Upper Instrumented Vertebra within 3 Levels of the Thoracic Apex is the Most Significant Risk Factor for Proximal Junctional Kyphosis in Lenke Type 5 and 6 Adolescent Idiopathic Scoliosis Patients

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INTRODUCTION:

Proximal junctional kyphosis (PJK) is a known complication of adolescent idiopathic scoliosis (AIS) deformity correction surgery. Previous literature has estimated the rates of radiographic PJK in all Lenke curve types to range between 9-27%. Specifically in Lenke 5 and 6 curves, the rate of radiographic PJK has been reported as significantly higher, up to 50%. Interestingly, while radiographic PJK has been reported at such high rates, in the AIS population, with most studies involving 2-5 year follow up, no literature has found significant differences in health related quality of life scores or other clinical outcomes.

AIS studies of all curve types have explored a multitude of radiographic risk factors preoperatively and postoperatively for PJK. Previous smaller studies have identified high pelvic incidence, increased preoperative proximal junctional angle (PJA), and large preoperative thoracic kyphosis (TK) as possible risk factors for developing PJK.

The goal of this study was to perform a multicenter retrospective cohort of patients who underwent specifically Lenke Type 5 and 6 deformity correction surgery.

METHODS:

A retrospective review of multicenter AIS databases was performed. Inclusion criteria was patients with Lenke type 5 or 6 curves who underwent posterior instrumentation and fusion. A total of 194 patients from 10 institutions were initially identified; 192 patients with 2 year follow up and 94 patients with 5 year follow up were included in the final analysis. Radiographic clinical parameters were measured preoperatively and at postoperative year 1, 2, and 5. Radiographic measurements were performed and confirmed by three authors. Measurements included proximal kyphosis, distal lordosis, proximal junctional angle (PJA), sacral slope, apex of thoracic kyphosis, pelvic tilt, and pelvic incidence. Other data extracted included patient demographics, surgical details, outcomes scores (SRS-22), and complications.

PJK was defined as the proximal junctional angle from the UIV and 2 levels cephalad to the UIV of at least 10° and 10° greater than preoperative measurement. Timing that PJK developed was recorded. Descriptive statistics were performed between patients with PJK and those without. ANOVA and T tests were used to evaluate for a significant risk factor for developing PJK. The following variables were analyzed: preoperative PJA, preoperative PI, preoperative thoracic kyphosis, and UIV Distance from Thoracic Apex. All analyses were performed with SAS and alpha was set at $P < 0.05$ to declare significance.

RESULTS:

In total, 16% of patients were male (n=31) and 84% (n=163) female. Lenke type 5CN (n=147) was the most common curve type (Table 1). T10 to L4 were the most frequently fused levels (n=54) followed by T11 to L3 (n=38) and T9 to L3 (n=34). Patients underwent an average 5-level fusion (range 3-9); 6.2% of patients (n=12) developed radiographic PJK; 1 at 1 year (8.3%), 9 at 2 years (75%), and 2 at 5 years (16.7%).

Total SRS-22 scores were significantly worse at postoperative years 2 and 5 in patients who developed PJK (2 years: PJK 4.16 ± 0.58 vs. 4.45 ± 0.43, p=0.018; 5 years: 3.96 ± 0.42 vs. 4.37 ± 0.48, p=0.021). At 2 years, SRS-22 pain and general function categories were significantly lower in PJK patients. At 5 years, SRS-22 pain, self-image, and general function categories were significantly lower in PJK patients. Between postoperative years 2 and 5, the PJK patients overall had lower scores, self-image in particular significantly lowered (p=0.0499).

No significant difference in BMI was found between patients who developed PJK and those who did not (nPJK) (PJK 20.1 kg/m² vs. nPJK 21.73 kg/m², p=0.38). The PJA trended toward being higher in patients who developed PJK as compared to those who did not (PJK 5.6° ± 3.2° vs. nPJK 4.5° ± 2.8°, respectively p=0.089). Preoperative pelvic incidence was not significantly different between those with PJK and those without (PJK 50° ± 13° vs. nPJK 49.3° ± 13.5°, p=0.45).

Location of UIV was significantly correlated with the development of PJK (Figure 1). Patients who developed PJK had an average distance from UIV to apex of thoracic kyphosis of 2 ± 1.1 as compared to 3.8 ± 1.1 for those who did not (p<0.0001, Hedges' effect g = 1.636364.). No patients with a distance greater than 3 levels from apex of thoracic kyphosis to UIV developed PJK (p<0.001).

Preoperative thoracic kyphosis T2-T12 was not significantly correlated with development of PJK (PJK 37.6° ± 13.6°, nPJK 36.6° ± 11.4°, p=0.39).

DISCUSSION AND CONCLUSION:

This study is the largest multicenter of 192 patients with Lenke 5 and 6 curves who underwent posterior deformity correction and instrumentation. The rate of radiographic PJK reported in this study, 6.2%, was lower than previously

reported for Lenke 5 and 6 curves. The only radiographic risk factor found to be significant was the distance from the UIV to the apex of thoracic kyphosis ($p<0.001$). In selective thoracolumbar fusions, UIV should be minimum 2-3 vertebral levels from the apex of thoracic kyphosis. In this study, patients with PJK had worse SRS-22 scores, specifically in pain, self-image, and general function.

Figure 1. 11F with Lenke Type 5CN who underwent T9-L3 fusion within 2 levels of the thoracic kyphosis apex (T7). Postoperative year 2 she developed radiographic and symptomatic junctional kyphosis.

Table 1. Risk factors for patients who developed radiographic PJK.

Variable	PJK	nPJK	P value
BMI	20.1 kg/m²	21.7 kg/m²	p=0.38
Preop PJA	5.6°	4.5°	p=0.089
Preop PI	50.0°	49.3°	p=0.45
Preop T2-12 Kyphosis	37.6°	36.6°	p=0.38
Preop T2-5 Kyphosis	10.6°	12.8°	p=0.13
Preop T5-12 Kyphosis	27.0°	25.3°	p=0.30
Distance UIV to Apex of Thoracic Kyphosis	2.0 Levels	3.8 Levels	p<0.001