Session 7 | Adult Spinal Deformity III Abstracts

Papers are listed in presentation order

Paper #95. Residual Pelvic Compensation After Spinal Reconstruction: The Role of Psoas Sarcopenia

Chukwuebuka Achebe, BS; Han Jo Kim, MD; Takashi Hirase, MD, MPH; Myles Allen, MbChB; Robert Uzzo, MBA; Chad Z. Simon, BS; Tejas Subramanian, BS; Atahan Durbas, MD; Jung Mok, MD; Austin Kaidi, MD; Kasra Araghi, BS; Justin T. Samuel, BS; Cole Kwas, BS; Michael Mazzucco, BS; Samuel Adida, MS; Matthew E. Cunningham, MD, PhD; *Francis C. Lovecchio, MD*

Hypothesis

Psoas sarcopenia influences changes in pelvic tilt (PT) after adult spinal deformity (ASD) surgery

Design

Retrospective cohort study

Introduction

Normalization of compensatory mechanisms after ASD surgery may improve clinical and mechanical outcomes. Correction of pelvic retroversion may depend partially on the capacity of the psoas to antevert the pelvis. The relationship between preoperative psoas health and change in PT after ASD surgery has not been explored.

Methods

A retrospective cohort of patients who underwent ASD surgery at a single center was assessed (2013-2021, 5 or more levels of fusion to the pelvis). Sarcopenia was assessed quantitatively using normalized psoas (NTPA) and paralumbar (NTPL) cross-sectional area at L3 and L4, and qualitatively using Goutallier classification. Sex-specific quartiles were created for each muscle metric, those within the lowest quartile of each metric were classified as sarcopenic according to that metric. Multivariate linear regression models were created to control for race, age, sex, ASA Class, PI, and corrections in global (ΔT1PA) and regional alignment (ΔT4-T12, ΔL1-S1 and ΔL4-S1, 6 week value-baseline value). The primary outcome measure was the ΔPT from preop to 6 weeks postop (the closest postoperative timepoint to the baseline muscle health MRI).

Results

The study included 137 patients (47 males; 90 females; mean age 64.3 ± 9.64). The mean change in PT was -4.96° ± 8.16. Mean PI was 53.9° ± 11.7. Mean corrections were -5.28 ± 30.7 for L4-S1, -18 ± 16.5 for L1-S1 and -8.99 ± 9.97 for T1PA. Multivariate analysis revealed that NTPA L4 sarcopenia was associated with a 2.51° decrease in ΔPT (CI = -4.76 to -0.26, $p = 0.031$). Muscle health of the extensors (NTPL) was not associated with ΔPT. Increased ΔT1PA was also independently associated with increased ΔPT ($\beta = 5.96°$, CI = 4.71 to 7.21, $p < 0.001$). The overall model explained 72.7% of the variance in ΔPT (Adjusted R-squared = 0.695, $p < 0.001$).

Conclusion

While improvement in global alignment has the largest influence on ΔPT, psoas health also affects ΔPT, likely through its role in pelvic anteversion. Muscle imbalance in the lumbopelvic unit may play a role in ΔPT after ASD reconstruction.

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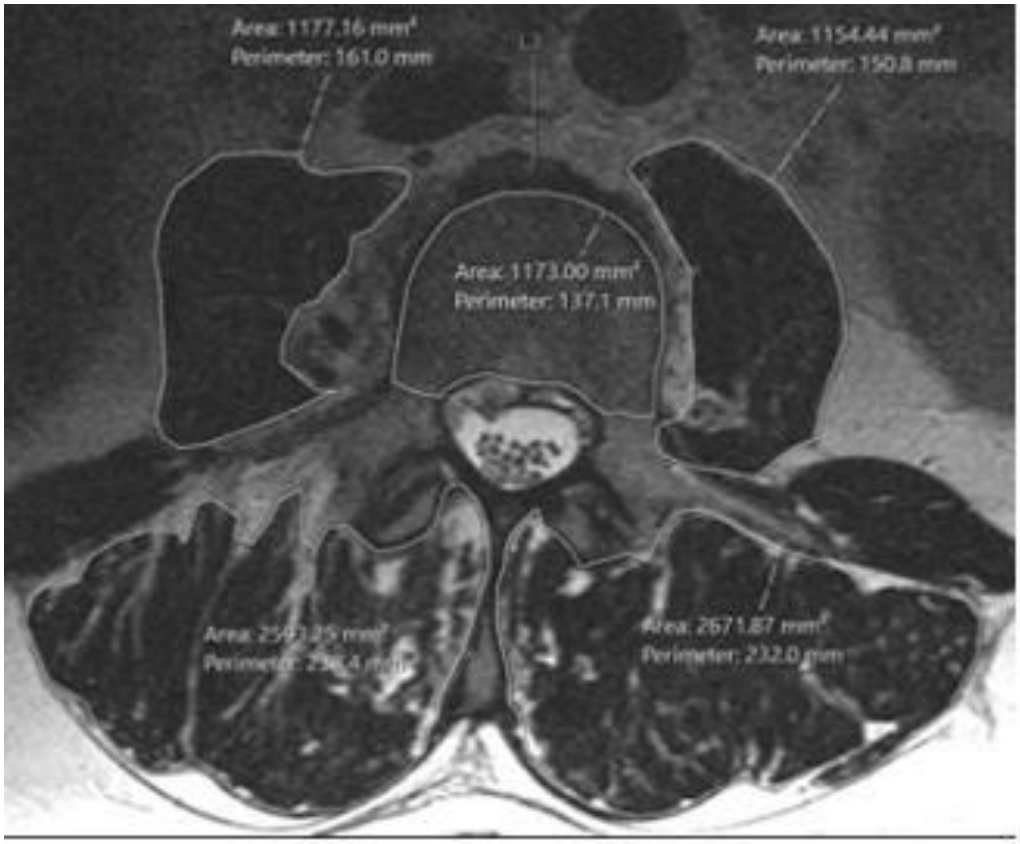

Axial MRI showing measured muscle areas in a patient with psoas sarcopenia.

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Paper #96. Maintaining Stability at the Lumbosacral-Pelvic Region in Adult Spinal Deformity Surgery Without SI Joint Fusion: Are Four Pelvic Screws Superior to Two Pelvic Screws?

Sarthak Mohanty, BS; *Stephen Stephan, MD*; Christopher Mikhail, MD; Andrew Platt, MD; Joshua Baksheshian, MD; Erik Lewerenz, BS; Fthimnir Hassan, MPH; Joseph M. Lombardi, MD; Zeeshan M. Sardar, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

Hypothesis
Dual, bilateral 4 pelvic screw fixation(4PvS) is more effective than single bilateral 2 pelvic screw fixation(2PvS) in reducing reoperation rates and screw breakage.

Design
Single-surgeon retrospective cohort.

Introduction
Up to 19% of adult spinal deformity(ASD) patients undergo revision surgery, often due to lumbosacral junction failures. This study compares 4PvS with 2PvS to improve stability at the lumbosacral junction.

Methods
ASD patients undergoing spinal fusion to the sacrum without SI fusion between 2015 and 2021 with at least two-year(2Y) follow-up were included. 4PvS was compared to 2PvS. Key outcomes included spinal implant-related reoperation, pelvic screw breakage, symptomatic screw reoperation, screw loosening/bending, L5-S1 pseudarthrosis, intraoperative adverse events, and PROs. Bias minimization was addressed using 4:1 propensity score matching(PSM) and inverse probability of treatment weighting(IPTW). Clinical outcomes were evaluated through conditional multivariable logistic regression.

Results
The study analyzed 406 patients(69% female, age 64.48, 22.41% osteoporotic), with an average of 12.85 total instrumented levels(TIL). Baseline demographic, alignment, and corrective techniques showed no significant differences in PSM and IPTW cohorts, with all variables having standardized differences below 0.15. In the 4:1 PSM cohort(228 2PvS matched to 57 4PvS), the 2Y reoperation rate was lower in the 4PvS group(3.51%) compared to the 2PvS group(10.53%, OR: 0.21, P=0.03). Pelvic screw breakage also favored 4PvS(3.51% vs. 9.21% in 2PvS, OR: 0.22, P=0.03). IPTW analysis showed a significant reduction in 2Y reoperation(10.45% vs. 1.18%, P=0.02) and screw breakage(8.72% vs. 1.18%, P=0.05) in the 4PvS group. Intraop complications were similar across groups: 16.37% in 2PvS vs. 12.5% in 4PvS(P=0.32). Dural tear(P=0.81) and neurologic deterioration(P=0.44) were comparable. No significant differences in baseline or 2Y PROs were observed. Two-year postoperative SRS Activity scores were 3.79(±0.09) for 2PvS vs. 3.57(±0.17) for 4PvS(P=0.27), and Pain scores were 3.7(±0.11) vs. 3.34(±0.21), respectively(P=0.15).

Conclusion
4PvS is superior to 2PvS in spinopelvic fixation for ASD patients, significantly reducing two-year implant-related reoperation and screw breakage rates, without increasing operative complications or adversely affecting PROs.

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	Unmatched Cohort				*4:1 Propensity Score Matched Cohort*			
	Two Screw Pelvic Fixation [2PvS, n=349]	**Four Screw Pelvic Fixation** [4PvS, n=57]	**P Value (Unmatched)**	**Std. Difference (Unmatched)**	**Two Screw Pelvic Fixation** [2PvS], n=228	**Four Screw Pelvic Fixation** [4PvS, n=57]	**P Value (Matched)**	**Std. Difference (Matched)**
Patient Characteristics								
Age	64.1 (±0.56)	66.72 (±1.15)	**0.0443**	-0.257	66.29 (±0.59)	66.72 (±1.15)	0.7382	-0.049
Gender [Female]	234 (68.22%)	42 (73.68%)	0.3608		154 (67.54%)	42 (73.68%)	0.4263	
Edmonton Frailty Score	3.51 (±0.13)	3.32 (±0.33)	0.5819	0.079	3.33 (±0.16)	3.32 (±0.33)	0.9621	0.007
Osteoporosis	71 (20.7%)	20 (35.09%)	**0.0168**		64 (28.07%)	20 (35.09%)	0.3308	
Total Instrumented Levels (TIL)	12.64 (±0.21)	14.11 (±0.58)	**0.0212**	-0.368	13.89 (±0.33)	14.11 (±0.58)	0.7543	-0.043
Total Number of Osteotomies	5.66 (±0.25)	8.84 (±0.71)	**<0.0001**	-0.652	8.34 (±0.27)	8.84 (±0.71)	0.5115	-0.094
Three Column Osteotomy (3CO)	79 (23.03%)	12 (21.05%)	0.8654		43 (18.86%)	12 (21.05%)	>0.9999	
Max Coronal Cobb Angle	37.06 (±1.22)	35.63 (±3.15)	0.6732	0.065	36.46 (±1.56)	35.63 (±3.15)	0.8142	0.036
PI - LL	22.58 (±1.08)	19.85 (±2.79)	0.3641	0.139	21.09 (±1.36)	19.85 (±2.79)	0.6906	0.062
T1 Pelvic Angle [T1PA]	27.46 (±0.68)	25.38 (±1.72)	0.266	0.168	26.59 (±0.84)	25.38 (±1.72)	0.5316	0.097
Two- Year Clinical Outcomes								
Implant Related Reoperation	31 (9.04%)	2 (3.51%)	0.1896		24 (10.53%)	2 (3.51%)	**0.0312**	**OR: 0.21 [0.04 to 0.99]**
Pelvic Screw Breakage	26 (7.58%)	2 (3.51%)	0.2498		21 (9.21%)	2 (3.51%)	**0.0349**	**OR: 0.22 [0.04 to 0.99]**
Screw Bending or Loosening	16 (4.68%)	1 (1.79%)	-		9 (3.96%)	1 (1.79%)	-	
Operative Repair Pelvic Screw	15 (4.37%)	1 (1.75%)	-		9 (3.95%)	1 (1.75%)	-	
L5-S1 Pseudarthrosis	10 (2.92%)	1 (1.75%)	-		7 (3.07%)	1 (1.75%)	-	
Complications								
Intraoperative Complications	49 (14.37%)	7 (12.5%)	0.5567		37 (16.37%)	7 (12.5%)	0.3169	
Massive EBL	16 (4.66%)	2 (3.51%)	0.5129		13 (5.7%)	2 (3.51%)	0.1785	
Dural Tear	31 (9.04%)	7 (12.28%)	0.6636		23 (10.09%)	7 (12.28%)	0.8104	
Neurologic Deterioration	77 (22.58%)	12 (21.05%)	0.6708		54 (23.68%)	12 (21.05%)	0.4359	
Sensory Deficit	29 (8.45%)	3 (5.26%)	0.6629		16 (7.02%)	3 (5.26%)	0.5932	
Motor Deterioration	65 (19.06%)	10 (17.54%)	0.7576		45 (19.74%)	10 (17.54%)	0.5107	

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Paper #97. Does Normalizing T4-L1PA Relationship in Long-Segment Fusions Independently Reduce Mechanical Complications and Improve Patient Reported Outcomes?

Sarthak Mohanty, BS; Zeeshan M. Sardar, MD; *Michael P. Kelly, MD*; Josephine R. Coury, MD; Justin Reyes, MS; Fthimnir Hassan, MPH; Nathan J. Lee, MD; Justin K. Scheer, MD; Steven G. Roth, MD; Chun Wai Hung, MD; Joseph M. Lombardi, MD; Ronald A. Lehman, MD; Lawrence G. Lenke, MD

Hypothesis
Normalizing T4-L1PA reduces reoperations attributable to mechanical complications(MC) but does not impact PROs

Design
Retrospective cohort of ASD patients undergoing >6 level PSF

Introduction
Investigations in asymptomatic adults revealed harmonious T4-L1-Hip Axis, characterized by T4 pelvic angle(T4PA) within 4° of L1PA. Understanding the impact of L1PA/T4PA malalignment on MC and PROs is critical.

Methods
T4PA-L1PA mismatch was assessed at 6 weeks postop following deformity correction and patients were followed for 2Y thereafter. Key outcomes were MC, encompassing implant-related reoperations and reoperations for PJK/F alongside attainment of MCID for SRS and ODI PROs at 2Y postop. MCID thresholds were 0.4 for SRS scores and -11 for ODI. A multivariable logistic regression model investigated the association between(T4PA-L1PA)2 and MC, adjusting for comorbidities(CCI), preop alignment, UIV, pelvic fixation, and the correction magnitude. A polynomial logistic regression was employed to model the quadratic relationship between T4PA-L1PA and MC risk, with plots illustrating the probability of MC across the T4PA-L1PA spectrum. Logistic regression analyses investigated the relationship between(T4PA-L1PA)2 mismatch and MCID in PROs.

Results
427 patients with mean age 61.2(±0.7), 12.50(±0.2) instrumented levels, and 78.7% undergoing pelvic fixation were included. 66(15.5%) patients underwent MC-related reoperations. Univariate analysis revealed higher CCI(OR=1.3,p=0.001), increased (T4PA-L1PA)2 (OR=1.01,p<0.001), lower preop TK(OR=0.99,p=0.021), increased ΔPI-LL(OR=1.01,p=0.037), and ΔT4PA(OR=1.03,p=0.029) were associated with higher odds of MC. In the multivariable model(AUC=0.72,p<0.001), higher CCI(OR=1.21,p=0.029),pelvic fixation(OR=2.78,p=0.022), and greater (T4PA-L1PA)2(OR=1.01,p<0.001) were independent predictors of MC. The probability of MC across T4PA-L1PA values indicated that both over- and under-correction are associated with MC. (T4PA-L1PA)2 was not associated with achieving MCID in SRS activity(p=0.635), pain(p=0.444), appearance(p=0.800), mental health(p=0.800), satisfaction(p=0.189), and ODI(p=0.472).

Conclusion
Aligning T4-L1PA mismatch within normative ranges mitigates mechanical complications but does not significantly influence attainment of MCID. This suggests that mechanical complications are driven by alignment, while PROs may be multifactorial.

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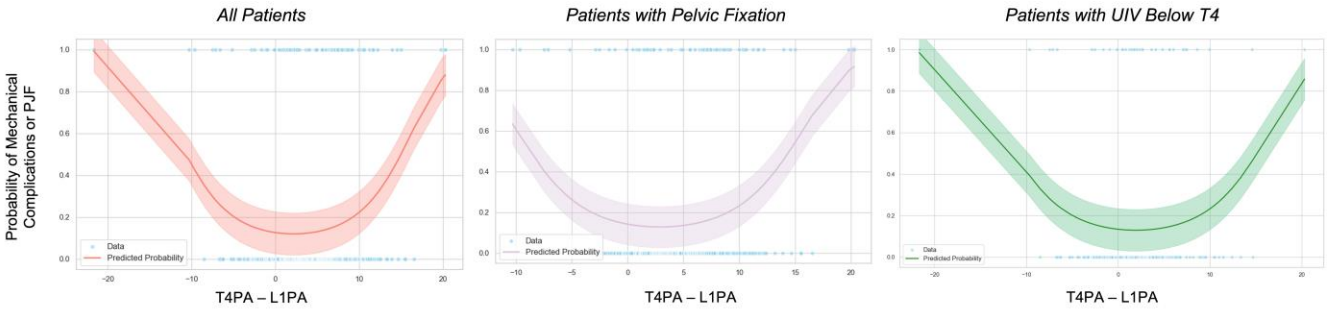
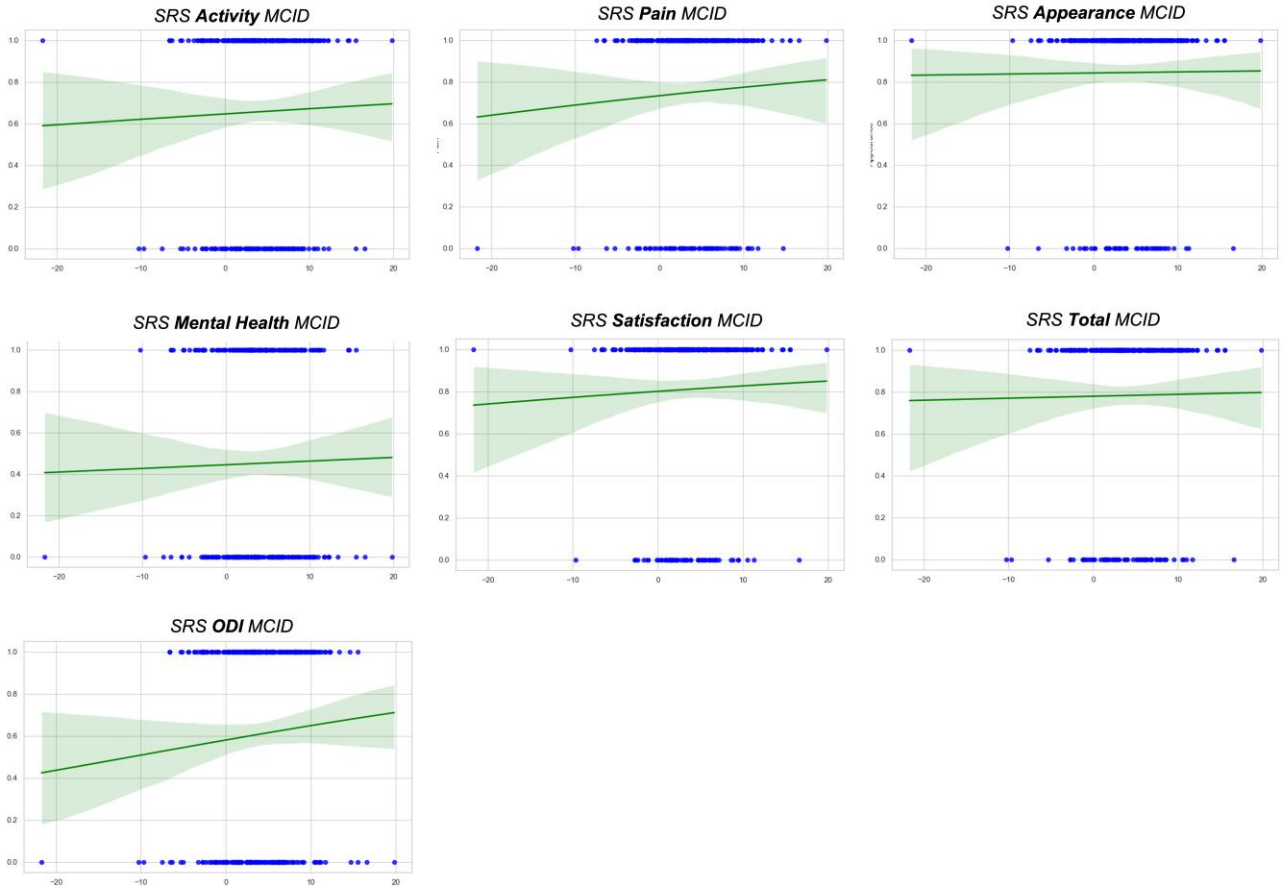
Polynomial Logistic Regression Plots for Reoperation for Mechanical Complications or PJF



Logistic Plots of Achieving MCID Across Patient Reported Outcome Domains



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Paper #98. Is Cortical Breach at the Upper Instrumented Vertebra Associated with Increased Risk of Proximal Junctional Kyphosis?

Samuel K. Ezeonu, BA; Juan D. Rodriguez-Rivera, BS; Nicholas S. Vollano, BS, MBS; Alyssa E. Capasso, BS; Constance Maglaras, PhD; Tina Raman, MD; *Themistocles S. Protopsaltis, MD*

Hypothesis
Cortical breach at the UIV increases the risk of proximal junctional kyphosis (PJK) following surgery.

Design
Single center retrospective cohort study

Introduction
While some studies have suggested that pedicle screw trajectory at the upper instrumented vertebra (UIV) is associated with PJK, it is unknown if screw cortical breach is also a significant risk factor.

Methods
Patients ≥ 18 years of age undergoing surgery with 5 ≥ levels fused were placed into PJK and no-PJK cohorts based on a clinical diagnosis of PJK documented by the operating surgeon within two years. Placement and trajectory of pedicle screws at the UIV were assessed at the first postoperative radiographic and CT-imaging. Medial or lateral breach was categorized if screw breach was ≥ 2 mm on either respective side of the pedicle tract at the UIV. Endplate breach was classified if any part of the screw tip surpassed the superior endplate at the UIV. Pedicle screw trajectory (UIV-PVA) was measured as the mean of the two angles between the UIV superior endplate and both UIV pedicle screws: Positive sign for UIV-PVA indicates cranially-directed screw, and negative sign indicates caudally-directed screw. T-tests, X2, and logistic regression were used for analyses of patient and radiographic outcomes.

Results
88 patients were included (mean age 66 yr, 64% female). 38 patients demonstrated a clinical diagnosis of PJK (43%). There was a significantly greater percentage of patients with history of diabetes in the PJK group ($p<0.05$). No differences were observed between the groups in UIV location or baseline and postoperative radiographic parameters. While no difference was seen in rates of medial or lateral breach, incidence of endplate breach at the UIV was found to be significantly higher in the PJK group ($p<0.001$). Patients in the PJK group also demonstrated significantly higher rate of cranially-directed screw trajectory at the UIV compared with non-PJK patients ($p=0.003$). Multivariate regression for variables $p<.05$, revealed endplate breach at the UIV as an independent predictor of PJK development (OR = 3.953, CI 1.17-13.39; $p=0.027$).

Conclusion
Pedicle screw endplate breach at the UIV contributed to a 3.95-fold increased risk for development of PJK. This data highlights the critical importance of screw trajectory and positioning at the UIV in minimizing risk for PJK.

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Table 1: Patient and Radiographic Analysis Comparing Patients Who Did Not Develop PJK Versus Those Who Did Develop PJK

		NoPJK (N= 58)	PJK (N= 30)	p-value
Patient and Surgical Factors	Age	64.77±10.11	67.60±7.52	0.182
	Gender (%F)	59.60%	73.30%	0.254
	BMI	28.86±5.51	28.94±6.27	0.947
	Smoking	7.00%	0.00%	0.294
	Diabetes	5.30%	23.30%	**0.028**
	UIV location			0.389
	Upper Thoracic (T1-T5)	36.20%	26.70%	
	Mid Thoracic (T6-T9)	12.10%	6.70%	
	Thoracolumbar (T10-T12)	51.70%	66.70%	
	Levels Fused	10.05±3.17	9.63±3.34	0.576
	3CO performed?	14.00%	6.70%	0.483
	Pelvic Fixation	80.70%	90.00%	0.363
Radiographic Analysis				
Preoperative	SVA (cm)	7.29±6.88	5.46±4.14	0.183
	TPA°	27.01±11.86	27.58±10.72	0.843
	PI °	54.61±12.77	58.82±12.68	0.195
	TK°	31.69±21.65	35.87±18.18	0.417
	PI-LL°	23.01±22.83	22.67±16.71	0.949
	PT°	26.35±9.61	29.57±10.38	0.201
Postoperative	SVA (cm)	3.75±5.00	4.12±3.80	0.787
	TPA°	19.02±9.52	24.15±9.12	0.066
	PI °	54.19±13.74	59.89±17.38	0.142
	TK°	42.24±10.56	43.85±12.57	0.626
	PI-LL°	7.42±14.29	12.03±12.02	0.220
	PT°	23.19±11.63	27.38±9.94	0.174
UIV Screw Analysis	Medial Breach	7 (12.1%)	7 (23.3%)	0.221
	Lateral Breach	10 (17.2%)	1 (3.3%)	0.089
	Endplate Breach	8 (14.0%)	15 (50.0%)	**<0.001**
	UIV-PVA°	0.32±5.79	4.47± 6.45	**0.003**

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Paper #99. Comparison of Elderly Patients with Spinal Deformity Fused from the Upper Versus the Lower Thoracic/Thoracolumbar Spine to the Sacrum. Prospective Evaluation of Elderly Deformity Surgery (PEEDS) Study

Zeeshan M. Sardar, MD; Roy Miller, MS; Scott Zuckerman, MD, MPH; Stephen J. Lewis, MD, FRCS(C); Marinus de Kleuver, MD; Yong Qiu, PhD; Yukihiro Matsuyama, MD, PhD; Lawrence G. Lenke, MD; Ahmet Alanay, MD; Ferran Pellisé, MD, PhD; Kenneth M. Cheung, MD, MBBS, FRCS; Maarten Spruit, MD; David W. Polly, MD; Christopher I. Shaffrey, MD; Justin S. Smith, MD, PhD; Michael P. Kelly, MD; Benny T. Dahl, Md, PhD, DMSc; Sigurd H. Berven, MD

Hypothesis
We hypothesized that patients fused to the Upper Thoracic (UT) spine would demonstrate more severe preoperative deformity, increased early complications but similar long term reoperation probability

Design
Prospectice, Multicenter, Observational study

Introduction
In adult spinal deformity (ASD) surgery, choosing the upper instrumented vertebra (UIV) between the upper thoracic (UT) or lower thoracic/thoracolumbar (LT) spine is critical to balancing the risk of periop surgical morbidity with durable long-term outcomes. This study compares outcomes of elderly patients fused to the sacrum from UT vs. LT

Methods
ASD patients (age 60+) undergoing fusion to the sacrum were divided into UT (UIV T1-T7) and LT (UIV T8-L2) groups and were followed up for 5 years. We compared demographics, radiographic parameters, perioperative outcomes, reoperation probability, and patients-reported outcome metrics (PROMs).

Results
145 ASD patients (80% females; mean age 68.0±5.4) were included (UT: 42, LT: 103). Although there was no significant difference in operative times, the UT group had higher estimated blood loss (EBL) than the LT group (2163.4cc vs. 1569.8cc; p=.01). Both groups had similar postop complication rates 40.5% vs. 40.8%. Preoperatively, the UT group had higher thoracic kyphosis (TK) (p<.05), higher thoracolumbar kyphosis angle (TLA) (p<.001), and higher distal lordosis (p=.006). At 5 year follow up, UT group demonstrated lower SVA of 33.1mm vs.65.3mm (p=.05) even though preop SVA was similar. The rate of radiographic PJK was not different. However, the probability of reoperation after 5 years was higher in the UT group (32.1% vs. 12.27%; p=0.003). Implant failure was the most common reason for reoperation (UT: 47%, LT: 28%). Junctional pathology accounted for 10% and 14% of reoperations in the UT and LT groups respectively. PROMs were similar at baseline and significantly improved postop in both groups.

Conclusion
The UT group had greater thoracic/thoracolumbar kyphosis, and higher EBL versus the LT group. The UT group maintained a lower SVA at final follow-up but had a higher reoperation probability. Surprisingly, implant failure was the most common cause of revision in both cohorts. Complication rates and PJK rates were similar. Importantly, both groups showed significant improvement in postop PROMs at all visits

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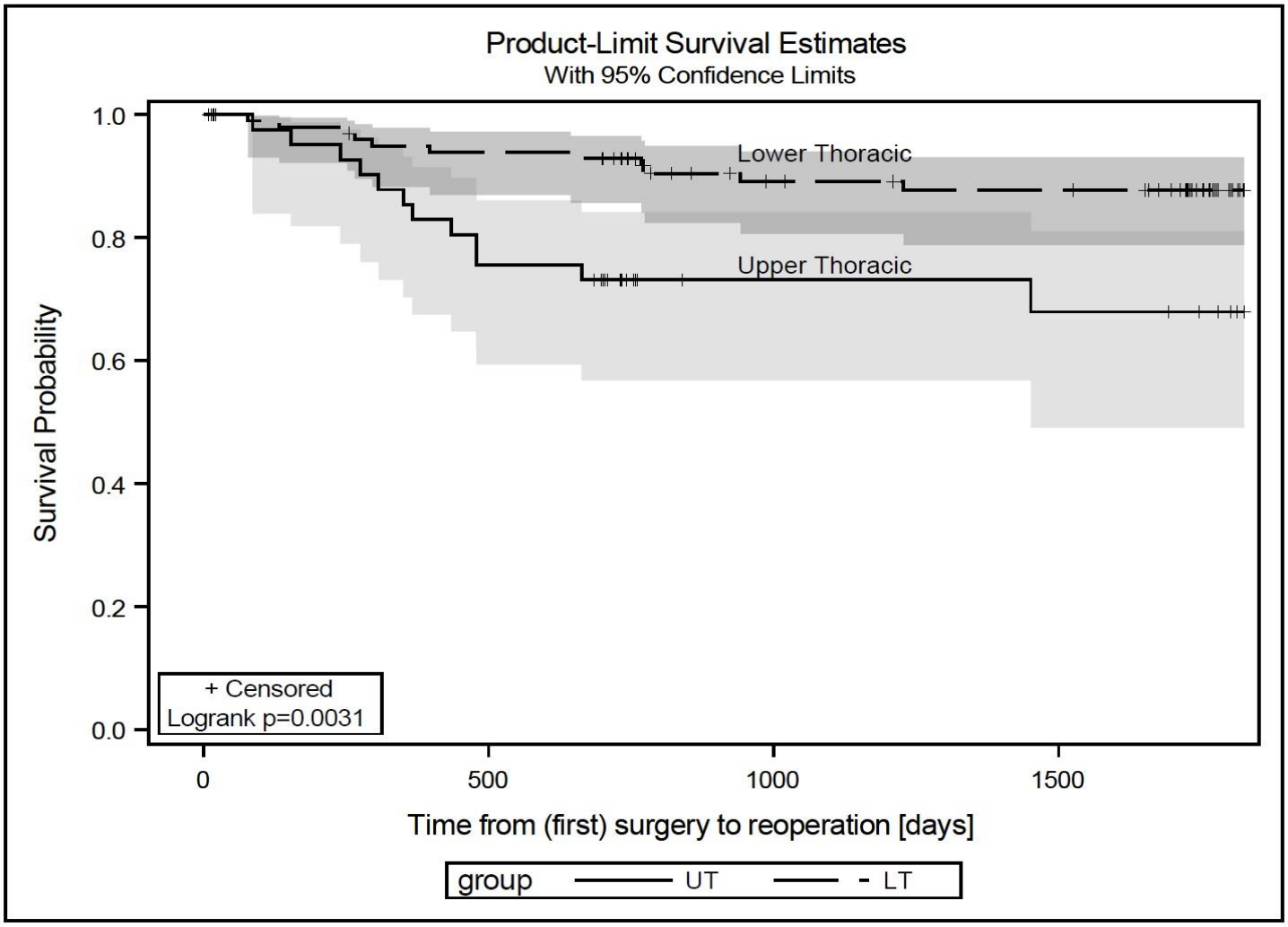
Figure 01: Kaplan-Meier curve for reoperations 5 years postop



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Paper #100. Upper Instrumented Vertebra Pedicle Screw Loosening Following Complex Adult Spinal Deformity Surgery: Incidence and Outcome Analysis of 147 Cases

John D. Arena, MD; Yohannes Ghenbot, MD; Connor Wathen, MD; Gabrielle Santangelo, MD; Mert Marcel Dagli, MD; Joshua L. Golubovsky, MD; Ben Gu, MD; Dominick Macaluso, PhD; Jang Yoon, MD, MSc; William C. Welch, MD; Ali Ozturk, MD

Hypothesis

The development of pedicle screw loosening following surgery for adult spinal deformity (ASD) is associated with increased odds of eventual hardware revision surgery.

Design

Retrospective cohort study

Introduction

ASD is a debilitating condition which is increasing in prevalence as the population ages. Surgical correction of ASD may confer considerable improvement in quality of life, however, there exists a high rate of hardware complication which can be challenging to predict. Hardware integrity and alignment are frequently followed with standing radiographs, where pedicle screw loosening may be incidentally identified, the clinical significance of which is often unclear.

Methods

A single-institution retrospective cohort of 147 patients (69% female, mean age 63.7) who underwent long-segment fusion for ASD was reviewed. Patients with minimum two-year follow-up (mean 4.1 years) and with follow-up standing radiographs were included. Upper instrumented vertebra (UIV) pedicle screws were graded on radiographs for evidence of loosening as: 0=no loosening, 1=positive radiolucency within screw threads, 2=positive radiolucency around screw threads, 3=screw dislodgement (Figure 1). T-Test and logistic regression analyses were performed.

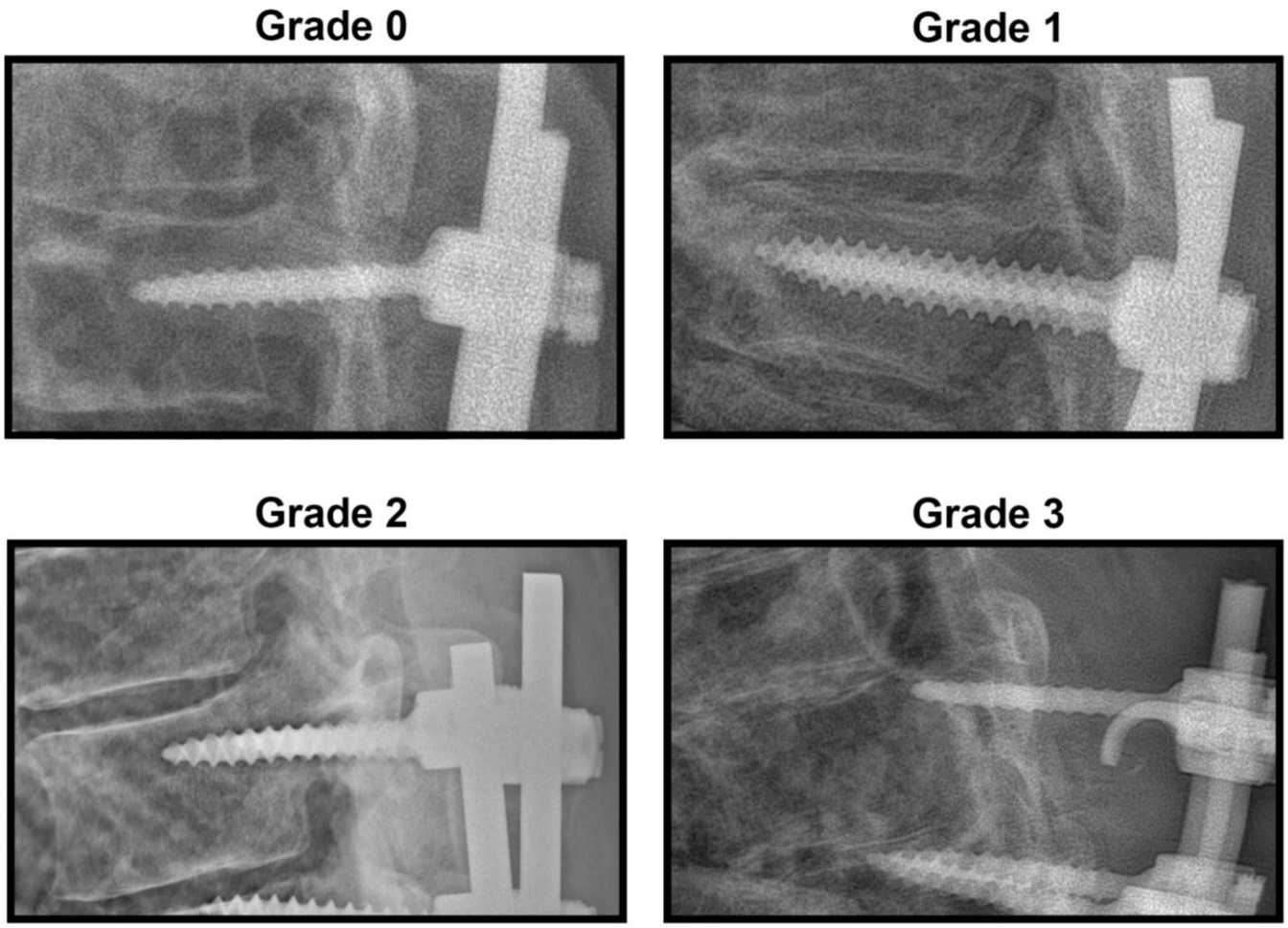
Results

109 cases (74.1%) demonstrated no loosening, 26 (17.7%) Grade 1 loosening, 9 (6.1%) Grade 2, and 3 (2.0%) Grade 3. No baseline patient characteristics or surgical construct features significantly differed between patients with and without High Grade (Grade 2/3) UIV loosening (all $p>0.05$). High Grade UIV loosening was associated with significantly increased odds of eventual hardware revision surgery (Odds Ratio 9.29, $p=0.002$), including specifically surgery for proximal junctional kyphosis (Odds Ratio 9.18, $p=0.015$). Among patients with PROMIS scores (n=88), those requiring hardware revision reported worse Pain Interference ($p=0.003$) and Physical Function ($p=0.031$). Patients with High Grade UIV Loosening trended toward higher Oswestry Disability Index (n=27) scores (44.7 vs 34.8, $p=0.263$).

Conclusion

Whereas Grade 1 UIV pedicle screw loosening may be a benign incidental finding, High Grade loosening is associated with significantly increased odds of hardware revision surgery, including PJK. High Grade loosening may also be associated with worse patient-reported disability. High Grade loosening warrants increased attention in follow-up.

Figure 1. UIV Pedicle Screw Loosening Grades



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Paper #101. Proximal Junctional Degeneration and Failure: A Novel Classification and Clinical Implications

Riza Mert Cetik, MD; Steven D. Glassman, MD; John R. Dimar, II, MD; Mitchell J. Campbell, MD; Mladen Djurasovic, MD; Charles H. Crawford III, MD; Jeffrey L. Gum, MD; Kirk Owens, MD; *Kathryn McCarthy Mullooly, MD*; Leah Y. Carreon, MD

Hypothesis
Varying mechanisms of proximal junctional degeneration or failure demonstrate different clinical characteristics and revision rates.

Design
Retrospective review

Introduction
Proximal junctional degeneration after spinal fusion is often identified as PJK/PJF. Existing classifications are descriptive, but not necessarily correlated with mechanism or clinical course.

Methods
Patients with posterior fusion of ≥3 levels and upper instrumented level (UIV) at or distal to T8, with minimum 2-year follow-up were identified from a single center database. Demographic, surgical and radiographic variables were recorded. The proposed classification system identified 4 patterns: Type 1: symmetrical collapse involving multiple levels cranial to the UIV, Type 2: single level adjacent level collapse with bony erosion ± screw penetration into disc space, Type 3: fracture, and Type 4: spondylolisthesis (Figure). Radiographic and clinical findings, and rates of progression were compared between different types of proximal junctional degeneration.

Results
150 patients were included (mean age 65.1 years and follow-up 3.2 years). 92 (61%) patients developed degenerative changes in the proximal junctional region, and were classified as Type 1 (32, 21%), Type 2 (15,10%), Type 3 (22, 15%) and Type 4 (12, 8%). All results in parentheses are for types 1,2,3 and 4, respectively. Greater preop SVA was associated with Types 3 and 4 (61±47, 97±121, 136±41, 155±15, p=0.019), greater preop PI-LL mismatch with Type 4 (23±14, 23±22, 22±16, 40±21, p=0.05) and greater postop thoracic kyphosis with Types 2 and 3 (33±12, 47±9, 48±12, 36±13, p=0.049). Mean time to revision was shorter for Type 3 cases (1.9, 2.1, 0.9, 2.1 years, p=0.004). Rates for PJK were 31%, 67%, 46% and 33% (p=0.125), for revision were 63%, 73%, 73% and 83% (p=0.564) and for neurologic deficit were 9%, 20%, 32% and 17% (p=0.221).

Conclusion
This novel comprehensive classification system defines different modes of degeneration at the proximal junction, without reliance on angular definitions of PJK/PJF. Different types have different clinical courses (fractures have significantly shorter time to revision). Pre/postop radiographic characteristics are associated with specific types of failure (i.e. spondylolisthesis had the highest preop SVA). Future studies with larger sample sizes are needed to validate this novel classification.

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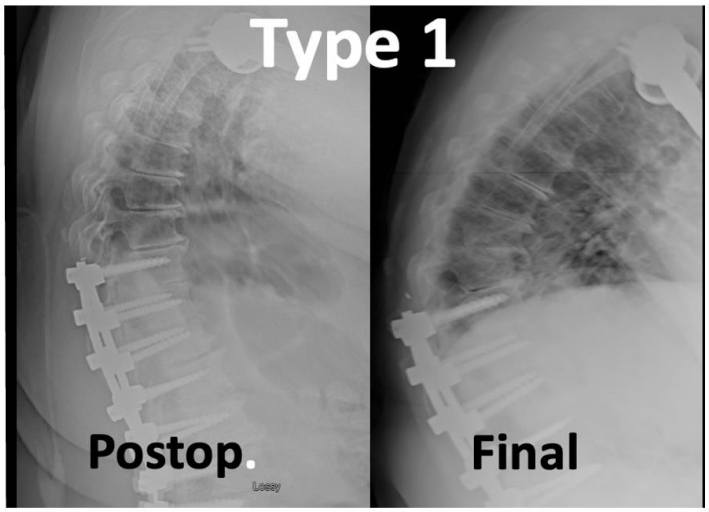

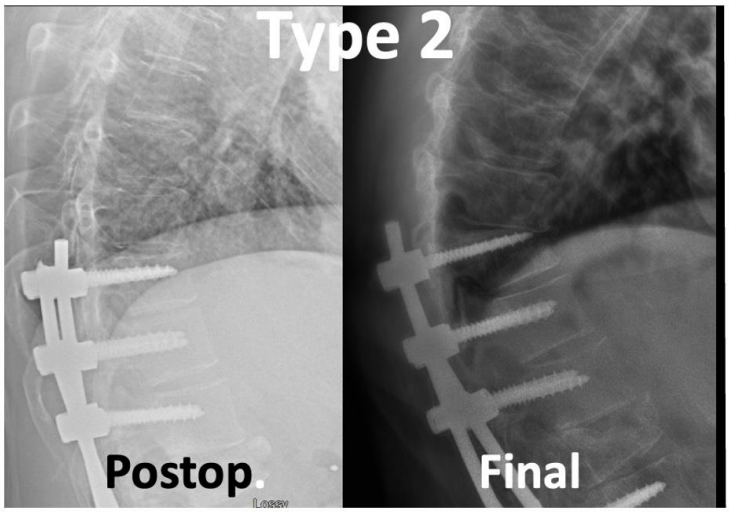

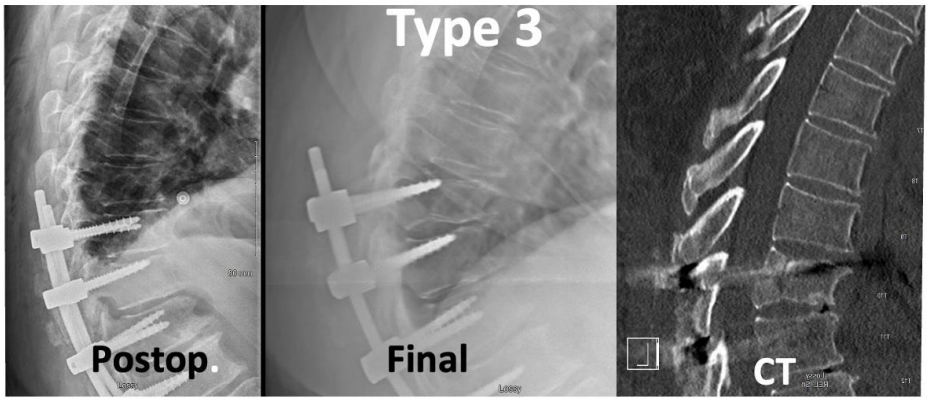

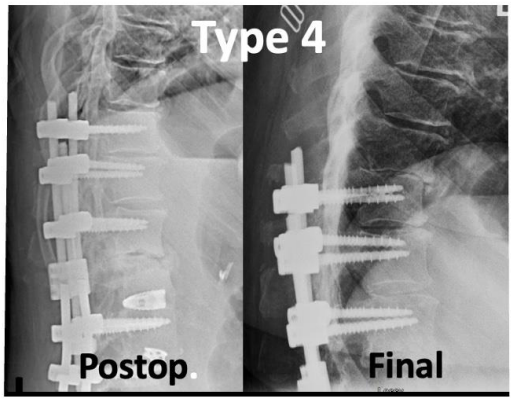

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Paper #102. Risk of Upper Instrumented Vertebra Fracture in Adult Spinal Deformity Surgery Associated with Insertion of Oversized Screws Relative to Pedicle Width

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Hypothesis

If the pedicle width at the upper instrumented vertebra (UIV) is smaller than the diameter of the pedicle screw, there is an increased likelihood of an upper instrumented vertebra fracture (UIVF).

Design

Retrospective cohort study

Introduction

The etiology of UIVF in adult spinal deformity (ASD) surgery is complex and involves multiple factors. Individual variability in pedicle width is a contributing factor, and when screws with a diameter exceeding the pedicle width are inserted into the UIV, there exists a potential risk of UIVF attributable to pedicle fractures induced by screw placement. The objective of this research is to examine the occurrence of UIVF in cases where the screw diameter within the UIV surpasses the width of the pedicles.

Methods

The research comprised 322 individuals who underwent ASD surgery, with a follow-up period exceeding 2 years. The UIV was positioned cephalad to the T10 vertebra, utilizing 5.5 mm screws. Preoperative CT scans measured pedicle width in the UIV, classifying individuals with pedicle widths below 5.5 mm as the N group and those with widths equal to or exceeding 5.5 mm as the W group.

Results

Among the participants, 264 individuals were categorized in the N group, while 58 were in the W group, with an average age of 68 years in both cohorts. The average pedicle width on both sides measured 4.0 mm in the N group and 6.2 mm in the W group. The incidence of UIVF was found to be 26% in the N group compared to 14% in the W group (P=0.046). In the N group, UIVF cases were distributed across T2 (1 case), T3 (1 case), T4 (18 cases), T5 (22 cases), T6 (11 cases), T7 (11 cases), T8 (29 cases), T9 (92 cases), T10 (79 cases). Conversely, in the W group, UIVF occurred at T5 (1 case), T8 (4 cases), T9 (13 cases), and T10 (40 cases). Notably, within the N group, the incidence of UIVF was 22.7% (48/211 cases) for those with UIV located at T7-10, compared to 39.6% (21/53 cases) for cases with UIV at T2-6.

Conclusion

A pedicle width smaller than the screw diameter is regarded as a contributing factor to UIVF. Special attention is warranted, especially when the UIV is positioned cephalad, as pedicle width tends to be narrower in such cases. In instances where the pedicle width is less than the screw diameter, careful consideration should be given to either reducing the screw diameter or employing alternative devices such as hooks.

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Paper #103. Beyond Kyphosis: Modes of Failure at the Proximal Junction in Adult Spinal Deformity

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Hypothesis
Modes of junctional failure are more diverse than just a kyphotic change.

Design
Retrospective analysis of prospective registry.

Introduction
Proximal segment disease in adult spinal deformity (ASD) surgery has been historically evaluated as a kyphotic change and is well known as Proximal Junctional Kyphosis (PJK). Junctional diseases such as endplate fracture, spinal canal stenosis, disc herniation, soft tissue failure, spondylolisthesis, and instrumentation failure without kyphosis, therefore, are overlooked.

Methods
Database entries and radiographs of 185 ASD patients with radiographic PJK (Lovecchio's criteria) or those who underwent revision surgery with proximal extension were reviewed by three independent readers. The readers qualitatively reported the type of failure in the junction zone using free text. After standardizing text descriptions, patterns of junctional issues were categorized, and the location of the failure was reported in relation to the last instrumented vertebra.

Results
Among the 1506 enrolled patients, 185 (12.3%) had severe junctional issues (67.5 yo, 86.5%F) after an upper thoracic (UT) to Pelvis (36.2%) or lower thoracic (LT) to pelvis (57.3%) surgery. Failure patterns included focal bony elements, focal soft tissues, or diffuse degeneration (Table). Focal bony vertebral body failure occurred in 122 (66%) patients, with a vertical collapse of the vertebra in 18 (9.7%) and angular collapse in 99 (53.5%), along with endplate fractures in 111 (60%). Focal soft tissue failure occurred in 120 (64.9%) patients, with a vertical disc collapse in 39 (21.1%), a kyphotic disc in 53 (29.2%), and spondylolisthesis in 34 (18.4%). Finally, 41 patients (22.2%) developed generalized degeneration across several levels. Median times to failure are reported in the Table. Patients with a LT UIV tended to have a higher rate of angular bony failure (55.7%), while those with lumbar UIV tended to have a higher rate of "non-angular" failures (58.3%).

Conclusion
Postoperative proximal junctional disease following ASD surgery is not always simply kyphosis. This study revealed three distinct modes of failure at the junction (vertebral failure, disc failure, junctional degeneration), with 25% of patients presenting with non-kyphotic junctional disease. Those modes not only varied in radiographic presentation, but also in their median time to onset from the index surgery.

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	N (Rate%)	Time to Failure in days
Vertebral Failure	122 (66%)	284 [46 to 647]
Vertebral Collapse	18 (9.7%)	369 [47 to 904]
UIV-1	0 (0%)	
UIV	**15 (8.1%)**	384 [45 to 946]
UIV+1	4 (2.2%)	
Vertebral Wedge	99 (53.5%)	248 [46 to 430]
UIV-1	2 (1.1%)	
UIV	**82 (44.3%)**	90 [43 to 422]
UIV+1	15 (8.1%)	304 [49 to 762]
UIV+2	3 (1.6%)	
UIV+3	1 (0.5%)	
Vertebral endplate fracture	111 (60%)	248 [45 to 457]
UIV-1	1 (0.5%)	
UIV	**100 (54.1%)**	215 [44 to 450]
UIV+1	8 (4.3%)	
UIV+2	1 (0.5%)	
UIV+3	1 (0.5%)	
Disc Failure	120 (64.9%)	384 [74 to 787]
Disc Collapse / DDD	39 (21.1%)	383 [363 to 751]
UIV / UIV+1	**39 (21.1%)**	383 [363 to 751]
UIV+1 / UIV+2	1 (0.5%)	
Disc Kyphotic	54 (29.2%)	370 [63 to 761]
UIV / UIV+1	**54 (29.2%)**	370 [63 to 761]
UIV+1 / UIV+2	1 (0.5%)	
Spondylolisthesis	34 (18.4%)	378 [89 to 728]
UIV-1 / UIV	1 (0.5%)	
UIV / UIV+1	**30 (16.2%)**	373 [89 to 534]
UIV+1 / UIV+2	3 (1.6%)	
Junctional Degeneration	41 (22.2%)	730 [315 to 1140]