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# Risk factor analysis of proximal junctional kyphosis after posterior fusion in patients with idiopathic scoliosis

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ABSTRACT

*Study design:* A retrospective analysis of 150 adolescents who underwent spinal fusion for idiopathic scoliosis.
*Objective:* To analyse the incidence of the postoperative proximal junctional kyphosis after posterior fusion to the upper thoracic vertebra in adolescents with idiopathic scoliosis and to explore its risk factors.
*Summary of background data:* The reported incidence of the proximal junctional kyphosis after the posterior fusion in patients with idiopathic scoliosis varies depending on surgical methods and strategies adopted by the institution.
*Methods:* The changes in the Cobb angle of the proximal junctional kyphosis on the lateral spine X-ray were measured and the presence of PJK was recorded. The risk factors were screened using statistical analysis.
*Results:* PJK occurred in 35 out of 123 patients with an overall incidence of 28%. Among them, 28 patients (80%) experienced PJK within 1.5 years after surgery. The PJK-inducing factors included greater than 10° intraoperative decrease in thoracic kyphosis, thoracoplasty, the use of a pedicle screw at the top vertebra, autogenous bone graft and fusion to the lower lumbar vertebra (below L2).
*Conclusions:* There is a high incidence of postoperative proximal junctional kyphosis after posterior fusion to the upper thoracic vertebra within 1.5 years after surgery in adolescents with idiopathic scoliosis. In order to reduce its incidence, the risk factors for PJK should be carefully evaluated before surgery.



## Introduction

In the past, thoracolumbar and lumbar idiopathic scoliosis have been treated by anterior spinal instrumentation and fusion, however, such treatment was associated with loss of fixation, high pseudoarthrosis rates, and kyphogenic effect at the instrumented level.[12,15] Posterior spinal fusion with segmental fixation provides better control of the lordosis and reduces the need for postoperative immobilization.[18] However, the incidence of proximal junctional kyphosis (PJK) caused by the accelerated degeneration of the joint capsule and smaller articular processes in the proximal junctional region has attracted the attention of many scholars.[3,5,7–9,13,18]

In the past, the incidence of proximal junctional kyphosis and its associated risk factors varied greatly according to the reporting institution (ranging from 9.2% to 46%). Lee et al.[13] first reported PJK as a complication, with an incidence as high as 46%. Their data showed that preoperative proximal junctional kyphosis greater than 5° is an important predictive factor for the development of postoperative PJK. However, Kim et al.[8,9] conducted two large studies of PJK and found the incidence of PJK ranged from 26% to 28%. Their data showed that different types of internal fixation and the degree of preoperative thoracic kyphosis were the dominant factors affecting the PJK occurrence. The latest data from Hollenbeck et al.[7] were obtained from a 4.9-year follow-up study on idiopathic scoliosis ($n = 174$). He found that only 9.2% patients showed increased postoperative proximal kyphosis.

There are many reasons for the aforementioned differences in the reported results including the definition of the proximal junction zone, the method used to measure the angle, surgical strategies, and the orthopaedic approach chosen.

According to the Lenke et al. classification,[14] there are a large proportion of patients with types 1–4 and type 6 idiopathic

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scoliosis. The surgical strategy for those patients requires fusion to the upper thoracic vertebra to prevent the postoperative superposition effect of physiological stress in the proximal junctional region, which will greatly affect the occurrence and development of kyphosis.

This study included adolescents with idiopathic scoliosis ($n = 150$) who received posterior fusion at our hospital from 2000 to 2005 and were assessed for changes in their proximal junctional kyphosis angle during follow-up of at least 2 years. The objectives of this study were to observe the incidence of postoperative proximal junctional kyphosis in this group of patients and to compare our data with the data reported in the literature. In addition, we systemically analysed the risk factors associated with the development of PJK in order to modify the current operational strategy at our institution.

## Materials and methods

### *Subjects*

We performed a retrospective analysis of 150 patients with idiopathic scoliosis who underwent orthopaedic surgery at Shanghai Changhai Hospital from 2000 to 2005. All the patients were citizens of mainland China. The postoperative follow-up time for all patients was more than 2 years with an average of 3.5 years. The selected patients were further screened to meet the following inclusion criteria:

(1) The type of scoliosis was adolescent idiopathic scoliosis.
(2) The surgical approach was simple posterior surgery (including patients who received the thoracoplasty during the same period).
(3) The top vertebra was in the upper thoracic region (T1–T7).
(4) No intraoperative or postoperative internal fixation-related complications occurred. The patients receiving revision surgery were excluded from the study.
(5) The proximal junctional vertebra could be identified on the lateral X-rays and the angle measurement was not affected.

### *Surgery*

The prone position was adopted during surgery. The posterior structures (including the supraspinous ligament, the interspinous ligaments, and spinous process) were extensively released during the surgery, but the supraspinous ligament, the interspinous ligaments, and spinous process of the segment between the UIV (top vertebra) and the first vertebra of the junctional vertebra were preserved. Laminar hooks, pedicle hooks, transverse process hooks, and pedicle screws were selected for the correction of the top vertebra of the thoracic vertebra. Free-hand implanting technique[10,11] was used to implant all the pedicle screws, and the positions of all the screws were confirmed to be excellent by intraoperative fluoroscopy performed using a C-arm fluoroscopy machine.

In terms of the bone graft material, the removed spinous process was trimmed into a bone strip and was implanted into the bone bed using three kinds of materials for the supplementation if the bone mass was insufficient. These materials included autologous ilium, allograft artificial bone, and biological bone material.[17]

All the patients practiced ambulation wearing a brace within 3–5 days after surgery. The brace wearing time was at least 3 months. Stressful activities were avoided for at least 1 year after surgery.

### *Imaging indexes*

The posterior–anterior and lateral X-rays of the spine for each patient were taken on a regular basis. The time points included before surgery, 2 weeks after surgery, 6 months after surgery, 1.5 years after surgery, and at the final follow-up appointment. The measured imaging indexes included the Cobb angle of the main curve, the distance between the C7 vertical line and the sacrum vertical line (CSVL), the thoracic kyphosis angle, and the lumbar kyphosis angle.

The measurement of the proximal junctional kyphosis angle was performed according to the definition of the proximal junctional region by Glattes et al.[3] The changes of the junctional angle were reflected by the two intravertebral discs adjacent to the head end of the UIV of the fused segment. We selected the UIV and the second vertebra near the head end of that vertebra and measured the angles according to the Cobb method. PJK was diagnosed when the kyphosis angle met the following two criteria: (1) the measured Cobb angle was greater than 10°; (2) compared to the preoperative angle of that region, the increase was more than 10°.

### *Statistical analysis*

Data were represented as median (interquartile range, IQR) for continuous variables and number (percentage) for categorical variables. The differences between the PJK patients and the control group were examined by Mann–Whitney *U*-test for continuous data and by chi-square test for categorical data. Univariate logistic regression analysis was utilised to ascertain the strength of correlation between a risk factor and PJK. The odds ratio (OR) with

**Table 1**
Baseline characteristics of 123 patients.

| | Control ($n = 88$) | PJK ($n = 35$) | $p$-Value[a] | Odds ratio (95% confidence interval) | $p$-Value[b] |
|---|---|---|---|---|---|
| Age (years) | 15.0 (13.0, 16.0) | 15.0 (13.0, 16.0) | 0.790 | 1.02 (0.90, 1.15) | 0.798 |
| Male gender | 17 (19.3) | 6 (17.1) | 0.780 | 1.16 (0.42, 3.23) | 0.780 |
| Risser | 2.0 (2.0, 4.0) | 3.0 (2.0, 4.0) | 0.201 | 1.20 (0.89, 1.62) | 0.233 |
| Cobb angle (°) | 48.5 (42.0, 58.0) | 51.0 (42.0, 73.0) | 0.400 | 1.02 (0.99, 1.04) | 0.164 |
| Flexibility | 45.5 (44.0, 54.0) | 45.0 (40.0, 54.0) | 0.264 | 0.99 (0.95, 1.03) | 0.530 |
| Postural curvature angle of thoracic vertebrae | | | 0.046* | | |
| <20° | 31 (35.2) | 7 (20.0) | | Ref | – |
| 30–40° | 21 (23.9) | 5 (14.3) | | 1.05 (0.30, 3.77) | 0.935 |
| >40° | 36 (40.9) | 23 (65.7) | | 2.83 (1.07, 7.49) | 0.036* |
| Kyphosis angle at proximal junction area | | | 0.015* | | |
| <5° | 49 (55.7) | 11 (31.4) | | Ref | – |
| ≥5° | 39 (44.3) | 24 (68.6) | | 2.74 (1.20, 6.28) | 0.017* |

PJK, proximal junction kyphosis; Ref, reference group.
[a] Continuous data were presented as median (interquartile range, IQR) and tested by Mann–Whitney *U*-test; categorical data were presented as number (percentage) and tested by chi-square test.
[b] Univariate logistic regression was performed.
* Significantly correlated with PJK, $p < 0.05$.