Neurospine 2024;21(4):1091-1093.
https://doi.org/10.14245/ns.2449350.675

Neurospine
pISSN 2586-6583 eISSN 2586-6591

Commentary

New Insights Into Risk Factors for Proximal Junctional Failure in Adult Spinal Deformity Surgery – A Commentary on "Proximal Junctional Failure Development Despite Achieving Ideal Sagittal Correction According to Age-Adjusted Alignment Target in Patients With Adult Spinal Deformity: Risk Factor Analysis of 196 Cases Undergoing Low Thoracic to Pelvic Fusion"

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See the article "Proximal Junctional Failure Development Despite Achieving Ideal Sagittal Correction According to Age-Adjusted Alignment Target in Patients With Adult Spinal Deformity: Risk Factor Analysis of 196 Cases Undergoing Low Thoracic to Pelvic Fusion" via https://doi.org/10.14245/ns.2448734.367.

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Proximal junctional failure (PJF) continues to be a significant complication in adult spinal deformity (ASD) surgery, even when optimal sagittal correction is achieved in accordance with age-adjusted alignment targets. This article[1] investigates the risk factors for the development of PJF in patients who underwent low thoracic to pelvic fusion for ASD, providing valuable insights into this clinical challenge. The study included 196 patients and identified several risk factors for PJF, including advanced age, higher preoperative sagittal vertical axis (SVA), nonuse of transverse process (TP) hooks, and an increased lumbar distribution index (LDI). This commentary explores the findings of the study and their implications for clinical practice.

Despite achieving ideal sagittal correction in ASD surgery, the incidence of PJF in this study remained substantial at 21.9%. This finding indicates that meeting age-adjusted targets for pelvic incidence minus lumbar lordosis (PI–LL) alone is insufficient to mitigate the risk of PJF. Identifying modifiable factors, including surgical technique and strategy, as contributors to PJF risk represents a crucial step toward refining preventative measures.

The multivariate analysis demonstrated that older age significantly increases PJF risk (odds ratio [OR], 1.063; p = 0.046). The authors suggest this finding may be related to age-related factors like sarcopenia and reduced compensatory capacity in elderly patients. Sarcopenia is characterized by decreased skeletal muscle mass; however, decreasing trunk

muscle mass—rather than skeletal muscle mass—has been reported to be strongly associated with low back pain and spinal sagittal alignment.[2] Thus, both sarcopenia and decreasing trunk muscle mass may be associated with PJF in older patients. In addition, although age was embedded in PI–LL calculations in this study, these calculations do not fully account for age-related biomechanical vulnerabilities.

A high preoperative SVA (OR, 1.007; p = 0.024) was associated with an increased risk of PJF. Patients with significant sagittal imbalance require extensive corrective measures, which may place additional stress at the proximal junction. This finding is consistent with previous studies indicating that overcorrection of LL relative to PI, especially when considering age-adjusted ideal sagittal alignment, tends to increase the incidence of proximal junctional kyphosis.[3] These findings highlight the need for careful preoperative planning to achieve truly appropriate spinal sagittal alignment. However, the definition of truly appropriate spinal sagittal alignment for older patients remains unclear.

The study identified the nonuse of TP hooks at the uppermost instrumented vertebra (UIV+1) as the most significant modifiable risk factor (OR, 5.556; p = 0.028). TP hooks provide a more gradual transition in stiffness, which may reduce stress at the surgical junction. These findings advocate for their routine use as a preventative measure, particularly in high-risk patients.

A high LDI was a significant contributor to PJF risk (OR, 1.136; p < 0.001). LDI quantifies the distribution of lordosis within the lumbar spine, and an elevated index may reflect disproportionate stress distribution. This highlights the importance of achieving the correct magnitude of lordosis and ensuring its appropriate anatomical distribution.

Although aging and higher SVA are inevitable, early intervention may be necessary to prevent the progression of severe spinal deformities associated with high SVA. In addition, the identification of modifiable factors such as TP hooks and LDI presents actionable strategies to reduce the incidence of PJF. Therefore, surgeons should consider the following recommendations:

- Utilize TP hooks, particularly in older patients or those with high preoperative SVA.
- Aim for optimal LDI values tailored to each patient's spinal morphology. This study recommends Roussouly-type-specific LDI thresholds (e.g., < 70.9% for type 2).
- Exercise caution against overcorrection of sagittal alignment, as it has been linked to increased junctional stress.

The study's retrospective design and single-institution cohort may limit the generalizability of the findings. The analysis focused solely on TP hooks at the UIV+1 level as a preventative measure for PJF. However, various instrumentation techniques, such as 2-level prophylactic vertebroplasty, flexible rods, sublaminar tapes, and multilevel stabilization screws at the UIV level, have been reported to be effective in preventing PJF after ASD surgery.[4] Therefore, future studies should explore these instrumentation techniques at the UIV level. Second, osteoporosis-related factors, including bone mineral density (BMD) and the perioperative use of teriparatide, were not detected as risk factors for PJF in this study. Although BMD is usually measured at the lumbar vertebra, PJF occurs at the low thoracic level. Recent research indicates that Hounsfield units (HU) of vertebrae are strongly associated with BMD and can be utilized to evaluate bone strength and the presence of osteoporosis. The measurement of HU values offers the advantage of assessing multiple vertebrae across both the lumbar and thoracic spine. Additionally, studies have reported that preoperative HU values at the UIV and UIV+1 levels are significantly lower in patients with PJF.[5] Evidence suggests that the perioperative use of teriparatide significantly reduces the incidence of PJF following ASD surgery.[6] Thus, in contrast to the results of this study, osteoporosis-related factors may be associated with PJF. More comprehensive information regarding osteoporosis-related factors will be necessary in further studies.

In conclusion, this study provides compelling evidence that modifiable factors such as TP hook usage and LDI significantly influence the risk of PJF, even when optimal sagittal alignment is achieved. These findings challenge the adequacy of current alignment targets and advocate for a more nuanced approach to surgical planning. By incorporating these insights into practice, spinal surgeons can further optimize outcomes for patients with ASD.

- **Conflict of Interest:** The authors have nothing to disclose.

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