

174. Influence of Cervical Range of Motion and Dynamic Cervical Sagittal Vertical Axis on Distal Junctional Kyphosis Following Adult Cervical Deformity Surgery

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Hypothesis

Dynamic cervical sagittal vertical axis (cSVA) is associated with distal junctional kyphosis (DJK) following cervical deformity (CD) surgery.

Design

Retrospective analysis of prospective, multi-center study

Introduction

Adult CD surgery aims to restore sagittal alignment and biomechanical stability across the cervicothoracic junction. Prior work has demonstrated that upper cervical extension reserve is associated with postoperative functional outcomes; however, the contribution of dynamic cervical alignment to DJK remains incompletely understood.

Methods

A total of 360 patients undergoing CD surgery were included (mean age 61.3±10.8 years; 64% female). DJK at one year was defined as a distal junctional angle $\geq 10^\circ$ with a change of $\geq 10^\circ$ from baseline. Dynamic cervical parameters included C0-2, C2-7, and T1 slope range of motion (ROM) on flexion/extension radiographs as well as dynamic cSVA range, defined as the difference between flexion and extension cSVA (C2-7). Multivariable logistic regression models adjusted for age and baseline alignment were constructed, with missing data addressed using multiple imputation.

Results

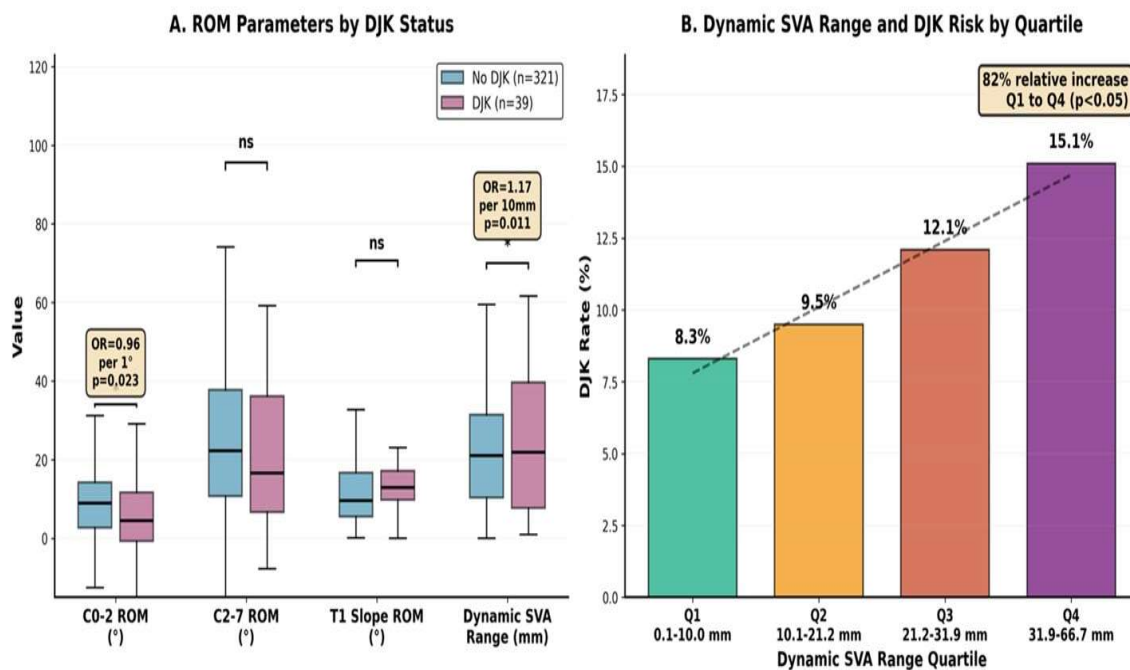
Dynamic imaging was available in 82% of patients, with DJK occurring in 39 patients (10.8%). On univariable analysis, greater C0-2 ROM was associated with lower odds of DJK (OR 0.96, P=0.02), whereas increased dynamic cSVA range was associated with higher DJK risk (OR 1.2 per 10mm, P=0.01). In multivariable analysis, dynamic cSVA range remained the strongest independent predictor of DJK (OR 1.6 per 10 mm, 95% CI 1.2–2.3), while C0-2 ROM demonstrated a protective trend. In a parsimonious model, both dynamic cSVA range and C0-2 motion were independently significant. Sensitivity analysis using complete cases confirmed the robustness of these findings. Quartile analysis suggested a dose-response relationship, with DJK rates increasing from 8.3% in the lowest quartile to 15.1% in the highest quartile of dynamic cSVA range.

Conclusion

Greater dynamic cervical sagittal vertical axis range is independently associated with distal junctional kyphosis following adult cervical deformity surgery. Incorporating dynamic cervical alignment and upper cervical mobility into preoperative assessment may improve risk stratification and inform surgical planning aimed at reducing distal junctional complications.

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

Cervical Motion Parameters and Dynamic Sagittal Balance in DJK Prediction



§ Hibbs Award Nominee – Best Clinical Paper, † Hibbs Award Nominee – Best Basic Science/Translational Science Paper,
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175. How Reliable is Intraoperative Neurophysiological Monitoring for Detecting Postoperative Deficits During Cervical Spine Surgery?

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Hypothesis

Intraoperative neurophysiological monitoring (IONM) provides high sensitivity and specificity for detecting postoperative neurological deficits in cervical spine surgery.

Design

Retrospective Review

Introduction

IONM is commonly used during thoracolumbar deformity and multi-level degenerative spine surgery to detect and mitigate neurological deficits. Understanding when IONM provides reliable reassurance and which patients are at higher risk for signal loss/alerts may improve operative planning and counseling. The purpose of this study was to quantify the diagnostic performance of IONM for postoperative neurologic deficits in cervical spine surgery and to identify factors associated with intraoperative IONM signal alert.

Methods

Patients who underwent cervical spine surgery with IONM at a single center consecutively between September 2015 and December 2021 were retrospectively reviewed. IONM alerts and postoperative neurologic deficits were extracted from the medical record. A positive IONM alert was defined as either a 50% or greater decrease in waveform amplitude or a 10% or greater increase in waveform latency. A postoperative deficit was defined as a new deficit present by postoperative day 1 that persisted until the first follow-up appointment. Firth's analyses were performed to model relationships between predictors and IONM positive readings.

Results

Among 1,020 operations, there were 54 IONM positives including 4 true positives and 50 false positives (PPV 0.07). There were 966 IONM negatives including 956 true negatives and 10 false negatives (NPV 0.99). Specificity was 0.95 (95% CI 0.94-0.96) and sensitivity was 0.29 (4/14). Prior fusion (OR 2.23, p=0.01), combined anterior-posterior approach (OR 3.98, p=0.004), and myelopathy (OR 4.70, p=0.006) were associated with higher odds of IONM signal alert.

Conclusion

In cervical spine surgery, intraoperative neurophysiological monitoring (IONM) provides strong reassurance when signals remain stable (NPV 0.99) that there will not be any postoperative deficits. However, IONM demonstrates low PPV and limited sensitivity for postoperative deficits. Prior fusion, combined approach, and myelopathy increase risk for IONM alerts.

	Postop Deficit	No Postop Deficit	Total
IONM Alert	4	50	54
No IONM Alert	10	956	966
Total	14	1006	1020

Variable	OR	95% CI	p-value
Base model (demographics only, n = 919, p = 0.040)			
Age (per year)	0.99	0.97-1.01	0.32
Sex (female vs male)	0.56	0.28-1.08	0.08
BMI (per kg/m ²)	1.01	0.95-1.06	0.83
Prior fusion	2.23	1.20-4.05	0.01
Surgical factors (n = 909, p < 0.001)			
Anterior levels (per level)	1.02	0.86-1.21	0.81
Posterior levels (per level)	1.15	0.96-1.37	0.12
Anterior approach (vs posterior approach)	1.52	0.54-4.69	0.44
Combined approach (vs posterior approach)	3.98	1.56-10.56	0.004
Neurologic presentation (n = 919, p < 0.001)			
Radiculopathy	1.82	0.58-5.07	0.30
Myelopathy	4.70	1.58-13.13	0.006
Radiographic characteristics (n = 599, p = 0.235)			
Kyphosis	1.66	0.52-5.27	0.38
Lordosis	1.78	0.66-5.21	0.26
cSVA (per mm)	1.02	0.99-1.04	0.23
Comorbidities (n = 919, p = 0.052)			
Comorbidities (per comorbidity)	1.24	0.79-1.69	0.30

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

176. Does Preoperative Myelopathy Portend Worse Outcomes After Cervical Deformity Surgery?

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Hypothesis

Myelopaths experience worse outcomes after cervical deformity surgery than non-myelopaths.

Design

Retrospective analysis of prospective multicenter study

Introduction

We evaluated the impact of preoperative myelopathy on: 1) perioperative morbidity, 2) complications, and 3) patient-reported outcome metrics (PROMs).

Methods

A retrospective cohort study (2009-18) was performed of patients undergoing cervical deformity surgery. Primary exposure was preoperative myelopathy, measured by the modified Japanese Orthopedic Association (mJOA) score and analyzed as both continuous and binary variables (severe ≤ 11 ; moderate/mild > 12). Primary outcomes were: 1) perioperative morbidity: estimated blood loss, operative time, and length of stay, 2) complications/reoperations, and 3) PROMs at 2-years, including Neck Disability Index (NDI) and EQ-5D Scores. Univariate/multivariable linear/logistic regression was performed, controlling for age, sex, and total instrumented levels.

Results

Of 153 patients (mean age 61.5 ± 10.4 years; 61.2% female), the mean mJOA score was 13.5 ± 2.8 and 37(24%) had severe myelopathy. Perioperative Outcomes: Higher/better mJOA scores were independently associated with shorter length of stay ($\beta: -0.6$, 95%CI: -1.1 - -0.05 , $p=0.033$), but no other perioperative metric. Severe myelopathy trended toward longer length of stay on bivariate (10.1 ± 15.0 vs. 6.8 ± 7.2 days, $p=0.205$) and multivariable analysis ($\beta: 3.3$, 95%CI: -0.2 - 6.8 , $p=0.063$). Complications: Higher/better mJOA scores or severe myelopathy were not significantly associated with complications or reoperations (all $p>0.05$). PROMS: At 2-years, higher/better baseline mJOA scores were independently associated with lower/better 2-year NDI scores ($\beta: -3.8$, 95%CI: -5.2 - -2.3 , $p<0.001$) and higher/better 2-year EQ-5D scores ($\beta: 0.02$, 95%CI: 0.01 - 0.03 , $p<0.001$). Severe myelopathy predicted significantly higher/worse 2-year NDI score (OR: 20.4, 95%CI: 10.5-30.4, $p<0.001$) and significantly lower/worse 2-year EQ-5D (OR: -0.1, 95%CI: -0.1 - -0.04 , $p=0.002$).

Conclusion

In patients undergoing adult cervical deformity surgery, more severe myelopathy was independently associated with longer length of stay and worse 2-year PROMs without an increase in complications/reoperations. These data support intervening before myelopathy ensues.

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

177. Pelvic Tilt Modifies the Effect of Cervicothoracic Kyphosis Correction on T1 Slope After Cervical Deformity Surgery

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Hypothesis

The effect of cervicothoracic correction on T1S is modified by preop pelvic tilt (PT).

Design

Retrospective analysis of prospective, multicenter study.

Introduction

T1 slope (T1S) is a key determinant in cervical deformity (CD). Despite cervical lordosis (CL) and thoracic kyphosis (TK) correction, unchanged or increased T1S may occur.

Methods

We analyzed 272 adult CD patients with pre- and postop 3 months imaging. T1S outcomes were categorized as T1S reduced (T1S-R, $>5^\circ$ decrease), T1S stable (T1S-S, $\pm 5^\circ$), or T1S increased (T1S-I, $>5^\circ$ increase) groups. We evaluated CL restoration, TK correction, preop PT, C2 tilt (C2T), global alignment parameters, surgical factors. Hierarchical regression assessed main effects for both CL and TK correction. Postop PT change (Δ PT) was measured to explore predicted compensation behavior.

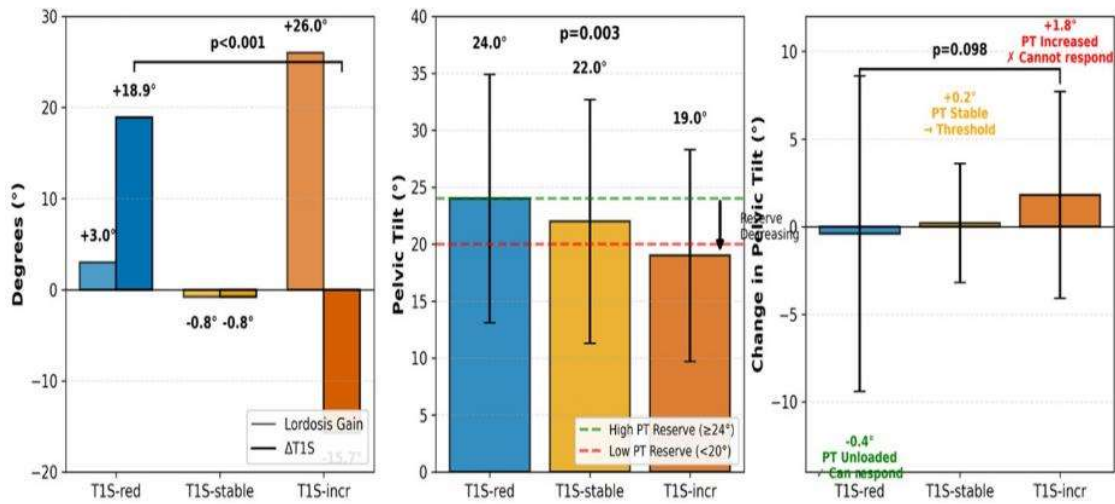
Results

Mean Δ T1S was $-0.3^\circ \pm 16.9^\circ$, with 32% achieving T1S-R ($>5^\circ$). A 3-tier T1S gradient emerged: T1S-R ($n=87$, Δ T1S $-19 \pm 12^\circ$), T1S-S ($n=79$, $-1^\circ \pm 3^\circ$), and T1S-I ($n=106$, $+16^\circ \pm 9^\circ$; $p<0.001$). The T1S-I group received greater CL correction than the T1S-R group ($+26^\circ$ vs $+3^\circ$, $p<0.001$) yet achieved similar postop CL ($+8^\circ$ vs $+6^\circ$, $p>0.1$). TK correction also differed (T1S-R $+6^\circ \pm 15^\circ$, T1S-S $-2^\circ \pm 6^\circ$, T1S-I $-6^\circ \pm 11^\circ$; $p<0.001$), with both CL and TK demonstrating similar correlations with Δ T1S ($r=0.5-0.6$). T1S-I predominantly upper thoracic LIV (74%) vs T1S-R lower thoracic LIV (47%). Upper thoracic 3 column osteotomy (UT3CO) was more frequent in T1S-R (21 vs 3%), (all $p<0.001$). Preop pelvic compensation demonstrated a clear gradient: PT was highest in T1S-R ($24.0^\circ \pm 10.9^\circ$) and lowest in the T1S-I group ($19.0^\circ \pm 9.3^\circ$; $p=0.003$), with parallel differences in C2T ($p<0.001$). Postop Δ PT was $-0.4^\circ \pm 9.0^\circ$ in the T1S-R group, $+0.2^\circ \pm 3.4^\circ$ in the T1S-S group and $+1.8^\circ \pm 5.9^\circ$ in the T1S-I group ($p=0.098$). Baseline PT and C2T were associated with Δ T1S, even accounting for CL and TK restoration. Including surgical factors, the model explained 62% of variance ($p<0.001$).

Conclusion

T1S can be reduced by more TK correction with UT3CO, caudal LIV after CD surgery but may also be modified by preop pelvic compensation reserve. High preop PT enables T1S reduction, whereas exhausted reserve predisposes to paradoxical T1S increase despite greater cervicothoracic correction. This suggests preop pelvic compensation as a predictor for risk stratification.

A) Greater CL correction associated with worse T1S outcomes, (B) Preop PT gradient, (C) Postop Δ PT trends



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

178. Is the Addition of Anterior Cervical Corpectomy Superior to Anterior Cervical Discectomy and Fusion Only for the Correction of Cervical Focal Kyphosis?

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Hypothesis

Patients undergoing anterior cervical discectomy and fusion with corpectomy (ACDF + Corp) will demonstrate significantly greater cervical focal kyphosis (CFK) correction than those undergoing anterior discectomy and fusion (ACDF) alone.

Design

Retrospective Comparative Cohort Study

Introduction

Preoperative focal kyphosis is associated with greater preoperative symptom burden and postoperative symptom recurrence, while surgical CFK correction correlates with improved clinical outcomes. Despite this, few studies compare the efficacy of various surgical approaches in correcting CFK. This study aims to compare CFK correction and surgical complication rates between ACDF alone and ACDF + Corpectomy.

Methods

We retrospectively reviewed patients with cervical spondylotic myelopathy who underwent ACDF or ACDF + Corpectomy. Inclusion criteria were preoperative CFK $> 0^\circ$ spanning 1-3 vertebral levels. Patients were stratified into ACDF and ACDF + Corp cohorts. Demographics, operative characteristics, radiographic parameters, and complications were collected. Wilcoxon rank-sum test and Fisher's exact tests were used with significance set to $P < 0.05$.

Results

68 pts were included, (mean age 59.8 ± 12.4 years) with 29 in the ACDF cohort and 39 in the ACDF + Corp cohort. Baseline demographics were similar, including comorbidities and prior cervical fusions. Both the ACDF + Corp and ACDF groups had similar preoperative radiographic alignment, including comparable CFK (6.7° vs 8.3° , $P = .741$). Immediate postoperative CFK correction was greater (-12.0° vs -8.4° , $P = .036$), and CFK was significantly less (-5.3° vs -0.15° , $P = .026$), in ACDF + Corp compared to ACDF alone. Immediate post-operative and final follow-up complications were comparable between the two groups.

Conclusion

In patients with preoperative cervical focal kyphosis (CFK), ACDF + Corpectomy creates greater immediate CFK correction and focal lordosis than ACDF alone with no increase in surgical complications. While ACDF also corrects CFK, these findings support consideration of ACDF + Corpectomy when greater immediate CFK correction is desired.

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

Demographics and Operative Characteristics

Variable	ACDF (n=29)	ACDF + Corp (n=39)	P-value
Age (years, mean ± SD)	58.4 ± 13.8	60.9 ± 11.3	.478
Female (N, %)	14 (48.3%)	16 (41.0%)	.625
BMI (kg/m ² , mean ± SD)	26.5 ± 5.1	28.6 ± 5.1	.337
Smoking History (N, %)	9 (31.0%)	15 (38.5%)	.612
Prior Cervical Fusion (N, %)	0 (0%)	2 (5.1%)	.504
Surpical Time (min, mean ± SD)	210.1 ± 86.7	225.3 ± 92.4	.603
Estimated Blood Loss (mL, mean ± SD)	73.7 ± 43.2	85.0 ± 34.5	.099
Neck Disability Index: Baseline (mean ± SD)	37.1 ± 19.2	28.0 ± 17.9	.180
Follow-up Period (months, mean ± SD)	16.7 ± 20.4	18.7 ± 21.7	.689

Number of Instrumented Levels

Levels	ACDF	ACDF + Corp	P-value
2 levels	8	5	
3 levels	11	20	
4 levels	10	12	
5 levels	0	2	
Overall Analysis			.26

Baseline Pre-Operative Radiographic Parameters (mean ± SD)

Parameter	ACDF	ACDF + Corp	P-value
C2-C7 Cervical Sagittal Angle (°)	-0.21 ± 12.2	-0.98 ± 11.7	.780
C2 Slope (°)	24.9 ± 12.6	23.6 ± 9.1	.968
T1 Slope (°)	28.3 ± 12.1	26.5 ± 10.5	.637
C2-C7 SVA (mm)	31.3 ± 18.5	29.8 ± 13.8	.920
Cervical Focal Kyphosis (°)	8.3 ± 8.3	6.7 ± 5.3	.741

Immediate Post-Operative Radiographic Parameters (mean ± SD)

Parameter	ACDF	ACDF + Corp	P-value
CSA (°)	-12.0 ± 14.0	-17.2 ± 9.6	.313
Δ CSA (°)	-11.4 ± 13.6	-16.0 ± 11.9	.242
C2 Slope (°)	21.0 ± 11.9	18.0 ± 8.6	.363
Δ C2 Slope (°)	-3.8 ± 8.2	-5.6 ± 10.5	.162
T1 Slope (°)	37.3 ± 7.1	35.4 ± 11.7	.373
Δ T1 Slope (°)	12.1 ± 7.2	7.4 ± 10.4	.052
cSVA (mm)	33.9 ± 18.2	28.2 ± 10.3	.447
Δ cSVA (mm)	2.4 ± 10.7	-1.2 ± 12.8	.358
CFK (°)	-0.15 ± 11.3	-5.3 ± 5.5	.026
Δ CFK (°)	-8.4 ± 11.1	-12.0 ± 7.2	.036

Complications (N, %)

Complication (Timepoint)	ACDF	ACDF + Corp	P-value
Wound Complication (90 Day)	0	1 (2.6%)	1
Wound Complication (2 Year)	0	1 (2.6%)	1
Mechanical Complication (90 Day)	0	1 (2.6%)	1
Mechanical Complication (2 Year)	0	0	1
Pseudarthrosis (2 Year)	1 (3.4%)	1 (2.6%)	1
Revision (90 Day)	0	1 (2.6%)	1
Revision (1 Year)	1 (3.4%)	0	1
Revision (2 Year)	0	1 (2.6%)	1
Dysphagia (90 Day)	7 (24.1%)	15 (38.5%)	.296
New Sensory Deficit (90 Day)	1 (2.9%)	0	1
New Sensory Deficit (2 Year)	1 (3.4%)	1 (2.6%)	1
New Motor Deficit (90 Day)	1 (3.4%)	1 (2.6%)	1
New Motor Deficit (2 Year)	0	0	1

Patient Reported Outcomes (mean ± SD)

Patient Reported Outcome (Timepoint)	ACDF	ACDF + Corp	P-value
NDI (6 Months)	9.7 ± 15.3	10.1 ± 10.6	.234

Table 1: Patient Characteristics, Radiographic Outcomes, and Complications Stratified by Procedure

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

179. Cervical Pedicle Screws are not the Safest Lateral Mass Screws are not the Best Fixation. What about Cervical Pedicle Inlet?

Mahmoud AbuAlkebash, MD; Jeffrey Gum, MD; Steven D. Glassman, MD; Haseeb Tariq, BS

Hypothesis

Hounsfield units (HU) will be greater in the pedicle inlet compared to lateral mass

Design

Retrospective observational cross- sectional study

Introduction

Cervical deformity correction or fusions into the cervical spine are rising, increasing the need for optimal cervical fixation. Lateral mass screw fixation is widely used in the posterior cervical spine as it is safe relative to vital structures. A recent technique alters the traditional lateral mass screw trajectory through the pedicle inlet. Improved mechanical stability with this trajectory may be due to superior bone quality around the pedicle inlet compared to the lateral mass, particularly in elderly and osteoporotic patients.

Methods

Patients aged 40-80, with no prior cervical surgeries, a DXA scan within 14 months of a cervical CT were identified. HU were obtained from axial CT scans from C3 to C6 bilaterally for both trajectories. Elliptical regions of interest (Figure 1), 10mm x 3.5mm to simulate screws sizes and trajectories, were created in the lateral mass (white ellipse) and pedicle inlet (black ellipse). DXA T-scores, BMD, BMI, smoking history, chronic medications, and comorbidities were collected.

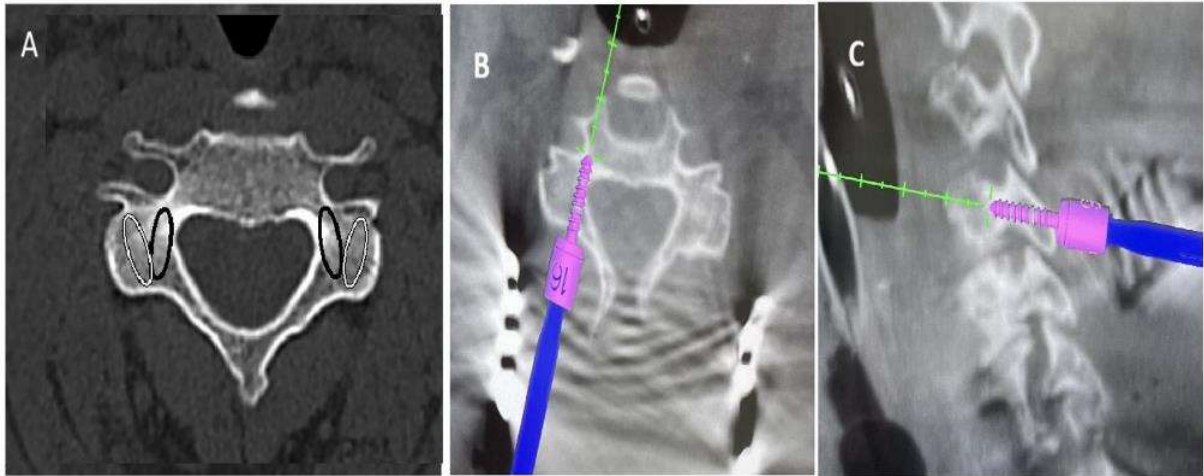
Results

45 patients met inclusion criteria, mean age of 61.5 years; 9 were osteoporotic, 16 were osteopenic and 14 were normal based on DXA T-scores. There was a statistically significant difference in HUs between the lateral mass (498.38 ± 175.89) and pedicle inlet (765.09 ± 213.36 , $p < 0.001$). There was a statistically significant decrease in lateral mass HUs between normal (521.03 ± 178.12), osteopenic (496.95 ± 183.36) and osteoporotic (445.58 ± 146.06 , $p = 0.010$) cases. This decrease was not seen in the pedicle inlet HUs (793.86 ± 175.70 , 738.84 ± 253.92 , 739.11 ± 209.16 , $p = 0.053$). There were no statistically significant associations between age and lateral mass HUs or pedicle inlet HUs.

Conclusion

BMD in the pedicle inlet is 65% higher than that in the lateral mass, partially explaining the improved mechanical stability and pull-out strength. A decrease in lateral mass BMD is seen in osteopenic/osteoporotic patients is not seen in the pedicle inlet BMD. This may confer an advantage to pedicle inlet screws over the lateral mass. The pedicle inlet trajectory may satisfy the increasing need for optimal cervical fixation.

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



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

180. The Influence of Halo-Gravity and Halo-Pelvic Traction on Osteotomy Grades in Severe Spinal Deformities: A Retrospective Study Based on Predictive Modeling

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

Hypothesis

Preoperative traction is effective for reducing the severity of spinal deformity and osteotomy grade

Design

Retrospective

Introduction

The traction technique is beneficial for treating severe spinal deformities, but the impact of preoperative traction on reducing osteotomy grade remains unclear.

Methods

Sixty patients with severe spinal deformity underwent preoperative Halo-pelvic traction (HPT) or Halo-Gravity traction (HGT) were included. Radiographic assessments were conducted at the beginning and end of traction, as well as during postoperative follow-up. Changes in osteotomy grade were evaluated using the osteotomy grade classification predictive model. Differences in the orthopedic effects and contribution to reducing osteotomy grade between the two traction methods were compared using inverse probability of treatment weighting (IPTW).

Results

This model can effectively anticipate the osteotomy grade. Before traction, the sagittal kyphosis was $131.82 \pm 30.29^\circ$, and the scoliosis was $132.70 \pm 28.77^\circ$, with a predicted average osteotomy grade of 5.1 ± 0.9242 . After traction, there was an average decrease of $34.3 \pm 29.5^\circ$ in the sagittal kyphosis and $31.8 \pm 20.8^\circ$ in the scoliosis angle. A significant reduction of 0.958 ± 1.01 in osteotomy grade post-traction compared to pre-traction was observed ($p < 0.001$). Moreover, the actual osteotomy grade decreased by 0.758 ± 1.022 compared to the predicted osteotomy grade before traction ($p < 0.001$). After IPTW adjustment, the efficacy of the two traction methods in reducing osteotomy grade was comparable; however, HPT demonstrated a significantly greater reduction in sagittal deformity angular ratio (SDAR) compared to HGT ($p = 0.014$), with notable advantages in kyphosis correction rate ($p < 0.001$).

Conclusion

This is the first study to utilize a precise osteotomy prediction model to quantify the effects of traction in patients with severe spinal deformity. The results illustrate that preoperative traction can effectively decrease the osteotomy grade in patients with severe spinal deformity. Importantly, for cases of severe spinal deformity, the preoperative HPT regimen outperforms the HGT in our study. These findings are crucial for clinical decision-making regarding severe spinal deformities.

181. Safety and Efficacy of One-Stage Spine-Shortening by Using Posterior Vertebral Column Resection for Severe Spinal Deformity Associated with Multiple Spinal Cord Malformation

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

Hypothesis

To elevate the safety and efficacy of spine-shortening by using posterior vertebral column resection (PVCR) for severe rigid spinal deformity with cord malformations.

Design

Retrospective case series.

Introduction

One-stage spinal-shortening osteotomy are suggested in previous articles for cord tethered treatment. However, the safety and efficacy of one-stage spinal-shortening osteotomy in the treatment of severe spinal deformity with variety cord malformations is still limit.

Methods

The records of 32 severe spinal deformity patients with variety cord malformations treated with spine-shortening by using vertebral column resection were retrospectively analyzed. Intraoperative combined monitoring of SEPs, MEPs and DNEPs was used in all cases. Radiographic parameters and neurological complications were analyzed to evaluate the clinical safety and efficacy.

Results

Spine-shortening by using PVCR were successfully conducted in all 32 patients. The mean main curve and kyphosis were corrected from 119.8° and 119.1° to 58.6° and 53.9°, with 51.4% and 54.3% corrective rates, respectively. The average correction loss of major curve and kyphosis were 2.3° and 2.6° respectively at mean 37.6 months follow-up. Intra-operative monitoring events occurred in 9 patients, of these patients, three were transient spinal cord injury who all recovered within one year (without complete paralysis).

Conclusion

Spine-shortening by using PVCR were successfully conducted in all 32 patients. The mean main curve and kyphosis were corrected from 119.8° and 119.1° to 58.6° and 53.9°, with 51.4% and 54.3% corrective rates, respectively. The average correction loss of major curve and kyphosis were 2.3° and 2.6° respectively at mean 37.6 months follow-up. Intra-operative monitoring events occurred in 9 patients, of these patients, three were transient spinal cord injury who all recovered within one year (without complete paralysis).

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

182. Beyond Cord Compression: Instability is a major driver for neurological deficit in Active Thoracic Spinal Tuberculosis

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Hypothesis

Mechanical instability, as assessed by the Spinal Tuberculosis Instability Scoring System (STISS), is an independent and dominant driver of neurological deficit in thoracic spinal TB.

Design

Retrospective observational study

Introduction

Neurological deficit remains the most serious complication of spinal TB, often leading to irreversible disability. While canal compromise, kyphotic deformity, and cord signal changes have been extensively studied as predictors, the role of mechanical instability has not been systematically assessed. This study aimed to evaluate the association between mechanical instability and neurological deficit in thoracic spinal TB and to compare its predictive strength against established radiological parameters.

Methods

Clinical and radiological data of 122 patients with active thoracic spinal TB were analysed. Instability was assessed using the STISS and categorised as stable, potentially unstable, or definitely unstable. Neurological status was documented at presentation. Radiological parameters, including canal encroachment area (CEA), kyphotic deformity, vertebral body loss, spine-at-risk signs, cord signal changes, and epidural compression, were evaluated.

Results

The mean age of the cohort was 51 ± 18 years, with 54.9% of participants male. Neurological deficit was present in 40 patients (32.8%). Based on STISS, 71 (58%) were stable, 10 (8.2%) were potentially unstable, and 41 (34%) were definitely unstable. MRI revealed cord signal changes in 18% and epidural compression in 64%. Definite instability emerged as the strongest independent predictor of neurological deficit (OR 9.77, 95% CI 2.85–38.9, $p < 0.001$), followed by greater canal encroachment area (OR 1.08, 95% CI 1.03–1.13, $p = 0.002$). In stable spines with epidural compression, the predicted probability of neurological deficit was 27%. In unstable spines, the likelihood was 50% even without epidural compression, and it was highest (63%) when instability coexisted with epidural compression.

Conclusion

Mechanical instability in thoracic spinal TB is an independent and dominant predictor of neurological deficit, even in the absence of epidural compression. Incorporating the STISS into routine clinical evaluation enhances risk stratification, facilitates timely surgical decision-making, and may prevent irreversible neurological deterioration.

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

183. Does Surgical Approach Affect Reoperation Rate in Surgical Treatment of L4-5 Degenerative Spondylolisthesis?

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Hypothesis

There is no difference between reoperation rate for surgical treatment of L4-5 spondylolisthesis using different surgical approaches.

Design

Retrospective Cohort Study

Introduction

Degenerative L4-5 spondylolisthesis is a common pathology and often treated with spinal fusion. However, few studies have compared the outcomes of different surgical approaches. The purpose of this study was to investigate reoperation rate for treatment of L4-5 spondylolisthesis using different surgical approaches.

Methods

We used data from a US-based integrated healthcare system. Adult patients with L4-5 spondylolisthesis who underwent lumbar fusion (2009-2024) were included. Patients were divided into four groups, 1) posterolateral fusion and instrumentation (PSF), reference group, 2) anterior interbody fusion and posterior instrumentation (ALIF+PS), 3) transforaminal interbody fusion and posterior instrumentation (TLIF+PS), 4) lateral interbody fusion and posterior instrumentation (LLIF+PS). Cox proportional hazards regression was used to evaluate reoperation risk for acute reasons (infection, hematoma/seroma, and wound dehiscence) and delayed reasons (adjacent segment disease (ASD) and nonunion)

Results

4,454 cases met the inclusion criteria: 2,019 with PSF, 363 with ALIF+PS, 1,789 with TLIF+PS, and 183 with LLIF+PS. Median follow-up was 4.5 years (interquartile range 2.1-6.7). Acute reoperation rate was 3.1%, 0.2%, 1.9%, and 0.6% respectively. Acute reoperation was rare in ALIF +PS and LLIF+PS groups and no difference was observed for TLIF+PS vs PSF. ASD had a 5-year incidence of 10.1%, 9.1%, 10.4%, and 9.6% for the respective groups, no differences were observed in ASD risk for ALIF+PS, TLIF+PS, and LLIF+PS compared to PSF. Nonunion incidence was 3.8%, 3.9%, 1.5% and 1.5% respectively at 5-years. No difference was observed for nonunion risk for ALIF+PS, however, a lower risk was observed for TLIF+PS compared with PSF. (Table 1).

Conclusion

In this large cohort, we found a lower risk of reoperation for nonunion in patients who underwent TLIF+PS compared to PSF, and a rare incidence of nonunion in LLIF+PS group. There was no difference between PSF and other groups for ASD. Additionally, acute reoperation was rare in ALIF +PS and LLIF+PS groups, however due to the low number of events this could not be analyzed with this statistical regression model.

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

Table 1. Operative Outcomes by Surgical Technique.

Reoperations, n events (5-year CIF)	PSF (n=2,019)	ALIF+PS (n=463)	ALIF+PS vs PSF	TLIF+PS (n=1,789)	TLIF+PS vs PSF	LLIF+PS (n=183)	LLIF+PS vs PSF
			Adjusted HR (95% CI), P-Value		Adjusted HR (95% CI), P-Value		Adjusted HR (95% CI), P-Value
Acute reoperations	62 (3.1)	1 (0.2)	—	34 (1.9)	0.75 (0.46-1.21), p=0.23	1 (0.6)	—
ASD	176 (10.1)	40 (9.1)	0.96 (0.68-1.36), P=0.81	144 (10.4)	0.96 (0.76-1.21), P=0.81	7 (9.6)	0.84 (0.41-1.72), P=0.64
Non-union	67 (3.8)	19 (3.9)	1.33 (0.65-2.74), P=0.44	21 (1.5)	0.36 (0.20-0.64), P=0.0006	2 (1.5)	—
Mean follow up years (standard deviation)	4.7 (2.6)	5.5 (2.8)		4.3 (2.7)		2.4 (2.1)	

CIF= cumulative incidence function, HR= hazard ratio, CI= confidence interval, PSF = Posterior spinal fusion, ALIF+PS = anterior interbody fusion + pedicle screw, TLIF+PS= transforaminal interbody fusion + pedicle screw, LLIF+PS= Lateral interbody fusion + pedicle screw

Models adjusted for age, BMI, gender, race/ethnicity, ASA category, BMP use, rod material, peripheral vascular disease

Acute reoperations include infection, hematoma/seroma, and wound dehiscence

— could not assess due to a low number of events

Figure 1. Cumulative Incidence of ASD reoperations.

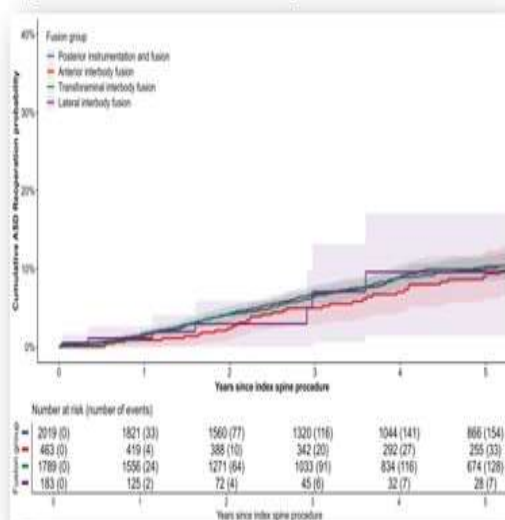


Figure 2. Cumulative Incidence of Nonunions.

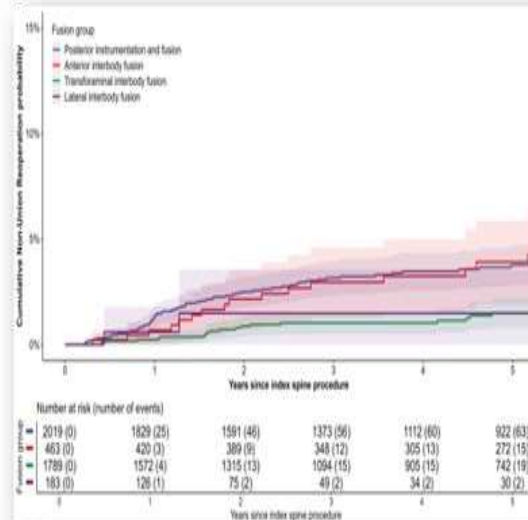


Table 1. Figure 1. Figure 2.

184. Sagittal Spinal Shape Remodeling and Inflection Point Migration After Anterior Versus Posterior Short-Segment Lumbar Fusion

Erh Ti E. Lin, MD; Yi Hsun Huang, MD; Jyun Hong Kuan, MD; Ben Long Shi, MD; Yi Chin Fong, MD, PhD; Yong Qiu, PhD; Yuan Shun Lo, MD, PhD

Hypothesis

Anterior short-segment lumbar fusion better preserves sagittal spinal shape (SSS) geometry and inflection point (IP) location, resulting in superior clinical outcomes and lower reoperation rates compared with posterior fusion.

Design

Retrospective cohort study.

Introduction

Sagittal alignment is a key determinant of outcomes after lumbar fusion. Beyond traditional spinopelvic parameters, sagittal spinal shape (SSS) geometry, particularly the locations of curve apexes and the inflection point (IP), may better reflect age-related and surgery-induced remodeling. However, how different surgical approaches influence SSS and its clinical relevance remains unclear.

Methods

We retrospectively analyzed 215 patients undergoing short-segment (≤ 5 levels) lumbar fusion for degenerative disease. Patients were divided into an anterior group (OLIF with percutaneous posterior instrumentation, $n=103$) and a posterior group (TLIF, $n=112$). Whole-spine standing radiographs were obtained preoperatively, postoperatively, and at 1-year follow-up. Spinopelvic parameters and SSS geometric features, including thoracic apex (TA), lumbar apex (LA), inflection point (IP), and SVAratio, were measured. Clinical outcomes were assessed using VAS, ODI, and SRS-22. Associations between SSS relocation and adverse outcomes or reoperation were analyzed.

Results

The posterior group showed greater early correction of C7 SVA and PI–LL mismatch, but these differences were not maintained at final follow-up. The anterior group demonstrated significantly greater cranial preservation of LA, TA, and IP, whereas the posterior group exhibited significant caudal migration of the IP over time. A postoperative downward shift of the IP was a strong predictor in univariate analysis of poor clinical outcome and reoperation. The anterior group achieved higher MCID rates for leg pain and had lower adverse event and reoperation rates (2.9% vs. 20.5%, $p < 0.001$). Preservation of youthful SSS geometry and stable IP location was associated with superior patient-reported outcomes.

Conclusion

Anterior and posterior approaches yield different SSS remodeling patterns. Anterior fusion better preserves SSS geometry, stabilizes alignment, and improves outcomes, supporting its consideration in lumbar short-segment fusion surgery.

185. Prevalence of Severe Sagittal Malalignment in Patients Undergoing Short-Segment Lumbar Fusion

Michael Farias, BS; Joseph E. Nassar, BS; Manjot Singh, BS; Alex Hernandez, BS; Zvipo Chisango, BS; Gabriel Gonzalez, BS; Catherine B. Hurley, MS; John Czerwein, MD; Bassel G. Diebo, MD; Eren Kuris, MD; Alan H. Daniels, MD

Hypothesis

Patients undergoing short-segment lumbar fusion have high prevalence of baseline sagittal alignment.

Design

Retrospective Cohort Study

Introduction

Short-segment 1-2 level lumbar fusion is frequently performed to address localized degenerative spine conditions. However, the prevalence and impact of baseline sagittal malalignment in these patients are not well understood. This study aimed to determine the prevalence and severity of baseline sagittal malalignment using Schwab modifiers and segmental L4-S1 lordosis in patients undergoing short-segment lumbar fusion.

Methods

Adult patients (≥ 18 years) who underwent 1-2 level lumbar interbody fusion were included. Sagittal alignment was classified using SRS-Schwab modifiers: pelvic incidence-lumbar lordosis (PI-LL; 0: $<10^\circ$, +: $10-20^\circ$, ++: $>20^\circ$), pelvic tilt (PT; 0: $<20^\circ$, +: $20-30^\circ$, ++: $>30^\circ$), and sagittal vertical axis (SVA; 0: <40 mm, +: $40-95$ mm, ++: >95 mm). SVA was assessed in a sub-group with full-body radiographs. Schwab modifier distribution was described overall and compared across age groups (<40 , $40-60$, >60 years), and surgical history (primary or revision) using chi-square analyses. Regional L4-S1 alignment was also compared across Schwab modifiers.

Results

Among 1,023 patients (mean age = 59.0 years, 54.5% female), 21.0% met severe SRS-Schwab criteria overall. Individually, 12.1% had PT++, 15.0% PI-LL++, and 14.6% SVA++. Severe malalignment rose with age (PT++: 5.1% <40 yrs, 8.9% $40-60$ yrs, 15.8% >60 yrs; PI-LL++: 3.8%, 10.0%, 20.5%; SVA++: 0.0%, 4.7%, 21.1%; all $p < 0.01$). Revision fusions showed greater deformity (PT++: 21.7% vs 10.4%; PI-LL++: 24.3% vs 13.3%; $p < 0.01$ for both). Decreased regional L4-S1 lordosis was significantly associated with increasing PT (0: 33.5° , +: 30.9° , ++: 24.2°), PI-LL (0: 33.5° , +: 31.7° , ++: 23.7°), and SVA (0: 33.0° , +: 28.2° , ++: 21.3°).

Conclusion

In this study of over 1,000 patients undergoing 1-2 level lumbar fusion, over 20% had baseline severe SRS-Schwab ++ sagittal malalignment. Rates of severe sagittal malalignment were higher in patients with increasing age and those undergoing revision fusion. These findings underscore the importance of standard preoperative assessment of segmental, regional, and global sagittal alignment to guide surgical planning and potentially prevent iatrogenic deformities.

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

186. Surgeon Achievement of Computer-Assisted Planning Targets in Lumbar Fusion Surgery: A Learning Curve Analysis

Catherine B. Hurley, MS; Michael Farias, BS; Feyza Achilova; Gabriel Gonzalez, BS; Nicolas Carayannopoulos, BS; John Czerwein, MD; Dina Kaplan, BS; Joseph E. Nassar, BS; Bassel G. Diebo, MD; Eren Kuris, MD; Alan H. Daniels, MD

Hypothesis

Surgeon achievement of computer-assisted patient-specific pre-contoured rod alignment targets in short-segment lumbar fusion improves over time.

Design

Retrospective cohort

Introduction

Computer-assisted surgical planning systems guide spinal fusion surgery through quantitative targets, yet success in achieving these targets remains poorly characterized. This study characterizes surgeon success in achieving patient-specific pre-contoured rod (PSPR) planned targets in lumbar fusion.

Methods

Patients undergoing degenerative spinal fusion procedures (≤ 3 -level constructs) who underwent PSRS planning between 2019 and 2025 were retrospectively reviewed. Target achievement was defined as postoperative measurement within 4° or 4 mm of the PSPR-planned values. Achievement rates were assessed overall and for SRS-Schwab modifiers. Learning curves were evaluated using: (1) chronological quartiles based on surgery date, and (2) sequential case number quartiles, with 60 patients per period.

Results

The overall achievement rate was 59.0% across 242 patients. Achievement rate varied significantly by parameter: L1 pelvic angle (L1PA) demonstrated the highest success (74.7%), followed by PI-LL (51.9%), L4-S1 (46.7%), and lumbar lordosis (47.5%) in patients with available L1PA measurements ($n=158$; $p < 0.001$). PT demonstrated higher achievement than PI-LL (63.6% vs 50.8%, $p = 0.010$), L4-S1 ($p < 0.001$), and lumbar lordosis ($p < 0.001$). SVA had the lowest achievement rate (7.1%). Achievement rates increased by 14.9% from 47.9% between October 2019 and April 2022 (first quartile) to 62.8% between June 2023 and May 2024 (third quartile). Between May 2024 and June 2025 (i.e., the most recent quartile), the achievement rate was 60.2%, demonstrating an overall improvement of 12.3% from first to last quartile.

Conclusion

Surgeons achieve approximately 60% of computer-assisted planning targets in lumbar fusion surgery, with substantial variability across radiographic parameters. Improvement over time demonstrates a clear learning curve, suggesting increased aptitude with PSPR adoption. Pelvic parameters show consistently high achievement, whereas SVA remains difficult to achieve, likely reflecting dependence on global spinal alignment beyond the surgical construct. The recent plateau in achievement may reflect need for further refinement of planning algorithms and intraoperative execution.

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

187. Patient-Reported Outcomes in Pediatric Spondylolysis

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Hypothesis

Baseline functional impairment in pediatric spondylolysis is due to increased pain and a decrease in physical activity.

Design

Cross-sectional study.

Introduction

Lumbar spondylolysis is a common cause of back pain in children and the leading identifiable cause in young athletes. Patient-Reported Outcomes Measurement Information System [PROMIS] scores for newly diagnosed spondylolysis have not been previously reported.

Methods

We analyzed PROMIS scores in new patients with symptomatic spondylolysis who were newly diagnosed (mean age 15.6 years, range 7-23) from a single institution. Three domains were assessed: pain interference (N=156), depressive symptoms (N=152), and physical activity (N=142). Scores were compared to published pediatric reference norms which included severity score cut off points. Cohen's d was calculated for effect size.

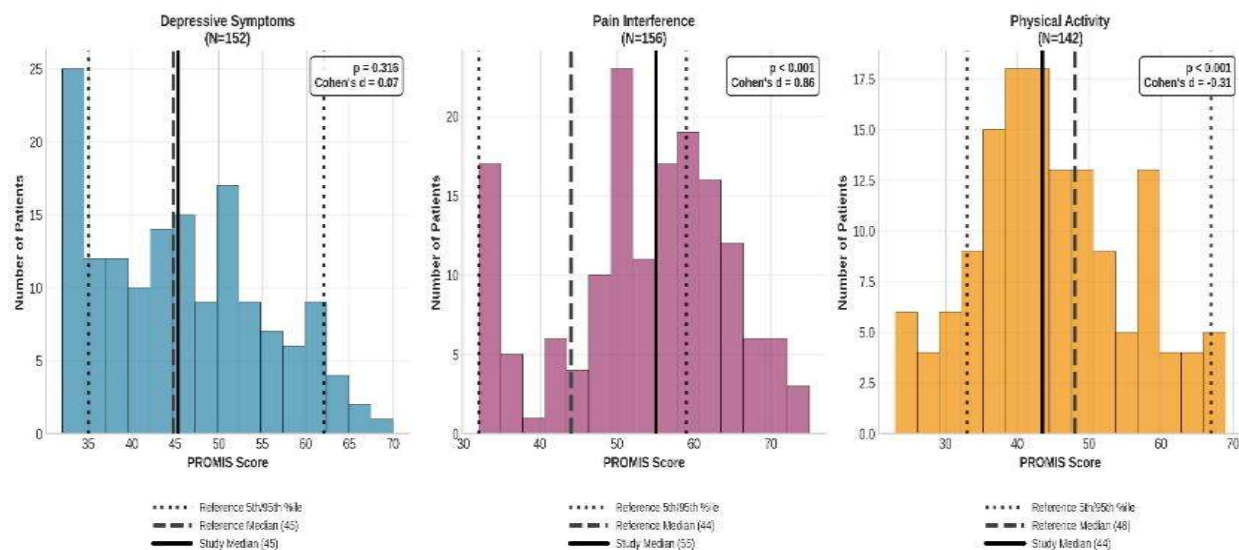
Results

Patients with spondylolysis reported significantly elevated pain interference (mean 53.5 vs. 44, Cohen's d=0.86, p<0.001). Thirty-three percent of patients reported severe pain interference, and 40% had moderate-severe pain interference. Physical activity was significantly lower in spondylolysis patients (mean 44.7 vs. 48, Cohen's d=-0.31, p<0.001). Spondylolysis was not associated with elevated depressive symptoms (mean 45.7 vs. 45, Cohen's d=0.07, p=0.316). Within the cohort, patients 16 and older reported more pain (58 vs. 51, p<0.001) and depressive symptoms (mean 49 vs. 44, p=0.014) than patients less than 16 years old with spondylolysis.

Conclusion

This is the first study to use PROMIS scores to demonstrate patient-reported outcomes in young people with newly diagnosed spondylolysis. Pain interference is the dominant patient-reported feature in this pediatric spondylolysis group, affecting one-third at severe levels. Depressive symptoms do not differ from norms.

Figure 1. Spondylolysis Patients' PROMIS Score Distribution vs. Reference Population



Distribution of PROMIS T-scores for depressive symptoms, pain interference, and physical activity in spondylolysis patients compared to reference population. Solid black lines indicate study medians; dashed black lines indicate reference medians. Dotted black lines represent reference 5th and 95th percentiles. For depressive symptoms, the study median was not statistically different from the reference median (45).

188. Back in the Game: High Return-to-Sport Following Direct Pars Repair in Young Patients

Sydney Thai, BS; Krystell E Ceballos Alvarez, BS; Emmanuel N. Menga, MD; Paul D. Sponseller, MD; Amit Jain, MD, MBA

Hypothesis

We hypothesize that Buck's direct repair will allow patients to return to pre-injury activity levels and result in good clinical outcomes.

Design

Retrospective cohort

Introduction

Direct repair and intralaminar screw fixation are among the most popular surgical treatments for spondylolysis. The aim of this study is to analyze the radiographic and clinical outcomes of patients undergoing direct pars repair at a single institution.

Methods

A single-center retrospective review was conducted of patients currently aged <25 years who underwent direct grafting and fixation with an intralaminar screw (Buck's technique) for spondylolysis repair over a 25-year period. Predisposing factors (mechanism, duration and methods of conservative treatment, level, and laterality); radiographic parameters (lysis distance and disc health), computed tomography (CT), and magnetic resonance imaging (MRI); and operative data (procedure, operative time, implants used, blood loss, and length of stay) were abstracted. Revision operations, complications, time to return to activity, and patient-reported outcomes were analyzed. Modified Odom criteria were used with the following definitions: "Excellent" outcome was defined as >90% pain relief and return to preinjury sport, while "good" was defined as >80% pain relief without requiring return to sport.

Results

87 patients were included in the study; average age at procedure was 16 years; 95% were competitive athletes. Preoperatively, 71 of 87 patients (82%) discontinued sports entirely. Sixty-one (70%) tried bracing for an average of 4 months, and 59 (68%) patients tried physical therapy (PT); mean duration of symptoms was 20 months. The mean preoperative VAS score was 6.0 and improved to 1.3 postoperatively ($p<0.001$). Average time to return to activity was 3.3 months after surgery. Twelve patients (14%) experienced complications, including 6 revision surgeries. Lysis distance on X-ray, CT, and MRI were not significantly associated with pain improvement. The caudal disc height, cephalad and caudal disc Pfirrmann grade were significantly associated with postoperative VAS scores ($p<0.05$). The mean duration of follow-up after surgery was 15.7 $\pm$ 18.5 months (range, 1 month – 92 months). 97% of patients returned to sports or baseline activity postoperatively.

Conclusion

The direct pars repair to treat spondylolysis-related low back pain results in clinical success in majority of young patients.

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