Original Article

Lowest Instrumented Vertebrae Selection for Posterior Fusion of Lenke 5C Adolescent Idiopathic Scoliosis: Can We Stop the Fusion One Level Proximal to Lower-end Vertebra?

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Abstract

Background: The most appropriate fusion levels remains challenging, especially in Lenke type 5 curves. In Lenke 5 adolescent idiopathic scoliosis (AIS) generally fusion includes the lower end vertebra (LEV). This study determines whether it is appropriate to fuse mild to moderate Lenke 5 curves to LEV-1, if possible. **Materials and Methods:** Forty-two patients with mild to moderate Lenke 5 AIS that underwent posterior fusion were retrospectively evaluated. The preoperative goal was to stop the instrumentation at LEV-1 in all patients if possible. However, the final decision was made intraoperatively according to the alignment of the disc below lowest instrumented vertebra (LIV). In 19 patients, this goal was achieved and LIV was LEV-1, whereas 23 patients were fused to LEV. Hence, two groups occurred and they were compared in terms of coronal, sagittal, and LIV related parameters at 1 year and 3 years postoperatively. Surgical times were also noted. Clinical outcomes were assessed using scoliosis research society (SRS-22) and Short Form-36 questionnaires. **Results:** Two groups were well matched according to preoperative values. Postoperative radiographic results were also similar, except LIV disc angle and LIV translation, which were significantly higher in LEV-1 group at 1 and 3 years followup ($P < 0.05$). Surgical times were significantly longer in LEV group ($P = 0.036$). No significant correction loss was observed between 1 and 3 years followup. There were no significant differences regarding postoperative clinical outcomes except the activity domain of SRS-22, which was significantly higher in LEV-1 group, but the significance was weak ($P = 0.045$). **Conclusions:** Fusion to LEV-1was associated with the higher amount of LIV disc angle and LIV translation, which did not cause coronal and sagittal imbalance and decreased the quality of life scores. Hence, if intraoperatively a level disc below LIV can be achieved, fusion to LEV-1 may be an option in mild to moderate Lenke 5 curves, to save one more mobile segment.

Keywords: *Lenke 5 adolescent idiopathic scoliosis, lower end vertebra, lower end vertebra-1, lowest instrumented vertebra*
MeSH terms: *Scoliosis, vertebrae, adolescent*

Introduction

The goals of surgical management of adolescent idiopathic scoliosis (AIS) include maintaining coronal and sagittal alignment, producing level shoulders, correcting deformity, and saving motion segments.[1] Classification systems for AIS have facilitated the surgical planning.[2] Even so, choosing the most appropriate fusion levels remains challenging, especially in Lenke type 5 curves. In these thoracolumbar/lumbar (TL/L) curves, most of the lumbar segments are needed to be fused, which would cause loss of lumbar mobility.[3] This would lead to a series of negative clinical outcomes, such as low back pain and decreased quality of life.[4]

Rose and Lenke recommended that the fusion should include at least lower-end vertebra (LEV), occasionally one level distal to LEV (LEV + 1) in TL/L curves.[3] Depending on the magnitude and the flexibility of the curves, LEV, LEV + 1 and rarely one level proximal to LEV (LEV-1), have been chosen as lowest instrumented vertebra (LIV) in different studies.[1-5] The results of fusion to LEV and LEV + 1 have been compared,[5] but no study has evaluated the radiographic and functional outcomes of fusion to LEV-1.

In this study, we compared radiographic and clinical results of posterior fusion of mild to moderate Lenke 5 AIS curves, in which we stopped the fusion at LEV and LEV-1. This study aims to determine whether it is appropriate to fuse to LEV-1, according to the alignment of the disc below LIV intraoperatively, to save one mobile segment.

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Materials and Methods

49 consecutive patients with TL/L AIS who were treated by posterior segmental instrumentation and fusion were included in this study and were retrospectively evaluated after institutional ethics committee review board approval. Exclusion criteria included patients with a diagnosis other than AIS, curves with a Cobb angle of more than 60°, age over 20 years, and having a prior spine surgery. Curves >60° were excluded because they were defined as severe curves.[5] Seven patients were excluded according to above criteria. Mean age of the 42 patients was 16.1 years (range 13–20 years) at the time of surgery. Thirty-three of the patients were female and 9 of them were male.

Preoperatively, the goal was to stop the instrumentation at LEV-1 in all of the patients. But the final decision was made intraoperatively according to the alignment of the disc below LIV. If a level disc below LIV was achieved, the instrumentation was stopped at LEV-1. Otherwise, the instrumentation was extended one level distally. In 19 patients, a level disc below LIV was achieved intraoperatively, and LIV was LEV-1, whereas 23 patients were fused to LEV. In none of the patients, fusion was needed to be extended to LEV + 1, because a level disc below LIV was achieved when stopped at LEV. Hence, patients were divided into two groups according to the relationship of LIV and LEV: LIV was LEV (LEV group, n = 23) and LIV was one level proximal to LEV (LEV-1 group, n = 19). The descriptive data of all patients are listed in Table 1.

All surgeries were performed by the same surgeon, the senior author, at a single institution using an identical surgical technique as described below. All patients underwent long (both TL/L and thoracic curves) fusions for their deformities. Patients were placed in the prone position on a radiolucent table. After a standard midline incision, subperiosteal dissection of the posterior soft tissues was performed to the tips of the transverse processes. Polyaxial pedicle screws were placed using a free hand technique bilaterally at every level in all of the patients. Especially on the convex side of the deformity, the posterior release was performed with partial facetectomies of all instrumented levels. After the insertion of precontoured rods, convex rod derotation technique was used to correct the deformity. Under fluoroscopic control compression, distraction and *in situ* bending maneuvers were added if necessary. With these maneuvers, LIV should become parallel or near-parallel to the vertebrae below. If this was not achieved with instrumentation to LEV-1 (the vertebra that was initially chosen as LIV), instrumentation was extended to LEV. To do this, the rods were released, additional instrumentation of the distal segment was performed, longer rods were prepared, and correction maneuvers were repeated. The alignment of the disc below LIV was evaluated again with fluoroscopy. The laminae and transverse processes were thoroughly decorticated. Allograft bone material was used for fusion. Neurophysiological monitoring was performed throughout the procedures. Surgical times were recorded.

Table 1: Demographic characteristics, preoperative values and surgical times

Variables	Mean±SD		*P*
	LEV group	LEV-1 group	
Age	16.3±2.1	15.7±1.8	0.827
Gender (female/male)	18/5	15/4	0.539
Thoracic curve angle (°)	26.7±3.1	24.3±2.6	0.752
TL/L curve angle (°)	45.3±7.2	43.2±6.9	0.846
TL/L curve flexibility (%)	58.2±14.8	60.7±18.3	0.823
C7PL-CSVL (mm)	24.2±8.1	21.6±9.4	0.354
CHD (mm)	8.1±5.7	7.8±6.3	0.797
LIV tilt (°)	23.4±4.3	22.8±4.9	0.814
LIV disc angle (°)	5.2±3.9	4.7±3.2	0.366
LIV translation (mm)	16.3±3.6	19.6±4.8	0.152
LIV+1 rotation (°)	16.4±5.8	18.8±4.7	0.258
Thoracic kyphosis (T5–T12) (°)	25.3±7.1	23.6±6.5	0.597
Lumbar lordosis (L1–L5) (°)	38.3±8.7	36.7±7.3	0.625
C7 plumb line (mm)	−13.3±29.7	−14.1±31.8	0.847
Surgical time (min)	202.7±32.3	178.3±26.8	0.036*

*Statistical significance. TL/L=Thoracolumbar/lumbar, C7PL-CSVL=C7 plumb line-central sacral vertical line, CHD=Coracoid height difference, LIV=Lowest instrumented vertebra, LEV=lower end vertebra, SD=Standard deviation

Measurements were made on 36-inch long cassette anteroposterior (AP) and lateral radiographs of the spine with the patient standing, preoperatively [Figure 1], at 1 year followup [Figure 2a and b] and at 3 years followup [Figure 2c and d]. A senior spinal surgeon who was independent of the operative team made all radiographic measurements.

The parameters examined included preoperative and postoperative coronal Cobb measurements of the major TL/L and minor thoracic curves, coronal balance as the perpendicular distance between the C7 plumb line and central sacral vertical line (C7PL-CSVL), shoulder balance as coracoid height difference (CHD),[6] and parameters related to LIV on AP radiographs. C7PL-CSVL distance more than 20 mm was defined as coronal imbalance.[5]

Parameters related to LIV were measured as follows: The inclination of the inferior endplate of LIV to the horizontal in degrees was defined as LIV tilt. LIV disc angle was measured between the inferior endplate of LIV and the superior endplate of the next caudal vertebra. LIV translation was defined as the distance between the center of LIV and CSVL in millimeters [Figure 3]. Rotation of the vertebra below LIV was measured according to Perdriolle method,[7] and was defined as LIV + 1 rotation.

The sagittal parameters examined included preoperative and postoperative thoracic kyphosis (T5–T12), lumbar lordosis (L1–L5), and sagittal balance as C7PL.

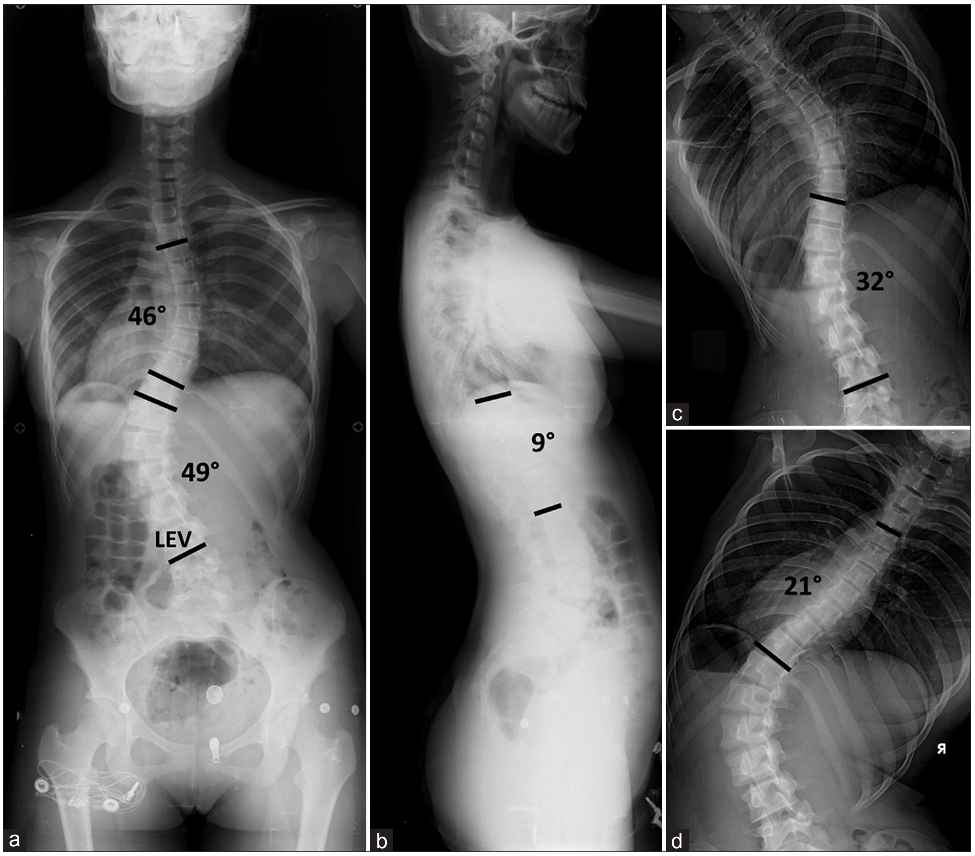

Figure 1: (a) Preoperative anterioposterior radiograph of 13-year-old girl with 49° thoracolumbar/lumbar curve. lower end vertebra is L3. (b) Preoperative lateral radiograph showing 9° of T10-L2 kyphosis. (c and d) Right and left bending graphies showing that only thoracolumbar/lumbar curve is structural

Curve flexibility was determined by push-prone AP radiographs using the following formula: (preoperative angle-reverse side bending angle)/preoperative angle × 100%

Clinical outcome measurements of the patients were evaluated by using the scoliosis research society (SRS)-22 questionnaire and the Short Form (SF)-36. The questionnaires were completed preoperatively and at 3 years followup.

All statistical analyses were conducted using SPSS for Windows (Version 21.0; IBM Corp., Armonk, NY, USA). All continuous variables were presented as mean ± standard deviation. Independent Student's *t*-tests were selected to assess the differences of clinical and radiographic parameters between the two groups for numerical variables. Statistical comparisons between groups preoperatively and postoperatively were performed using the Mann–Whitney U-test. The value of $P < 0.05$ was considered to be statistically significant.

Results

There were no differences between two groups in terms of age and gender [Table 1]. The comparison of preoperative TL/L and thoracic curve angles, curve flexibility, C7PL-CSVL distance, and CHD between groups revealed statistically similar results and this was also same for comparative analysis of postoperative values at 1 and 3 years followup. Sagittal plane analyses revealed similar results between groups in terms of thoracic kyphosis, lumbar lordosis and C7PL preoperatively and postoperatively at 1 and 3 years followup [Tables 1 and 2]. There were no significant differences between 1 and 3 years followup values of each group in terms of coronal and sagittal parameters [Table 2]. No significant correction loss was observed between 1 and 3 years followup, in terms of coronal thoracic and TL/L curve angles as well as thoracic kyphosis and lumbar lordosis [Table 3]. Surgical times were significantly longer in LEV group [Table 1].

In regard to LIV related parameters, preoperatively LIV tilt, LIV disc angle, LIV translation and LIV + 1 rotation showed no difference between two groups [Table 1]. On postoperative 1 and 3 years followup, LIV tilt and LIV + 1 rotation were also similar between groups. However, LIV disc angle and LIV translation were significantly greater in LEV-1 group. For each group, there was no significant change in LIV related parameters between 1 and 3 years followup [Table 4]. In both groups, patient-reported outcomes improved significantly at 3 years followup. There was no association with LIV level and SF-36 scores. Activity domain of SRS-22 score was significantly better in LEV-1 group postoperatively, but the significance was weak ($P = 0.045$). There were no significant differences

Table 2: Postoperative values in coronal and sagittal plane

Variables	1 year followup			3 years followup			$P^{\dagger}$	$P^{\ddagger}$
	LEV group	LEV-1 group	*P*	LEV group	LEV-1 group	*P*		
Thoracic curve (°)	5.2±3.7	4.9±3.1	0.357	5.5±4.3	5.1±3.9	0.235	0.875	0.912
TL/L curve (°)	7.2±4.9	8.3±5.7	0.402	7.7±5.6	8.9±6.5	0.382	0.672	0.596
C7PL-CSVL (mm)	8.7±5.2	9.2±6.3	0.321	7.4±4.3	8.1±3.9	0.265	0.348	0.284
CHD (mm)	4.6±3.1	4.9±3.7	0.673	5.1±3.3	5.5±3.7	0.631	0.792	0.831
Thoracic kyphosis (T5-T12) (°)	23.6±6.7	22.3±7.2	0.798	24.8±7.1	23.7±6.4	0.754	0.813	0.927
Lumbar lordosis (L1-L5) (°)	38.8±7.8	37.3±8.1	0.932	41.4±8.3	40.9±9.1	0.934	0.841	0.945
C7 plumb line (mm)	−14.1±22.7	−17.3±25.7	0.573	−15.8±25.2	−16.1±23.5	0.668	0.892	0.916

†Comparison of 1 year and 3 years followup values of LEV group, ‡Comparison of 1 year and 3 years followup values of LEV-1 group. TL/L=Thoracolumbar/lumbar, C7PL-CSVL=C7 plumb line-central sacral vertical line, CHD=Coracoid height difference, LEV=Lower end vertebra

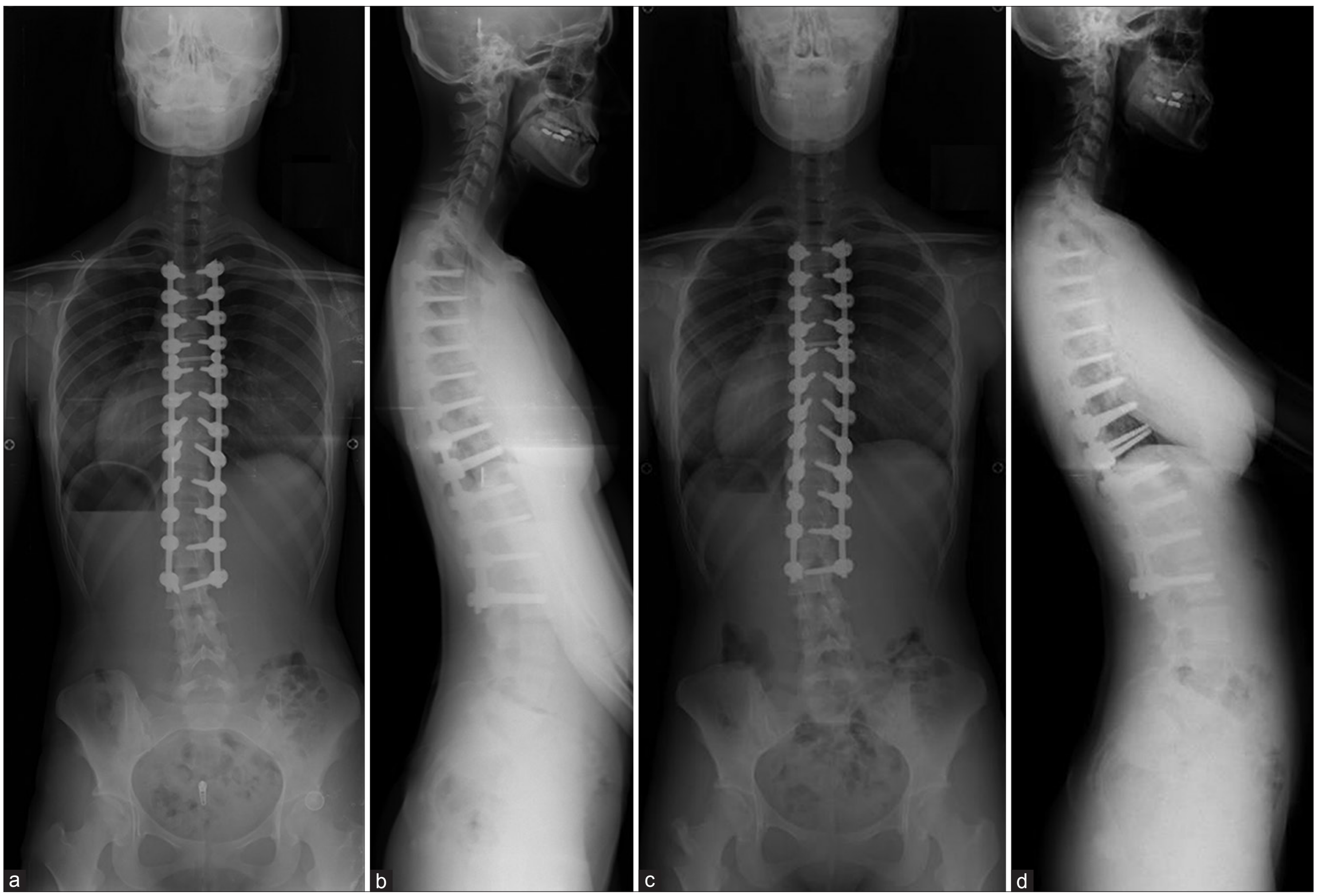

Figure 2: (a and b) Postoperative anteroposterior and lateral radiographs at 1 year followup that shows fusion to lower end vertebra-1 (L2). (c and d) Postoperative anteroposterior and lateral radiographs at 3 years followup

between the groups in terms of all other domains and total scores of SRS-22 [Table 5].

One patient in LEV-1 group developed coronal imbalance without clinical manifestation, which required no revision surgery. There were also no neurologic complications and postoperative infection. Implant failure was not observed.

Discussion

LIV selection is a critical decision in the treatment of Lenke 5 AIS patients because it is important to save lumbar mobility while achieving optimal correction. Preserving more lumbar mobile segments is possible with a more proximal LIV selection, which decreases risks of disc degeneration and low back pain.[4] For this reason, we tried to stop the fusion as proximal as possible in our mild to moderate Lenke 5 AIS patients, and in this study, we investigated the effect of LIV level on radiologic and clinical outcomes.

Several studies reported the outcomes of posterior surgery in Lenke 5 AIS according to LIV selection.[5,8-12] In the study of Halm *et al*. 10 patients of 12 were fused to LEV and two patients to LEV + 1.[8] Shufflebarger *et al*. reported the results of 51 Lenke 5 AIS patients which were fused to LEV.[9] Geck *et al*. compared in their study anterior and posterior instrumentation in Lenke 5 AIS.[10] 27 of 31 posterior cases were fused to LEV, and 4 were fused to LEV + 1. In all of these studies, satisfactory results were achieved in terms of curve correction and spinal balance when fused to LEV. No patients were fused to LEV-1 in these studies. On the other hand, in some studies, occasionally patients were fused to LEV-1.[5,12,13] Li *et al*. analyzed radiographic parameters relevant to LIV and defined risk factors for postoperative coronal imbalance.[13] 12 of 27 patients were fused to LEV-1, but they did not compare these patients' results with LEV and LEV + 1 groups. The sagittal plane analysis was not performed in this study. Liu *et al*. investigated the role of upper and LIV in predicting the postoperative coronal balance.[12] Eight of 40 patients were fused to LEV-1. A comparison according to LIV level was also not performed in their study. Sun *et al*. compared the results of patients fused to LEV or LEV + 1.[5] They concluded that there was no benefit for fusing to LEV + 1 in moderate TL/L AIS. Three of 37 patients were fused to LEV-1 in this study, which was a small number to generate an additional group, and hence, there were no conclusions for LEV-1 patients. In our study, patients were fused either to LEV or to LEV-1 according to the intraoperative alignment of the disc below LIV, which were compared in two groups. No patients were fused to LEV + 1.

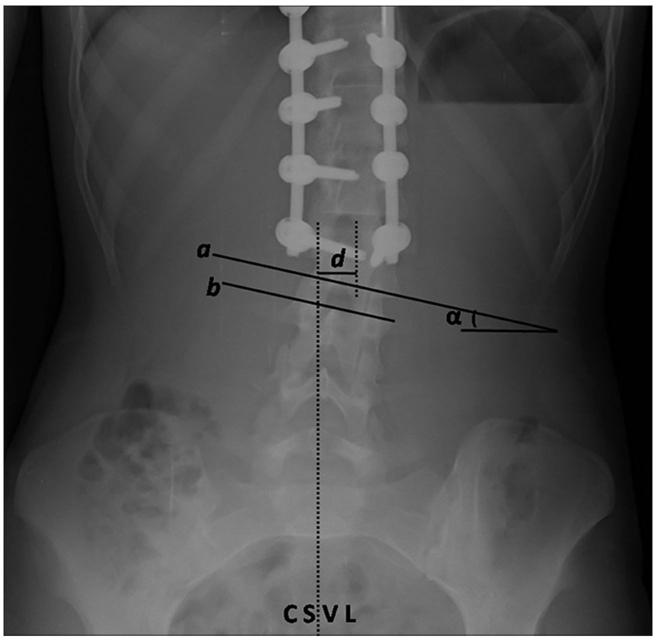

Figure 3: Measurement of lowest instrumented vertebra related parameters. Lowest instrumented vertebra tilt: (α) lowest instrumented vertebra disc angle: Angle between the inferior endplate of lowest instrumented vertebra (line a) and the superior endplate of next caudal vertebra (line b). lowest instrumented vertebra translation (d)

The study results of coronal plane parameters are as good as reported in the literature.[5,9,12,14] Inspite of stopping the fusion more proximally, in the LEV-1 group, we achieved comparable results to LEV group in terms of coronal and shoulder balance. This may be related to long fusions extended to upper thoracal levels. We do not perform selective lumbar fusion in 5 AIS to prevent potential risks of thoracic curve correction loss and increase in rib hump deformity due to the increased thoracal vertebral rotation.[15] Thoracic fusions did not change the thoracic sagittal profile significantly. The study results in sagittal plane are comparable with previous studies.[5,9,12] There were also no significant differences between groups in terms of sagittal plane parameters. Hence, we conclude that fusing to LEV-1 does not cause sagittal imbalance. Lack of correction loss in coronal and sagittal plane between 1 and 3 years followup also supports this opinion. On the other hand, in the study of Okada *et al*., they investigated to determine whether it was appropriate to select one level below to upper-end vertebra (UEV-1) as a upper instrumented vertebra (UIV) in the treatment of Lenke 5 AIS.[16] They evaluated 29 patients who were treated with selective fusion for Lenke 5 AIS retrospectively and compared radiographical parameters between patients with an UIV at the UEV and those with an UIV at the UEV-1. Although the correction rate of the main curve was lower in the patients with an UIV at the UEV-1 in the final followup, the other radiographical parameters (Cobb angle of thoracic curve, global coronal balance, apical vertebral translation, L4 tilt, UIV tilt, LIV tilt, UIV disc angle, and LIV disc angle) were equivalent.

Table 3: Postoperative correction loss in coronal and sagittal parameters between 1 and 3 years followup

Variables	LEV group	LEV-1 group	*P*
Thoracic curve (°)	0.3±2.8	0.2±3.1	0.782
TL/L curve (°)	0.5±3.4	0.6±4.1	0.853
Thoracic kyphosis (T5-T12) (°)	1.2±5.2	1.4±5.8	0.941
Lumbar lordosis (L1-L5) (°)	2.6±6.3	3.6±7.3	0.794

TL/L=Thoracolumbar/lumbar, LEV=Lower end vertebra

Table 4: Postoperative comparison of lowest instrumented vertebra related parameter values

Variables	1 year followup			3 year followup			*P*†	*P*‡
	LEV group	LEV-1 group	*P*	LEV group	LEV-1 group	*P*		
LIV tilt (°)	5.9±2.1	6.1±2.5	0.812	6.4±2.2	6.8±2.7	0.637	0.641	0.563
LIV disc angle (°)	2.1±1.6	3.1±2.8	0.041*	2.4±1.9	3.5±2.1	0.025*	0.854	0.782
LIV translation (mm)	11.3±7.1	18.4±9.5	0.017*	9.0±5.1	15.9±8.3	0.008*	0.357	0.443
LIV+1 rotation (°)	19.7±7.3	22.1±8.2	0.513	17.2±5.3	19.6±5.8	0.315	0.842	0.795

†Comparison of 1 year and 3 years followup values of LEV group, ‡Comparison of 1 year and 3 years followup values of LEV-1 group, *Statistical significance. LIV=Lowest instrumented vertebra, LEV=Lower end vertebra

Table 5: Comparison of clinical outcomes

Variables	LEV group	LEV-1 group	*P*	*P*†	*P*‡
Preoperative SF-36 PCS	34.8±4.2	35.6±5.3	0.463	0.025*	0.021*
Postoperative SF-36 PCS	40.3±3.1	41.7±4.2	0.375		
Preoperative SF-36 MCS	42.3±5.7	43.5±2.4	0.658	0.032*	0.029*
Postoperative SF-36 MCS	47.5±4.9	49.2±3.9	0.412		
Preoperative SRS-22 activity	4.0±0.7	4.1±0.4	0.871	0.043*	0.039*
Postoperative SRS-22 activity	4.1±0.4	4.5±0.9	0.045*		
Preoperative SRS-22 pain	4.7±0.5	4.5±0.8	0.545	0.036*	0.028*
Postoperative SRS-22 pain	4.8±0.8	4.7±0.6	0.752		
Preoperative SRS-22 self-image	3.4±0.8	3.5±0.4	0.653	0.031*	0.029*
Postoperative SRS-22 self-image	3.9±0.7	4.1±0.6	0.475		
Preoperative SRS-22 mental health	3.6±0.6	3.8±0.3	0.362	0.025*	0.033*
Postoperative SRS-22 mental health	3.8±0.5	4.0±0.8	0.538		
Preoperative SRS-22 satisfaction	4.1±0.7	3.9±0.9	0.584	0.027*	0.018*
Postoperative SRS-22 satisfaction	4.3±0.6	4.4±0.9	0.642		
Preoperative SRS-22 total	4.0±0.8	4.0±0.6	0.972	0.034*	0.027*
Postoperative SRS-22 total	4.1±0.9	4.2±1.2	0.785		

†Comparison of preoperative and postoperative values of LEV group, ‡Comparison of preoperative and postoperative values of LEV-1 group, *Statistical significance. SF=Short form, PCS=Physical component summary, MCS=Mental component summary, SRS=Scoliosis Research Society, LEV=Lower end vertebra

This study showed that even in selective fusion for the treatment of Lenke 5 AIS, 1 vertebra less fusion level can also maintain favorable coronal and sagittal balances.

Postoperative LIV related parameters were significantly different between groups except LIV tilt and LIV + 1 rotation. Higher values of LIV translation in LEV-1 group did not effect global coronal balance, because preoperative LIV translation was <28 mm, which is described as an upper limit for coronal imbalance risk by Wang *et al*.[17] Furthermore, preoperative and postoperative LIV tilt angles were below 8° and 25°, respectively, which prevented postoperative coronal imbalance, as described by Li *et al*.[13] Higher values of LIV disc angle in LEV-1 group may be related to compensatory mechanisms which tend to approximate LIV to CSVL in order to constitute coronal balance. The insignificant decline in LIV translation and C7PL-CSVL distance between 1 and 3 years followup may be related to this mechanism.

We also evaluated the rotation of the first unfused vertebra, since it has been shown that its rotation can be increased in some cases, especially if the curve is severe.[18] LIV + 1 rotation was slightly increased in both groups, but the increase was statistically insignificant. It may be expected that increase in the LIV + 1 rotation would be higher since we did not perform direct vertebral rotation maneuver. However, all of our patients had mild to moderate curves. Another explanation may be that our postoperative radiographs were taken at 1 and 3-year followup, when an adjustment of the spine in transverse plane may have been occurred.

Surgical times were longer in LEV group. Intraoperatively, if the achieved correction did not provide successful disc alignment below LEV-1, we released the rods, performed the additional instrumentation of LEV, prepared additional rods longer than the first ones and repeated the correction maneuver. This additional process increased the surgical times significantly. In our opinion, it was worth to save one more mobile segment in this young and active group of patients, which was the main intention of this study.

Clinical outcome measurements were similar between groups except SRS-22 activity domain, which was significantly better in LEV-1 group, although the significance was weak. This may be related to saving one more mobile segment in LEV-1 group. The decreased lumbar range of motion with the distal extension of the fusion has been shown in previous studies.[4,19] Sanchez-Raya *et al*. found LIV to be correlated with lumbar mobility and spinal pain (SRS-22 pain subscale).[4] According to our study, SRS-22 pain domain scores were remote to the LIV. Takayama *et al*. also found no relation between LIV level and postoperative low back pain.[20] In our study activity, rather than pain, was affected from loss of mobile segments. Although long term magnetic resonance studies show no relation between LIV level and disc degeneration,[21] segmental motion of the unfused levels is increased if the fusion is extended distally,[22] which may disrupt normal spinal biomechanics and restrict activity. With stopping one level proximal in LEV-1 group, we aimed to preserve more mobile lumbar segments, which may explain better activity scores in this group.

To the best of our knowledge, this is the first study that evaluated fusion to LEV-1in a separate group of patients. One of the strong points of this study is the uniformity of the surgical procedure. All surgeries were performed by the same surgeon with identical correction maneuvers and with segmental all pedicle screw instrumentation. As far as we know, this is also the first study that evaluated the quality of life, among the studies which investigated LIV selection.

There are also some limitations. First, it was a retrospective study. Another limitation is that we did not measure the segmental mobility of the lumbar spine radiographically or clinically. A significant difference in LIV disc angle and LIV translation may suggest an increased risk for adding-on phenomenon. We did not observe this complication in our patients. However, this may be related to the relative short followup time. Therefore, studies with long term followup are needed to see effect of LIV disc angle and LIV translation. The study cohort did not include patients with curves larger than 60°, so we cannot conclude that fusion to LEV-1 is effective in severe curves. We decided the distal fusion level intraoperatively since there is no consensus in the literature to determine it preoperatively. The inability of preoperative factors to predict the possibility of fusion to LEV-1 may be a limitation, larger studies could provide better data on this subject.

Conclusions

Treatment of mild to moderate Lenke 5 curves with posterior segmental all pedicle screw instrumentation gives satisfactory results when choosing LIV as LEV-1, if a level disc below LIV can be achieved intraoperatively. Greater amounts of LIV disc angle and LIV translation did not cause coronal or sagittal imbalance and decreased the quality of life scores when compared with fusion to LEV. Hence, in mild to moderate Lenke 5 curves fusion to LEV-1 may be an option to save one more mobile segment.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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