Spontaneous lumbar curve correction in selective anterior instrumentation and fusion of idiopathic thoracic scoliosis of Lenke type C

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Abstract

Background Posterior pedicle screw instrumented correction and fusion have become the gold standard in the surgical treatment of thoracic scoliosis. However, in thoracic Lenke type C curves selective posterior fusion of the thoracic curve may lead to spinal imbalance. The aim of the study was to analyse the radiological results of selective anterior thoracic fusion using a standard open dual rod technique with special respect to spontaneous lumbar curve correction (SLCC).

Methods Twenty-eight patients (26 patients with Lenke 1C and 2 patients with Lenke 2C curves) with an average age of 15 years were surgically treated with an anterior dual rod system through a standard open double thoracotomy approach. Average clinical and radiological follow-up was 4 years (24–84 months).

Results Fusion was carried out mostly from end-to-end vertebra. The primary curve was corrected from 61.6° (average correction on reverse bending films 42.9 %) to 27.1° (56.0 % correction) with an average loss of correction of 2.2°. The secondary lumbar curve measured 47.7° preoperatively (40–56°, average correction on reverse bending films 66.2 %) and corrected spontaneously to

30.1° (36 % SLCC) and remained stable without any cases of deterioration or decompensation during follow-up. Lumbar apical vertebral translation increased minimally by an average of 4 mm directly, postoperatively, and returned to an average of preoperative values during follow-up. All but two curves remained as type C lumbar modifier at follow-up. Preoperatively, three patients showed a marked coronal imbalance of more than 3 cm (all left, average 4.0 cm); at follow-up, two patients were still out of balance by more than 3 cm (all to the left, average 3.4 cm). Preoperatively, a marked shoulder imbalance of more than 1.0 cm was found in 11 patients; this was corrected in all patients to <1.0 cm at follow-up. The apical vertebral rotation measured according to Perdriolle was corrected from 23.5° to 15.0° in the thoracic spine (36.2 % correction) with an average clinical reduction of the rib hump of 63.2 %. In the lumbar spine, there was no relevant radiological derotation; however, clinically, the lumbar hump corrected spontaneously by 44.3 %. Thoracic kyphosis measured 28.5° preoperatively and 32.3° at follow-up. All six patients with a preoperative hypokyphosis (<20°) of an average of 9.5° were successfully corrected to an average thoracic kyphosis of 23.8° at follow-up. There were no cases of junctional thoracolumbar kyphosis. There were neither reoperations nor implant failures with pseudarthrosis.

Conclusion Selective anterior correction and fusion in primary thoracic curves with lumbar modifier type Lenke C resulted in a reliable and satisfactory SLCC. Advantages of anterior versus posterior techniques are the true segmental derotation with excellent rib hump correction and a superior restoration of thoracic kyphosis.

Keywords Spontaneous lumbar curve correction · Selective thoracic fusion · Adolescent idiopathic scoliosis · Anterior fusion · Anterior dual rod instrumentation

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Introduction

The goal of instrumented correction and fusion of thoracic scoliosis is a well-balanced and three-dimensionally corrected spine while minimizing the number of segments fused. Posterior pedicle screw-based correction and fusion have become the gold standard in the surgical treatment of thoracic scoliosis [1–3]. However, there exists an uncertainty as to whether in primary thoracic scoliosis with a significant secondary lumbar curve having the apical vertebra crossing the central sacral vertical line (CSVL; lumbar modifier Lenke type C), the lumbar curve can be left unfused [4]. This phenomenon is mainly based on reports in the past on lumbar decompensation after selective posterior thoracic fusion [5, 6]. Newton et al. [7] reported a rate of selective thoracic fusion even among experienced scoliosis surgeons of only 68 % in Lenke 1 type C curves.

The discussion, whether posterior or anterior approaches are better and safer in selective thoracic fusions in Lenke type C curves, remains controversial. Whereas some authors report on superior results of posterior over anterior techniques [8, 9], other studies have shown greater spontaneous curve correction after anterior procedures [10]. Patel et al. [11] again did not find any differences between anterior and posterior techniques.

The aim of the present study was to analyse the clinical and radiological results with special attention to spontaneous lumbar curve correction (SLCC) after selective anterior thoracic correction and fusion in thoracic Lenke type C curves performed in a single centre using modern full length dual rod instrumentation.

Materials and methods

Inclusion criteria for this study were patients with an idiopathic adolescent scoliosis and a primary thoracic curve with a lumbar modifier type Lenke C, who were surgically treated from anterior with a dual rod instrumentation of the thoracic curve and a minimum follow-up of 24 months. The indications for a selective thoracic fusion were thoracic curves with lumbar modifier Lenke type C and a larger thoracic than the lumbar curve, a larger rib than lumbar hump and the absence of a thoracolumbar kyphosis [12]. Twenty-eight patients fulfilled these criteria and were included into this study. Clinical and radiological follow-up was an average of 47 months (24–84 months). All patients had Lenke 1C curves except for two patients with Lenke type 2C curves (Table 1). Average age at surgery was 15 years (12–22 years). The clinical and radiometric data were collected prospectively by an independent observer. All patients were operated by one surgeon at one institution (U. L.).

Radiographic analysis included Cobb angle measurements of the primary and secondary curves and of their flexibility on bending films. All curves were classified according to Lenke's classification [4]. The apical vertebral rotation (AVR) of the thoracic and lumbar apex vertebra was measured according to Perdriolle [13]. Translation of the apical vertebra (AVT) of both the thoracic and the lumbar curves was measured as the distance of the centre of the apical vertebra from the CSVL in centimetres. Shoulder balance was measured by comparing the height difference in centimetre from the points of intersection of the clavicles with the first or second rib. Trunk decompensation was determined as the deviation of the CSVL from the spinous process of C7 in centimetres. Sagittal plane analysis included the measurement of thoracic kyphosis (T4–T12), thoracolumbar junction (T10–L2) and lumbar lordosis (L1–L5). Long cassette anterior–posterior and lateral standing radiographs were obtained preoperatively, postoperatively and at follow-up.

Rib and lumbar hump were measured clinically with the scoliometer. Perioperative parameters including operating time, intraoperative blood loss, transfusion of autologous and homologous blood, as well as intra- and postoperative complications were documented.

Surgical technique

With a double lumen tube, the patient is positioned in a left lateral position. Preoperatively, a thoracic epidural catheter was placed by the anaesthetists for postoperative pain control [14]. A single skin incision usually over the seventh rib and a double thoracotomy (usually intercostal 7/8 or 8/9 and removal of fifth rib) are performed. After complete disc resection with visualization of the posterior longitudinal ligament, the lid plates are placed on the lateral aspect of the vertebral body (HaZi System, DePuy Spine, Kerkel-Limbach, Germany). Usually every second vertebra is instrumented with the lid plates and dual screw insertion with intermediate single screw instrumentation. At the upper levels, parts of the rib heads need to be excised to enable an appropriate lid-plate placement. For screw insertion, the holes are prepared with an awl and explored with a sounder to exclude any posterior vertebral cortex violation. Routinely, a bicortical screw purchase is aimed for, however, excessive contralateral penetration must be prevented in order not to risk any impingement of the aorta [15, 16]. Proper screw length is ensured by manually palpating the contralateral screw tips with the finger. To enable an accurate screw length, the different screw lengths are available in 2.5 mm increments.

Curve correction is achieved by intersegmental compression routinely using the more posteriorly placed smooth 4 mm rod. The segmental derotation is achieved by bringing the individually displaced screw heads, and

Table 1 Patient data with frontal and transverse plane parameters of the main thoracic curve (MTC)

Patient no.	Age (years)	Curve type	Curve length	Fusion length	Preop. Cobb angle MTC	Bending Cobb angle MTC	Postop. Cobb angle MTC	Follow-up Cobb angle MTC	Preop. AVR	Follow-up AVR	Preop. rib hump	Follow-up rib hump
1	14	IC+	T6-T11	T6-T12	50	22	28	34	20	15	15	5
2	12	1CN	T5-T11	T5-T11	69	17	26	30	15	10	25	10
3	15	2CN + PT	T6-T12	T6-T12	60	25	22	23	20	15	20	8
4	14	1CN	T6-T12	T6-T12	66	38	23	29	25	10	20	10
5	16	1CN	T5-T11	T5-T11	65	40	28	24	20	15	20	5
6	14	1CN + PT	T6-T11	T6-T11	60	33	30	33	25	20	10	3
7	15	IC+	T7-L1	T7-L1	78	48	30	34	35	20	20	3
8	14	IC+	T6-T12	T6-T12	72	45	27	29	25	15	35	10
9	13	1CN	T6-T12	T6-T12	70	44	28	32	25	15	30	10
10	13	1CN	T6-T12	T6-T12	55	36	21	26	20	15	12	5
11	14	IC-	T6-T12	T6-T12	64	36	25	24	30	20	15	10
12	22	IC+	T5-T11	T5-T11	56	48	30	32	28	15	14	8
13	12	IC+	T7-T12	T7-L1	79	42	29	30	25	15	20	0
14	14	1CN	T6-T11	T6-T11	53	33	27	30	20	15	17	9
15	14	1CN	T5-T12	T5-T12	75	38	26	30	25	15	15	10
16	14	IC-	T5-T11	T5-T11	62	38	30	30	30	15	15	6
17	15	1CN	T6-T11	T6-T12	51	33	22	23	20	15	20	5
18	16	1CN	T5-T11	T5-T11	52	38	35	32	20	15	12	5
19	15	1CN	T5-T11	T5-T11	55	34	30	37	20	15	15	3
20	13	IC-	T5-T11	T5-T11	66	33	19	19	20	15	10	5
21	18	1CN	T5-T10	T5-T11	58	26	28	32	25	10	20	8
22	17	1CN	T5-T12	T6-T12	61	36	28	30	25	15	15	4
23	17	1CN	T6-T12	T6-T12	58	35	22	26	25	20	15	6
24	20	1CN	T6-T12	T6-T12	59	38	34	38	20	10	15	5
25	16	1CN	T6-T11	T6-T11	48	26	22	22	20	15	15	5
26	17	1CN	T6-T11	T6-T12	55	24	28	21	30	15	18	4
27	15	1CN	T6-T12	T6-T12	74	42	28	32	25	15	15	8
28	20	2C-	T6-T11	T6-T11	54	38	34	38	20	15	15	10
Average	15.3 ± 2.4				61.6 ± 8.7	35.2 ± 7.7	27.1 ± 4.0	29.3 ± 5.1	23.5 ± 4.4	15.0 ± 2.7	17.4 ± 5.5	6.4 ± 2.8

AVR apical vertebral rotation

Fig. 1 At time of surgery, 15-year-old girl with Lenke 1 CN scoliosis (patient number 17) and a primary thoracic curve of 51° and a lumbar curve of 40° (a, b). Anterior dual rod instrumentation T6–12 with

correction of the thoracic curve to 23° and a spontaneous lumbar curve correction to 25° resulting in a balanced spine with a normal sagittal profile (c, d)

Fig. 2 At time of surgery, 15-year-old girl with Lenke 2 CN scoliosis (patient number 3) and a primary thoracic curve of 60° and secondary lumbar curve of 40° (a, b). Anterior dual rod instrumentation T6–12

with correction of the thoracic curve to 23° and a spontaneous lumbar curve correction to 18° resulting in a balanced spine with balanced shoulders and a normal sagittal profile (c, d)

Fig. 3 Preoperative (a, b) and postoperative (c, d) clinical pictures of patient number 17 (Fig. 1) demonstrating the excellent correction of the rib hump deformity due to instrumented derotation (no costoplasty performed)

according to the vertebral rotation, into one line by inserting the posterior rod. Prior to curve correction, the endplates are prepared and the disc spaces are filled with morselized bone chips from the resected rib. Finally, the solid rod is bent according to the residual frontal curve—aimed at the thoracic kyphosis—and inserted into the lid plates. Additionally, either slight segmental compression (to increase kyphosis) or distraction (to decrease kyphosis) can be administered. Due to the low profile of the implant (8.5 mm), the parietal pleura can be completely closed with a running stitch [17].

The patients are mobilized without any external support on the first postoperative day. The chest drain was removed an average of on the fifth postoperative day. In eight patients with a residual lumbar curve $>25^\circ$, a brace treatment was initiated to control the lumbar curve until skeletal maturity. Costoplasties were not performed.

Results

Average operative time was 190 min (150–270 min) with an average intraoperative blood loss of 494 ml (250–1,400 ml).

Predonated autologous blood was retransfused in five patients; in one patient additional homologous blood transfusion was necessary. In two cases, the amount of the intraoperatively salvaged blood loss was sufficient to retransfuse an average amount of 260 ml.

Patient data and radiological frontal and transverse plane parameters of the primary thoracic curve are summarized in Table 1. The Cobb angle of the thoracic curve was reduced from 61.6° to 27.1° (56.0 % correction) with an average loss of correction of 2.2° (Figs. 1, 2). The preoperative curve flexibility on reverse bending films was 42.9 %. Thoracic AVT was corrected preoperatively from 3.1 cm (0.5–7.0 cm) to 0.5 cm (–1.0 to 2.3 cm) at follow-up. AVR was corrected from 23.5° to 15.0° in the thoracic spine (36.2 % correction) with an average reduction of the clinically measured rib hump of 63.2% (preop. 17.4° , follow-up 6.4°) (Figs. 3, 4).

Data on the secondary lumbar curve are compiled in Table 2. The preoperative lumbar Cobb angle of 47.7° (40° – 56° , correction on reverse bending films 66.2 %) corrected spontaneously to 30.1° (36 % SLCC) and remained stable during follow-up without any cases of curve deterioration. Even those lumbar curves with Cobb angles of between 50° and 60° ($n = 11$) corrected

Fig. 4 Preoperative (a, b) and 3 years follow-up (c, d) clinical pictures of patient number 14 demonstrating the excellent correction of both the rib hump and lumbar hump deformity due to instrumented thoracic and the spontaneous lumbar derotation (no costoplasty performed)

spontaneously to between 27° and 39° . There was no relevant radiological derotation; however, clinically, the lumbar hump corrected spontaneously from 7.9° preoperatively to 4.4° at follow-up (44.3 % correction). Lumbar AVT increased minimally directly postoperatively (from 2.8 to 3.2 cm) and returned to an average of preoperative values during follow-up. While in 12 patients the lumbar AVT improved or remained unchanged, 8 patients showed an increase in translation of more than 5 mm. All curves remained type C lumbar modifier, except for two patients who became type B modifier.

Data on shoulder and coronal balance are compiled in Table 3. The average preoperative shoulder imbalance amounted to 0.9 cm (0–2.3 cm) with 15 patients having an elevated right shoulder. Eleven patients had a preoperative shoulder imbalance of more than 1.0 cm. At follow-up, all patients had balanced shoulders within the range of 1.0 cm with an average shoulder imbalance of 0.3 cm (0–1.0 cm). Average trunk shift was 1.8 cm preoperatively (0–4.7 cm) and was corrected to 1.4 cm at follow-up (0–3.5 cm). Both preoperatively and at follow-up, 18 patients were shifted to the left. At follow-up, only two patients showed a marked coronal imbalance of more than 3.0 cm. There was no case

of relevant lumbar curve progression or a trunk decompensation leading to surgical revision.

Overall, thoracic kyphosis was increased from 28.5° (0° – 48°) preoperatively to 32.3° (15° – 46°) at follow-up (Table 4). In six patients with a preoperative hypokyphosis ($<20^\circ$) of an average of 9.5° (0° – 18°), thoracic kyphosis was corrected to 23.8° (15° – 34°) with normal values ($>20^\circ$) in all but one patient at follow-up. In five patients with a preoperative hyperkyphosis ($>40^\circ$) of an average of 46.0° (44° – 48°), thoracic kyphosis was corrected to 37.8° (20° – 46°). There were no cases of junctional thoracolumbar kyphosis.

Complications

There were no surgical revisions, no cases of pseudarthrosis or wound infection and neither vascular nor neurological complications. Postoperatively, three patients developed an atelectasis of the left lung requiring a bronchoscopic lavage. In one of these patients, ventilatory support was necessary for 6 days. The further course in these patients was uneventful, however, associated with a prolonged hospital stay of 16–28 days.

Table 2 Frontal and transverse plane parameters of the secondary lumbar curve (LC)

Patient no.	Preop. Cobb angle	Bending	Postop. Cobb angle	Follow-up Cobb angle	Preop. AVT	Follow-up AVT	Preop. AVR	Follow-up AVR	Preop. lumbar hump	Follow-up lumbar hump
1	43 ^a	12	40 ^a	35	2.2	3.0	15	20	5	0
2	53 ^a	14	30 ^a	27	2.2	1.5	15	10	20	10
3	40	10	22	18	2.0	3.0	10	15	5	2
4	52 ^a	14	19 ^a	29	3.3	3.3	25	25	20	15
5	49	22	33	39	3.2	4.9	30	25	10	10
6	45	17	30	32	2.6	3.2	17	25	10	8
7	56	21	32	36	2.0	2.3	20	15	8	0
8	48	17	24	27	2.2	2.9	15	15	4	2
9	50 ^a	24	29 ^a	32	2.6	3.2	18	20	15	10
10	48	12	25	38	3.0	3.5	15	15	7	0
11	53	10	35	29	2.0	2.8	10	5	0	0
12	44	13	36	37	3.4	2.9	10	15	5	3
13	55 ^a	18	35 ^a	28	2.6	3.0	30	30	7	0
14	50 ^a	14	37 ^a	28	2.8	2.7	25	20	10	9
15	56 ^a	18	25 ^a	31	2.8	3.5	20	20	7	5
16	50	24	32	39	2.8	3.3	20	20	5	5
17	40	10	20	25	2.7	2.5	15	15	10	4
18	43	20	34	37	2.6	1.9	15	10	6	0
19	40	22	26	35	3.7	3.3	25	20	7	8
20	42	16	23	15	3.0	0.5	20	5	5	0
21	44	18	35	30	3.2	3.3	15	15	7	5
22	50	21	35	27	3.0	3.1	15	20	6	2
23	48	20	25	30	2.4	2.5	13	20	5	3
24	45	18	36	30	2.7	2.8	20	20	10	8
25	46	12	30	32	4.0	2.5	20	20	5	3
26	46	2	26	20	2.8	2.5	10	5	6	3
27	52 ^a	16	38 ^a	31	3.6	3.3	17	20	10	5
28	48	15	32	36	2.2	1.9	10	10	5	3
Average	47.7 ± 4.8	16.1 ± 5.0	30.1 ± 5.8	30.5 ± 6.0	2.8 cm ± 0.5	2.8 cm ± 0.8	17.5 ± 5.7	17.0 ± 6.3	7.9 ± 4.4	4.4 ± 4.0

AVT apical vertebral translation, AVR apical vertebral rotation

^a Brace treatment for lumbar curve control until skeletal maturity

Table 3 Data on shoulder and coronal balance

Patient no.	Preop. shoulder levels	Follow-up shoulder levels	Preop. coronal balance	Follow-up coronal balance
1	0.5	0	1.5	0.5
2	1.3	1.0	1.5	0.8
3	0.5	0	0	1.3
4	1.7	1.0	4.0	3.5
5	2.0	0	3.0	3.3
6	1.5	0	1.5	1.8
7	0.5	1.0	0.5	1.8
8	2.3	0	2.8	3.0
9	1.0	0	1.0	1.5
10	2.2	0.8	2.5	2.5
11	0.3	0	1.5	1.5
12	0	0	1.0	0
13	0	0.5	1.5	3.0
14	0.5	0.8	0.5	2.3
15	2.0	0	2.7	3.0
16	0.5	0	0	0
17	0	0	2.5	0
18	1.3	0.5	2.0	0
19	1.5	0	4.7	0
20	2.0	0.5	2.7	0
21	0.5	0.5	1.4	1.5
22	0.3	0	0.2	0
23	0.5	1.0	2.7	1.3
24	1.0	0	1.0	0.5
25	0.5	0	2.0	0
26	0.3	0	3.2	2.2
27	1.5	0	2.0	2
28	0	0	0	1
Average	0.9 ± 0.7 cm	0.3 ± 0.4 cm	1.8 ± 1.2 cm	1.4 ± 1.2 cm

Discussion

The present study could demonstrate that with anterior correction and instrumentation, a reliable and safe selective fusion of primary thoracic curves with a lumbar modifier Lenke type C (apical lumbar vertebra crossing the CSVL) is possible. Prerequisites, besides a reduction of the secondary lumbar curve to $<25^\circ$ on the reverse bending films, are a larger thoracic than lumbar curve, a larger rib than lumbar hump and the absence of a thoracolumbar kyphosis.

In the present study, the lumbar Cobb angle was corrected in all patients without any cases of lumbar curve deterioration (average SLCC 36 %). There were no reoperations due to curve decompensation within an average follow-up of 4 years. Even those curves with Cobb angles of between 50° and 60° ($n = 11$) corrected spontaneously to between 27° and 39° (Table 2). While there was no radiographically measurable lumbar derotation, the

lumbar hump corrected spontaneously by 44 %. Shoulder imbalance was successfully corrected in all cases to 1.0 cm or less. Average coronal imbalance was reduced from 1.8 to 1.4 cm, however, at follow-up two patients remained markedly out of balance by more than 3.0 cm.

In the literature, on selective thoracic fusion in Lenke type C curves most studies focus on posterior instrumentation and correction techniques. The published average spontaneous correction rates of the unfused lumbar curve with posterior techniques range between 24 % [1], 34 % [18], 52 % [11] and 81 % [8]. Whereas some authors warn of an overcorrection of the thoracic curve beyond the lumbar flexibility [19], other authors propagate excessive thoracic correction resulting in SLCC even exceeding its preoperative flexibility [8].

The data on SLCC after selective anterior correction and instrumentation in thoracic curves with Lenke type C modifier are limited. Lenke et al. [10] reported a 50 %

Table 4 Sagittal plane parameters

Patient no.	Preop. thoracic kyphosis	Follow-up thoracic kyphosis	Preop. lumbar lordosis	Follow-up lumbar lordosis
1	44	38	80	75
2	20	36	47	49
3	39	36	46	48
4	22	31	38	31
5	18	20	49	50
6	39	40	50	46
7	44	45	64	49
8	46	40	44	33
9	29	33	57	50
10	34	35	52	55
11	8	20	58	60
12	48	46	58	50
13	48	20	68	61
14	27	24	48	36
15	24	25	45	40
16	7	25	40	46
17	37	42	45	54
18	28	34	53	50
19	33	41	57	58
20	8	29	72	66
21	36	44	62	66
22	20	27	38	50
23	28	30	64	42
24	28	32	58	54
25	16	34	54	58
26	40	38	54	55
27	26	25	63	45
28	0	15	38	35
Average	28.5° ± 13.2°	32.3° ± 8.4°	53.6° ± 10.6°	50.4° ± 10.3°

SLCC in seven patients, and Potter et al. [9] reported a 36 % correction in four patients. The largest series have been published by Patel et al. [11] with 51 patients treated anteriorly and a reported SLCC rate of 41 %.

Patel et al. [11] analysed the behaviour of the unfused secondary lumbar curve in 65 patients with Lenke type C curves and compared anterior ($n = 51$) with posterior ($n = 14$) approaches. After matching the curves, the authors found no differences between both groups, except for a distally by one to two segments longer fusion extension in the posterior group. Following factors influenced the amount of SLCC: the lowest instrumented vertebra, preoperative lumbar curve flexibility and thoracic curve percent correction. However, only coronal plane parameters like Cobb angle, AVT and coronal imbalance were analysed. Data on sagittal plane parameters or on rotational behaviour were not given.

Clear advantages of anterior over posterior techniques are the superior correction of the rotational deformity and

the ability to restore thoracic kyphosis. This is due to the complete disc excision which enables both a true segmental derotation and an anterior spinal column shortening (Figs. 3, 4). In correspondence with other studies, we found an average clinical reduction of the rib hump of 63 % and of the lumbar hump of 44 % [20, 21]. Thoracic kyphosis was enhanced and measured 32.3° at follow-up with sufficient correction of all preoperatively hypokyphotic curves. On the contrary, posterior techniques tend to decrease thoracic kyphosis (lordogenic effect) or at least are unable to restore kyphosis in preexisting hypokyphosis [22]. Studies comparing anterior with posterior techniques have clearly shown that anterior techniques are superior in creating and preserving thoracic kyphosis [23–25].

Major reasons why anterior thoracic instrumentation techniques enjoy limited popularity are the complications having occurred with single rod single screw techniques in the past like proximal screw pullouts of up to 20 % and rod fractures of up to 31 % with pseudarthrosis rates of up to

6 % [26–29]. Due to the dual-rod instrumentation with dual-screw fixation, the biomechanical flaws of anterior systems have been overcome [17, 30, 31]. There were no cases of pseudarthrosis or intraoperative screw pullout in the present series.

Conclusion

The present study has demonstrated that with anterior correction and instrumentation a reliable and safe selective fusion of primary thoracic curves with a lumbar modifier Lenke type C is possible. There were no lumbar curve deterioration or decompensation noted during an average follow-up of 4 years. According to the literature, there is probably no major difference concerning the correction of coronal plane parameters between anterior and posterior techniques. However, in cases of thoracic hypokyphosis or severe malrotation, anterior techniques may be preferred due their superior derotating and kyphogenic capabilities.

Conflict of interest None.

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