

43. Thoracic Kyphosis Restoration Is Associated with Improvement of the L1 Pelvic Angle in Thoracic Adolescent Idiopathic Scoliosis

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Hypothesis

In thoracic adolescent idiopathic scoliosis (AIS), restoring thoracic kyphosis (TK) helps normalize the L1 pelvic angle (LPA) with minimal impact on global alignment.

Design

Retrospective cohort study.

Introduction

Thoracic AIS is commonly associated with hypokyphosis, which may induce compensatory changes in lumbar and pelvic alignment. LPA integrates lumbar alignment relative to pelvic morphology and may serve as a sensitive marker of lumbopelvic compensation. However, the impact of TK restoration on LPA in thoracic AIS remains uncertain.

Methods

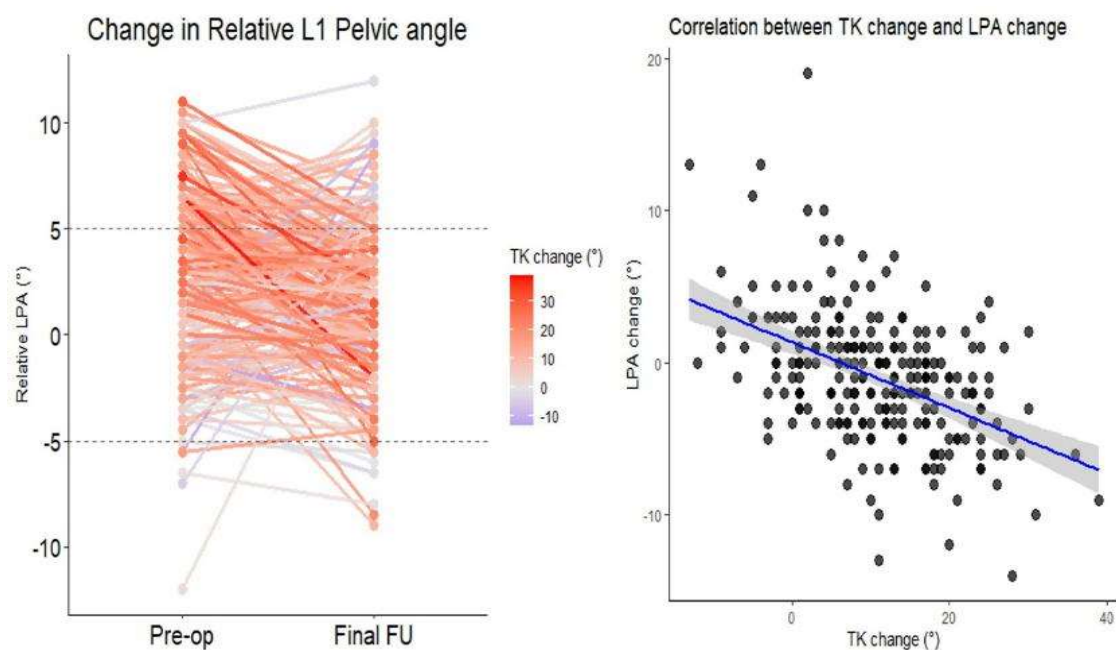
This study included 239 patients (mean age, 16 ± 4 years; 88% female; Lenke type 1, 51%; type 2, 49%; sagittal modifier –, 49%) with AIS who underwent posterior spinal fusion and had a minimum two-year follow-up. Radiographic sagittal parameters, including LPA and T4 pelvic angle (T4PA), were measured preoperatively and at final follow-up. Ideal LPA was defined as $0.5 \times PI - 21$, and relative LPA was defined as the difference between measured and ideal LPA. Associations between $\Delta TK(T5-12)$ and changes in sagittal parameters were evaluated using Pearson correlation.

Results

TK increased from 10.8° preoperatively to 21.7° at final follow-up ($p < 0.001$). Relative LPA improved from 4.7° to 3.7° ($p < 0.001$), and the proportion within the normal range ($\pm 5^\circ$) increased from 52% to 63%. In sagittal modifier– patients, relative LPA improved from 6.4° to 4.0° , with the normal-range proportion increasing from 34% to 61%. ΔTK correlated with ΔLPA ($r = -0.46$, $p < 0.001$), corresponding to LPA normalization (see image). ΔTK also correlated with $\Delta C2-7$ ($r = -0.45$) and $\Delta L1-S1$ ($r = -0.41$) kyphosis, showed a weak correlation with $\Delta T4PA$ ($r = 0.30$), and no correlation with ΔTPA . Mean $T4PA-LPA$ was -2.1° preoperatively and -2.0° at final follow-up, and the proportion within the normal range ($\pm 4^\circ$) showed no significant change (71.1% vs 73.6%).

Conclusion

In thoracic AIS, particularly in patients with hypokyphosis, LPA was increased, suggesting compensation for reduced TK through decreased LL and pelvic retroversion. Surgical restoration of TK facilitated normalization of lumbopelvic alignment; however, its impact on global sagittal alignment was limited.



Individual changes in relative LPA from preoperative to final follow-up (left), with dashed lines indicating the normal range ($\pm 5^\circ$). Changes in TK showed a significant negative correlation with changes in LPA (right; $r = -0.46$, $p < 0.001$).

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

44. Global Sagittal Equilibrium in Pediatric Scoliosis is Maintained Postoperatively via Compensations Rather than Construct Optimization

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Hypothesis

We posit that the C2 tilt = 0 relationship is maintained pre- and postoperatively regardless of achievement of regional PI-based anatomic targets, reflecting the immense compensatory ability of pediatric patients

Design

Retrospective review

Introduction

Maintaining global sagittal balance is paramount. C2-Pelvic Angle (C2PA) reflects global balance with a goal of C2 tilt = 0. Since $C2\ tilt = C2PA - PT$, $C2PA \approx \text{pelvic tilt (PT)}$. In typical anatomy, C2PA and PT are both functions of pelvic incidence (PI). However, longitudinal postoperative changes to PT and PI in Juvenile and Adolescent Idiopathic Scoliosis (J/AIS) requires quantification.

Methods

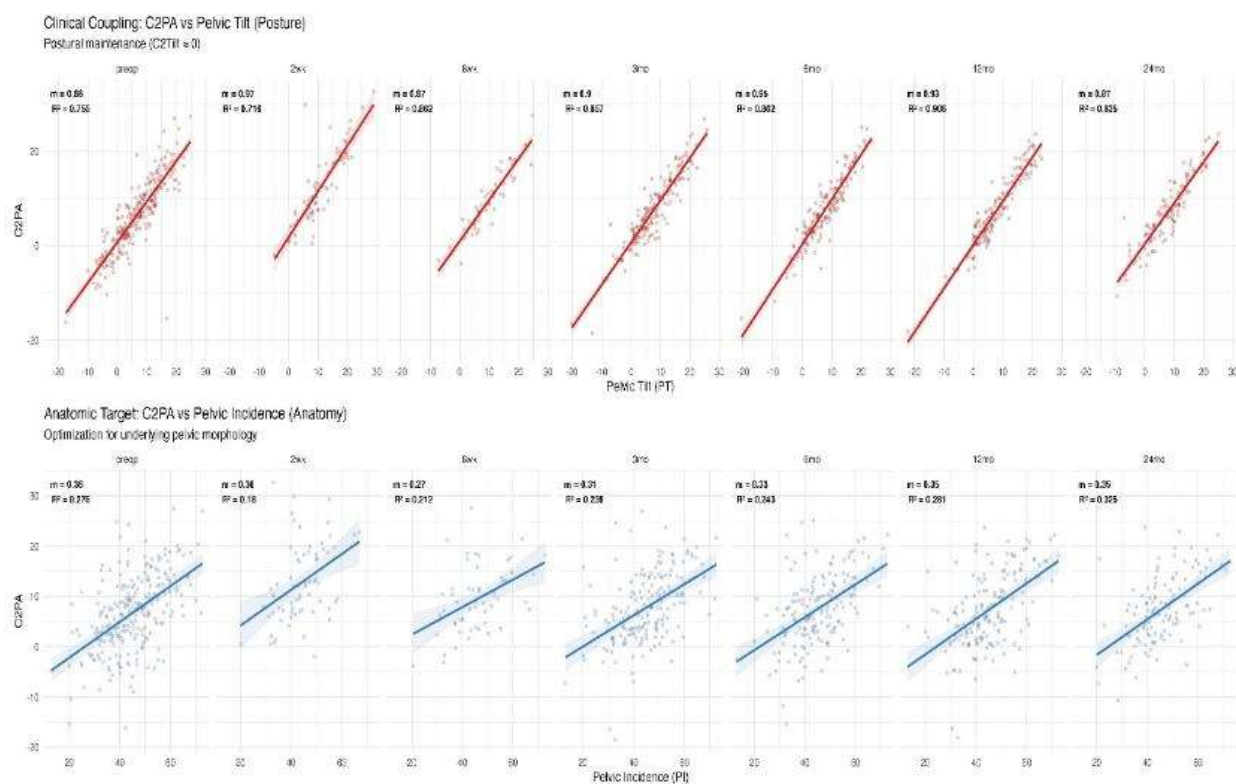
We retrospectively analyzed 251 JIS and AIS patients after instrumented spinal fusion. Standing full-spine lateral radiographs were evaluated pre- and post-operatively at 2 weeks, 6 weeks, 3 months, 6 months, 12 months, and 24 months. Linear regression was utilized to assess global postural coupling (C2PA vs. PT) and the regional anatomic target (C2PA vs. PI) across time.

Results

The $C2PA \approx PT$ relationship demonstrated clear postural coupling from preoperative baseline through 24 months. Across all intervals, correlation remained high (mean $R^2 = 0.83$; range 0.71–0.90) with slopes consistently approaching 1.0 (range 0.86–0.97). In stark contrast, the relationship between global balance and regional balance (C2PA vs. PI) was consistently weak (mean $R^2 = 0.25$; range 0.18–0.32), with significantly lower slopes (≈ 0.35). While global parameters stabilized into a final compensated state by 3 months postoperatively ($p > 0.05$), this balance was driven by postural maintenance ($C2\ tilt \approx 0$) rather than optimization for the patient's underlying pelvic morphology.

Conclusion

In patients with JIS and AIS, global sagittal balance is maintained via a constant, invariant postural equivalence where $C2PA \approx PT$ ($C2\ tilt \approx 0$). While the pediatric spine and pelvis demonstrate an immense capacity to preserve global equilibrium, the high correlation in postural coupling versus the profound discrepancy in anatomic alignment suggest that the system prioritizes global balance over PI-based regional optimization. While patients may appear balanced in the short-term, their global position is often uncoupled from their individual regional anatomic requirements.



Global compensation (C2 tilt = 0, $R^2 > 0.7$) despite poor PI-driven C2PA correlation ($R^2 < 0.35$)

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

45. Impact of Three-Dimensional Thoracic Hypokyphosis on Lower Cervical Degeneration and Cervical Alignment After Deformity Correction in Adolescent Idiopathic Scoliosis

Hong Jin Kim, MD, PhD; Chang Hwa Ham, MD; Subin Lim, MD; Hyung Rae Lee, MD; Jae Hyuk Yang, MD, PhD; Seung Woo Suh, MD, PhD

Hypothesis

Thoracic hypokyphosis in adolescent idiopathic scoliosis (AIS) is associated with cervical disc degeneration, and restoration of three-dimensional (3D) thoracic kyphosis (TK) improves postoperative cervical alignment.

Design

Retrospective study

Introduction

Thoracic hypokyphosis is common in AIS and may adversely affect cervical alignment; however, its relationship with cervical degeneration and sagittal alignment in a three-dimensional context remains unclear. This study evaluated the association between 3D hypo-TK, cervical degeneration, and cervical alignment, and assessed the impact of kyphosis restoration after deformity correction.

Methods

A total of 195 patients with AIS who underwent posterior deformity correction were retrospectively reviewed. Following calculation of 3D TK using a formula $18.1 + 0.81 * (2D\ TK) - 0.54 * (2D\ coronal\ Cobb)$, the patients were categorized into hypo-TK and control groups. The DSI2 score and sagittal grade of herniation on preoperative magnetic resonance imaging were measured to evaluate disc degeneration and herniation. Cervical alignment parameters, including cervical lordosis (CL), T1 slope (T1S), and cervical sagittal vertical axis (cSVA), were evaluated preoperatively, postoperatively, and at 2-year follow-up.

Results

The hypo-TK group demonstrated a higher prevalence of lower cervical disc degeneration, predominantly at C6-7 level ($P = 0.010$), compared with control group. Preoperative 3D TK showed significant correlations with cervical lordosis ($r = 0.34$, $P < 0.001$), T1 slope ($r = 0.45$, $P < 0.001$), and the lowest DSI-2 level ($r = -0.27$, $P = 0.016$). Restoration of 3D TK correlated with improvements in cervical alignment parameters; however, 2-year follow-up CL was significantly correlated with the 2-year follow-up 3D TK, rather than the extent of kyphosis correction. Multiple linear regression model revealed that 2-year follow-up CL was significantly associated with 2-year follow-up 3D TK ($B = 0.30$; $P = 0.045$) and preoperative CL ($B = 0.42$, $P < 0.001$).

Conclusion

3D TK is associated with lower cervical disc degeneration and cervical kyphosis in AIS. Adequate restoration of 3D TK through deformity correction appears to mitigate cervical malalignment, suggesting that thoracic sagittal correction plays a key role in optimizing cervical alignment and reducing lower cervical stress.

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

46. Preoperative Thoracic Kyphosis, Not Implant Choice or Navigation, Predicts Proximal Junctional Kyphosis in Adolescent Idiopathic Scoliosis

Eddie Geagea, MD; Manas Peddiboyina, MS; John Lovejoy, MD

Hypothesis

Increased preoperative thoracic hyperkyphosis would be independently associated with PJK, whereas UIV instrumentation type and navigation would not independently mitigate this risk.

Design

Retrospective cohort study

Introduction

Proximal Junctional Kyphosis (PJK) remains a common sagittal complication following posterior spinal fusion (PSF) for Adolescent Idiopathic Scoliosis (AIS). While various surgical techniques have been proposed to mitigate this risk, including the use of hooks at the Upper Instrumented Vertebra (UIV) or CT-guided navigation, their efficacy remains controversial.

Methods

A retrospective review of 543 AIS patients who underwent PSF between 2016 and 2024 was conducted. All patients had a minimum of 2-year clinical and radiographic follow-up (mean 3.3 years). PJK was defined as a proximal junctional sagittal Cobb angle (UIV to UIV+2) $\geq 10^\circ$ greater than the preoperative measurement. Variables analyzed included age, BMI, preoperative thoracic kyphosis (TK), UIV instrumentation type (Hook vs. Screw), and surgical technique (Navigation vs. Freehand). Statistical analysis included Fisher's exact tests for categorical variables, Mann-Whitney U tests for continuous variables, and a multivariate logistic regression model.

Results

The overall incidence of PJK was 21.7% (118/543). Patients who developed PJK had significantly higher preoperative TK ($40.8^\circ \pm 12.1^\circ$) compared to those who did not ($27.3^\circ \pm 10.4^\circ$; $p < 0.001$). Multivariate logistic regression confirmed that preoperative TK was a significant independent predictor of PJK (OR 1.08 per degree increase; 95% CI 1.05-1.11; $p < 0.001$). No statistically significant difference in PJK rates was found between UIV hooks (21.0%) and UIV screws (21.9%; $p = 0.81$), nor between the use of Navigation (22.8%) and Freehand techniques (20.8%; $p = 0.65$). Age and BMI were not significant predictors in the multivariate model ($p > 0.05$).

Conclusion

In this large cohort of AIS patients, preoperative thoracic kyphosis was the primary driver of PJK development. Notably, the selection of UIV instrumentation (hooks vs. screws) and the use of navigation did not significantly reduce the incidence of PJK. These findings suggest that PJK risk is dominated by preoperative sagittal alignment rather than specific hardware choices or placement techniques, highlighting the need for patient-specific surgical planning in high-kyphosis cohorts.

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

47. Sagittal Profiles and their Reciprocal Changes Manifesting in Proximal Junctional Kyphosis in Adolescent Idiopathic Scoliosis

Hong Jin Kim, MD, PhD; Hyung Rae Lee, MD; Subin Lim, MD; Jae Hyuk Yang, MD, PhD; Seung Woo Suh, MD, PhD

Hypothesis

The sagittal profiles, including sagittal shape and alignment in adolescent idiopathic scoliosis (AIS), are significantly associated with the development of proximal junctional kyphosis (PJK) as a reciprocal change after deformity correction

Design

A retrospective cohort study

Introduction

Unlike adult spinal deformity (ASD), sagittal alignment in AIS is characterized by alteration of thoracic kyphosis (TK) resulting from relative anterior spinal overgrowth. While recent studies on PJK in ASD have focused on spinal shape and alignment, little information is available in AIS.

Methods

A total of 282 AIS patients who underwent deformity correction were retrospectively reviewed. Patients were categorized into two groups according to the presence of PJK at the 2-year follow-up: the PJK group (n = 48) and the non-PJK group (n = 234). Sagittal shape was classified as normal TK, hypo-TK with/without thoracolumbar kyphosis (TLK), and cervico-thoracic kyphosis. Coronal, sagittal, and spinopelvic radiographic parameters were measured. Changes in Roussouly classification and correction relative to the functional T10 pelvic angle target were assessed to evaluate sagittal restoration and its association with PJK.

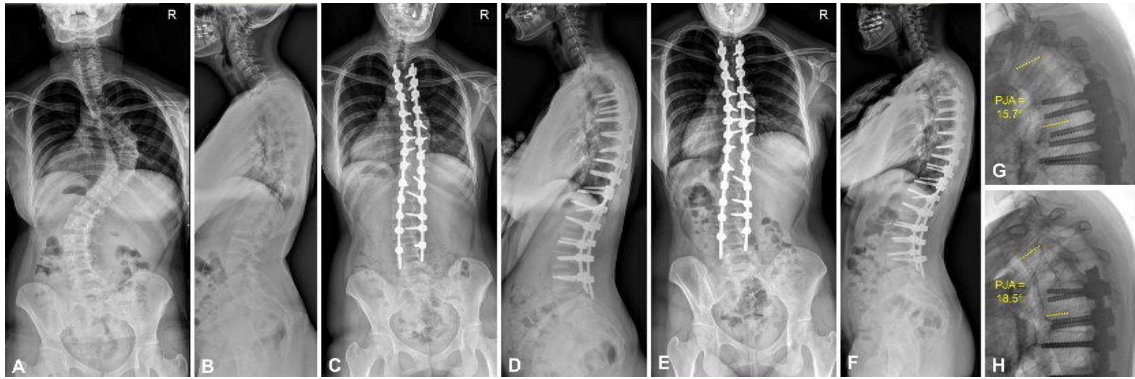
Results

At the 2-year follow-up, the incidence of PJK was 17.0% (48 of 282). The upper instrumented vertebra (UIV) level differed significantly between the two groups ($P = 0.002$). The mean absolute Δ sagittal vertical axis (SVA) between the postoperative and the 2-year follow-up was also greater in the PJK group (28.9 mm vs 17.3 mm, $P = 0.008$). Regarding sagittal shape, the PJK group was most prevalent in normal TK (43.8%) and cervico-thoracic kyphosis (31.3%), whereas the non-PJK group was most prevalent in hypo-TK without TLK (40.2%), followed by normal TK (35.0%) ($P < 0.001$). Multivariate logistic regression showed that lower UIV level, cervico-thoracic kyphosis, and greater Δ SVA were significantly associated with PJK.

Conclusion

Our findings indicated that UIV level, cervicothoracic kyphotic profile, and greater changes in the SVA were the main factors associated with PJK. In contrast to ASD, PJK in AIS rarely causes serious clinical sequelae but instead represents reciprocal changes driven by the original sagittal shape and subsequent alterations in sagittal alignment.

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



Case presentation of AIS with PJK associated with sagittal spinal shape

48. Does T4PA–L1PA Mismatch Matter? Patient-Reported Outcomes After Posterior Fusion for Adolescent Idiopathic Scoliosis: Min 20 years follow-up

Ibrahim Dag, MD; Hamisi M. Mraja, MD; Mustafa Buğra Ayaz, MD; Ahmet Hamdi Olcar, MD; Ilyas Dolas, MD; Sinan Kahraman, MD; Meric Enercan, MD; Selhan Karadereler, MD; Azmi Hamzaoglu, MD

Hypothesis

T4-L1PA mismatch in AIS correlates with clinical outcomes at long term f/up

Design

Retrospective case series

Introduction

Many studies focused on T4-L1PA mismatch for adult deformity pts, but there is gap in the literature for AIS pts in terms of T4-L1 mismatch in longterm f/up. This is the first study that evaluates longterm PROs and their relation with T4L1PA mismatch and other sagittal parameters in AIS pts with a min 20yrs f/up

Methods

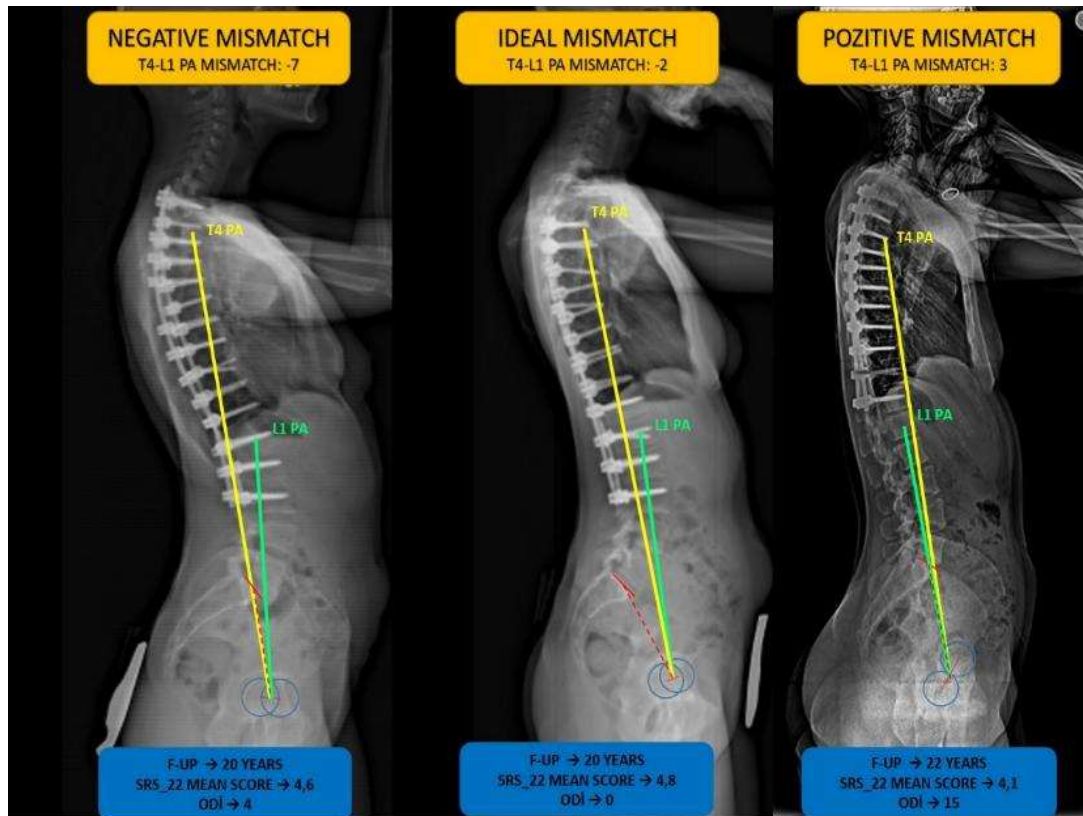
30 AIS pts (28f,2m) who underwent PSF and had min 20 yrs f/up(20-30)duration were included. Standing full-spine x-rays were analyzed preop and final f/up. Coronal cobb and sagittal parameters were assessed, including pelvic parameters, LL, TK, T4PA–L1PA mismatch, PI–LL mismatch, T4PA, L1PA, C2PA. T4PA–L1PA mismatch was defined as the angular difference between T4PA and L1PA and categorized as ideal (between $-3^{\circ}+1^{\circ}$), negative ($<-3^{\circ}$), positive ($>+1^{\circ}$). Clinical outcomes at final f/up were evaluated using the SRS-22 and ODI

Results

PT, MT and TL curves demonstrated significant correction from preop to f/up ($p < 0.001$). At f/up, mean T4PA was 2.53 ± 6.76 , mean L1PA was 5.60 ± 7.54 , mean T4PA–L1PA mismatch was -3.80 ± 4.11 . Comparison between preop and f/up measurements revealed no significant changes in pelvic p, LL, PI–LL mismatch, T4PA, L1PA, or T4PA–L1PA mismatch ($p > 0.05$). T4PA–L1PA mismatch distribution showed a trend toward improvement from preop to last f/up. Pts classified as ideal mismatch increasing from 26.7% preop to 46.7% at f/up. Clinical outcomes at f/up were satisfactory, with a mean SRS-22 total score of 4.24 (pain of 4.29, function of 4.55). Significant positive correlation found between the SRS-22 total score with T4PA–L1PA mismatch at the f/up ($r = 0.96, p < 0.05$). Mean ODI was 7.2, only 2 patients (6%) had ODI > 20 with positive T4-L1 mismatch

Conclusion

This long-term (> 20 yrs) f/up study showed that the ideal (47%) and negative (47%) T4PA–L1PA mismatch pts demonstrate improved coronal cobb corrections and sagittal plane restorations with higher pts reported outcomes in AIS. However, 6% of the pts who were in the positive T4PA–L1PA mismatch resulted in lower clinical satisfactory results with improved coronal corrections. Our study showed that T4PA-L1PA mismatch is significantly correlated with HRQoL scores at the end of 20 yrs f/up. Maintaining T4PA–L1PA mismatch within ideal or negative ranges over the long term will provide satisfactory clinical outcomes



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Hypothesis

T4-L1PA mismatch in AIS correlates with clinical outcomes at long term f/up

Design

Retrospective case series

Introduction

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Methods

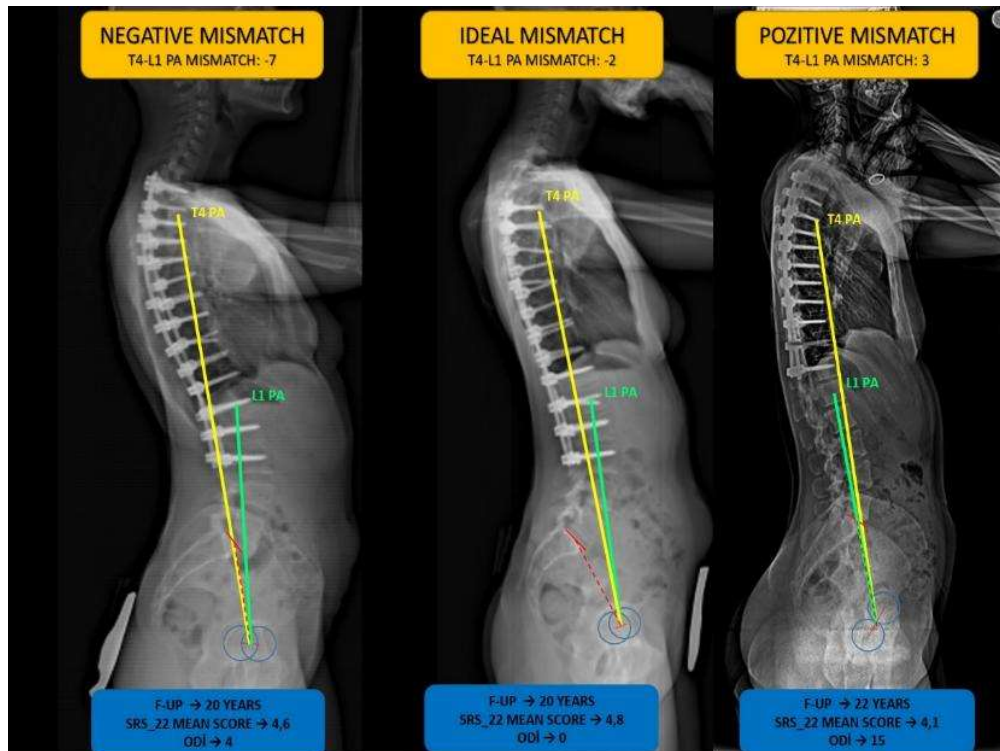
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§ Hibbs Award Nominee – Best Clinical Paper, † Hibbs Award Nominee – Best Basic Science/Translational Science Paper,
‡SRS Funded Research Grant

49. How Can We Minimize Disc Wedging and Trunk Shift After Selective Thoracic Fusions in AIS?

Joshua M. Pahys, MD; Tej Azad, MD; Alexander J. Schupper, MD; Amer F. Samdani, MD; Terrence G. Ishmael, MBBS; Firoz Miyanji, MD, FRCS(C); Suken A. Shah, MD; Peter O. Newton, MD; Harms Study Group; Steven W. Hwang, MD

Hypothesis

Early postop correction imbalance predicts trunk shift and can guide goal thoracic correction to reduce trunk shift

Design

Retrospective multicenter study

Introduction

Selective thoracic fusions (STF) have problematic residual trunk shift and disc wedging

Methods

Lenke 1–4C pediatric AIS patients undergoing STF with ≥ 2 -year follow-up were analyzed. Main thoracic (MT) correction% and SLCC% were calculated on first-erect (FE) radiographs. Primary outcome was trunk shift >1.5 cm at 2 years. Disc wedging was defined as the angle of the disc below LIV opening contralaterally

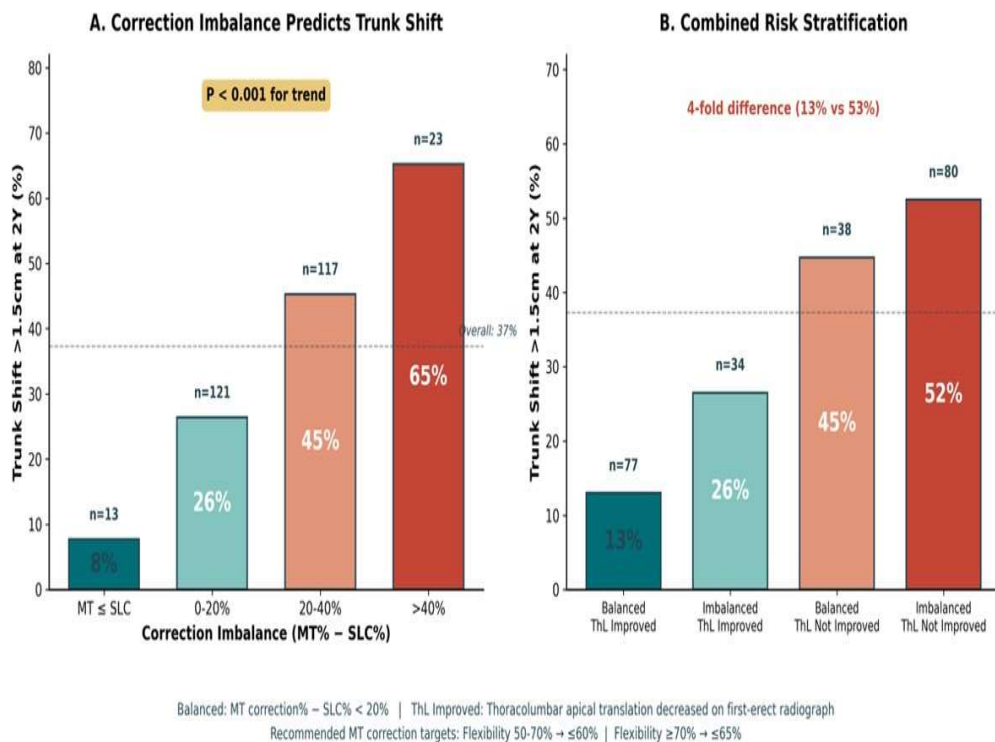
Results

Among 385 patients, mean MT correction was 64% and mean SLCC was 43% (imbalance 22%); trunk shift >1.5 cm occurred in 37% (103/276) at 2 years and 32% (35/110) by 5 years. Preop predictors were modest: lumbar bending flexibility was associated with 2-year trunk shift ($p<0.05$), while LIV position relative to the lumbar apex was not predictive ($p=0.72$); lumbar flexibility (LF) remained the strongest preop predictor at 5 years ($p<0.01$). Greater LF was associated with slightly higher SLCC (45% SLCC with $LF\geq 70\%$ vs 42% SLCC with $LF 50\text{--}60\%$), supporting goal correction of MT up to 60% for $LF 50\text{--}70\%$ and MT correction up to 65% for $LF\geq 70\%$ to maintain balance. Combining correction balance with early ThL translation improvement stratified risk four-fold (13% of patients had a trunk shift in the setting of balanced correction + initial ThL improvement vs 53% rate of trunk shift with imbalanced correction and no initial ThL improvement). Early ThL improvement was also associated with better SRS-22 self-image scores (4.4 vs 4.2, $p=0.02$). The W group did have shorter construct lengths (9.2 ± 0.99 vs. 9.7 ± 1.2 levels, $p=0.027$), and the LIV was more rostral (T11 vs. T12, $p<0.001$). The W group had LIV further from the lumbar apex (2.5 vs. 2.1 levels, $p=0.005$). Multivariate analysis demonstrated that number of levels was the strongest predictor of post-op wedging ($p<0.001$, 95% CI: 0.341–0.637).

Conclusion

1/3 of patients undergoing STF will have significant trunk shift at 2 years with improvement at 5 years. Maintaining MT correction within 20% of expected SLCC and assessing early ThL translation on FE radiographs may help identify and mitigate risk for persistent trunk shift. Post-op DW occurred in 13% of patients; LIV selection and number of fusion levels was most predictive of post-op wedging, highlighting the importance of level selection in STF.

§ 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

50. The Role of Vertebral Rotation Discrepancy for Add-on Phenomenon in Thoracic Curves of Adolescent Idiopathic Scoliosis

Hong Jin Kim, MD, PhD; Hyung Rae Lee, MD; Subin Lim, MD; Jae Hyuk Yang, MD, PhD; Seung Woo Suh, MD, PhD

Hypothesis

Considering the SRS-Lenke-Aubin 3D classification, vertebral rotation in the remnant lumbar curve may be contributed to the distal add-on when the lowest instrumented vertebra (LIV) is set at the touched vertebra (TV) in adolescent idiopathic scoliosis (AIS).

Design

Retrospective study

Introduction

There is little doubt that selecting the LIV at the TV represents the most balanced landmark between the risk of the add-on phenomenon and the preservation of motion segments. Given that the add-on is not uncommon when the LIV is set at the TV, the role of vertebral rotation in the determination of the LIV remains unclear.

Methods

A total of 96 thoracic AIS patients who underwent deformity correction with LIV = TV were retrospectively analyzed to evaluate the distal add-on. Patients were divided into the DA group (distal add-on) and the non-DA group (non-distal add-on). Radiological variables included coronal parameters (Cobb's angle, coronal balance, sacral slanting angle, and L4 vertebral tilt), sagittal parameters (sagittal vertical axis, thoracic kyphosis, and lumbar lordosis), and axial parameters (vertebral rotation angle).

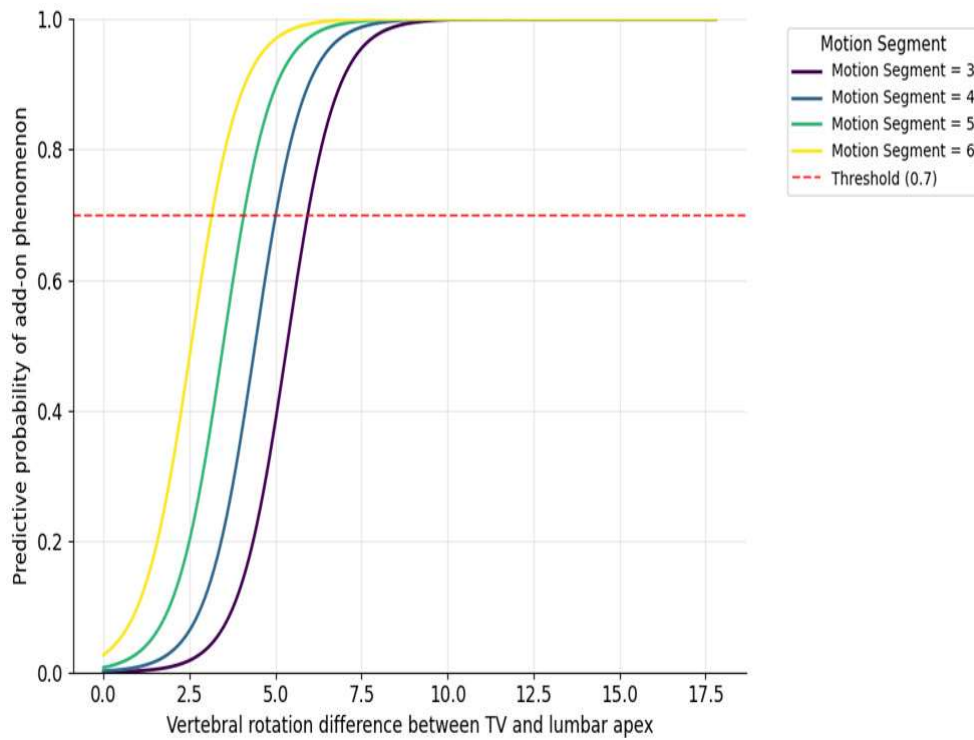
Results

When selecting the TV as the LIV, the occurrence of distal add-on was 20.8% at a mean follow-up of 3 years. The mean number of remnant motion segments was significantly higher in the DA group (4.7) compared to the non-DA group (3.8) ($P < 0.001$). Furthermore, the difference in the vertebral rotation angle between the lumbar apex and the TV level was significantly higher in the DA group (6.6°) than in the non-DA group (1.3°) ($P < 0.001$). Multivariate logistic regression analysis demonstrated that the occurrence of distal add-on was significantly associated with remnant motion segments (OR = 3.69, 95% CI: 1.03–13.18) and the vertebral rotation discrepancy (OR = 4.09, 95% CI: 1.98–8.43). In this model, the boundary of the high predictive probability was located at vertebral rotation discrepancy = 3.15° , 4.08° , 5.01° , and 5.93° when LIV = T12, L1, L2, and L3

Conclusion

The distal add-on was influenced by the number of remnant motion segments and the vertebral rotation discrepancy between the LIV and the lumbar apex. In light of the rotation parameter in the SRS-Lenke-Aubin 3D classification, surgeons may need to select an LIV caudal to the TV in cases with significant rotational discrepancy.

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



Predictive probability of distal add-on phenomenon

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

51. Δ UIV Tilt Correction $\geq 10^\circ$ Is an Independent Risk Factor for Left PSI at 2 Years in Lenke 1 AIS

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Hypothesis

Greater correction of upper instrumented vertebra (UIV) tilt increases the risk of postoperative shoulder imbalance (PSI) in Lenke 1 adolescent idiopathic scoliosis (AIS).

Design

Single-center retrospective cohort study.

Introduction

PSI remains a concern in Lenke 1 AIS when the proximal thoracic (PT) curve is left unfused. We tested whether larger Δ UIV tilt correction is associated with PSI and compared outcomes between proximal thoracic side-bending (PTSB) groups.

Methods

Female Lenke 1 AIS pts undergoing posterior spinal fusion were reviewed ($n=120$). Δ UIV tilt was defined as UIV tilt at 2 years minus preoperative UIV tilt. Pts were categorized by Δ UIV tilt ($\geq 10^\circ$ vs $<10^\circ$; prespecified) and grouped by PTSB angle: F ($<15^\circ$) vs R ($15\text{--}25^\circ$). PSI was defined as left shoulder elevation by signed radiographic shoulder height (RSH ≥ 10 mm) at 2 years (absolute value not used). Multivariable logistic regression adjusted for Risser ≥ 3 , preop RSH >0 mm, preop T1 tilt, and PT flexibility.

Results

PSI occurred in 34/120 pts (28.2%) and did not differ between PTSB groups (26.3% vs 29.1%, $p=0.80$). Δ UIV tilt $\geq 10^\circ$ was independently associated with PSI (OR 2.78, 95% CI 1.07–7.24; $p=0.02$), along with Risser ≥ 3 (OR 10.32, 95% CI 1.27–87.78; $p=0.03$) and preop RSH >0 mm (OR 2.90, 95% CI 1.13–9.31; $p=0.04$). In Risser ≥ 3 pts, PSI tended to be higher with Δ UIV tilt $\geq 10^\circ$ (42% vs 23%, $p=0.06$).

Conclusion

Δ UIV tilt correction $\geq 10^\circ$ was an independent risk factor for left PSI at 2 years in Lenke 1 AIS with the PT curve left unfused. PTSB $15\text{--}25^\circ$ alone was not associated with higher PSI.

52. Distal Instrumentation Failure After Posterior Spinal Fusion in Adolescent Idiopathic Scoliosis: Incidence, Risk Factors, and Radiographic Impact

Myeong Geun Song, MD; Chang Ju Hwang, MD, PhD; Dong-Ho Lee, MD, PhD; Jae Hwan Cho, MD, PhD; Sehan Park, MD, PhD; Wan Soo Park, MD

Hypothesis

We hypothesized that distal instrumentation failure is associated with distal construct and curve characteristics and results in loss of correction and distal curve deterioration after posterior spinal fusion in adolescent idiopathic scoliosis (AIS).

Design

Retrospective cohort study.

Introduction

Distal instrumentation failure, including axial rod slip (ARS) and distal screw fixation failure, may compromise maintenance of correction after posterior spinal fusion for AIS. This study evaluated its incidence and associated factors.

Methods

We retrospectively reviewed 302 AIS patients who underwent posterior spinal fusion with all pedicle screw constructs and had at least 2 years of radiographic follow-up. Distal instrumentation failure was defined as ARS (≥ 2 mm rod shortening at the LIV) or screw fixation failure (pull-out) on follow-up radiographs. Patients were classified into failure ($n=35$) and non-failure ($n=267$) groups, and distal construct-related clinical and radiographic parameters were analyzed.

Results

Distal instrumentation failure occurred in 35 of 302 patients (11.6%), predominantly ARS (28/302, 9.3%). ARS developed within 3 months in 50.0% of cases and was more frequent on the convex side (64.3%). Failure was associated with larger preoperative lumbar curves, higher lumbar modifiers, distal LIV selection (L3 or L4), and inferior LIV screw trajectory. The failure group showed greater correction loss (7.0% vs. 1.1%, $p = 0.007$) and higher distal curve progression $>5^\circ$ (69.2% vs. 3.0%, $p < 0.001$). Torque-limiting locking mechanisms showed a lower failure incidence than break-off systems.

Conclusion

Distal instrumentation failure after AIS fusion was not uncommon and was mainly attributable to ARS. Larger preoperative lumbar curves, distal LIV selection (L3/L4), inferior screw angulation, and high lumbar modifiers were associated risk factors. Awareness of these distal construct-related risk factors may help surgeons adopt preventive strategies during instrumentation. In particular, transverse traction at the LIV may help maintain correction in AIS surgery.

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

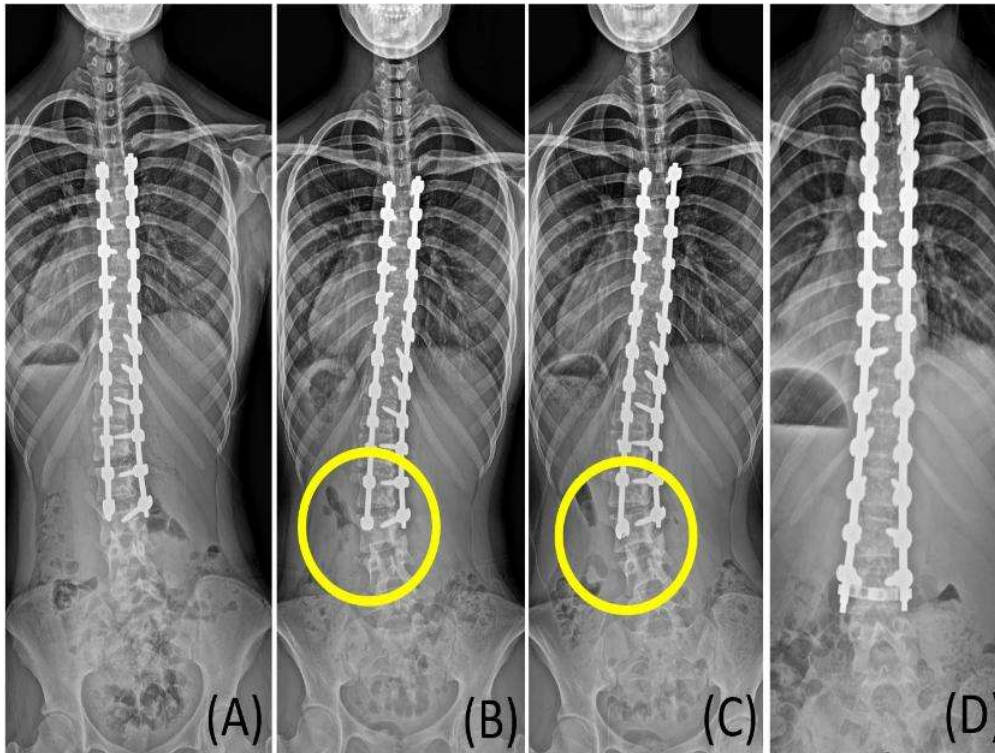


Figure 1. Representative case of distal instrumentation failure and preventive transverse traction. (A) Immediate postoperative radiograph. (B) Axial rod slip at 1yr follow-up. (C) Distal screw dislodgement at 2yr follow-up. (D) Transverse traction applied at the distal end of the construct.

53. What Factors Allow Us to Predict Ideal Radiographic Outcomes at 2 and 5 Years in Selective Thoracic Fusion in Lenke C AIS?

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Hypothesis

Lumbar curve size and flexibility predict achievement of radiographic success (RS) following selective thoracic fusion (STF) in Lenke C AIS curves.

Design

Retrospective multicenter database

Introduction

STF is increasingly performed in AIS to preserve lumbar motion, yet ideal selection criteria remain elusive.

Methods

We included Lenke type 1-4 C AIS patients who underwent STF (LIV <L1) with a minimum of 2Y follow-up. Primary outcome was composite RS, defined as meeting all 5 RS criteria (Schulz 2014): lumbar Cobb <26°, C7-CSVL ≤2 cm, trunk shift <1.5 cm, lumbar correction >37%, and deformity-flexibility quotient (DFQ, residual lumbar Cobb/# unfused levels) <4. Multivariable regression evaluated pre-op predictors of RS. Risk groups were stratified by predictive thresholds, and SRS-22r patient-reported outcomes at 2Y were compared between RS/no-RS groups within each risk stratum. 5Y RS was also assessed.

Results

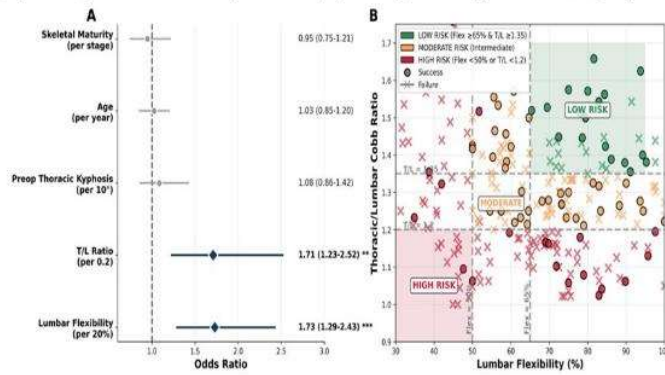
268 patients with mean age of 14.6±2.1 yrs were included; curve types included Lenke 1 (60%), 2 (19%), 3 (12%), and 4 (6%). Mean pre-op thoracic and lumbar curves were 55±10° and 43±8°, respectively. Composite RS was achieved in 29% at 2Y (78/268) and increased to 34% at 5Y (36/107), with older age and Lenke 1 curve type associated with success. LIV selection and achieved thoracic correction magnitude did not differ between RS/no RS groups (p>0.3). L1 LIV was associated with lumbar correction >37% (p<0.001), T11/12 vs L1 LIV was associated with achieving DFQ <4 (p=0.04), while greater thoracic curve correction was associated with worse trunk shift (p=0.02). On multivariable analysis, greater pre-op lumbar flexibility (OR 1.8/20% increase, p<0.001) and higher pre-op thoracic:lumbar (T/L) curve ratio (OR 1.6/0.2 increase, p=0.002) independently predicted RS (AUC=0.70). Risk stratification using both predictors identified high (flexibility <50% or T/L ratio <1.2), moderate, and low-risk (flexibility ≥65% and T/L ratio ≥1.35) groups with 2Y RS rates of 16% (N=121), 37% (N=102), and 53% (N=36), respectively (p<0.001). Within risk groups, RS was associated with better SRS-22r self-image (high-risk: 4.6±0.4 vs 4.3±0.6, p=0.03) and satisfaction scores (low-risk: 4.9±0.3 vs 4.4±0.8, p=0.03).

Conclusion

Greater lumbar flexibility (≥65%) and higher preoperative T/L ratio (≥1.35) predicted RS in 53% of patients undergoing STF.

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

(A) Forest plot of multivariable predictors. (B) Scatterplot of key predictors/risk groups.



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54. Lumbar Curve Correction is Durable at 5 Years After Thoracic Fusion in Patients with Open Triradiate Cartilage

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Hypothesis

The lumbar spine responds differently in patients with open triradiate cartilage (OTRC) versus those with closed triradiate cartilage (CTRC) after thoracic fusion (TF) in adolescent idiopathic scoliosis (AIS).

Design

Retrospective Cohort Study

Introduction

TF in AIS maintains mobile lumbar segments in patients with primary thoracic and compensatory lumbar curves. In AIS patients with substantial growth remaining, little is known about the behavior of the unfused spine and coronal balance after TF. This study aims to assess the behavior of the unfused lumbar spine 5 years after TF in AIS patients with OTRC.

Methods

A multicenter AIS database was queried for patients who underwent TF with the lowest instrumented vertebra L1 or cephalad. Patients were grouped based on 1) OTRC, or 2) CTRC and Risser 4/5. Radiographic measures at preop, 1st postop, 1 year, and 5 years included lumbar curve magnitude (LCM), lumbar apical vertebral translation (LAVT), coronal balance, adding on, thoracic curve magnitude (TCM), and thoracic kyphosis (TK). A generalized linear model was utilized to estimate and evaluate differences in means of variables.

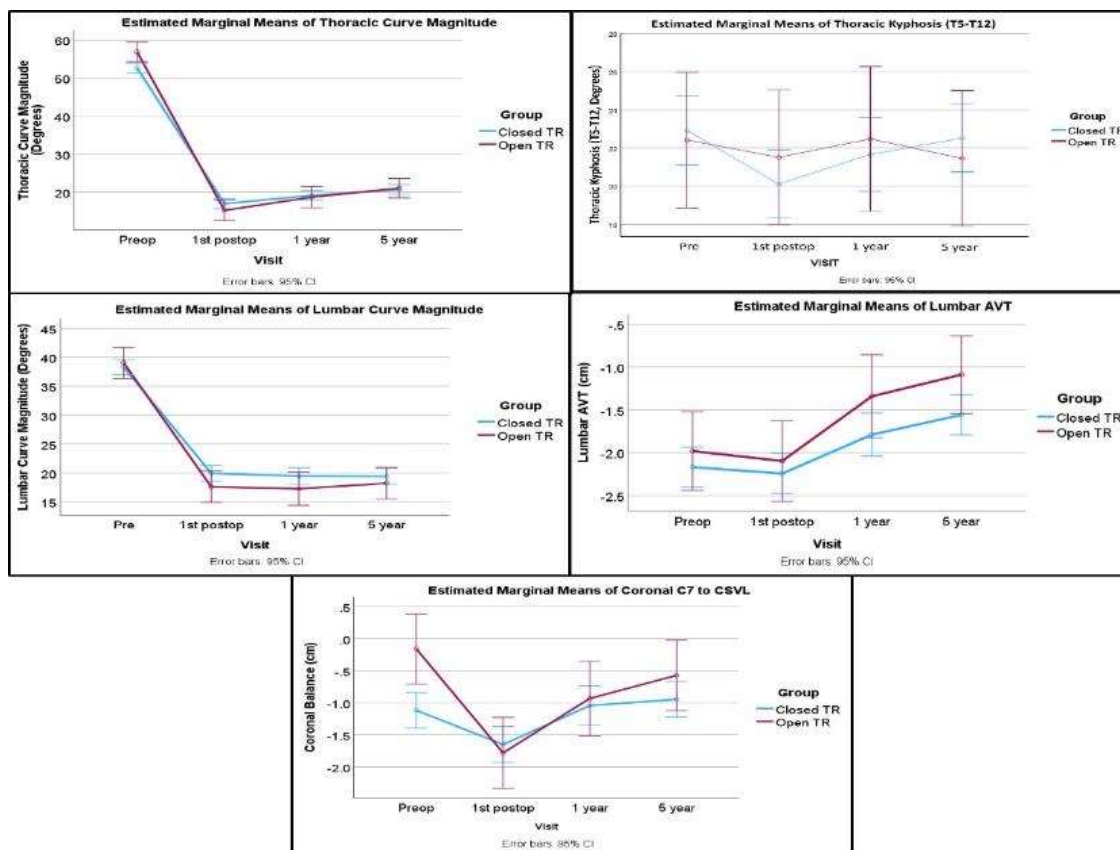
Results

The OTRC group included 33 patients (mean 11.9 years). The CTRC group included 131 patients (mean 15.3 years). Both groups had comparable curve types and magnitudes, with >85% Lenke 1 or 2, B or C curves. LCM and TCM decreased significantly from preop to the 1st postop visit in both CTRC and OTRC groups (Figure 1), with no change at 1 year and 5 years postop in both groups. In both groups, there was significant coronal balance decompensation at 1st postop with significant improvement at 1 year and 5 years compared to 1st postop. In both groups, LAVT did not change from preop to 1st postop, though improved significantly at 1 year and 5 years compared to preop. In all postoperative periods, there was no significant difference between OTRC and CTRC groups in LCM, LAVT, coronal balance, and TK. Although there was significantly higher rate of adding on at 5 years in the OTRC versus CTRC group (OTRC 48%, CTRC 24%, $p=0.003$), this drove improvement in balance in the OTRC group.

Conclusion

TF alone in young patients with OTRC results in similar balanced spine with maintained lumbar correction at 5 years follow up compared to more skeletally mature patients and remains a reasonable surgical option for compensatory lumbar modifier B and C curves.

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Radiographic Measures

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55. Health Related Quality of Life Assessment Using the Srs-22 Questionnaire Comparing Adolescent Idiopathic Scoliosis (AIS) versus Adult Idiopathic Scoliosis (AdIS) who had undergone Posterior Spinal Fusion (PSF): A Propensity Score Matched Study

Chris Yin Wei Chan, MD, MSOrth; Amanda W. Leong, MBBS; Van Jet Leong, MBBS; Hui Chin Ting, MBBS; Zhi Sean Teng, MBBS; Chee Kidd Chiu, MBBS, MSOrth; Mun Keong Kwan, MBBS, MSOrth

Hypothesis

AIS and AdIS patients demonstrate different health-related quality-of-life outcomes and rates of MCID achievement following surgical treatment, as measured by the SRS-22r.

Design

Retrospective study

Introduction

Adolescent Idiopathic Scoliosis (AIS) and Adult Idiopathic Scoliosis (AdIS) differ in clinical characteristics and treatment challenges, yet comparative data on surgical outcomes and patient-reported quality of life are limited. This study evaluates health-related quality of life and the achievement of the Minimum Clinically Important Difference (MCID) using the SRS-22r in AIS and AdIS patients.

Methods

388 patients (316 AIS, 72 AdIS) were recruited. Following propensity score matching (PSM), there were 46 pairs in each group. Matching was based on gender, Lenke classification, major Cobb angle, and number of fusion levels with match tolerance 0.005. The SRS-22r questionnaire was assessed preoperatively and at a minimum of two years postoperatively.

Results

AIS patients (mean age 14.1 ± 2.0 years) and AdIS patients (mean age 25.2 ± 4.9 years) were comparable in terms of BMI and average follow-up duration. There was also no significant difference in terms of mean operative times (136.5 ± 47.2 vs. 138.5 ± 47.9 min, $p=0.839$), blood loss (833.4 ± 405.6 vs. 785.0 ± 435.5 mL, $p=0.584$), and screw density (1.2 ± 0.2 vs. 1.2 ± 0.1 , $p=0.606$). The odds of AIS patients achieving MCID compared to AdIS is 11.6 times (95% CI 3.891-34.483, $p<0.001$) for function domain and 6.3 times (95% CI 2.110-18.868 $p<0.001$) for the pain domain, while the odds of AdIS patients achieving MCID for self-image is 2.1 times (95% CI 0.892-4.921, $p=0.087$). 1 AIS patient was recorded to have superficial surgical site infection and 1 AdIS patient had T10 radiculitis postoperatively.

Conclusion

AIS patients had higher odds of achieving MCID in function (11.6 times) and pain domain (6.3 time) compared to AdIS patients.

56. Age Matters: Increased Perioperative Morbidity in Young Adults Compared to Adolescents Undergoing Posterior Spinal Fusion for Idiopathic Scoliosis

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Hypothesis

We hypothesized that young adults undergoing posterior spinal fusion for idiopathic scoliosis have higher risk of perioperative morbidity than adolescents.

Design

This was a retrospective cohort study using data from NSQIP databases from 2016 to 2024.

Introduction

The purpose of this study was to compare perioperative outcomes between adolescents and young adults undergoing posterior spinal fusion for idiopathic scoliosis using a large clinical registry.

Methods

Patients aged 10–40 years who underwent posterior spinal fusion for idiopathic scoliosis were included. Two study cohorts were defined: (1) adolescent idiopathic scoliosis (AIS) (10–17 years) and (2) young adult idiopathic scoliosis (YADIS) (18–40 years). Outcomes included operative time, length of stay (LOS), allogeneic transfusion, any adverse event, 30-day readmission, 30-day reoperation, and non-home discharge. Groups were compared using chi-square test and Student's t-test. Multivariable regression analyses were performed controlling for sex, ASA, and number of fusion levels.

Results

There were 31,120 AIS patients (mean age 14.5 years) and 439 YADIS patients (mean age 21.9 years). Compared with the AIS cohort, YADIS had significantly longer operative times (AIS: 276.4 minutes vs YADIS: 353.7 minutes; $p < 0.001$) and longer LOS (AIS: 3.4 days vs YADIS: 5.1 days; $p < 0.001$). The YADIS cohort had higher rates of allogeneic transfusion (AIS: 10.9% vs YADIS: 33.3%; $p < 0.001$), any adverse event (AIS: 1.6% vs YADIS: 3.0%; $p = 0.03$), reoperation (AIS: 1.3% vs YADIS: 2.5%; $p = 0.03$), and non-home discharge (AIS: 0.4% vs YADIS: 2.7%; $p < 0.001$). There was no significant difference in readmission (AIS: 1.7% vs YADIS: 2.7%; $p = 0.10$). In multivariable logistic regression analyses, the YADIS cohort had higher odds of allogeneic transfusion (OR 4.8, $p < 0.001$), reoperation (OR 1.9, $p = 0.04$), any adverse event (OR 1.8, $p = 0.04$), and non-home discharge (OR 7.19, $p < 0.001$). In multivariable linear regression analyses, YADIS was associated with longer operative time (+78.9 minutes, $p < 0.001$) and length of stay (+1.7 days, $p < 0.001$).

Conclusion

Compared with adolescents, young adults undergoing posterior spinal fusion for idiopathic scoliosis experience greater perioperative morbidity and resource utilization.

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

	Adolescent Idiopathic Scoliosis (n=31,120)	Young Adult Idiopathic Scoliosis (n=429)	
Operative time (minutes)	276.4 ± 94.6	353.7 ± 124.7	t=16.92, p<0.001 mean difference 77.3
Length of stay (days)	3.4 ± 4.1	5.1 ± 3.1	t=8.5, p<0.001 mean difference 1.7
Allogeneic transfusion	10.9%	33.3%	X ² = 215.7, p<0.001
Any adverse event	1.6%	3.0%	X ² =46.7, p=0.03
Unplanned readmission	1.7%	2.7%	X ² =2.7, p=0.10
Unplanned reoperation	1.3%	2.5%	X ² =4.5, p=0.03
Non-home Discharge	0.4%	2.7%	X ² =59.1, p<0.001

Comparison of perioperative measures

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‡SRS Funded Research Grant

57. Longitudinal Patient-Reported Outcomes Following Spinal Fusion for Adolescent Idiopathic Scoliosis: Recovery Trajectories and Implications for Surgical Timing

Wai Wang Chau, MS; Alec Lik Hang Hung, FRCS; Adam Yiu Chung Lau, FRCS

Hypothesis

Beyond skeletal maturity and curve severity, incorporating patient-reported outcome measures (PROMs), such as the SRS-22r and the Spinal Appearance Questionnaire (SAQ), which reflect perceptions of function, pain, and quality of life, may help determine the optimal surgical timing in otherwise asymptomatic AIS patients.

Design

Retrospective cohort study

Introduction

Current guidelines recommend surgery for AIS at Cobb angles $\geq 45^\circ$, but patient centered criteria are lacking. This study aims to determine the optimal surgical age for spinal fusion surgery in adolescents with idiopathic Scoliosis (AIS) by incorporating PROMs to assess recovery trajectories.

Methods

Patients with severe AIS (Cobb $\geq 45^\circ$) who underwent spinal fusion surgery at a single tertiary center were included. Longitudinal SRS-22r and SAQ data were collected from preoperative assessment to more than 20 years postoperatively. Age at surgery was analyzed as a predictor of “good recovery” using receiver operating characteristics (ROC) curves, linear mixed models, and AI-assisted trajectory segmentation.

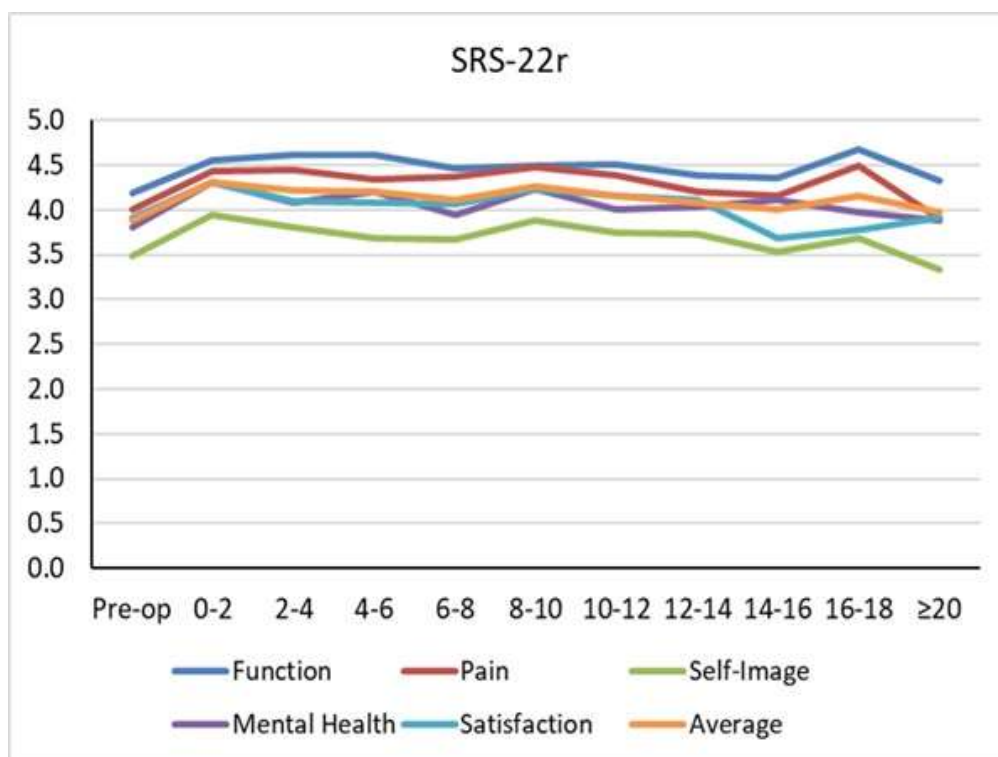
Results

A total of 388 AIS patients (1539 records; mean surgical age 15.3 ± 2.1 years; mean Cobb angle $59^\circ \pm 12^\circ$) were included. ROC analysis identified 14.5 years (area under curve (AUC)=0.72, 95%CI:0.65-0.79) and 15.2 years (AUC=0.70) as optimal cut-offs for SRS-22r and SAQ recovery, respectively. Patients operated at 12-16 years showed faster HRQOL improvement (slope:0.45vs.0.28/year, $p=0.021$) and reached maximum improvement earlier (4 years for SRS-22r; 6 years for SAQ). Age ≥ 14.5 years predicted good recovery (OR=2.45, 95%CI:1.67–3.60, $p<0.001$). Long-term HRQOL remained stable at normative levels (>20 years:SRS-22r:4.10 $\pm$ 0.40), with no significant decline.

Conclusion

Our finding indicates that surgery between 14.5 and 15.2 years optimizes the HRQOL recovery trajectory in severe AIS. Scheduling surgery at approximately age 14.5, guided by SRS-22r data and accounting for a 6-month lag in body image improvement, yields the most favorable recovery trajectory. AI-based modeling provides actionable age thresholds, supporting the integration of age-HRQOL data into shared decision-making for optimal surgical timing.

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



Longitudinal mean SRS-22r domain scores

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