Preoperative pelvic axial rotation: a possible predictor for postoperative coronal decompensation in thoracolumbar/lumbar adolescent idiopathic scoliosis

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Abstract

Background The pelvis as the biomechanical foundation of spine, plays an important role in the balance of the stance and gait through the multi-link spinal-pelvic system. If the pelvic axial rotation (PAR) exists in adolescent idiopathic scoliosis (AIS) patients, it should theoretically have some effects on the body balance.

Purpose To explore the probable effects of preoperative PAR on the spinal balance in coronal plane in AIS patients with main thoracolumbar/lumbar (TL/L) curve after posterior spinal instrumentation.

Methods Thirty-eight AIS patients (age: 15 ± 1.5 years) with main TL/L curve ($51^\circ \pm 6.2^\circ$) were recruited retrospectively into this study. The mean follow-up period was 27 months (24–36 months). Standing full spine postero-anterior radiographs were taken preoperatively, 3 month and 1 year postoperatively, and at last follow-up. The convex/concave ratio (CV/CC ratio) of the anterior superior iliac spine laterally and the inferior ilium at the sacroiliac joint medially was measured on posteroanterior radiographs. According to the preoperative CV/CC ratios, the patients were divided into two groups: normal group (N-group: $0.95 \leq \text{CV/CC} \leq 1.05$); and the asymmetrical group (A-group: $\text{CV/CC} < 0.95$, or > 1.05).

Results In all the patients, the 3-month-postoperative CV/CC ratio (1.026 ± 0.087) was significantly different from the preoperative CV/CC ratio (0.969 ± 0.095 , $P < 0.001$), indicating that the pelvis had rotated in the opposite

direction of the corrective derotation load applied to the TL/L spine after surgery. No significant change was found in the CV/CC ratio from 3-month-postoperative to the last follow-up (1.013 ± 0.103 , $P > 0.05$). There was no significant difference in the demographic, phenotypic, and treatment variables between the N- ($n = 16$) and A-groups ($n = 22$) ($P > 0.05$). However, more coronal decompensation occurred in the A-group after surgery (36.4 vs. 0.0 %, $P = 0.013$): two patients having trunk translation, three having lower instrumented vertebra (LIV) translation, and one having LIV tilt; meanwhile, one patient having both LIV translation and LIV tilt, and one having both trunk translation and LIV tilt.

Conclusions The present study confirmed the existence of PAR in AIS patients, and indicated that the pelvis would experience an active rebalancing in the transverse plane within 3 months after spinal correction, and since then, its position would remain stable. Moreover, TL/L-AIS patients with preoperative asymmetrical PAR probably had greater risk of coronal decompensation postoperatively.

Keywords Idiopathic scoliosis · Pelvis · Rotation · Transverse plane · Decompensation

Introduction

Idiopathic scoliosis is a complex deformity deviates the trunk from its normal plane of symmetry and induces geometric changes of the spine in three dimensions of space [1, 2]. As described as “pelvic vertebra” [3] in scoliosis, the pelvis could be regarded as the extension in the function and structure of the spine. Thus, like the thoracic or lumbar vertebra in adolescent idiopathic scoliosis (AIS), the pelvis could also have axial rotation to some

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extent, which could contribute to the asymmetrical shadow of the pelvis on the posteroanterior radiographs between the concave and convex sides in AIS patients [4, 5]. While another interpretation [6–8] of this pelvic asymmetry on posteroanterior radiographs was the anatomic abnormality of the hemi-pelvises, like the other extra-spinal deformities such as relative lengthening of the ilium on the concave side of the AIS patients with lumbar curve [7].

In addition, the pelvis, as the biomechanical foundation of spine, was demonstrated to be intimately correlated with the balance of the stance and gait through the multi-link spinal-pelvic system [9–11]. Therefore, if the pelvic axial rotation (PAR) exists, it should theoretically have some effects on the body balance. However, to our knowledge, few studies [4, 5] have been focused on the PAR in AIS patients in the literatures; none reported the effects of preoperative PAR on the clinical outcomes. The purpose of this study was to identify the existence of PAR in AIS patients, and to explore the probable effects of the preoperative PAR on the postoperative spine global and regional balance in thoracolumbar/lumbar (TL/L) AIS patients in coronal plane.

Materials and methods

Patients

This retrospective study consisted of 333 records of AIS patients consecutively retrieved from our database from February 2008 to August 2009. The inclusion criteria for this study were (1) AIS patients with main TL/L curves of 45° – 70° ; (2) 13- to 18-year old at surgery; (3) Risser sign ≥ 2 ; (4) only posterior correction and instrumentation with pedicle screws; (5) minimum 24-month follow-up after surgery; (6) implant density [12] (the number of fixation anchors placed per available anchors sites) $>80\%$. The patients would be excluded if they had anterior release, developmental deformities of the lower extremities, or previous trauma, surgeries, or any other treatment affecting the pelvic morphology. Thirty-eight patients who met these criteria were recruited for the present study with an average age of 15 ± 1.5 years and a mean TL/L curve magnitude of $51^{\circ} \pm 6.2^{\circ}$. The mean follow-up period was 27 months (range, 24–36 months). This study was approved by the Clinical Research Ethics Committee of our hospital.

Convex/concave ratio of hemi-pelvis widths in posteroanterior radiographs

Standing full-length spine posteroanterior radiographs were taken preoperatively, 3 month postoperatively, 1 year postoperatively and at last follow-up. Patients were in a

standing position with the lines connecting their both tip-toes parallel to the X-ray cassette. The convex/concave ratio (CV/CC ratio) of hemi-pelvis widths on posteroanterior radiographs was determined as previously described by Gum et al. [4]. The anterior superior iliac spine (ASIS) laterally and the inferior ilium at the sacroiliac joint (SI) medially were determined on both sides. For each side, the linear distance between upright lines through the two ipsilateral points (ASIS-SI) was measured and expressed as a CV/CC ratio (Fig. 1).

As defined by Lucas et al. [13] that the normal range of the CV/CC ratio was from 0.95 to 1.05, all the patients were divided into two groups according to their preoperative CV/CC ratios: normal group (N-group: $0.95 \leq \text{CV/CC} \leq 1.05$), and asymmetrical group (A-group: $\text{CV/CC} < 0.95$, or >1.05).

Clinical and radiographic variables

Other clinical and radiographic variables were collected, including gender, age at surgery, Cobb angle, the number of fusion segments, the level of upper end vertebra, apex of the main curve, lower end vertebra, upper instrumented vertebra (UIV) and lower instrumented vertebra (LIV), and the lumbosacral hemicurve which is defined as the angle between the inferior endplate of L4 and the horizontal Ref. [14]. The side-bending films were used to determine the curve flexibility [15]. Rotation of the TL/L and the thoracic apex, and rotation of UIV, LIV and the first vertebra below LIV were assessed using Nash–Moe method [16]. Moreover, the tilt of the first vertebra below LIV [5] in coronal plane was also measured.

Surgical procedure

The fusion levels were basically decided according to the Lenke et al. [17, 18]. TL/L curves were fused in some patients, and both thoracic and TL/L curves were fused in others. The posterior instrumentation was achieved by standard convex rod derotation as described in the literature [19–21]. Briefly, the convex rod was first inserted into the upper screws and the rod was sequentially captured distally onto the screws but not fully tightened. The precontoured rod was derotated toward the convex side. All screws on the convex side were now gradually loaded by compression with the apical ones being locked first. After completely locking the convex rod to each screw, the precontoured concave rod was attached to the upper level of the construct and gradually captures the subsequent screws. Iliac cancellous bone was used for spine fusion. Both somatosensory-evoked and motor-evoked potentials' neurological monitoring was used continuously throughout operation.

Fig. 1 ID:6102, ♀, 14 years, Lenke type 5 AIS, main TL/L Cobb 48°, pre- CV/CC ratio = 0.99, N-group patient. No compensation happened after surgery in this patient: preoperative (**a**), 3 month postoperatively (**b**), and at 24-month follow-up (**c**). The measurement of the CV/CC ratio, which is directly related with the pelvic

asymmetry, was illustrated. The landmarks were the ASIS (anterior superior iliac spine) and the SI (sacroiliac joint). For each side, the horizontal distance between the two points (ASIS-SI) was measured and the ratio of ASIS-SI between the convex and the concave sides was expressed as CV/CC ratio

Coronal decompensation

Patients with any of the following conditions at the last follow-up were identified as coronal decompensation [22, 23]: (1) |trunk translation| ≥ 20 mm, (2) |LIV translation| ≥ 20 mm, (3) |LIV tilt| $\geq 10^\circ$. Consistent with previous studies [24–26], the global decompensation was determined by the trunk translation, which was described as deviation of C7 plumb line of greater than 20 mm from the CSVL (the vertical line that bisects proximal sacrum). Regional balance [22, 23] was determined by the LIV position which includes LIV tilt (the tilt angle between the LIV lower endplate and the horizontal line) and LIV translation (the distance from the LIV geometrical center to the CSVL).

All the data were collected by the first author who was not involved in the patients' surgery. All the assessments were repeated with an interval of 2 weeks.

Statistical analysis

The data were analyzed using SPSS statistical software (version 17.0, SPSS Inc., Chicago, USA). Continuous variables were evaluated for normality of distributions and equality of variances. If data appeared closer to normal distribution, parametric statistical analysis was applied for the comparisons of the variables between the N- and

A-groups; otherwise non-parametric analysis was used. Paired-samples *t* tests were performed to compare the CV/CC ratios across the time points. χ^2 test was used to evaluate the proportion of patients with coronal decompensation after surgery between the two groups. $P < 0.05$ was regarded as statistically significant.

Results

The intra-observer agreement for the CV/CC ratio measurement was 0.96, which was considered to be excellent reliability. For all the patients, the 3-month-postoperative CV/CC ratio (1.026 ± 0.087) was significantly different from the preoperative ratio (0.969 ± 0.095 , $P < 0.001$), implying that the pelvis had rotated in the opposite direction of the corrective derotation load applied to the TL/L spine at 3 months postoperatively. Compared with the 3-month-postoperative CV/CC ratio (1.026 ± 0.087), the last follow-up (26.8 $\pm$ 4.2 months) CV/CC ratio was 1.013 ± 0.103 , with a demonstration of no significant change of CV/CC ratio since 3 months postoperatively ($P = 0.135$) (Fig. 2).

The demographic, phenotypic, and treatment variables with the possibility to influence the surgical outcome were listed in Table 1. The TL/L curve magnitude did not show significant difference between A- ($50^\circ \pm 5.6^\circ$) and

Fig. 2 The preoperative CV/CC ratio (0.969 ± 0.095) and the 3-month-postoperative ratio (1.026 ± 0.087) was significantly different ($P < 0.001$), indicating that the pelvis had rotated in the opposite direction of the corrective derotational load applied to the TL/L spine. No significant change happened in the CV/CC ratio from 3-month-postoperative to the last follow-up (3m-post-PAR = 1.026 ± 0.087 vs. last-PAR = 1.013 ± 0.103 , $P = 0.135$). S*** indicates $P < 0.001$; NS no significance

N-groups ($53^\circ \pm 6.8^\circ$, $P = 0.193$), as well as the TL/L apex rotation (A-group: 1.9 ± 0.3 , N-group: 2.1 ± 0.3 , $P = 0.100$) and the flexibility of the TL/L curve (A-group: 0.65 ± 0.175 , and N-group: 0.66 ± 0.128 , $P = 0.787$). Similarly, the two groups also did not differ in terms of the preoperative global and regional balance, such as the trunk translation, LIV translation, LIV tilt, lumbosacral hemi-curve. There was also no significant difference in the variables related to the instrumentation between N- and A-groups, such as the level of LIV ($P = 0.693$), the number of fusion segments ($P = 0.271$), and so on.

There was no significant difference in correction rate between two groups (N-group $78 \pm 12\%$, A-group $75 \pm 14\%$, $P = 0.486$), as well as loss of correction (N-group $3.0^\circ \pm 2.9^\circ$, A-group $3.8^\circ \pm 3.5^\circ$, $P = 0.676$). However, more coronal decompensation occurred in the A-group than in the N-group (36.4 vs. 0.0% , $P = 0.013$) (Table 2; Figs. 1, 3, 4): two patients having trunk translation to the convex side, three having LIV translation more than 20 mm, and one having LIV tilt more than 10° ; meanwhile one patient having both LIV translation and LIV tilt, and one having both trunk translation (to the convex side) and LIV tilt. Subanalysis of the patients showed that the A-group exhibited more trunk translation than the N-group at last follow-up (8 ± 5.2 vs. 12 ± 5.5 mm, $P = 0.045$). However, there was no significant difference of the coronal decompensation in A-group

between ratios <0.95 and ratios >1.05 ($6/16$ vs. $2/6$, $P = 1.000$). No neurological complications occurred in both groups, and there were no identified pseudarthrosis or instrumentation failure in both groups at last follow-up.

Discussion

Pelvic axial rotation (PAR)

Adolescent idiopathic scoliosis is typically defined as a structural, lateral, rotated curvature of the spine that arises in otherwise healthy children at or around puberty [1, 2, 27]. However, other extra-spinal skeletal asymmetries [7, 28–30] such as a relative lengthening upper limb on the convexity have been reported. Recently, some abnormalities related to the pelvis were also found in AIS [6, 7, 31]. Karski et al. [6, 31] reported that AIS patients had significant adduction range deficit of the right hip compared with the normal subjects, and a relative lengthening of the ilium on the concavity was also found in TL/L scoliosis [7]. Thus, some researchers [6–8, 31] supposed that the pelvic asymmetry on posteroanterior radiographs in AIS patients was due to its anatomic asymmetry of two hemi-pelvises.

However, other researchers interpreted that it was the PAR that resulted in the pelvic shadow asymmetry on posteroanterior radiographs [4, 5]. Gum et al. [4] introduced the concept of PAR into AIS by the method of the left/right hemi-pelvis widths ratio on posteroanterior radiographs, demonstrating that most of major thoracic AIS had a trend of PAR in the same direction as the thoracic curve. One previous study [8] further showed that: (1) the two hipbones symmetrically developed in AIS patients (the concave and convex hipbone volumes were equivalent), (2) no distortion of two hipbones existed and (3) the abduction of the two hipbones were similar in AIS patients. In other words, there was no hipbone asymmetry in AIS patients. The present study also showed that the CV/CC ratios changed from preoperative to postoperative, which further confirmed that the clinical phenomenon of asymmetry in ilia on the concave and convex sides was related to transverse pelvic rotation, as suggested by Gum et al. [4].

Furthermore, the results of our study displayed a natural history of pelvic rotation in TL/L AIS patients with posterior instrumentation. The pelvis rotated in the opposite direction of the corrective derotational load applied to the TL/L spine and then remained stable since 3 months postoperatively. However, Asher et al. [5] showed that the pelvis obviously rotated in the same direction as the corrective derotational load applied to the TL/L spine immediately postoperatively, then had slight reverse rotation, and finally remained stable after 1-year follow-up. We interpreted this phenomenon as follows: as in the coronal

Table 1 Comparisons of the demographic, phenotypic, and treatment variables between the N- and A-groups

	All (<i>n</i> = 38)	N-group (<i>n</i> = 16)	A-group (<i>n</i> = 22)	A-group vs. N-group <i>P</i> value
Age (years old)	15 ± 1.5	15 ± 1.9	15 ± 1.3	0.648 ^a
TL/L Cobb (°)	51 ± 6.2	53 ± 6.8	50 ± 5.6	0.193 ^a
Thoracic Cobb (°)	31 ± 9.7	34 ± 11.7	29 ± 7.4	0.094 ^a
Lumbosacral hemicurve (°)	15 ± 7.5	15 ± 8.6	15 ± 6.8	0.847 ^a
TL/L apex rotation	2.0 ± 0.3	2.1 ± 0.3	1.9 ± 0.3	0.100 ^b
Thoracic apex rotation	0.4 ± 0.5	0.4 ± 0.6	0.3 ± 0.5	0.629 ^b
LIV rotation	1.5 ± 0.5	1.5 ± 0.5	1.5 ± 0.5	1.000 ^b
Rotation of the first vertebra below LIV	0.7 ± 0.5	0.6 ± 0.5	0.8 ± 0.4	0.328 ^b
Flexibility of the TL/L curve	0.65 ± 0.155	0.66 ± 0.128	0.65 ± 0.175	0.787 ^a
Flexibility of the thoracic curve	0.60 ± 0.183	0.59 ± 0.125	0.60 ± 0.218	0.756 ^a
Flexibility of the lumbosacral hemicurve	1.31 ± 0.755	1.22 ± 0.731	1.38 ± 0.782	0.527 ^a
Upper end vertebra [#]	10 ± 0.9 (T10 ± 0.9)	10 ± 0.8 (T10 ± 0.8)	10 ± 0.9 (T10 ± 0.9)	0.614 ^a
Apex of TL/L curve [#]	13 ± 0.7 (L1 ± 0.7)	13 ± 0.7 (L1 ± 0.7)	13 ± 0.7 (L1 ± 0.7)	0.860 ^a
Lower end vertebra [#]	15 ± 0.5 (L3 ± 0.5)	15 ± 0.4 (L3 ± 0.4)	15 ± 0.6 (L3 ± 0.6)	0.277 ^a
Upper instrumented vertebra [#]	7 ± 2.3 (T7 ± 2.3)	7 ± 2.0 (T7 ± 2.0)	7 ± 2.6 (T7 ± 2.6)	0.232 ^a
LIV [#]	15 ± 0.5 (L3 ± 0.5)	15 ± 0.4 (L3 ± 0.4)	15 ± 0.6 (L3 ± 0.6)	0.693 ^a
Number of fusion segments	9 ± 2.3	10 ± 2.0	9 ± 2.6	0.271 ^a
Preoperative tilt of first vertebra below LIV (°)	22 ± 5.1	22 ± 5.4	22 ± 5.0	0.852 ^a
Preoperative trunk translation (mm)	17 ± 9.3	17 ± 9.3	17 ± 9.6	0.959 ^a
Incidence of the preoperative trunk translation	37 % (14/38)	31 % (5/16)	40 % (9/22)	0.735 ^c
Preoperative LIV translation (mm)	22 ± 6.1	23 ± 5.6	21 ± 6.4	0.284 ^a
Preoperative LIV tilt (°)	25 ± 4.6	26 ± 4.6	25 ± 4.7	0.477 ^a

LIV lower instrumented vertebra

[#] If the vertebrae number ≤12, it refers to thoracic vertebrae; and if the vertebrae number >12, it represents lumbar vertebrae (i.e., 10 means T10, 13 means L1, 15 means L3, and so on)

^a Independent-sample *t* test

^b Wilcoxon rank-sum test

^c Fisher's exact test

Table 2 Comparison of surgical outcomes between N- and A-groups

	All (<i>n</i> = 38)	N-group (<i>n</i> = 16)	A-group (<i>n</i> = 22)	N-group vs. A-group <i>P</i> value
Correction rate (%)	76 ± 13	78 ± 12	75 ± 14	0.486
Loss of correction (°)	3.5 ± 3.2	3.0 ± 2.9	3.8 ± 3.5	0.676
Trunk translation (last follow-up) (mm)	10 ± 5.6	8 ± 5.2	12 ± 5.5	0.045*
LIV translation (last follow-up) (mm)	12 ± 5.5	12 ± 4.0	13 ± 6.5	0.752
LIV tilt (last follow-up) (°)	5.5 ± 3.3	5.1 ± 2.6	5.8 ± 3.8	0.555
Incidence of coronal decompensation (last follow-up)	21.1 % (8/38)	0.0 % (0/16)	36.4 % (8/22)	0.029*

Loss of correction was tested by Wilcoxon rank-sum test; incidence of coronal decompensation was tested by Fisher's exact test; then the other variables using independent-sample *t* test

* *P* < 0.05

and sagittal planes, the spinal-pelvis may spontaneously establish its own balance in the transverse plane in scoliosis patients. After surgery, the pelvis needs to seek a new

proper position to compensate for the spinal imbalance caused by surgical correction load; therefore, several determinants (maybe the curve pattern, the flexibility of the

Fig. 3 ID:7932, ♀, 13 years, Lenke type 5 AIS, main TL/L Cobb 50°, pre- CV/CC ratio = 0.85, A-group patient. LIV tilt (the regional imbalance) happened after surgery: preoperative (a), LIV tilt = 29°;

at 3 months postoperatively (b), LIV tilt = 13°; at 24-month follow-up (c), LIV tilt = 14°

lumbar spine, surgical manipulation, soft tissue, and so on) would have multiple effects on the rotation direction of the pelvis. Combining the immediate-postoperative assessments of PAR in Asher's study [5], we speculated that the pelvis might rotate in the same direction as the corrective derotational load applied to the TL/L spine immediate-postoperatively, and then a reverse rotation would occur in the following 3 months as an active rebalancing between the corrective load and the reverse tension from the pelvic surrounding tissues, and finally the pelvic rotation tended to remain stable. In other words, PAR was just a compensation of body balancing at the distal end for scoliosis [4].

The relationship between PAR and coronal decompensation after surgery

Coronal decompensation is one common complication of posterior instrumentation for AIS. The risk factors for coronal decompensation have been described thoroughly in the literature [22, 32–34], including improper selection of the distal fusion level [32] and the instrumentation pattern [34], hypercorrection of the main curve [22], use of over distraction [34], great growth potentiality [32], and so on. However, most of the risk factors were identified for King

2 curve (Lenke 1C, Lenke 3); risk factors for decompensation in patients with main TL/L curve are poorly documented. Schwender et al. [14] found that the lumbosacral hemicurve represented an important structure predisposing to left coronal plane imbalance in AIS with a large left lumbar curve as a component of the curve pattern; risk factors for persistent postoperative coronal decompensation included iliac and sacral obliquity noted on the preoperative standing full-length radiographs [14]. Li et al. [23] suggested that the pre and postoperative LIV tilt were important radiographic parameters that were strongly correlated with postoperative global and regional coronal balance. In patients with Lenke 5C curves undergoing posterior correction using pedicle screw constructs, preoperative LIV tilt equal to or exceeding 25° and failure of postoperative LIV tilt to reduce below 8° were correlated with a high risk of developing postoperative global coronal imbalance. In the present study, the lumbosacral hemicurve and LIV tilt were comparable between N- and A-groups. However, more coronal decompensation occurred in the A-group (more pelvic axial rotation) than in the N-group (normal range of pelvic axial rotation), strongly indicating that preoperative PAR was probably a risk factor for coronal imbalance postoperatively in patients with main TL/L curve.

Fig. 4 ID:6196, ♀, 13 years, Lenke type 5 AIS, main TL/L Cobb 47°, pre- CV/CC ratio = 0.90, A-group patient. The trunk translation (TT) happened after surgery: preoperative (a), TT = 19 mm; at 3 months postoperatively (b), TT = 7 mm; at 24-month follow-up (c), TT = 20 mm

To our knowledge, this is the first study to explore the effects of the preoperative PAR on the clinical outcome postoperatively in scoliosis. The results of our study demonstrated that the coronal decompensation, especially the trunk translation, was more likely to occur in the pelvic rotational patients (A-group) than the normal ones (N-group) (Figs. 3, 4). Given a good match of the preoperative and operative variables between the N- and A-groups (the normal and the pelvic rotational patients), our interpretation of the postoperative coronal decompensation could be the instability of the spine foundation (i.e., the pelvis) outside the areas of instrumentation [35]. From a biomechanical point of view, the spine and pelvis linking the head to the lower extremities could be regarded as a chain [36]. Thus, change in any segment would affect the others. Thereby, preoperative rotational pelvis should be regarded as an instable foundation for the spine and the spinal instrumentation; more the rotational, more the instability. Hence, the preoperative PAR would have some effects on the spinal balance till postoperative, and cause relevant coronal decompensation.

There were some limitations in the present study. Firstly, this was just a radiographic study without evaluating the patients' clinical cosmesis [37]; meanwhile we only assessed the decompensation in coronal plane. Given

the complicated effects of PAR on trunk balance in three-dimension space, it would be difficult to analyze the change of the body balance in coronal plane together with the other planes; so the effects in other planes (i.e., the sagittal plane) and their associations with clinical outcomes would be worth exploring in further studies. The second was the difficulty in the assessment of PAR on postero-anterior radiographs, because the evaluation of PAR on X-ray films would be influenced by the patients' position. An alternative method was CT scan; however, the patients would take massive doses of radiation and have to take the supine position, which would affect the pelvic natural position. Moreover, the method of the L/R ratio we chose was documented in previous studies [4, 5], and our intra-observer agreement was also good. Therefore, the measurement of PAR on the standing full-length postero-anterior radiographs would not be a perfect, but a practical method to assess the pelvic position.

Conclusions

The clinical phenomenon of pelvic asymmetry in AIS patients on posteroanterior radiographs was probably due to the pelvic axial rotation, which could change in the

opposite direction of the corrective derotational load applied to the TL/L spine at 3 months postoperatively, and since then, remains relatively stable. Moreover, TL/L AIS patients with great pelvic axial rotation were probably to have higher risk of coronal decompensation postoperatively.

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Conflict of interest None.

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