Neurospine 2024;21(3):903-912.
https://doi.org/10.14245/ns.2448544.272

Neurospine
pISSN 2586-6583 eISSN 2586-6591

Original Article

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Received: May 26, 2024
Revised: July 11, 2024
Accepted: July 12, 2024

Postoperative Coronal Imbalance in Lenke 5C Adolescent Idiopathic Scoliosis: Evolution, Risk Factors, and Clinical Implications

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Objective: To explore the changes in coronal imbalance (CIB) in Lenke 5C adolescent idiopathic scoliosis (AIS) after posterior selective fusion surgery and determine their implications for surgical decision-making.
Methods: One hundred twenty patients were categorized according to the preoperative coronal pattern (type A, coronal balance distance [CBD] < 20 mm; type B, CBD ≥ 20 mm and coronal C7 plumbline [C7PL] shifted to the concave side of the curve; type C, CBD ≥ 20 mm and C7PL shifted to the convex side of the curve). CIB group (CIB+) was defined as having a CBD ≥ 20 mm at the 2-year follow-up.
Results: Compared to type A patients, the prevalence of postoperative CIB was higher in type C patients both immediately postoperative (22% vs. 38%, $p < 0.05$) and at the final follow-up (5% vs. 29%, $p < 0.05$), whereas type A patients showed a greater improvement in CBD (9 of 12 vs. 6 of 24, $p < 0.05$) at the final follow-up. The majority of patients in all groups had recovered to type A at the final follow-up (96 of 120). The proximal Cobb-1 strategy reduced the incidence of postoperative CIB (1 of 38) at the 2-year follow-up, especially in preoperative type C patients. Multivariate logistic regression analysis revealed that type C and overcorrection of the thoracolumbar curve were risk factors for CIB at the 2-year follow-up ($p = 0.007$ and $p = 0.026$, respectively).
Conclusion: Patients with type C CIB in AIS exhibited unsatisfactory restoration, with 29% of them exhibiting CIB at the final follow-up. The selective fusion strategy of proximal Cobb-1 may reduce the risk of postoperative CIB especially when the preoperative coronal pattern is type C.

Keywords: Evolution, Lenke 5C, Adolescent idiopathic scoliosis, Coronal imbalance

INTRODUCTION

The goal of surgical treatment in patients with adolescent idiopathic scoliosis (AIS) includes regional deformity correction and global alignment restoration.[1-3] Recently, a considerable amount of literature has focused on the incidence and risk factors of postoperative coronal balance (CB) restoration in patients with AIS.[4-6] Failure to correct coronal imbalance (CIB) may not only impair health-related quality of life,[7,8] but also cause implant failure and the need for revision surgery.[9] In particular, Lenke 5C AIS has been reported to be associated with a higher rate of postoperative CIB.[10] According to Qiu et al.,[11] a CIB rate of 17.5% appeared immediately in Lenke 5 curves after surgery, while all patients had restored CB at 2-year follow-up. In contrast, Wang et al.[12] reported postoperative CIB was present in 28% of patients with Lenke 5 AIS, 8% of which persisted until

the final follow-up. These disparate findings suggest that the cause of postoperative CIB is multifactorial, and the severity of imbalance can fluctuate over an extended period of follow-up.

Among reported risk factors for postoperative CIB in patients with Lenke 5 AIS,[7] preoperative CB distance (CBD) has been found to be correlated.[13] Nevertheless, due to the disparities in the directions of trunk shift against the major curve, the CBD alone cannot fully reflect the CB.[14-16] In patients with degenerative scoliosis (DS), Bao et al.[17] showed that postoperative CIB occurred most often when the C7 plumb line shifted to the convex side of the main curve (type C imbalance). Additionally, a similar correlation between preoperative coronal pattern and postoperative CIB was also recently found in patients adult idiopathic scoliosis (AdIS) patients,[18] underscoring the importance of exploring the behavior of coronal pattern in AIS. However, compared to DS and AdIS, there is a paucity of literature on the effects of preoperative coronal patterns on the occurrence and resolution of postoperative CIB in AIS.

In this study, for the first time, we attempt to evaluate the patterns of CIB following corrective surgery based on the coronal classification system in patients with Lenke 5 AIS. We aim to determine the risk factors for CIB at final follow-up and discuss its implications for surgical decision-making.

MATERIALS AND METHODS

1. Patient Population

This is a retrospective cohort study that was performed for AIS underwent posterior selective fusion (PSF) surgery from November 2015 to April 2022. The main criteria were about (1) Lenke 5C AIS patients; (2) age less than 18 years old and above 10 years old; (3) with all-pedicle-screws instrumentation; (4) with a minimum follow-up of 2 years. The exclusion criteria were as follows: (1) the patients exhibited other types of AIS, such as Lenke 3 or Lenke 6; (2) patients with previous surgery; (3) other pathogeny of scoliosis, such as neuromuscular scoliosis and DS; (4) concomitant limb length discrepancy or pelvic pathology.

This study was approved by the Institutional Review Board (IRB) of Nanjing Drum Tower Hospital, The Affiliated Hospital of Nanjing University Medical School (IRB No. 2021-398-01).

2. Selection Strategy

As a general rule according to Lenke classification,[1] the fusion level was selected from upper end vertebra (UEV) to lower end vertebra (LEV): If following criteria was met, the fusion levels were adjusted accordingly (one of the following criteria must be met for a vertebra to be considered as the upper instrumented vertebra [UIV] or lower instrumented vertebra [LIV]).

1) UIV selection[19]

UEV-1: (1) Risser ≥ 2 with thoracic curve ≥ 15°; (2) thoracolumbar/lumbar (TL/L) curve ≥ 50°; (3) curve with long segments.

UEV+1: (1) Atypical apex at the disc between L1 and L2 or lower than that; (2) without proximal compensatory curve.

2) LIV selection

(1) For large TL/L curve ≥ 60°, LIV can be reliably stopped at L3 if L3 translation on preoperative concave side-bending film was less than 10 mm; (2) If presumed LIV tilt ≥ 25°, fusion was extended to LIV+1.[20]

3. Data Collecting and Measurement

The demographic data including age, sex, T curve flexibility, and fusion level were recorded. CBD defined as a distance between the coronal C7 plumbline (C7PL) and the central sacral vertical line (CSVL) was measured preoperatively, immediately after surgery, and above 2 years after surgery. Standing whole-spine posteroanterior and lateral standing radiographs were reviewed preoperatively and above 2 years after surgery, including TL/L Cobb, thoracic (T) Cobb, apical vertebral translation (AVT) of the MT (the distance between the geometrical center of the apical vertebra of the thoracic curve and the C7PL), apical vertebral rotation (AVR) (the rotation angle of the apical vertebra). The preoperative direction of trunk shift is also collected.

Based on the coronal classification and the definition of CIB in AIS,[21] 3 types of coronal pattern were determined (Fig. 1): type A, CBD < 20 mm; type B, CBD ≥ 20 mm and C7PL shifts to the concave side of the curve; type C, CBD ≥ 20 mm and C7PL shifts to the convex side of the curve.

In addition, patients enrolled in the study can be divided into 2 groups including CIB (+) and CIB (-) groups. The definition of CIB is that the distance between the C7PL and the CSVL surpasses 20 mm at the final follow-up.

4. Statistical Analysis

All statistics were performed using IBM SPSS Statistics ver. 27.0 (IBM Co., Armonk, NY, USA). Paired or independent Student t-test were used to analyze continuous data. The chi-square test and Fisher exact test was used to analyze enumeration data. Univariate logistic regression analysis was performed to screen for potential variables related to CIB (+). Variables with a p-val-

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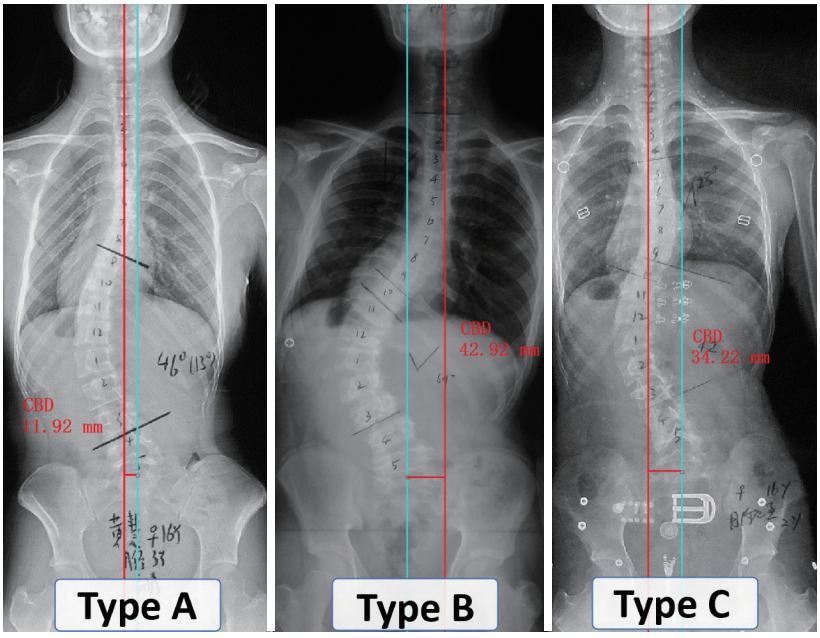

Fig. 1. Three preoperative coronal patterns in adolescent idiopathic scoliosis. Type A, coronal balance distance (CBD) < 20 mm; type B, CBD ≥ 20 mm and coronal C7 plumbline (C7PL) shifts to the concave side of the curve; type C, CBD ≥ 20 mm and C7PL shifts to the convex side of the curve.

Table 1. Demographical and radiographical parameters of patients with Lenke 5C adolescent idiopathic scoliosis among 3 groups; mean values with standard deviations

Variable	Type A	Type B	Type C
Sex, male:female	8:47	1:1	11:52
Age (yr)	14.8 ± 2.0	15.5 ± 0.7	14.7 ± 1.7
T flexibility	28.6 ± 18.1	31.0 ± 31.1	32.5 ± 19.1
TL/L curve	45.7 ± 6.8	53.5 ± 14.8	46.6 ± 8.3
Pre-CBD	11.7 ± 6.5	37.2 ± 9.5	31.9 ± 6.7*
Fusion level	5.4 ± 0.5	6.5 ± 0.7	5.7 ± 0.8

Values are presented as number or mean ± standard deviation.
Type A, coronal balance distance (CBD) < 20 mm; type B, CBD ≥ 20 mm and coronal C7 plumbline (C7PL) shifts to the concave side of the curve; type C, CBD ≥ 20 mm and C7PL shifts to the convex side of the curve; T, thoracic; TL/L, thoracolumbar/lumbar; CBD, coronal balance distance.
*$p < 0.05$, compared with type A group.

ue < 0.1 were included in a logistic regression model to determine independent risk factors for CIB (+). Statistical significance was set at $p < 0.05$.

RESULTS

One hundred twenty patients with Lenke 5 AIS were enrolled in this study, The demographic and radiological measurements of the patients are summarized in Table 1. The 120 patients with AIS are divided into 3 groups based on the preoperative CB: (type A, 55; type B, 2; type C, 63). The 3 groups showed no significant differences except for the preoperative CBD (type A, 11.7 ± 6.5; type B, 37.2 ± 9.5; type C, 31.9 ± 6.7; $p < 0.05$) (Table 1).

Table 2. Prognosis of each group of patients in terms of coronal balance

CIB	Type A (n = 55)	Type B (n = 2)	Type C (n = 63)
Postoperative CIB	12 (22)	0 (0)	24 (38)*
Final follow-up CIB	3 (5)	0 (0)	18 (29)*

Values are presented as number (%).
CIB, coronal imbalance group; type A, coronal balance distance (CBD) < 20 mm; type B, CBD ≥ 20 mm and coronal C7 plumbline (C7PL) shifts to the concave side of the curve; type C, CBD ≥ 20 mm and C7PL shifts to the convex side of the curve.
*$p < 0.05$, compared with type A group.

In terms of the change in coronal patterns (Table 2, Fig. 2), CIB was observed in 12 patients (22%), immediately after surgery in preoperative type A (n = 55), and the final follow-up in 3 patients (5%). Most of patients in preoperative type A (Figs. 2 and 3) maintained type A (43 of 55) and the remaining 12 patients changed to type C postoperatively; However, at the final follow-up there were 3 patients remaining in type C (3 of 55). All patients with preoperative type B disease (Figs. 2 and 4)

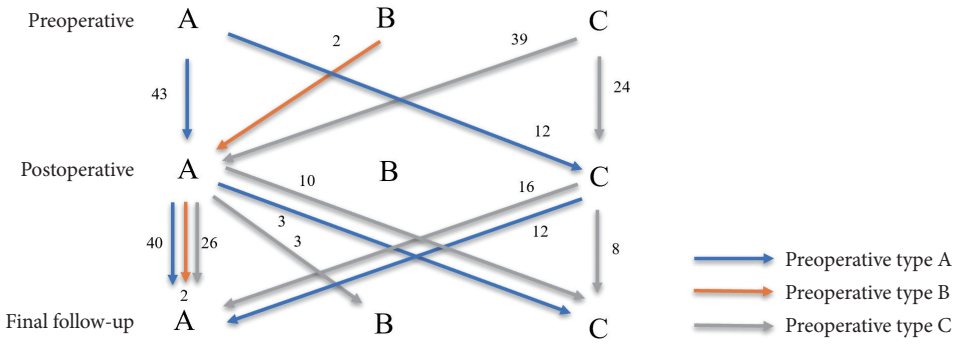

Fig. 2. Coronal imbalance evolution of each group of patients. Type A, coronal balance distance (CBD) < 20 mm; type B, CBD ≥ 20 mm and coronal C7 plumbline (C7PL) shifts to the concave side of the curve; type C, CBD ≥ 20 mm and C7PL shifts to the convex side of the curve.

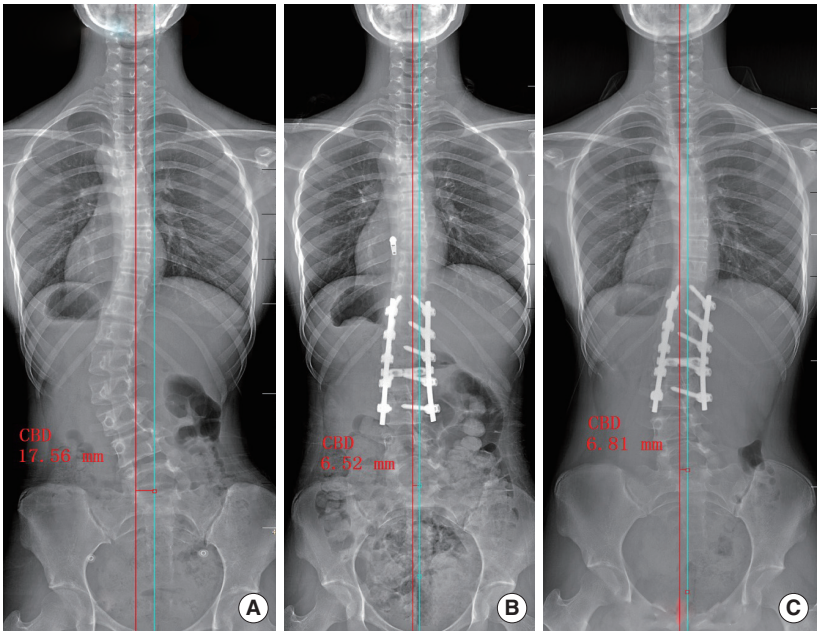

Fig. 3. Radiographs of a 14-year-old girl with adolescent idiopathic scoliosis in type A preoperative coronal pattern (A), postoperative (B), and 2-year follow-up (C) images showed well-restored coronal balance. Type A, coronal balance distance (CBD) < 20 mm.

turned into type A while persisting CB until the final follow-up. Among the 63 patients with preoperative type C disease, 39 patients turned into type A immediately postoperative, and 24 patients remained in type C. At the final follow-up, 18 patients (29%) showed CIB (Figs. 2 and 5). Of the 36 patients who were identified with type C immediately postoperative, 28 patients (78%) were restored to type A and 8 patients (22%) maintained in type C. Of 84 patients who were identified with type A immediately postoperative, 68 patients remained type A, 13 patients changed to type C, and 3 patients turning into type B. More preoperative type C patients had postoperative imbalance than type A patients ($p < 0.05$). Many preoperative type C patients did not experience restoration of CB at the final follow-up.

The 120 patients were grouped into CIB (+) and CIB (-) groups (Table 3) including type A (n = 55, 46%), type B (n = 2, 1%), and type C (n = 63, 53%), with no significant difference ($p > 0.05$) between groups in terms of the pre- and postoperative magnitude of the T curve, AVT, AVR, and flexibility of the thoracic vertebra except for the ΔTL/L curve ($p = 0.023$). Univariate logistic regression analysis (Table 4) showed 3 potential risk factors, including type C ($p = 0.003$), Cobb-Cobb selective strategy ($p = 0.032$), ΔTL curve (final follow-up–preoperative) ($p = 0.026$). Multivariate logistic regression analysis (Table 5) indicated that type C ($p = 0.007$), ΔTL curve ($p = 0.026$) are 2 independent

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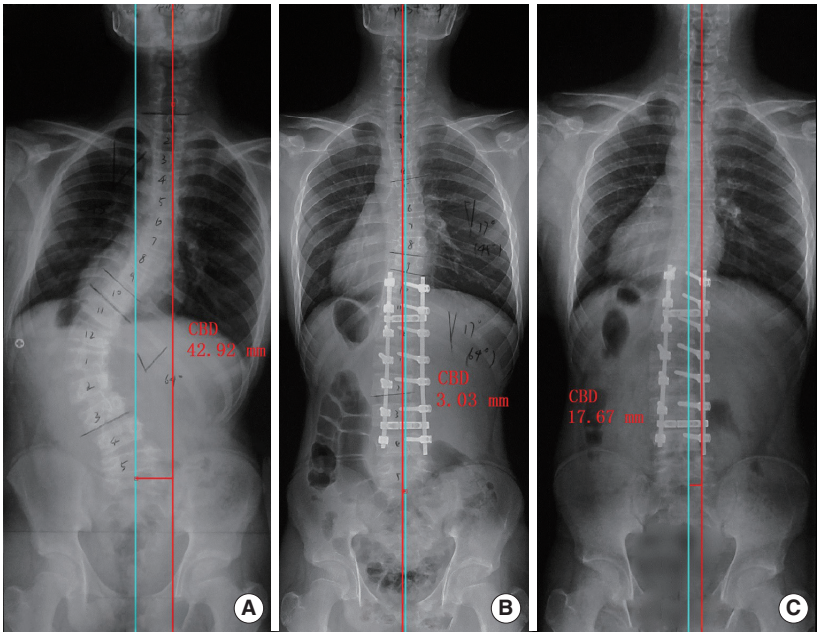

Fig. 4. Radiographs of a 15-year-old boy with adolescent idiopathic scoliosis in type B preoperative coronal pattern (A), after surgery (B) immediately, coronal balance was maintained well, the coronal balance distance (CBD) was worsened at 3-year follow-up (C), but still within normal range. Type B, CBD ≥ 20 mm and coronal C7 plumbline shifts to the concave side of the curve.

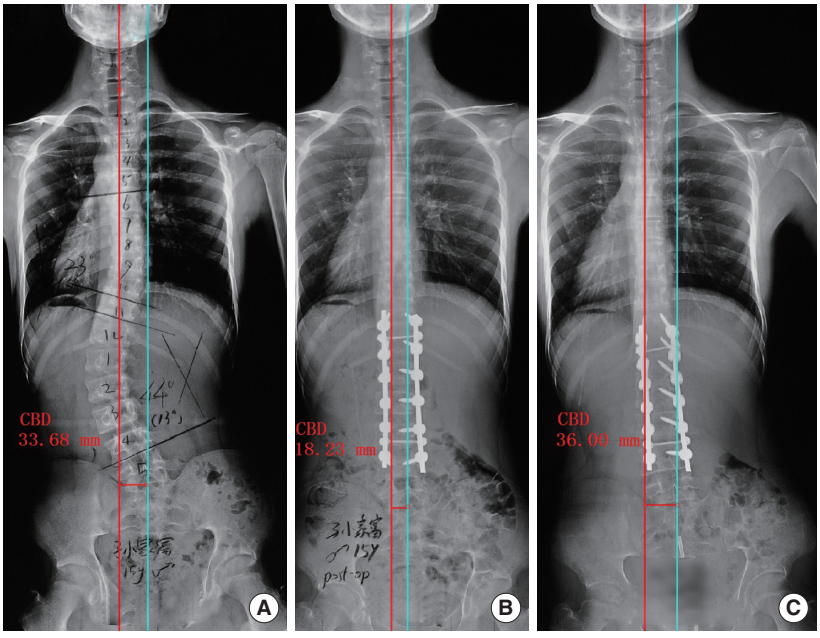

Fig. 5. Radiographs of a 15-year-old boy with adolescent idiopathic scoliosis in type C preoperative coronal pattern (A). The coronal balance was improved after surgery immediately (B), but 2 years later, the coronal plane recovered to the primary unbalanced state (C). Type C, coronal balance distance (CBD) ≥ 20 mm and coronal C7 plumbline shifts to the convex side of the curve.

risk factors of CIB at 2-year follow-up. We next performed chi-square test to further evaluate the role of the fusion strategy in CIB of type C patients (Table 6). The results revealed that it differed significantly ($p < 0.05$) between proximal Cobb-1 (Fig. 6) and other fusion strategies in terms of the incidence of CIB at the 2-year follow-up.

The Scoliosis Research Society-22 was assessed at the final follow-up for the 3 groups (Table 7), however, there was no sig-

nificant differences between the 3 groups in the 5 domains, including function, pain, mental health, satisfaction, and self-image. Furthermore, the complication rate of these patients is 5% (screw loosening, proximal junctional kyphosis [PJK], distal decompensation); among them, 2 patients were found to have screw loosening and 1 patient with distal decompensation in the type A group and 2 patients was found to develop PJK at 2.5-year follow-up and 1 patient with distal decompensation in the type C group.

Table 3. Comparison of radiological parameters of all 120 AIS patients between CIB (+) and CIB (-) groups; mean values with standard deviations

Variable	CIB (+) N = 21	CIB (-) N = 99	p-value
T curve flexibility (°)	33.0 ± 18.8	30.2 ± 18.8	0.545
T curve at preoperative (°)	27.9 ± 9.9	25.5 ± 7.2	0.208
T curve at postoperative (°)	13.8 ± 8.6	14.7 ± 7.2	0.619
ΔT curve (°)	14.1 ± 8.5	10.8 ± 7.1	0.068
TL/L curve at preoperative (°)	46.7 ± 11.1	46.2 ± 6.9	0.797
TL/L curve at postoperative (°)	12.2 ± 6.6	14.7 ± 7.5	0.166
ΔTL/L curve (°)	36.0 ± 10.8	31.3 ± 8.1	0.023*
AVR at preoperative (°)	23.5 ± 4.3	21.8 ± 5.9	0.216
AVR at postoperative (°)	14.7 ± 6.9	14.1 ± 4.9	0.682
ΔApical vertebra rotation (°)	8.9 ± 6.8	7.7 ± 5.7	0.410
AVT at preoperative (mm)	15.0 ± 12.8	13.3 ± 8.0	0.431
AVT at postoperative (mm)	9.3 ± 4.2	8.9 ± 7.1	0.802
ΔAVT (mm)	5.7 ± 12.8	4.4 ± 8.7	0.571

Values are presented as mean ± standard deviation.
AIS, adolescent idiopathic scoliosis; CIB, coronal imbalance; T, thoracic; TL/L, thoracolumbar/lumbar; CBD, coronal balance distance; AVR, apical vertebral rotation; AVT, apical vertebral translation.
*$p < 0.05$, statistically significant differences.

DISCUSSION

This study is the first to reveal the behavior and restoration of different types of CIBs in Lenke 5C AIS at a 2-year follow-up. We found that type C patients had a significantly ($p < 0.05$) higher risk of postoperative CIB than type A patients (24 of 63 vs. 12 of 55, $p < 0.05$), and that most type C (18 of 24) patients did not exhibit restoration of CB at the final follow-up. In addition, when selective fusion was performed at proximal Cobb-1, the risk of CIB was significantly reduced (1 of 38 vs. 11 of 55, $p < 0.05$) compared to when using Cobb-Cobb strategy. Our results indi-

Table 5. Multivariate logistic regression analysis related to the final follow-up coronal imbalance

Variable	OR (95% CI)	p-value
Coronal classification		
Type A	Ref	
Type C	6.408 (1.645–24.960)	0.007
ΔTL/L curve	1.083 (1.010–1.161)	0.026

OR, odds ratio; CI, confidence interval; type A, coronal balance distance (CBD) < 20 mm; type C, CBD ≥ 20 mm and coronal C7 plumbline shifts to the convex side of the curve; ΔTL/L, preop ΔTL/L curve–postop ΔTL/L curve.

Table 6. The difference between other fusion strategies and the proximal Cobb-1 group in preoperative type C in terms of the patients' number of CIB at 2-year follow-up

Group	CIB (+)	CIB (-)	Total
Proximal Cobb-1	1	15	16
Other strategies	17	30	47
Total	18	45	63

CIB, coronal imbalance.

Table 4. Analysis of the radiological parameters related to the final follow-up coronal imbalance (CIB)

Variable	CIB (+)	CIB (-)	p-value†	OR (95% CI)	p-value‡
Coronal pattern			0.001		
Type A	3 (5%)	52 (95%)		Ref	
Type C	18 (29%)	45 (71%)		6.933 (1.917–25.080)	0.003
Selection strategy			0.011		
Proximal Cobb-1	1 (3)	37 (97)		Ref	
Cobb-Cobb	11 (21)	41 (79)		9.927 (1.222–80.644)	0.032
ΔTL/L curve	36.0 ± 10.8	31.3 ± 8.1	0.023	1.072 (1.008–1.141)	0.026

Values are presented as mean ± standard deviation or number (%) unless otherwise indicated.
OR, odds ratio; CI, confidence interval; type A, coronal balance distance (CBD) < 20 mm; type C, CBD ≥ 20 mm and coronal C7 plumbline shifts to the convex side of the curve; ΔTL/L, preop ΔTL/L curve–postop ΔTL/L curve.
†The chi-square test or t-test. ‡Univariate logistic regression analysis.

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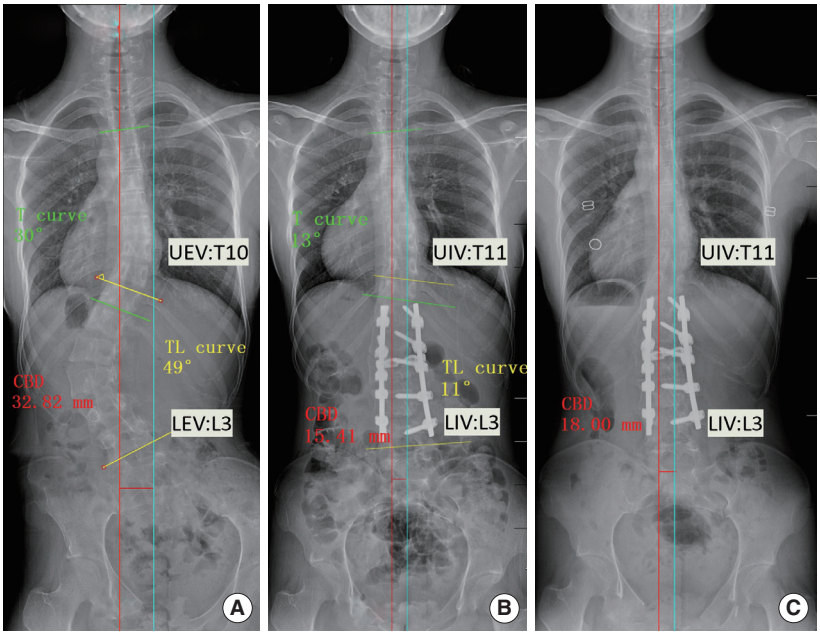

Fig. 6. Radiographs of a 16-year-old girl with adolescent idiopathic scoliosis in type C preoperative coronal pattern (A). After selecting the UIV at 1 level caudal to UEV (Cobb-1) and LIV at LEV (B), the coronal balance improved significantly and has been persisting until 2 years after surgery (C). Type C, coronal balance distance (CBD) ≥ 20 mm and coronal C7 plumbline shifts to the convex side of the curve; UIV, upper instrumented vertebra; UEV, upper end vertebra; LIV, lower instrumented vertebra; LEV, lower end vertebra; TL, thoracolumbar.

Table 7. Scoliosis Research Society-22 questionnaire evaluation of 3 groups at final follow-up

Variable	Type A	Type B	Type C	p-value†
Function	4.1 ± 0.5	4.0 ± 0.1	4.0 ± 0.5	0.132
Self-image	4.1 ± 5.8	4.0 ± 0.3	4.0 ± 0.5	0.364
Mental health	4.0 ± 0.5	3.9 ± 0.1	4.0 ± 0.5	0.914
Satisfaction	4.0 ± 0.6	4.2 ± 0.1	3.9 ± 0.4	0.270
Pain	4.1 ± 0.5	4.2 ± 0.1	4.1 ± 0.4	0.691
Total	4.1 ± 0.3	4.1 ± 0.1	4.0 ± 0.2	0.080

Values are presented as mean ± standard deviation.
Type A, coronal balance distance (CBD) < 20 mm; type B, CBD ≥ 20 mm and coronal C7 plumbline (C7PL) shifts to the concave side of the curve; type C, CBD ≥ 20 mm and C7PL shifts to the convex side of the curve.
†The comparison between types A and C.

cate proximal Cobb-1 strategy effectively decreased the incidence of CIB in type C at the 2-year follow-up. These findings provide valuable information for the optimizing surgical fusion strategy in patients with Lenke 5C AIS.

Reconstruction of postoperative coronal CB represents a major concern for spine surgeons.[17,18,21] Previous studies have revealed that, despite the correction of the main Cobb angle and a great CBD immediately after surgery,[6,20] a subset of patients still exhibit CIB until the final follow-up, in which the evolution of CIB on compensation status was not clear. Subsequently, multiple studies have reported that the preoperative CBD is related to postoperative CB.[13] Nevertheless, due to disparities in the direction of trunk shift against the major curve, CBD alone cannot fully reflect CB. Furthermore, it is unclear how does CBD affects surgical decision-making when handling Lenke 5 curves. In our study of 120 patients with Lenke 5C curve, the rate of CIB is about 30.0% in total at postoperative which is consistent with previous literature reporting 17.5%–45.0%.[6,7,11] But the percentage of CIB decreased to 17.5% (type A, 2.5%; type C, 15.0%) at the final follow-up (≥ 2 years), which revealed that only 12.5% of patients recovered to CB at the final follow-up (Table 2). The prognosis of CB in AIS has been well documented, Wang et al.[12] reported CIB rates of 28% and 8% postoperatively and at the final follow-up respectively, with many other studies reporting similar results.[21-23] The discrepancy suggests some patients are unable to regain CB after surgery, although the causes is unclear. In our analysis, the poor prognosis may be attributed to the enrollment of 63 patients whose preoperative coronal pattern was type C.

Recent studies have attempted to interpret the CBD by incorporating the directionss of trunk shift.[24] Bao et al.[17] divided pa-

tients with DS into 3 groups based on their coronal patterns and found patients with type C coronal pattern may be at greater risk of postoperative CIB; these findings were also validated in patients with AdIS. Our findings on the changes in CB patterns elucidate the prognosis of different coronal patterns in Lenke 5 curves. In our analysis, we categorized the coronal pattern of patients with AIS into 3 types according to the CBD and the direction between the main curve and the location of C7PL. Our results revealed a lower rate of postoperative CIB in type A than in type C (22% vs. 38%, $p < 0.05$), and at the final follow-up, only 2 patients (5%) maintained the status of CIB. In contrast to type A, type C had a poor prognosis, in which 24 patients (38%) were found to have CIB postoperatively. Among these cases, 18 patients remain in type C, and only 6 patients restored to the balanced status at final follow-up. These findings suggested that type C patients have a worse compensatory capacity compared with type A.

Nowadays, PSF has emerged as a principal surgical strategy for Lenke 5C AIS.[2,25,26] As Baghdadi et al.[27] reported inappropriate UIV selection may cause correction loss, global malalignment and even mechanism complication,[3,23,28] in the majority of the cases, the Cobb-Cobb (UEV-LEV) fusion strategy is adopted as a standard approach. In particular, the strategy may vary, and UEV-1 may serve as an alternative to achieve similar clinical outcomes.[19,20,29] Compared to the UIV selection, there is less controversy for the LIV selection of Lenke 5C curves. The standard UEV-LEV criteria has been verified to produce satisfactory radiographic and clinical outcomes.[30] Li et al.[2] retrospectively enrolled 37 patients with UEV-LEV selection and the curve correction rate maintains at 75%. At 5-year follow-up, along with 1 patient had adding-on and 5 patients had PJK. Seo et al.[31] identified that the correction rate of unfused thoracic curve and TL/L curve was 52.7 and 79.9% when choosing LEV as LIV, showing no significant difference compared to those at LEV+1. Last touched vertebra (LTV) is a frequently adopted strategy for LIV selection in Lenke 1 and 2 curves. This method has been introduced to the selection of LIV in Lenke 5C curves.[29,31,32] Typically, selection LTV as LIV can save mobile segments than the classic LEV methods. Kim et al.[33] found the LIV can be selected at LTV on preoperative supine film with 77.8% ± 10.2% curve correction and satisfied sagittal restoration with the low risk of adding-on. Similarly, compared with LIV fusing proximal to LTV, Sarwahi et al.[34] chose LTV as LIV with minimal rotation on prone radiograph to maximize motion segments and decrease the incidence of adding-on (9.3% vs. 37.9%). In our study, LEV is frequently adopted as LIV (account for 90% patients) to achieve the comparable curve correction (69% ± 16%) with low risk for radiographic complication (2 patients with adding-on).

Importantly, the interpretation of CB patterns in AIS also has implication in the formulation of surgical strategies. We verified that type C has the poorest compensatory capacity, and it is essential to adjust the compensatory capacity by adopting an appropriate fusion strategy.[32] Here, we divide 120 patients into 2 groups, CIB (+) and CIB (-), based on their CBD at 2-year follow-up. Approximately 1 of 38 patients who were fixed with the Cobb-1 strategy changed to CIB at the final follow-up, while 11 of 55 patients changed to CIB after undergoing fusion from Cobb-Cobb. These findings suggest that the proximal Cobb-1 (UEV-1) can prevent the trunk from shifting to CIB (Table 4). Particularly, in type C patients, the proximal Cobb-1 strategy could similarly reduce the incidence of CIB (Table 6).

This is the first study to categorize patients with AIS into different coronal patterns preoperatively and to elucidate the behavior and prognosis of CIB at 2-year follow-up. However, the limitations of this study should be acknowledged. As a common coronal pattern in adult spine deformity, type B is very rare in Lenke 5C AIS. As a result, this disproportionate grouping does not allow us to identify valuable trends with statistical difference. Theoretically, the apex translation of the lumbar curve is generally large, and it is very rare for compensatory thoracic curve to drive the trunk back towards the concave side. larger samples of type B in multicenter analysis are required for prospective studies to further validate this classification method and the prognosis of other Lenke types need to be explored as well in the future studies.

CONCLUSION

Our findings show type C patients may be at the greatest risk of developing CIB following PSF in Lenke 5C AIS, and 29% patients remain in a state of CIB at the final follow-up. The illustration on the behavior and prognosis of CIB offers new insights into surgical treatment and global balance restoration in AIS. In particularly, the proximal Cobb-1 strategy may protect type C patients from developing CIB at a 2-year follow-up.

NOTES

Conflict of Interest: The authors have nothing to disclose.

Funding/Support: This work was supported by the National Natural Science Foundation of China (82072518) and Nanjing

 https://doi.org/10.14245/ns.2448544.272

Medical Science and Technology Development Key Project (ZKX22017).

Author Contribution: Conceptualization: JL, ZL; Data curation: YF; Formal analysis: YF; Funding acquisition: ZH, ZL; Methodology: YF, JL; Project administration: YF, JL, ZZ, YQ, ZL; Visualization: ZH, ZZ, YQ; Writing – original draft: YF; Writing – review & editing: YF, JL, ZL.

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