

The Impact of Lumbopelvic Realignment Versus Prevention Strategies at the Upper-instrumented Vertebra on the Rates of Junctional Failure Following Adult Spinal Deformity Surgery

Peter G. Passias, MD,^a Tyler K. Williamson, MS,^a Rachel Joujon-Roche, BS,^a Oscar Krol, BA,^a Peter Tretiakov, BS,^a Bailey Imbo, BA,^a Andrew J. Schoenfeld, MD, MSc,^b Stephane Owusu-Sarpong, MD,^c Jordan Lebovic, MD, MBA,^c Jamshaid Mir, MD,^a Pooja Dave, BS,^a Kimberly McFarland, BS,^a Shaleen Vira, MD,^d Bassel G. Diebo, MD,^e Paul Park, MD,^f Dean Chou, MD,^g Justin S. Smith, MD, PhD,^h Renaud Lafage, MS,ⁱ and Virginie Lafage, PhDⁱ

Study Design/setting. Retrospective

Objective. Evaluate the surgical technique that has the greatest influence on the rate of junctional failure following ASD surgery.

Summary of Background Data. Differing presentations of adult spinal deformity (ASD) may influence the extent of surgical

intervention and the use of prophylaxis at the base or the summit of a fusion construct to influence junctional failure rates.

Materials and Methods. ASD patients with two-year (2Y) data and at least 5-level fusion to the pelvis were included. Patients were divided based on UIV: [Longer Construct: T1-T4; Shorter Construct: T8-T12]. Parameters assessed included matching in age-adjusted PI-LL or PT, aligning in GAP-relative pelvic version or Lordosis Distribution Index. After assessing all lumbopelvic radiographic parameters, the combination of realigning the two parameters with the greatest minimizing effect of PJF constituted a good base. Good s was defined as having: (1) prophylaxis at UIV (tethers, hooks, cement), (2) no lordotic change (under-contouring) greater than 10° of the UIV, (3) preoperative UIV inclination angle < 30°. Multivariable regression analysis assessed the effects of junction characteristics and radiographic correction individually and collectively on the development of PJK and PJF in differing construct lengths, adjusting for confounders.

Results. In all, 261 patients were included. The cohort had lower odds of PJK (OR: 0.5, [0.2–0.9]; $P=0.044$) and PJF was less likely (OR: 0.1, [0.0–0.7]; $P=0.014$) in the presence of a good summit. Normalizing pelvic compensation had the greatest radiographic effect on preventing PJF overall (OR: 0.6, [0.3–1.0]; $P=0.044$). In shorter constructs, realignment had a greater effect on decreasing the odds of PJF (OR: 0.2, [0.02–0.9]; $P=0.036$). With longer constructs, a good summit lowered the likelihood of PJK (OR: 0.3, [0.1–0.9]; $P=0.027$). A good base led to zero occurrences of PJF. In patients with severe frailty/osteoporosis, a good summit lowered the incidence of PJK (OR: 0.4, [0.2–0.9]; $P=0.041$) and PJF (OR: 0.1, [0.01–0.99]; $P=0.049$).

Conclusion. To mitigate junctional failure, our study demonstrated the utility of individualizing surgical approaches to emphasize an optimal basal construct. Achievement of tailored goals at the cranial end of the surgical construct may be equally important, especially for higher-risk patients with longer fusions.

From the ^aDivision of Spinal Surgery, Departments of Orthopaedic and Neurosurgery, NYU Langone Medical Center, NY Spine Institute, New York, NY; ^bDepartment of Orthopaedic Surgery, Brigham and Women's Hospital/Harvard Medical Center, Boston, MA; ^cDepartment of Orthopaedic Surgery, NYU Langone Medical Center, New York, NY; ^dDepartment of Orthopaedic Surgery, UT Southwestern Medical Center, Dallas, TX; ^eDepartment of Orthopaedic Surgery, SUNY Downstate Medical Center, New York, NY; ^fDepartment of Neurosurgery, Semmes-Murphey Clinic, Memphis, TN; ^gDepartment of Neurological Surgery, Columbia University College of Physicians and Surgeons, New York, NY; ^hDepartment of Neurosurgery, University of Virginia, Charlottesville, VA; and ⁱDepartment of Orthopaedics, Lenox Hill Hospital, Northwell Health, New York, NY.

Acknowledgment date: October 21, 2022. Acceptance date: February 6, 2023.

Institutional Review Board approval was obtained before enrolling patients in the prospective database. Informed consent was obtained from each patient before enrollment.

This study was presented at the American Academy of Neurological Surgeons (AANS) Annual Meeting. Poster Presentation. May 2, 2022. Philadelphia, PA.

Poster Presentation at the International Society for the Advancement of Spine Surgery (ISASS) Annual Meeting on June 4, 2022 at the Bahamas.

The authors report no conflicts of interest.

Address correspondence and reprint requests to Peter G. Passias, MD, New York Spine Institute, Division of Spinal Surgery, Departments of Orthopaedic and Neurological Surgery, NYU Langone Medical Center, Orthopaedic Hospital – NYU School of Medicine 301 East 17th St, New York, NY, 10003, USA; E-mail: Peter.Passias@nyumc.org

Supplemental Digital Content is available for this article. Direct URL citations are provided in the HTML and PDF versions of this article on the journal's website, www.spinejournal.com.

DOI: 10.1097/BRS.0000000000004732

E72 www.spinejournal.com

Key words: Adult spinal deformity, spine, proximal junctional kyphosis, complex realignment, PJK prophylaxis, cement augmentation, tethering, transverse process hooks

Level of Evidence. 3.

Spine 2024;49:E72–E78

Adult spinal deformity (ASD) is increasingly prevalent in the aging population and has a substantive impact on disability and decreased functionality.^{1–4} Surgical correction of the thoracolumbar deformity has shown promising results to restore function and quality of life, but often at the cost of an increased risk of complications.⁵ One of the most clinically relevant surgical morbidities continues to be proximal junctional kyphosis (PJK) and proximal junctional failure (PJF), as these entities often require ongoing clinical care and revision surgery.⁶

Research in the realm of ASD surgery has targeted the risk factors for the development of PJK and PJF postoperatively.^{6–8} In doing so, surgeons can identify high-risk individuals and tailor their surgical planning to mitigate the development of these conditions. Surgical practices to prevent PJK and PJF come in two forms: correction of deformity informed using realignment classifications and the use of prophylactic surgical techniques. Two published criteria for realignment are present: the Sagittal Age-Adjusted Score (SAAS), which tempers realignment of lumbopelvic parameters to a patient's age to combat radiographic failure, and the Global Alignment and Proportion (GAP) score, which was developed to realign the spine in proportion to a patient's pelvic incidence to mitigate mechanical failure.^{9,10} Surgical techniques currently present to prophylax the junctional region of the construct include cement augmentation, hooks connected to the transverse processes, tethering, minimally invasive approaches near the UIV, and contouring the UIV.^{11–16}

However, differing realignment strategies may have a greater effect on the potential for PJK and PJF, maybe even more so than prophylactic techniques in certain instances. Employing a realignment strategy can increase the surgical intensity and the prospect of longer-term complications, while the use of prophylactic techniques can increase operative time and immediate costs. In addition, the influence of realignment *versus* prophylaxis, as well as synergistic effects, may vary depending on the extent of patient-specific factors at baseline including the extent of deformity and inherent risk of postoperative morbidity. The intersection of these various parameters is not well understood in the current literature.

In this context, we sought to evaluate the influence of different surgical strategies on the development of PJK and PJF, including realignment of the base (lumbopelvic parameters) surgical techniques at the summit of the fusion and incorporation of prophylaxis, stratified by the length of fusion construct. We hypothesized that realignment at the base is most effective in reducing rates of junctional failure among all ASD patients, while prophylactic measures would have a greater effect in longer fusion constructs only.

MATERIALS AND METHODS

Data Source and Study Design

This is a retrospective analysis of a prospectively collected, single-center database containing ASD patients enrolled between 2012 and 2020. This data set, along with its inclusion criteria, has previously been successfully used as a substrate for investigations on clinical and health policy aspects of the treatment of ASD.^{17,18} Institutional Review Board (IRB) approval was obtained before the enrollment, and all patients provided informed consent. Patients enrolled in the database were older than 18 years of age and had the plan to undergo surgical correction with at least a five-level fusion extending from the pelvis for ASD. The inclusion criteria of the present study required operative ASD patients with complete demographic and surgical data, as well as radiographic, clinical, and complication surveillance for a minimum of two years postoperatively.

Data Collection and Radiographic Parameters

Standardized data collection forms assessed patient demographics [including age, gender, race, BMI, labor status, Charlson Comorbidity Index (CCI), and the ASD modified frailty index], surgical parameters [including the ISSG ASD Surgical Invasiveness Index], and comorbidities at the initial presentation.^{17,19} Lateral spine radiographs were used to assess radiographic parameters at baseline and follow-up intervals. All images were analyzed with SpineView (ENSAM, Laboratory of Biomechanics, Paris, France).^{20–22} Spinopelvic radiographic parameters assessed included pelvic tilt (the angle between the vertical and the line through the sacral midpoint to the center of the two femoral heads), the mismatch between pelvic incidence and lumbar lordosis (PI-LL), the sagittal vertical axis (C7 plumb line relative to the postero-superior corner of S1), T1 pelvic angle and the GAP score.^{9,23}

Complication Assessment

Proximal junctional kyphosis (PJK) was defined by a PJK angle of $<-10^\circ$ and a PJK angle difference of $<-10^\circ$ from baseline at any time point up to two years. Proximal junctional failure (PJF) was defined using the criteria of *Lafage et al*: a PJK angle of $<-28^\circ$ and a difference in PJK angle of $<-22^\circ$ from baseline at any follow-up time point up to two years.²⁴

Definition of a Good Base

Age-adjusted sagittal alignment was defined corresponding to the classification per the *Lafage et al* spinopelvic parameters (pelvic tilt, PI-LL, T1 pelvic angle, sagittal vertical axis) and a comprehensive SAAS.^{10,24} Patients were described as “Matched” if they met an ideal age-adjusted postoperative alignment, consisting of the criteria matched, undercorrected, and overcorrected. The lumbar lordosis distribution index, first categorized by *Yilgor et al* as a part of the GAP score, is calculated by dividing the L4-S1 lordosis by the L1-S1 lordosis and multiplying the output by

100.⁹ Relative Pelvic Version, per the original GAP score, was defined as the sacral slope relative to the pelvic incidence. After assessing the realignment of each lumbopelvic radiographic parameter postoperatively and its effect on PJK/PJF development, the combination of the two parameters with the greatest minimizing effect of PJK and PJF constituted a good base.

Definition of a Good Summit

A good summit was defined as having all of the following parameters: (1) the use of PJK prophylaxis [injection of polymethylmethacrylate cement at the UIV and/or UIV+1, a transverse process hook placed at the UIV, or a polyethylene tether inserted at the spinolaminar junction of the UIV+1 and/or UIV+2], (2) no lordotic change (under-contouring) greater than 10° of the UIV during surgery, and (3) a preoperative UIV inclination angle less than 20°. ^{12,13,25} The use of prophylaxis at the proximal junction was decided by the treating surgeon.

Statistical Analysis

The primary outcome was the development of PJK and/or PJF by two years. The primary predictors included: a good summit and/or a good base. Patients were stratified by shorter constructs (UIV at T8-T12) and longer constructs (UIV at T1-T4). Baseline data was reported using descriptive statistics and compared between the cohorts using χ^2 and *t*-tests. Binary logistic regression identified individual factors predictive of PJK or PJF by two years. Analysis of Variance (ANOVA) compared the rates of developing PJK and PJF with the use of either a good summit or a good base based on construct length. Multivariable logistic regression controlling for age, CCI, number of levels fused, use of three-column osteotomy, and baseline deformity (GAP Score) was used to determine significant associations between either a good base or a good summit and the outcome variables. Sub-analysis was performed on a cohort of patients with osteoporosis and/or severe frailty to assess the effects of lumbopelvic realignment and prophylaxis using the multivariable approach described above. All *P* values less than 0.05 were considered significant. All statistical analyses were conducted using SPSS, version 28.1.1 (Armonk, NY).

RESULTS

Cohort Overview

We included 261 operative ASD patients who met the inclusion criteria. Table 1 highlights the baseline demographics and surgical details, along with the Supplemental Table, Supplemental Digital Content 1, <http://links.lww.com/BRS/C116> detailing the UIV levels present among the cohort. Within the entire cohort, 37.6% of patients received PJK prophylaxis: 14.9% tethering at the UIV, 22.8% a transverse process hook, 4.0% had a cement augmentation at the UIV, and 2.9% had an MIS posterior approach to maintain muscular and ligamentous supporting structures at the UIV.

TABLE 1. Cohort Demographic and Surgical Details

Cohort details	Mean values
Mean age (y)	63.8 ± 9.6
Gender, %	79% F
Mean BMI (kg/m ²)	27.6 ± 5.1
Charlson Comorbidity Index	1.8 ± 1.7
Osteoporosis, %	19.9
ASD-mFI	7.2 ± 4.7
History of prior fusion	43.1
Surgical details	Mean values
Operative time (min)	457 ± 4178
Estimated blood loss (mL)	1886.3 ± 1319
Number of levels fused	12.7 ± 3.5
Length of stay (days)	8.1 ± 4.3
Surgical approach, %	Posterior: 64.4; Combined: 35.6
Osteotomy, %	80
Three-column osteotomy, %	27
Decompression, %	70
SICU admission, %	68
Invasiveness index	107 ± 34

Regarding prophylaxis utilization by approach, posterior approaches used PJK prophylaxis 40% of the time (4.5% cement, 23.0% hooks, 0.9% MIS posterior, and 21.9% tethering), and combined approaches used PJK prophylaxis 34% of the time (3.1% cement, 22.5% hooks, 6.1% MIS posterior, and 16.2% tethering).

Radiographic Alignment Outcomes and Junctional Complications of Cohort

Radiographic parameter outcomes of the cohort are displayed in Table 2. When assessing age-adjusted alignment postoperatively, 24.6% were matched in the SAAS. The mean GAP score at six weeks was 4.4 ± 3.5, with 34.9% being proportioned. By two years, 37.5% of patients developed radiographic PJK (37.6% in shorter constructs and 35.7% in longer constructs) and 10.2% developed PJF (9.4% in shorter constructs and 11.6% in longer constructs). Patients developing PJK had significantly greater baseline deformity in GAP score (9.4 *vs.* 8.1, *P*=0.022), as well as surgical invasiveness (110 *vs.* 101, *P*=0.036). Patients developing PJF were older (66.4 *vs.* 63.0 years, *P*=0.048), higher comorbidity status (CCI: 2.6 *vs.* 1.8; *P*=0.030) with significant differences in baseline deformity of GAP Score (9.7 *vs.* 8.2; *P*=0.047) compared with those not developing either PJK or PJF.

Individual Effects of Surgical Techniques and Realignment on the Development of PJK or PJF

These surgical techniques and realignment strategies were examined for their effects on postoperative rates of PJK and PJF in Table 3. Patients were less likely to develop PJK by

Downloaded from http://journals.lww.com/spinejournal by BHDMSepHKavI zEoum1tQINa+kLhEz9sH04XMI0N CwCXC1AWNYQpI/ID3I3D00dRy7ITVSFI4C13V/C1y0abgQZxdImfKZB7WS= on 12/05/2024

TABLE 2. Cohort Radiographic Outcomes

Radiographic parameter	Preoperative	Postoperative	<i>P</i>
PI	55.2 ± 12.4°	—	—
PI-LL	21.5 ± 19.9°	0.2 ± 13.3°	< 0.001
PT	26.6 ± 10.2°	19.6 ± 10.1°	< 0.001
C7-S1 SVA	82.2 ± 69.9 mm	23.0 ± 42.0 mm	< 0.001
T1PA	26.5 ± 12.7°	15.3 ± 9.4°	< 0.001
L1PA	12.2 ± 10.3°	9.2 ± 8.1°	< 0.001
L4-S1	32.5 ± 14.8°	34.2 ± 12.1°	0.021
T4-T12	-32.1 ± 18.5°	-44.4 ± 14.3°	< 0.001
GAP score	8.8 ± 3.9	4.4 ± 3.5	< 0.001
GAP-relative pelvic version, %	23.8	47.7	< 0.001
Lordosis Distribution Index, %	23.1	55.0	< 0.001

P-value < 0.05.

two years when aligned in PI-based pelvic version (OR: 0.6, 95% CI: [0.3–1.0]; *P* = 0.044), along with the use of either PJK prophylaxis, specifically transverse process hooks, and lordotic change at the UIV (both *P* < .05). Incorporation of a good summit into surgical strategies led to a lower likelihood of developing PJK (OR: 0.5, 95% CI: [0.2–0.9]; *P* = 0.044) and PJF (OR: 0.1, 95% CI: [0.0–0.7]; *P* = 0.014) by two years. Surgical approach and history of prior thoracolumbar fusion did not play a role in the development of PJK or PJF in either shorter or longer constructs (*P* > .3); however, the use of three-column osteotomies was associated with higher rates of PJK in longer constructs (OR: 2.2, 95% CI: [1.3–5.6]; *P* = 0.011).

Effect of Surgical Techniques and Realignment on the Development of PJK or PJF

Patients were assessed for meeting the criteria of either a good base or a good summit and compared for the rates of PJK and PJF development after dividing the cohort into shorter and longer constructs. Controlling for age, CCI, number of levels fused, and baseline GAP score, the presence of a good summit (present in 23 patients) did not influence rates of PJK or PJF (both *P* > 0.08) in shorter constructs (Table 4). Realignment patients to ideal relative pelvic version and lumbar lordosis distribution (43 patients), this combination significantly reduced the likelihood of developing PJF (OR: 0.2, 95% CI: 0.02–0.9]; *P* = 0.036) by two years.

For Longer Constructs, adjusted analysis revealed the presence of a Good Summit (present in 27 patients) led to a lower likelihood of developing PJK (OR: 0.3, 95% CI: 0.1–0.9]; *P* = 0.027) and PJF (0% vs. 25%, *P* < 0.001). When realigning patients to the ideal relative pelvic version and age-adjusted PI-LL (20 patients), this combination significantly reduced the likelihood of developing PJF (0% vs. 20%, *P* < 0.001) by two years (Table 4).

Among the sub-cohort of patients deemed frail by the ASD modified frailty index (*n* = 137), 35.8% developed PJK and 11.7% developed PJF. Adjusted analysis revealed the presence of a good summit (present in 25 patients) led to a

lower likelihood of developing PJK (OR: 0.4, 95% CI: 0.2–0.9]; *P* = 0.041) and PJF (OR: 0.1, 95% CI: 0.01–0.99]; *P* = 0.049). When realigning patients to ideal relative pelvic version and age-adjusted PI-LL (13 patients), this combination significantly reduced rates of developing PJF (0% vs. 11%, *P* = 0.004) by two years, but not PJK (10% vs. 11%, *P* = 0.876; Table 4).

DISCUSSION

Proximal junctional failure remains a prevalent concern following interventions for adult spinal deformity, occurring between 5% and 57%.²⁶ This complication has proven to substantially impact clinical outcomes, as well as having major economic consequences given the increased likelihood of reoperation.^{6,27} Our study examined the impact of lumbopelvic realignment at the caudal end of the construct and the use of prophylactic and minimally invasive measures at the cranial aspect of the fusion on the eventual development of PJK/PJF. We found lumbopelvic realignment to be the most efficient intervention for constructs ending in the lower thoracolumbar region, whereas both realignment and prophylactic measures were effective among constructs extending proximal to the thoracic apex. Effective realignment and prophylactic strategies, in this instance, returned no instances of junctional failure within the first two years following surgery.

Many studies have examined the various outcomes of realignment and surgical techniques, but, to our knowledge, ours is the first to directly compare the effect of synergy between the two in preventing proximal junctional kyphosis and failure. We found lumbopelvic realignment to be more influential within shorter fusions compared with prophylactic measures, whereas both had minimizing effects in longer fusions. The explanation for this key finding may be found in the stress a construct places on the spine and the number of proximal levels available to compensate. In shorter constructs ending between T9 and T12, the spine still has the majority of the thoracic spine and the entirety of the cervical spine to compensate for changes effected by

TABLE 3. Effect of Realignment or Surgical Techniques on Development of PJK and PJF

Factor	Odds ratio	[95% confidence interval]; <i>P</i>
Development of PJK		
Realignment		
Matched in SVA	1.5	[0.8–2.5]; <i>P</i> =0.196
Matched in PT	0.5	[0.3–1.1]; <i>P</i> =0.083
Matched in PI-LL	1.3	[0.7–2.5]; <i>P</i> =0.425
Matched in T1PA	1.0	[0.5–1.8]; <i>P</i> =0.967
Matched in SAAS	0.8	[0.5–1.6]; <i>P</i> =0.598
Aligned in RPV	0.6	[0.3–1.0]; <i>P</i>=0.044*
Aligned in LDI	0.9	[0.5–1.6]; <i>P</i> =0.761
Proportioned in GAP	1.1	[0.6–2.0]; <i>P</i> =0.790
Surgical technique		
PJK prophylaxis	0.5	[0.3–1.0]; <i>P</i>=0.034*
Transverse process hook	0.3	[0.1–0.8]; <i>P</i>=0.009*
Lordotic change at the UIV	2.6	[1.3–4.9]; <i>P</i>=0.004*
High UIV inclination Angle	1.4	[0.6–3.2]; <i>P</i> =0.491
Good summit	0.5	[0.2–0.9]; <i>P</i>=0.044*
Development of PJF		
Realignment		
Matched in SVA	1.0	[0.4–2.4]; <i>P</i> =0.933
Matched in PT	0.8	[0.3–2.2]; <i>P</i> =0.684
Matched in PI-LL	0.3	[0.2–1.6]; <i>P</i> =0.179
Matched in T1PA	1.3	[0.5–3.3]; <i>P</i> =0.582
Matched in SAAS	1.1	[0.4–2.8]; <i>P</i> =0.896
Aligned in RPV	0.5	[0.2–1.2]; <i>P</i> =0.106
Aligned in LDI	1.2	[0.5–2.8]; <i>P</i> =0.662
Proportioned in GAP	0.9	[0.4–2.4]; <i>P</i> =0.896
Surgical technique		
PJK prophylaxis	0.5	[0.2–1.2]; <i>P</i> =0.114
Lordotic change at the UIV	0.7	[0.3–1.7]; <i>P</i> =0.407
High UIV inclination Angle	3.8	[1.2–12.5]; <i>P</i>=0.025*
Good summit	0.1	[0.0–0.7]; <i>P</i>=0.014*

*significant *P*-value below .05.

this situation, both realignment and prophylactic measures may prove vital in minimizing stress placed on the proximal junction and the amount of compensation needed in the mobile segments, respectively.

Numerous approaches have been posited to mitigate the potential for junctional issues following corrective surgery. Surgical intervention at the UIV has shown to lower rates of both PJK and PJF in previous studies.^{13,14,29} *Line et al* highlighted the synergistic effect of avoiding overcorrection in PI-LL and the utilization of either cement, hooks, or tethering.¹⁴ However, recent studies have questioned the broad utility of prophylactic techniques, maintaining that these may not be a cost-effective intervention except in specific at-risk subsets of the ASD population.^{30,31,32} Similar conclusions are supported by the results of the work we have conducted here. In the present investigation, constructs extending to the upper thoracic region (T1–T4), the use of prophylactic measures, and preoperative assessment of the targeted UIV led to significantly lower rates of PJK and PJF in a potentially higher-risk cohort with longer fusion constructs. While each prophylactic technique was not parsed out for its individual effects within each cohort, the role of prophylaxis in general seems to have an exponential effect and should be considered when targeting a UIV above the thoracic apex.

Similarly, achieving the idealized realignment of adult spinal deformity has also been shown to lower rates of junctional complications. The findings from the present study indicate there are separate realignment strategies that best mitigate the incidence of junctional failure in fusion constructs that differ based on whether the construct ends in the lower or upper thoracic region. Our study identified rates of PJF were lowest in the lower thoracolumbar region with the use of a pelvic incidence-based approach, properly distributing the lumbar lordosis and relieving the compensation of the pelvis. Because the lumbar spine comprises the majority of in-construct vertebra in these fusions, what is done within the lumbar spine has a great magnitude of effect on outcomes, as demonstrated by the influence of lumbar distribution.³³ Whereas in constructs extending into the upper thoracic region, correction to age-adjusted standards in both PI-LL and pelvic tilt resulted in no instances of PJF. Previous studies have suggested a positive linear association between the severity of deformity and the length of the ultimate surgical construct.²⁴ At the same time, there is also a similar association between age and deformity severity. As such, correction back to low deformity standards may not be necessary to achieve favorable results, and tailoring realignment goals to age-adjusted standards may be more efficacious in preventing mechanical complications. Therefore, per the results of this study and the experience of the senior author, we recommend attentive preoperative planning for both shorter and longer constructs by correcting the lumbar lordosis and its shape with relevance to the pelvic incidence and the patient’s age, relieving the pelvis of its compensatory mechanisms as a result. In addition, when extending the construct into the upper thoracic region, careful measures to

surgical correction. Therefore, proper realignment within the construct may leave little need for further compensation in the proximal spine. This then translates to lower rates of junctional failure, in and of itself, and prophylactic measures have little effect. Conversely, in longer constructs, the spine has less mobile segments within which to dissipate forces, resulting in more drastic compensation within the levels available and higher consequent rates of failure.²⁸ In

Downloaded from http://journals.lww.com/spinejournal by BHD/MSep/HKav/zEum/tIQN4ak+LHeZg0sho4XM10H CwCXC1AWNY/Op/ll/04H/D313D00d/7/VSFI4C/3V/C1y0abgQZxdwIKZBYms= on 12/05/2024

TABLE 4. Effect of Good Base and Good Summit on Development of PJK and PJF

Longer constructs (112 patients)						
	PJK			PJF		
Presence	No PJK	PJK	<i>P</i>	No PJF	PJF	<i>P</i>
Presence of a good summit, %	33.9	17.5	0.062	33.9	0.0	<0.001
Presence of a good base, %	11.9	7.5	0.485	11.9	0.0	<0.001
Shorter constructs (149 patients)						
	PJK			PJF		
Presence	No PJK	PJK	<i>P</i>	No PJF	PJF	<i>P</i>
Presence of good summit, %	20.3	8.9	0.059	20.3	14.3	0.607
Presence of a good base, %	35.4	25.0	0.192	35.4	7.1	0.004
Severe frailty and/or osteoporosis (137 patients)						
	PJK			PJF		
Presence	No PJK	PJK	<i>P</i>	No PJF	PJF	<i>P</i>
Presence of a good summit, %	26.4	10.2	0.019	26.4	6.3	0.018
Presence of a good base, %	11.1	10.2	0.876	11.1	0.0	0.004

significant *P* value below .05.

preserve the muscular and ligamentous attachments and further augment with hooks and tethering have been shown in the current study to stabilize the construct and minimize the excessive kyphotic change at the proximal junction that often leads to poor clinical improvement and reoperation.

Along with these results, we also acknowledge several limitations inherent to this research. First, utilizing a retrospective database of patients undergoing an operation at a single center incurs the risk of selection, expertise, and indication bias. Secondly, we acknowledge there are likely confounding variables present that may not be fully accounted for by controlling within the analysis, separating patients into cohorts based on fusion length, and grouping both realignment and surgical technique schemes. Certain subgroups had no instances of junctional failure, which may represent restricted clinical variation. This is unlikely to be the case, even just by chance, in more robust samples. Therefore, future studies with prospective designs, in addition to cohorts with greater clinical variation, are necessary to validate the findings of the current work. Last, we acknowledge that the statistical approach employed here was exploratory in outlook, and the findings should not be considered prescriptive. While awaiting confirmatory analyses envisioned in the future, our results can be used to inform surgical planning and help patients and surgeons understand the role that realignment and prophylactic measures can play in modulating adverse mechanical outcomes following surgery.

CONCLUSIONS

Previous literature has demonstrated realignment of adult spinal deformity, and prophylactic measures at the upper-instrumented vertebra confer benefits in terms of lowering rates of proximal junctional kyphosis and failure. To further mitigate junctional failure, our study demonstrated the utility

at two years of individualizing surgical approaches to emphasize an optimal basal construct by promoting correction of lumbar shape in shorter constructs and age-adjusted lordosis in longer constructs. Achievement of tailored goals and employment of prevention strategies at the cranial end of the surgical construct may be equally important, especially for higher-risk patients with longer fusions.

➤ Key Points

- ❑ It is unclear whether interventions at the base, summit, or both are needed to effectively prophylaxis against junctional failure.
- ❑ This study sought to evaluate the surgical technique and lumbopelvic realignment strategies that have the greatest influence on the rate of junctional failure following ASD surgery.
- ❑ Our study demonstrated the utility of individualizing surgical approaches to emphasize an optimal base (lumbopelvic realignment) in constructs extending into either the lower or upper thoracic region.
- ❑ Achievement of tailored goals at the cranial end of the surgical construct may be equally important, especially for longer fusions in higher-risk patients, such as those with severe frailty and/or low bone mineral density.

References

1. Laverdière C, Georgiopoulos M, Ames CP, et al. Adult Spinal deformity surgery and frailty: a systematic review. *Glob Spine J.* 2021;12:689–99.
2. Smith JS, Fu K, Urban P, Shaffrey CI. Neurological symptoms and deficits in adults with scoliosis who present to a surgical clinic: incidence and association with the choice of operative versus nonoperative management. *J Neurosurg Spine.* 2008;9:326–31.

Downloaded from http://journals.lww.com/spinejournal by BHDMSepHKavI zEumIhQIN4akUlhEzGjsHo4XMI0n CwCXT1AWNyQpI/QH/D3I3D00dRy/ITV5FI4C/3V/C1y0abgQZxdImfKZB7yws= on 12/05/2024

