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ORIGINAL ARTICLE

Postoperative Disc Wedging in Adolescent Idiopathic Thoracolumbar/Lumbar Scoliosis: a Comparison of Anterior and Posterior Approaches

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Objective To evaluate the different influences of anterior and posterior correction and fusion approaches upon disc wedging in adolescent idiopathic thoracolumbar/lumbar scoliosis.

Methods The retrospective study was conducted with the medical records and radiographs of adolescent idiopathic thoracolumbar/lumbar scoliosis patients that underwent anterior (group A) or posterior (group B) correction and fusion surgery from December 1998 to May 2008. The correction of the main curve and changes of the disc wedging were analyzed.

Results Fifty-three patients were included, 26 in group A and 27 in group B. The mean coronal Cobb angles of the main curve in group A and group B were significantly corrected after surgery ($P < 0.05$), with an average correction rate of 75.2% and 88.2%, respectively. Upon final follow-up, the coronal Cobb angles of the two groups were $18.9^\circ \pm 11.1^\circ$ and $7.7^\circ \pm 5.6^\circ$, respectively, with an average correction loss of $6.8^\circ \pm 6.5^\circ$ and $2.7^\circ \pm 3.3^\circ$, respectively. The coronal Cobb angle after operation and at final follow-up, and the correction rate were significantly better in group B than those in group A ($P < 0.05$), while the coronal Cobb angle loss in group A was greater than that in group B ($P < 0.05$). The disc wedging before operation, after operation, and at final follow-up were $3.2^\circ \pm 3.0^\circ$, $5.7^\circ \pm 3.0^\circ$, and $8.6^\circ \pm 4.4^\circ$ in group A, and $2.4^\circ \pm 3.2^\circ$, $3.3^\circ \pm 3.4^\circ$, and $3.7^\circ \pm 3.6^\circ$ in group B, respectively. Postoperative disc wedging was significantly larger compared with preoperative measurements in group A ($P < 0.05$), but not in group B ($P > 0.05$). The difference between disc wedging at final follow-up and that after surgery was significant in group A ($P < 0.05$), but not in group B ($P > 0.05$). Between the two groups, group A had larger disc angles after operation and at final follow-up ($P < 0.05$), and a greater loss of disc angle ($P < 0.05$).

Conclusion For adolescent idiopathic thoracolumbar/lumbar scoliosis, posterior approach using all pedicle screws might produce a better result in terms of disc wedging compared with anterior approach.

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ANTERIOR spinal fusion with instrumentation has long been adopted to correct adolescent idiopathic thoracolumbar/lumbar (TL/L) scoliosis. After anterior spinal fusion with instrumentation, the lower endplate of the lowest instrumented vertebra (LIV) and the upper endplate of the next caudal vertebra usually form an angle called disc wedging or disc angle.¹⁻⁵ With widespread application of segmental pedicle screws, posterior correction and fusion with all pedicle screws has also been performed for TL/L scoliosis.⁶⁻⁸ In the posterior approach, postoperative disc wedging also exists.⁹ To our knowledge, comparison between anterior and posterior approaches in terms of disc wedging in adolescent idiopathic TL/L scoliosis has rarely been conducted or reported. Therefore, focusing the changes of disc wedging, we reviewed the records of such patients who underwent anterior or posterior spinal fusion with instrumentation in our hospital to find out the possible differences between these two approaches.

PATIENTS AND METHODS

Patients

With the approval of Institutional Review Board in our hospital, we reviewed the medical records and radiographs of adolescent idiopathic TL/L scoliosis patients who received anterior (group A) or posterior (group B) spinal fusion with instrumentation from December 1998 to May 2008 in our hospital. The inclusion criteria included: (1) adolescent idiopathic scoliosis; (2) single anterior or posterior approach; (3) thoracolumbar or lumbar scoliosis, PUMC classification Ib, Ic, IIc1, and IIc1,¹⁰ Lenke classification type 5;¹¹ (4) at least 12 months follow-up.

Surgical procedures and measurements

The instrumentations all used third-generation implants. Single-rod instrumentation was applied in group A, and the fusion levels were determined according to John Hall's principle for anterior short segment: if the apex is a vertebra, fuse one vertebra above and one vertebra below the apex; if the apex is a disc, fuse two vertebrae above and two vertebrae below the apex.¹² But the disc below and above the fusion segment should be mobile. As for group B, all pedicle screws with dual-rod instrumentation were used, and the fusion levels were generally from the upper end vertebra to the lower end vertebra.

With the standing anteroposterior (AP) film, lateral film, and supine bending films of the full spine taken before the surgery, and the standing AP and lateral films of the full spine taken after the surgery and at final follow-up, we

measured and recorded the coronal and sagittal Cobb angles, flexibility of the curves, correction rate, the lowest end vertebra (LEV), LIV, the position of LIV relative to LEV, the disc wedging, and the obliquity of LIV. The position of LIV relative to LEV was recorded as LIV-LEV and was defined as "1" when the LIV was one segment distal to the LEV, "0" when the LIV was same to the LEV, and "-1" when the LIV was one segment proximal to the LEV.⁴ The disc wedging was defined as "-" when opening to the preoperative convex side of TL/L and "+" when opening to the concave side. The absolute values of the disc angles were also calculated regardless of the opening side.² The obliquity of LIV was defined as the angle between the lower endplate of the LIV and the horizon.

Statistical analysis

Continuous variables of these two groups were compared using independent 2-sample *t* test. Ordinal variables were compared using the Chi-square test or the Mann-Whitney U test. Statistical analyses were performed with the statistics software SPSS 10.0. A *P* value less than 0.05 was considered statistically significant.

RESULTS

Altogether 53 patients were included, 9 males and 44 females, with an average age of 14.5 years (range, 10-18 years). The mean follow-up period was 21.6 months (range, 12-42 months). The mean coronal Cobb angle of the TL/L curve before operation was $46.7^\circ \pm 9.4^\circ$ (range, 30° - 62°), and it was corrected to $13.2^\circ \pm 10.3^\circ$ (range, 0° - 45°) at final follow-up. The mean fusion level in group A was significantly shorter than that in group B (4.5 ± 0.6 vs. 5.7 ± 1.1 vertebrae, $P < 0.05$). The general parameters of all the included patients are listed in Table 1. The changes of the disc wedging before operation, after operation, and at final follow-up are presented in Table 1.

Group A included 26 patients, 4 males and 22 females, with an average age of 14.7 years (range, 10-18 years). The disc wedging after operation was significantly greater than that before operation ($P < 0.05$), and the angle measured at final follow-up was in turn greater than that after operation ($P < 0.05$) (Table 1). At final follow-up, L₃₋₄ disc wedging was significantly larger than that of L₄₋₅ ($P < 0.05$) and also with a larger loss of the disc wedging ($P < 0.05$) (Table 2). The patients with a more proximal LIV (LIV-LEV=-1 vs. LIV-LEV=0) had a larger disc wedging at final follow-up ($11.5^\circ \pm 3.7^\circ$ vs. $7.3^\circ \pm 4.1^\circ$, $P < 0.05$). Figure 1 presents the X-ray films of a typical case in group A.

Table 1. General parameters and disc wedging changes in the 53 adolescent idiopathic TL/L scoliosis patients[§]

Group	n	Coronal Cobb angle			LIV obliquity			Convex-bending Cobb angle
		Preoperative	Postoperative	At final follow-up	Preoperative	Postoperative	At final follow-up	
Group A	26	49.0°±9.3°	12.2°±9.0°	18.9°±11.1°	25.7°±8.2°	10.7°±7.7°	15.4°±8.3°	13.9°±10.2°
Group B	27	44.4°±9.2°	5.1°±3.7°**	7.7°± 5.6°**	22.1°±6.6°	3.5°±3.0°**	4.5°±3.4°**	11.0°±10.5°

Group	n	Flexibility (%)	Correction rate (%)	Correction loss	Disc wedging			
					Preoperative	Postoperative	At final follow-up	Loss
Group A	26	71.1±15.5	75.2±15.8	6.8°±6.5°	3.2°±3.0°	5.7°±3.0° [#]	8.6°±4.4° [‡]	2.9°±4.4°
Group B	27	74.9±23.3	88.2± 8.5**	2.7°±3.3°**	2.4°±3.2°	3.3°±3.4°**	3.7°±3.6°**	0.4°±3.2°*

§: Plus-minus values are means±SD.

TL/L: thoracolumbar/lumbar; LIV: lowest instrumented vertebra.

P*<0.05, *P*<0.01 compared with group A; [#]*P*<0.05 compared with the preoperative disc wedging of group A; [‡]*P*<0.05 compared with the postoperative disc wedging of group A.

Table 2. Details of the changes of L₃₋₄ and L₄₋₅ disc wedging[§]

Item	L ₃₋₄ disc wedging		L ₄₋₅ disc wedging	
	Group A (n=20)	Group B (n=13)	Group A (n=6)	Group B (n=14)
Preoperative	2.4°±2.8°	2.5°±3.0°	5.5°±2.5°	2.4°±3.5°
Postoperative	5.8°±3.2°	4.2°±2.7°	5.3°±2.3°	2.4°±3.7°
At final follow-up	9.8°±4.0°	5.8°±3.6°**	4.5°±2.9°*	1.6°±2.2° [‡]
Loss	4.0°±4.4°	1.6°±3.8°	-0.8°±1.0°*	-0.8°±2.0° [#]

§: Plus-minus values are means±SD.

P*<0.05, *P*<0.01 compared with the result for L₃₋₄ disc wedging in group A; [#]*P*<0.05 compared with the result for L₃₋₄ disc wedging in group B; [‡]*P*<0.05 compared with the result for L₄₋₅ disc wedging in group A.

**Figure 1.** A 16-year-old girl with idiopathic scoliosis classified as PUMC IIId1, Lenke 5CN, receiving anterior fusion from T₁₂ to L₃.

- Preoperative standing anteroposterior film shows a 48° thoracic curve (T₅-T₁₀) and a 62° lumbar curve (T₁₁-L₃), with a 2° disc wedging;
- Preoperative standing lateral film shows a 11° thoracolumbar kyphosis;
- Postoperative anteroposterior film after selective fusion of the major lumbar curve. Since the apex of the lumbar curve is L₁₋₂ disc, fusion from T₁₂ to L₃ is performed according to Hall's principle. The major lumbar curve is corrected to 5° and the minor thoracic curve improved to 25° spontaneously, with a 10° disc wedging;
- No thoracolumbar kyphosis is found on the postoperative lateral film;
- Standing anteroposterior film at follow-up 18 months after surgery. The major lumbar curve turns to 6° and minor thoracic curve 32°. The disc wedging is found aggravated to 16° with a good coronal balance and normal lumbar lordosis;
- Standing lateral film at the follow-up.

Twenty-seven patients were included in group B, 5 males and 22 females, with an average age of 14.3 years old (range, 11-18 years). There was no significant difference in the disc wedging before and after surgery ($P>0.05$), neither was there between final follow-up and postoperative angles ($P>0.05$) (Table 1). In addition, neither before nor after surgery was there significant difference in disc wedging between the patients with LIV located at L_3 and those with LIV located at L_4 ($P>0.05$). While at the final follow-up, L_{3-4} disc wedging was found larger than that of L_{4-5} ($P<0.05$) and also with a larger loss of the disc wedging ($P<0.05$) (Table 2). The patients with LIV-LEV=-1 had a larger disc wedging than those with LIV-LEV=1 at final follow-up ($7.2^\circ\pm3.8^\circ$ vs. $1.2^\circ\pm1.3^\circ$, $P<0.05$), while there was no significant difference between patients with LIV-LEV=-1 and LIV-LEV=0 ($7.2^\circ\pm3.8^\circ$ vs. $3.7^\circ\pm3.5^\circ$, $P>0.05$), nor between patients with LIV-LEV=1 and LIV-LEV=0 ($1.2^\circ\pm1.3^\circ$ vs. $3.7^\circ\pm3.5^\circ$, $P>0.05$). Table 2 also showed that whether it was L_{3-4} disc wedging or L_{4-5} disc wedging, group B presented better results than group A did at final follow-up (both $P<0.05$). Figure 2 presents the X-ray films of a typical case in group B.

Six patients in group A had a 5° - 10° thoracolumbar

kyphosis in the sagittal plane before operation, and 1 out of the 6 patients still had a 5° thoracolumbar kyphosis after operation and at final follow-up. In group B, 8 patients had an average of 28° (range, 7° - 56°) thoracolumbar kyphosis before operation, and that condition persisted in 3 of them at final follow-up. The other patients' normal lumbar lordosis was well maintained and no other local kyphosis was noted at the three reviewed stages.

DISCUSSION

For adolescent idiopathic scoliosis (AIS) patients with a TL/L curve, the surgical procedure can adopt single anterior or posterior approach. The correction rate of anterior approach is about 58%-83%,¹³⁻¹⁵ and that of posterior approach about 64.6%-87.6%.^{8,16} Similar with the findings in Geck's report,¹⁶ both approaches produced good correction in the present study. This study also found that the correction rate in the group using posterior approach was significantly higher than that in the group using anterior approach. While in Li's report, no such significant difference is detected.¹⁵ In the posterior group in our series, the average correction rate was 88.2%, while in Li's report it

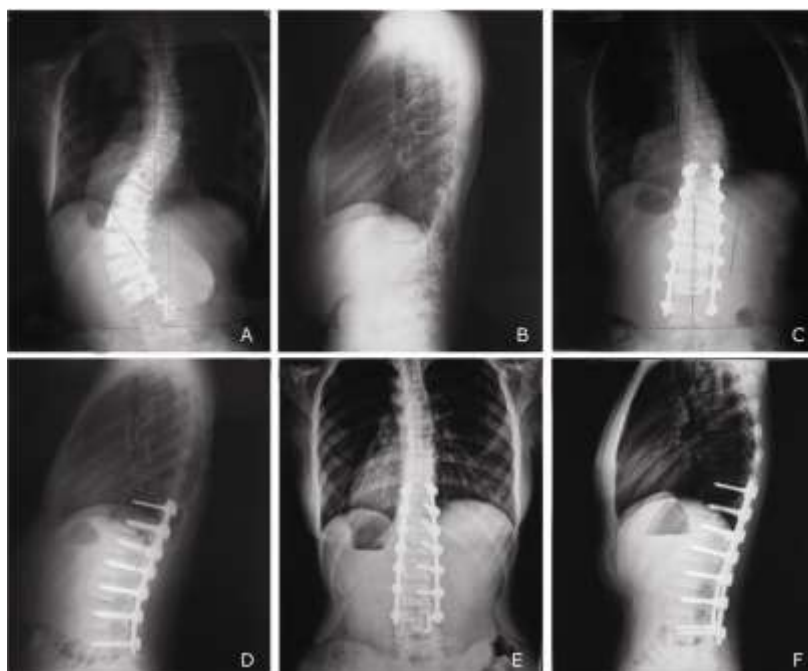


Figure 2. A 12-year-old girl with idiopathic scoliosis classified as PUMC IIId1, Lenke 5CN, receiving posterior fusion from T_{10} to L_4 .
 A. Preoperative standing anteroposterior film shows a 40° thoracic curve (T_4 - T_{10}) and a 62° thoracolumbar curve (T_{11} - L_3), with a 0° disc wedging;
 B. No thoracolumbar kyphosis is found on the preoperative standing lateral film;
 C. Postoperative anteroposterior film after selective fusion of the major thoracolumbar curve. The major TL curve is corrected to 3° and the minor thoracic curve improved to 10° spontaneously, with a 0° disc wedging;
 D. No thoracolumbar kyphosis is found on the postoperative lateral film;
 E. Standing anteroposterior film at follow-up 18 months after surgery. The major TL curve turns to 4° and minor thoracic curve 8° . The disc wedging is 0° with a good coronal balance and normal lumbar lordosis;
 F. Standing lateral film at the follow-up.

was only 57.7%, which might be the cause for the difference in finding.

Kaneda et al¹³ reported postoperative disc wedging in AIS patients with TL/L involvement following anterior fusion with instrumentation using Kaneda dual-rod. In their study, the mean disc wedging angle was 6.6° in patients who underwent a short fusion and 3.0° in patients with lower end vertebra fused, suggesting that the more proximal the LIV and the shorter the fusion range, the larger the disc wedging would be below the LIV. Our study also showed that the patients with LIV located one segment proximal to LEV had a larger disc wedging compared to those with LIV located at LEV (in anterior approach group) or LIV located one segment distal to LEV (in posterior approach group). In another study about anterior surgery for AIS, the preoperative disc angle, the mean value of which being 10° , was significantly corrected to 2° ($P=0.0001$).¹ They suggested that the larger the disc angle, the more the shear stress on the next caudal vertebra and the risk of future degeneration. Satake et al² reported that in the 61 studied adolescent idiopathic TL/L scoliosis patients, the preoperative disc angle ($4.49^\circ \pm 5.48^\circ$) was turned to $5.85^\circ \pm 4.37^\circ$ after anterior spinal fusion. They concluded that the compressive force applied to secure the intervertebral implants tends to create wedging below the LIV by pulling the LIV closer to the apex.

Disc wedging can also occur after posterior approach. Stasikelis et al⁹ reported that the disc wedging after combined anterior and posterior approach was $8.4^\circ \pm 6.0^\circ$, but $4.1^\circ \pm 4.1^\circ$ after single posterior approach ($P<0.01$). In their report, the patients undergoing combined anterior and posterior approach had a better correction rate compared with those undergoing single posterior approach ($P<0.05$). It was suggested in that report that over-correction of the upper lumbar curve might explain the increased disc angle. Shufflebarger et al,⁸ on the other hand, reported that LIV tilt was 27° before surgery, and was corrected to 5° after operation, with no following enlargement during the follow-up. Since the LIV tilt was defined as the angle between the lower endplate of the LIV and the horizon (LIV obliquity in the present study), and the disc wedging as the angle between the lower endplate of the LIV and the upper endplate of the next caudal vertebra, LIV tilt may indirectly reflect disc wedging. Thus their study indirectly indicates that there might be very little change of the disc wedging after posterior surgery. It might be because of simultaneous distraction at the concave side, compression at the convex side, and pedicle screws at LIV in posterior approach.

There have scarcely been reports comparing the

change of disc wedging after different correction approaches for TL/L curve. In this study, disc wedging changed significantly more in the anterior approach group than in the posterior approach group. Posterior correction and fusion of TL/L curve could provide a better disc wedging compared to the anterior approach, while with a longer fusion range. However, disc wedging changes after correction and instrumentation are only identified based on radiographic findings. The patients reviewed in this study are all asymptomatic. The definite reason, natural history, and significance of disc wedging are still to be discovered. Since a larger disc wedging means more shear stress on the next caudal vertebra and a risk of future degeneration,¹ long-term follow-up is needed for further investigation into disc wedging change after surgical procedure.

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