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The Effect of Fusion End-Levels on Sagittal Parameters and Quality of Life in Thoracic and Lumbar Adolescent Idiopathic Scoliosis Patients

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Abstract

Study design: Retrospective cohort study.

Objectives: The study aimed to evaluate the effect of fusion end levels on sagittal parameters and quality of life.

Methods: A total of 162 patients (72 Lenke-1 and 90 Lenke-5 who underwent Posterior Spinal Fusion (PSF) were included in the study. Of these, 57 patients underwent Cobb-to-Cobb (CC) fusion (18 patients in Lenke-1 and 39 in Lenke-5), and 105 patients underwent non-Cobb to Cobb (non-CC) fusion (54 patients in Lenke-1 and 51 in Lenke-5). Cervical lordosis, thoracic kyphosis, lumbar lordosis, and spinopelvic parameters were measured preoperatively, post-operative 6th months and at the final follow-up. Short Form-36 (SF-36) score, Scoliosis Research Society-22 (SRS-22) score, and radiographic measurement parameters were compared between the groups.

Results: The post-operative 6th months cervical lordosis angle in Lenke-1 patients was significantly lower in the CC group than in the non-CC group (5.9 ± 4.4 *vs.* 12.1° ± 10.9°, p=0.022), and in Lenke-5 patients, the thoracic kyphosis angle was significantly higher in the CC group than in the non-CC group at 6 months and at the final follow-up visit. (46.8 ± 8.9 *vs.* 37.4 ± 11.0, p<0.001 and 43.6 ± 9.2 *vs.* 37.9 ± 10.6, p=0.009, respectively). Our results support the idea that instrumentation is limited to the main curve when proximal levels of the curve are instrumented.

Conclusion: The choice of CC or non-CC surgery affects the parameters proximally rather than distally in both Lenke-1 and Lenke-5 patients. The effect of level selection on the parameters was mostly prominent in the early post-operative period.

Keywords: Scoliosis; Sagittal balance; Spinal fusion; Lenke; Selective; cervical lordosis; Thoracic kyphosis; Lumbar lordosis; Spinopelvic parameters

Abbreviations: PSF: Posterior Spinal Fusion; AIS: Adolescent Idiopathic Scoliosis; UEV: Upper End Vertebra; LEV: Lower End Vertebra; CC: Cobb-to-Cobb; Non-CC: Non Cobb-to-Cobb; G1: Group1/Lenke1; G2: Group2 /Lenke5; LIV: Lower Instrumented Vertebrae; UIV: Upper Instrumented Vertebrae; CL/C2-C7: Cervical Lordosis; TK/T1-T12: Thoracic Kyphosis; LL/L1-L5: Lumbar Lordosis; SS: Sacral Slope; PT: Pelvic Tilt; PI: Pelvic Incidence

Introduction

The current approach in Adolescent Idiopathic Scoliosis (AIS) surgery is to provide both coronal and sagittal balance while correcting the curvature and preserving spinal movements as much as possible [1]. This allowed the formation of the concept of selective fusion, in which only the structural curve is instrumented. The selection of the most proximal and most distal vertebrae to be instrumented in patients undergoing selective fusion is a current question [2-4]. Many recent studies have examined the relationship between Upper and Lower End Vertebra (UEV and LEV) selection and sagittal balance in lumbar and thoracic curvatures and the results of preserving the mobile segments of the spine [5-9]. However, the specific structural features of curves and the incompatibility of patients' clinical expectations with radiograph lead to significant differences between surgeons in the selection of levels [10]. In the literature, no study has evaluated the effect of fusion end levels on the sagittal parameters and quality of life of patients. The aim of this study was to evaluate the impact of fusion end levels on sagittal parameters and patients' quality of life. We hypothesized that both Cobb-to-Cobb (CC) and non-Cobb-to-Cobb (non-CC) fusion would provide similar sagittal parameters and quality of life improvement in both thoracic and lumbar curve patients.

Materials and Methods

Patients

Patients who underwent surgery at our clinic between 2006 and 2016 with a diagnosis of AIS were examined retrospectively. In order to minimize the number of variables while evaluating level selection differences, Lenke-1 (proximal thoracic) and Lenke-5 (thoracolumbar/lumbar) patients with a single structural curve were evaluated, and the effects of non-structural curves on parameters were excluded. Among the AIS patients who were screened, 208 patients with Lenke-1 (Group 1, G1) and Lenke-5 (Group 2, G2) curves, technically treated with Posterior Spinal Fusion (PSF) and Segmental Spinal Instrumentation (SSI), were found in archive records. AIS patients with at least 18-month follow-up, those with AP and lateral whole spine roentgenograms in pre-operative, post-operative 6th month, and the last follow-up visits, and those with SF-36 and SRS-22 forms in pre-operative and the last follow-up visit were included in the study. A total of 162 patients, 72 patients with Lenke-1 (G1) and 90 patients with Lenke-5 (G2) curves treated with PSF and SSI were included. Of these, 57 patients underwent CC fusion (18 patients in G1 and 39 patients in G2), and 105 patients underwent non-CC fusion (54 patients in G1 and 51 patients in G2). In our current clinical approach, we used the Lenke criteria for defining the type of curvature and deciding on selective fusion in AIS patients, and the Scoliosis Research Society (SRS) criteria for selecting Upper Instrumented Vertebrae (UIV) and Lower Instrumented Vertebrae (LIV) for patients who will undergo selective fusion [11,12]. Patients with UEV=UIV and LEV=LIV were referred to as CC, and the others as non-CC [13,14]. Patients with a history of revision surgery, MRI with signs of intraspinal pathology, and patients with non-AIS etiology were excluded from the study. Parameters were compared within the populations as CC and non-CC by time and between groups at all three time points. Lenke-1 and Lenke-5 populations were considered as a statistically whole patient population, and no parameter comparison was made between the populations Standing AP and lateral whole spine roentgenograms taken preoperatively, post-operatively at 6^{th} months and at the last follow-up visit were evaluated, and sagittal and regional measurements were made using a single monitor. The measurement results were statistically compared, and the SF-36 and SRS-22 measurements were applied preoperatively and at the last follow-up visit.

Imaging

As a standard radiological evaluation, graphs were taken with the same device (Ecoray, HF 525 Plus) with 90 × 35 cassettes. Sagittal plane radiographs were obtained while the patient was standing, with the shoulders flexed forward and the elbows fully flexed. Measurements were performed using a single monitor with INFINITT PACS (INFINITT Healthcare Co.) software. In the sagittal plane and balance assessment, Cervical Lordosis (CL) (C2-C7), Thoracic Kyphosis (TK) (T1-T12), T2-T5 kyphosis, T5-T12 kyphosis, T10-L2 kyphosis, Lumbar Lordosis (LL) (L1-L5), spinopelvic parameters (Sacral Slope (SS), Pelvic Tilt (PT), and Pelvic Incidence (PI)) levels were measured using the Cobb angle method. Data on age, sex, operation surgery time, instrumentation levels, and post-operative follow-up period of the patients included in the study were recorded.

Surgical technique

All cases included in the study received PSF. Transpedicular screws were used for fixation of the spine, and they were connected to each other with titanium rods. In the fusion level determination, fusion level selection rules were applied according to the SRS criteria mentioned in the above sections. Compression was applied to the convex side of the curve, and distraction was applied on the concave side. Scoliotic curve correction maneuvers were performed by applying derotation forces to the apical region. The technique of “freehand” technique was used during screwing. Before installing the rods, a suitable slope was provided for physiological kyphosis and lordosis in the sagittal plane. The neuromonitoring system has been used since 2009. The patients were mobilized on the 1^{st} day after surgery.

Statistical analysis

Mean, standard deviation, median lowest, highest, frequency, and ratio values were used in the descriptive statistics of the data. The distribution of variables was measured using the Kolmogorov–Smirnov test. The Mann–Whitney U test was used to analyze quantitative independent data. The Wilcoxon test was used to analyze dependent quantitative data. The *chi-square* test was used for the analysis of qualitative independent data. The SPSS 22.0 program was used in the analyses. Statistical significance was set at P<0.05.

Results

There was a significant difference between the CC and non-CC group in the operation time and the number of the instrumented levels (195.5 ± 65.9 *vs.* 261.4 ± 73.5 and 8.2 ± 1.8 *vs.* 12.1±1.4, respectively, p<0.001) but not in the mean age of the patients and the follow-up period (Table 1). In Lenke-1 patients, there were significant differences between the CC and non-CC groups regarding post-operative 6^{th} month CL (5.9 ± 4.4 *vs.* 12.1 ± 10.9, p=0.022) and T2-T5 kyphosis (10.7 ± 3.8 *vs.* 14.2 ± 5.9°, p=0.023) angles. There were significant pre to post-operative changes in the T5-T12 angle in the non-CC group (23.7 ± 11.6 *vs.* 18.1 ± 8.5°, p<0.001), T10-L2 angle in the CC group (9.6 ± 6.6 *vs.* 5.5 ± 4.7°, p=0.003), and LL in the non-CC group (50.7 ± 9.7 *vs.* 53.6 ± 11.1°, p=0.032) (Table 2). In Lenke-5 patients, there were significant differences between CC and non-CC groups regarding post-operative 6^{th} month and the final follow-up TK angle (46.8 ± 8.9 *vs.* 37.4 ± 11.0, p<0.001 and 43.6 ± 9.2 *vs.* 37.9 ± 10.6, p=0.009, respectively), preoperative and the final follow-up T2-T5 angle (17.8 ± 10.6 *vs.* 12.3 ± 7.4, p=0.005 and 10.3 ± 5.6 *vs.* 14.8 ± 6.7, p=0.001, respectively), post-operative 6^{th} month and the final follow-up T5-T12 angle (37.4 ± 9.4 *vs.* 25.2 ± 8.5, p<0.001 and 34.4 ± 11.4 *vs.* 24.7 ± 7.6, p<0.001, respectively), preoperative T10-L2 angle (8.3 ± 5.6 *vs.* 13.2 ±12.8, p=0.028), and preoperative and the final follow-up PT angle (9.6 ± 4.9 *vs.* 12.8 ± 6.9, p=0.015, and 8.4 ± 5.1 *vs.* 11.3 ± 7.3, p=0.040, respectively). In addition, there were significant pre to post-operative changes in TK, LL, and SS angles in both the CC and non-CC groups (Table 3). Comparison of SF36 and SRS22 scores between the CC and non-CC groups in the preoperative and post-operative periods did not show a significant difference (p=510, p=0.555, p=0.773, p=0.981, respectively) (Table 4).

	Total (N=162)		CC (N=57)		Non-CC (N=105)		p
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	
Age (Years)	15.6 ± 2.7	11-23	15.6 ± 2.4	11.3-23	15.4 ± 2.4	11-21.7	0.943
Follow-up (Months)	41.1 ± 25.9	4-138	43.6 ± 29.3	5-138	41.1 ± 23.5	4-85	0.099
Operation time (Min)	238.2 ± 77.5	90-480	195.5 ± 65.9	110-450	261.4 ± 73.5	90-480	<0.001

Number of instrumented levels	10.7 ± 2.4	5-15	8.2 ± 1.8	5-13	12.1 ± 1.4	6-15	<0.001

Table 1: Comparison between age/follow-up period/operation period/instrumentation quantities among groups.

		CC (N=18)		Non-CC (N=54)		p
		Mean ± SD	**Range**	**Mean ± SD**	**Range**	
Cervical lordosis (C2-C7)	Pre-op	8.14 ± 8.2	0.47-26.7	9.86 ± 9	0.1-40.2	0.474
	Post-op 6th month	5.9 ± 4.5	0.2-15.2	12.2 ± 10.9	0.04-49.7	0.022
	Post-op last	7.6 ± 7.4	0.3-23.3	12 ± 9.6	0.47-40.3	0.077
	p	0.586		0.233		
Thoracic kyphosis (T1-T12)	Pre-op	33.7 ± 11	6.05-48.9	38.7 ± 11.2	18.6-66.5	0.109
	Post-op 6th month	33.3 ± 8.9	12.6-53.2	36.4 ± 11.3	6.51-62.35	0.287
	Post-op last	35.3 ± 10	11.4-51.9	36.2 ± 9.9	15.6-65.6	0.748
	p_{time}	0.614		0.201		
T2-T5	Pre-op	11.4 ± 6.4	4.7-27.8	12.5 ± 6.57	0.7-28.4	0.536
	Post-op 6th month	10.8 ± 3.9	4.7-19.4	14.3 ± 5.9	2.2-30.1	0.023
	Post-op last	11.1 ± 4.4	2.8-18.7	13.7 ± 6.4	3.2-44	0.112
	p_{time}	0.874		0.24		
T5-T12	Pre-op	19.2 ± 10.5	1.1-37	23.7 ± 11.6	1.4-52.3	0.15
	Post-op 6th month	20 ± 8.3	0.8-32.7	18.9 ± 7.5	4.6-42.9	0.62
	Post-op last	20.2 ± 6.7	8.9-34.9	18.1 ± 8.6	3.6-45.4	0.34
	p_{time}	0.805		<0.001		
T10-L2	Pre-op	9.6 ± 6.7	1.5-23.7	7.1 ± 5.4	0.08-26.76	0.11
	Post-op 6th month	5.8 ± 5	0.07-18.4	6.89 ± 6.22	0.27-21.98	0.513
	Post-op last	5.6 ± 4.8	0.4-17.6	8.6 ± 6.6	0.7-33	0.079
	p_{time}	0.003		0.186		
LL (L1-S1)	Pre-op	50.2 ± 8.6	36.5-62.3	54 ± 10.4	26.36-70.78	0.169
	Post-op 6th month	50.3 ± 1	32.1-72.3	53.6 ± 11.1	29.35-81.2	0.886
	Post-op last	51.1 ± 10.3	31.3-71.4	50.7 ± 9.7	28.7-79.2	0.413
	p_{time}	0.873		0.032		
Pelvic tilt	Pre-op	7.3 ± 3.9	2.4-13.5	7.4 ± 5.7	0.1-27	0.928
	Post-op 6th month	7.7 ± 4.5	2.2-16.9	7.1 ± 5.4	0.6-23.7	0.664
	Post-op last	6.6 ± 5.1	0.1-14	7.3 ± 5.5	0.01-24.3	0.615
	p_{time}	0.458		0.839		
Sacral slope	Pre-op	37.6 ± 9.1	23.4-54.6	37 ± 9.5	15.2-56.3	0.813

	Post-op 6th month	38.1 ± 10.1	24.4-61.1	37.2 ± 8.3	18.6-55.9	0.708
	Post-op last	35.1 ± 7	22.9-47.8	38.1 ± 10.4	9.3-61.5	0.26
	p_{time}	0.251		0.53		
Pelvic incidence	Pre-op	44.3 ± 10.6	26.6-60.9	44.5 ± 11.7	17-70.4	0.95
	Post-op 6th month	45.8 ± 11.6	26.7-69.1	44.3 ± 10.4	20.5-67.7	0.604
	Post-op last	41.7 ± 10.3	26.2-60.5	53.7 ± 64.9	21.5-51.5	0.441
	p_{time}	0.084		0.292		
Sag. Balance (mm)	Pre-op	-7.2 ± 33.8	-143.1	-10 ± 28.1	-133	0.728
	Post-op 6th month	8.2 ± 36.4	-141.5	-1.1 ± 38.3	-254.5	0.37
	Post-op last	-3.8 ± 31.1	-112.1	-5.6 ± 33.3	-148.5	0.835
	p_{time}	0.096		0.179		

Table 2: Lenke 1 patient's sagittal plane measurements.

		CC (N=39)		Non-CC (N=51)		p
		Mean ± SD	**Range**	**Mean ± SD**	**Range**	
Cervical lordosis (C2-C7)	Pre-op	-14 ± 12	-56.2	-12.1 ± 13.6	-67.2	0.529
	Post-op 6th month	-14.2 ± 12	-61.2	-11.2 ± 12.3	-60	0.243
	Post-op last	-15.1 ± 8.8	-41.8	-12.1 ± 10.8	-63.4	0.16
	p_{time}	0.869		0.837		
Thoracic kyphosis (T1-T12)	Pre-op	37.9 ± 13.8	-76	33.3 ± 12.5	5.4-63.4	0.098
	Post-op 6th month	46.8 ± 8.9	22-63.3	37.4 ± 11	0-61.2	<0.001
	Post-op last	43.6 ± 9.2	23.1-72.3	37.9 ± 10.6	18.7-68.8	0.009
	p_{time}	<0.001		0.019		
T2-T5	Pre-op	17.8 ± 10.6	2.3-42.4	12.3 ± 7.4	1.5-33.6	0.005
	Post-op 6th month	14.3±7.5	0-30.1	14.7 ± 6.3	2.1-37.6	0.763
	Post-op last	10.3 ± 5.7	1.36-23.1	14.8 ± 6.8	2.9-30.2	0.001
	p_{time}	0.001		0.076		
T5-T12	Pre-op	27.2 ± 11.5	7.5-59.2	23.3 ± 11.1	1.2-51.8	0.11
	Post-op 6th month	37.4 ± 9.5	16.2-58.3	25.2 ± 8.5	2.7-48.5	<0.001
	Post-op last	34.5 ± 11.5	4.4-55.1	24.7 ± 7.7	8.3-45.3	<0.001
	p_{time}	<0.001		0.351		
T10-L2	Pre-op	8.3 ± 5.6	0.8-25.3	13.3 ± 12.8	1.5-54.3	0.028
	Post-op 6th month	7.4 ± 5.8	0.2-24.9	8.3 ± 6.45	0.3-26.6	0.537
	Post-op last	8.2 ± 6.1	0.5-25.4	22.8 ± 95.7	0.2-69.1	0.346
	p_{time}	0.62		0.359		
LL (L1-S1)	Pre-op	-55.7 ± 13.3	-51.3	-55.8 ± 11.8	-55	0.95

	Post-op 6th month	-42.8 ± 19	-118.9	-43.0 ± 9.7	-42	0.942
	Post-op last	-46.9 ± 12.3	-53.3	-45.3 ± 17.3	-110.1	0.623
	p_{time}	<0.001		<0.001		
Pelvic tilt	Pre-op	9.6 ± 4.9	1.6-19.4	12.8 ± 7	1.7-29.9	0.015
	Post-op 6th month	11.3 ± 8.6	0.2-40.4	12.6 ± 8.1	1.1-39.7	0.451
	Post-op last	8.4 ± 5.1	1.4-23.9	11.3 ± 7.3	0.4-33.6	0.04
	p_{time}	0.068		0.27		
Sacral slope	Pre-op	39.6 ± 9.5	20.1-57.5	40.11 ± 9.8	20.8-67.6	0.833
	Post-op 6th month	34.7 ± 11.2	14-55.8	37.6 ± 10.2	15.1-60.3	0.206
	Post-op last	39.6 ± 9.7	16.3-59.4	40.6 ± 10.8	20-67.7	0.64
	P_{time}	0.008		0.048		
Pelvic incidence	Pre-op	49.2 ± 11.4	28.8-74.6	52.9 ± 11.4	28.7-82.3	0.13
	Post-op 6th month	46 ± 10.9	26.7-72.7	50.2 ± 13.7	25.9-86.3	0.118
	Post-op last	48 ± 10.8	22.9-68.2	51.9 ± 12.4	24.4-89.6	0.122
	p_{time}	0.181		0.121		
Sag. Balance (mm)	Pre-op	-10.5 ± 35.2	-130.1	-6.5 ± 31.2	-147.8	0.564
	Post-op 6th month	-11 ± 28.2	-115.5	-6.9 ± 25.9	-143.4	0.485
	Post-op last	2.2 ± 22	-99.9	0.3 ± 22.9	-131.1	0.695
	p_{time}	0.034		0.171		

Table 3: Lenke 5 patient's sagittal plane measurements.

SF-36			**SRS22-R**		
	Pre-op	**Post-op**		**Pre-op**	**Post-op**
	Mean ± SD p	**Mean ± SD** p		**Mean ± SD** p	**Mean ± SD** p
Physical function	76.02 ± 18 p=0.616	76.54 ± 16.4 p=0.396	Function	15.5 ± 0.1 p=0.552	16.2 ± 0.1 p=0.578
P. Role limitation	60.03 ± 36.7 p=0.378	66.82 ± 34.3 p=0.399	Pain	18.5 ± 0.3 p=0.973	18.9 ± 0.2 p=0.762
Emotional role lim.	54.75 ± 36.6 p=0.325	69.35 ± 35.5 p=0.282	Self-image	13.6 ± 0.3 p=0.610	19.5 ± 0.2 p=0.906
Energy	54.29 ± 20.9 p=0.753	64.17 ± 19.4 p=0.840	Mental health	15.3 ± 0.1 p=0.573	15.8 ± 01 p=0.913
Mental health	63.80 ± 16.3 p=0.488	69.43 ± 18.2 p=0.895	Satisfaction with management	6.7 ± 0.1 p=0.628	8.6 ± 0.1 p=0.811
Social functioning	67.69 ± 24.3 p=0.897	74.22 ± 25.2 p=0.826	Subtotal	62.9±0.6 p=0.799	70.2±0.4 p=0.929
Pain	60.27 ± 24.9 p=0.662	72.38 ± 23.7 p=0.784	Total	69.5 ± 0.6 p=0.743	79.1 ± 0.5 p=0.989

General health	55.09 ± 14.7 p=0.967	69.65 ± 14.4 p=0.784	Ave. function	3.1 ± 0.1 p=0.552	3.2 ± 01 p=0.578
Health transition	49.85 ± 28.2 p=0.510	76.54 ± 22.1 p=0.555	Ave. pain	3.7 ± 0.5 p=0.973	3.8 ± 0.1 p=0.762
			Ave. self-image	2.7 ± 0.1 p=0.650	3.9 ± 0.1 p=0.906
			Ave. mental health	3 ± 01 p=0.573	3.1 ± 0.1 p=0.903
			Ave. satisfaction w. m.	3.4 ± 0.1 p=0.628	4.3 ± 0.1 p=0.811
			Ave. subtotal	3.1 ± 0.1 p=0.799	3.5 ± 0.1 p=0.925
			Ave. total	3.2 ± 0.1 p=0.773	3.5 ± 0.1 p=0.981

Table 4: Comparison of SF-36 and SRS-22 scores between CC and non-CC groups in pre-op and post-op period.

Discussion

The most important finding of this study was that the choice of CC or non-CC surgery affects the parameters proximal rather than distal to the instrumentation, and the effect of the level selection on the parameters is mostly limited to the early post-operative period, and the long-term results are similar.

In our study, the CL level showed a statistically significant difference only in terms of the post-operative 6^{th} month measurement averages in the G1 population when CC and non-CC were compared (p=0.022). In a study by Dumpa (4) no significant difference was found between the preoperative and post-operative periods in thoracic curves, in the level of CL after selective and non-selective surgeries. These results are consistent with those of the present study. Moreover, Charles and Norheim considered in their study that LL may affect CL [15,16]. This result may be significant in terms of the reflection of the differences in LL parameters of the CC and non-CC groups on the CL level in populations with thoracic and lumbar curves. In our study, there was no significant difference between groups in terms of CL when evaluating the CC and non-CC groups in both populations. The relationship between CL level and LL and spinopelvic parameters is worth investigating. When the TK level was compared in terms of the 6^{th} post-operative month and after the last follow-up measurements in the G2 population, TK level was found to be significantly higher (p<0.05) in the CC group. In the CC group, the post-operative 6^{th} and post-operative final check levels were also significantly higher than those in the pre-operative period (p<0.05). In their study comparing selective and non-selective surgery, Carreon found that the TK level was higher in the group that underwent selective surgery in both the pre-operative and post-operative periods [17]. Our findings are consistent with the literature. In our study, while there was no difference between the groups in patients who underwent thoracic isolated fusion, the high level of CC fusion in patients who underwent lumbar isolated fusion suggested that we iatrogenically decrease the TK level of the proximal level in lumbar curves. When T2-T5 and T5-T12 levels were examined together, these levels were found to be significantly higher in the CC group both in the preoperative period and in the final check when the G2 population was examined (p<0.05). Charles suggested that LL could affect the level of TK. Wang reported that thoracolumbar fusion provides spontaneous improvement in thoracic sagittal parameters [18]. When the results were evaluated, the statistical difference between thoracic fusion and lumbar fusion was evaluated as the effect of lumbar fusion on thoracic parameters *via* the lumbar curve by affecting the level reached at the proximal. Our results support Lenke 's views on the level reached at the proximal in lumbar fusion and Suk's views regarding descending to distal stroke in thoracic fusion. When we evaluated LL levels in both populations, there was no difference between the CC and non-CC groups [19]. When the Lenke 1 population was evaluated, the variation in time was significant in the non-CC group. Accordingly, this variation was between the preop-postop times of 6^{th} months (p=0.019) (Table 3). In the Lenke 5 population (G2), the variation in the LL variable in the CC group was statistically significant (p<0.001). Accordingly, this variation was between the periods of preop-postop of 6^{th} months (p=0.001). The variation in LL by time was statistically significant in the non-CC group (p<0.001). Accordingly, this variation was between the preop-postop 6^{th} months (p=0.001) (Table 4). In their studies, Park did not observe any difference between CC fusion and LEV+1 (non-CC) fusion in terms of sagittal parameters. The difference between the findings may be due to the fact that Sun did not consider the proximal fusion level differences in their study, and they only applied LEV+1 fusion for curves above 60°. Although these findings suggest that the selection of CC fusion may be appropriate in the lumbar fusion group, the level selection needs to be evaluated in detail. When examining the sagittal spinopelvic parameters, no significant difference between the CC and non-CC groups in either population (p>0.05) was noted. In their study, Zachary obtained similar results in patients with Lenke 1 and 2 [20]. Pasha argued that the sagittal spinopelvic parameters in patients with Lenke 1 did not change [21]. In a study by Ilharreboerde that compared hyperselective and selective patients, they showed that the sagittal spinopelvic parameters were not affected. The results of our study are consistent with those in the literature. In our study, both populations were evaluated with the SRS-22 and SF-36 scoring systems in preoperative and post-operative final checks. Groups showed significant score increases within themselves in the 6th post-operative month and post-operative final checks compared to the preoperative period, but there was no significant difference when the groups were compared. In a study by Lark, when comparing the selective TL/L fusion group with the non-selective fusion group, they reported that there was no significant difference in both groups when they compared the selective fusion group with the non-selective fusion group before surgery in terms of the SRS-22 score [22]. In our study, there was no significant difference between the groups, which supports the literature. No major complications were observed in the patients included in the study. Since re-operated patients and patients with revision were not included in the study, this may be considered among the reasons for not having complications in our patients.

Our study had a few limitations. Our study was retrospective, conducted in a single center, and was not evaluated separately for fusion end levels. The fact that the patients were operated in a 10-year interval and were operated by more than one surgeon made the optimization of the level selection difficult. In our study, the patients consisted of two different large populations and the level selection criteria of each population were different, which is limiting in terms of standardization of level selection. Although the number of patients is higher than that reported in the literature, we think that more patients are needed to reflect the general population.

Conclusion

The most important finding of our study is that the choice of cobb-to-cobb or non cobb-to-cobb surgery affects the parameters proximal rather than distal to the instrumentation, and the effect of the level selection on the parameters is mostly limited to the early post-operative period, and the long-term results are similar. We believe that it is in the best interest of the patient to limit the instrumentation to the main curve as much as possible and to protect the mobile segments.

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Declaration of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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