomic burden.

Methods:

Participants included PGY3–7 residents and attending spine surgeons with prior spinal fusion experience. No exclusions were made based on gender, hand size, height, or weight. A simulated posterior spinal fusion was performed using a model spine, adjustable table, and standard instruments. Participants placed pedicle screws using manual and power screwdrivers, performed rod bending with a French bender, and completed tasks at both optimal and non-optimal table heights. Surface EMG sensors were placed on seven muscles of the dominant arm. Muscle activation was normalized to maximal voluntary contraction. Surveys assessed demographics, perceived exertion, pain, and instrument difficulty. EMG and survey data were analyzed using amplitude analysis and independent samples t-tests.

Results:

Female surgeons demonstrated significantly higher flexor carpi radialis activation during rod bending ($p = 0.005$) and power screwdriver use ($p = 0.024$), indicating increased forearm strain. No other muscles showed statistically significant gender differences, though EMG amplitudes generally trended higher among women. Survey results mirrored EMG findings: female participants reported greater perceived exertion, increased difficulty using the French bender, and lower comfort with standard instruments. Neck pain was the most commonly reported symptom (55%), followed by lower back (27%) and hand pain (18%).

Conclusion:

Standard spinal instrumentation may place disproportionate ergonomic demands on female and smaller-stature surgeons. These findings support the need for ergonomically adaptive tools to reduce injury risk and improve accessibility and longevity in spine surgery.