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MAIN CURVE CORRECTION AND SPONTANEOUS THORACIC CURVE CORRECTION AFTER SELECTIVE THORACLUMBAR/LUMBAR FUSION IN LENKE TYPE 5C ADOLESCENT IDIOPATHIC SCOLIOSIS: UP TO 10 YEARS FOLLOW-UP

Özcan Kaya[1], Tunay Şanlı[2], Hüseyin Sina Coşkun[3], Onur Levent Ulusoy[4], Recep Dinçer[5], Selhan Karadereler[2], Meriç Enercan[2], Azmi Hamzaoğlu[2]

[1]*University of Health Sciences Turkey, İstanbul Kanuni Sultan Süleyman Training and Research Hospital, Clinic of Orthopaedics and Traumatology, İstanbul, Turkey*
[2]*İstanbul Bilim University Spine Center, Florence Nightingale Hospital, Clinic of Orthopedics and Traumatology, İstanbul, Turkey*
[3]*Samsun 19 Mayıs University Faculty of Medicine, Department of Orthopaedics and Traumatology, Samsun, Turkey*
[4]*İstanbul Bilim University Spine Center, Florence Nightingale Hospital, Clinic of Radiology, İstanbul, Turkey*
[5]*Süleyman Demirel University Faculty of Medicine, Department of Orthopaedics and Traumatology, Isparta, Turkey*

ABSTRACT

Objective: Thoracolumbar/lumbar (TL/L) curves are a rare type of adolescent idiopathic scoliosis (AIS). Historically anterior selective fusion and posterior selective fusion provided satisfied results in terms of curve correction, maintenance of correction and spontaneous thoracic curve correction. Aim of our study was to present the results of selective posterior Cobb to Cobb TL/L fusion in patients lenke type 5c AIS patients with a single surgeon experience for up to 10 years of follow.

Materials and Methods: Patients who underwent selective TL/L posterior fusion for a diagnose of Lenke type 5c AIS were retrospectively analyzed. Patients who were followed up minimum 2 years and underwent full preoperative, early postoperative and follow-up radiologic work up and last follow-up SRS22r scores were included in descriptive statistical analysis performed.

Results: Fifty one patients (47 F, 4M) were included in the study. Mean age was 15 (12-17). Mean follow-up period was 84 months (24-120). The mean preoperative major TL/L curve improved to 6.3 (0-20) from 42.8 (38-71) with an 85% correction rate. The mean thoracic curve correction rate was %57. At follow main TL/L and upper thoracic curve did not show correction loss. Coronal imbalance has not been recorded. At last follow-up mean SRS22r was mean 4.3 (3.6-4.9).

Conclusion: Selective TL/L posterior Cobb to Cobb fusion improves main TL/L and upper thoracic curves in AIS lenke type 5c patients and maintains long-term stability for the uninstrumented upper thoracic curve.

Keywords: Adolescent idiopathic scoliosis, thoracolumbar curve, lenke type 5c curve, posterior instrumented fusion, selective thoracolumbar Cobb to Cobb fusion, spontaneous thoracic curve correction

INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is a structural spinal deformity consisting of lateral curvature in the coronal plane, rotation of the spine in the axial plane, and abnormal alignment in the sagittal plane[1]. The main goal in the treatment of scoliosis is to obtain a well balanced and mobile vertebral column with correction of the existing curvature. Anterior, posterior, combined anterior and posterior approaches and interventions are used for these purposes[1-5]. Lenke 5 curves subtypes are rarely seen subtype of AIS curve patterns and consist of structural thoracolumbar/lumbar (TL/L) and minor nonstructural thoracic curve components[1]. For lumbar modifier C, the central sacral vertical line (CSVL) falls completely medial to the concave lateral aspect of the TL/L apical vertebral body or bodies (if the apex is a disc). In the surgical treatment of Lenke type 5c curves, the selective fusion surgery via thoracoabdominal approach has been used very frequently, but nowadays, posterior approach and fusion techniques have become the standard approach. Posterior pedicle screw systems have came to the fore even more due to their superiority in sagittal plane control compared to anterior surgery[4-7].

Address for Correspondence: Özcan Kaya, University of Health Sciences Turkey, İstanbul Kanuni Sultan Süleyman Training and Research Hospital, Clinic of Orthopaedics and Traumatology, İstanbul, Turkey
Phone: +90 541 307 80 08 **E-mail:** ozcankaya.md@gmail.com **Received:** 01.06.2022 **Accepted:** 10.06.2022
ORCID ID: orcid.org/0000-0002-4547-3042

Selective fusion surgery, in which fewer spinal segments are fused, has been described in order to obtain a balanced and mobile spine[1,2,4]. It is aimed to preserve more mobile segments in cases with selective posterior fusion. In Lenke type 5 curves main TL/L curves included to the fusion site and by choosing lower end vertebra (LEV) as lower instrumented vertebra (LIV) more mobile lumbar segments preserved. It has been reported that non-structural thoracic curvature that is not included in the fusion has the potential for spontaneous improvement, does not progress over time, and has no correction loss[8,9]. Coronal imbalance (CIB) may develop in cases with selective thoracolumbar fusion in Lenke type 5 structural TL/L curves. Although upper instrumented vertebra (UIV) translation and preop LIV tilt were stated as a high risk factor for the development of CIB, it was observed that this CIB improved over time after selective fusion. Wang et al.[8] stated that LIV selection significantly correlates with 2-year correction maintenance and balance. A translation of 28 mm and a tilt of 25° may be used as a general criterion for selecting LIV[10-15]. In this study, we aimed to evaluate the clinical and radiological results of Lenke type 5 patients who were operated with the posterior Cobb to Cobb method in a single center by a single surgeon, and to evaluate the amount of spontaneous improvement and preservation of the thoracic curvature that did not included in the fusion.

MATERIALS AND METHODS

After obtaining ethics committee approval (İstanbul Bilim University Ethics Commitee date no: 21/01/2016, approval no: 44140529-2016/06) for this pediatric deformity study, all AIS cases operated by a single surgeon in the same center were retrospectively reviewed by 2 authors. Inclusion criterias for study defined as; 1-Patients with a Lenke type 5 curve AIS 2-At least 24 months follow-up with full preoperative and postoperative radiologic work up 3-Patients underwent selective TL/L posterior spinal fusion (Cobb to Cobb). Patients with a history of previous surgery, anterior surgery, and a follow-up of less than two years were excluded from the study. For Lenke type 5 curves, it was accepted to choose upper end vertebra (UEV) as UIV and LEV as LIV in posterior fusion with selective TL/L Cobb to Cobb method[2,4,16]. Before starting the operation, the amount of correction of the curvature and the relationship of the LEV and pelvis with the horizontal plane were evaluated with traction X-ray under general anesthesia (TRUGA). For protection more mobile segment in the lumbar spine, LIV determined according to neutral rotation of most proximal vertebra with TRUGA. Cobb to Cobb instrumentation was performed between the UEV and LEV using pedicle screws and posterior instrumentation with 5.5 titanium rods. After the correction, the correction was confirmed by intraoperative X-ray. Fusion was achieved using an allograft after facet decortication.

Radiologic Evaluation

Preoperative radiographs were taken on long cassettes and the final follow-up radiographs were taken in the same center using EOS. Spine deformity group guidelines were used for the measurement of radiological parameters[17]. The radiological parameters evaluated were TL/L curve Cobb angle, coronal balance (C7-CSVL), thoracic kyphosis Cobb angle, lumbar lordosis angle, thoracolumbar transition kyphosis angle (T10-L2), sagittal balance. In addition to these measurements, LIV tilt angle, Disc wedging below LIV (Dw LIV) values were recorded. LIV tilt was defined as as the inclination in degrees of the inferior endplate to the horizontal line; disc angulation (disc wedging below LIV) was defined as angle between inferior end plate of LIV and superior end plate of the caudal vertebra of LIV.
The presence of stable sagittal and coronal balance along the instrumented segments, the absence of clinical and radiological findings without non-union or implant failure were evaluated as fusion.

Clinic Outcome

The Scoliosis Research Society-22r (SRS-22r) questionnaire was applied for the clinical outcomes[18].

Statistical Analysis

Statistical analyses were conducted by SPSS 25.0 (SPSS Inc., Chicago IL, USA). Normality exploration and descriptive statistic tests performed. Pretest post test analysis was performed for comparing preoperative and postoperative spine parameters.

RESULTS

Patient Demographics

This study was conducted with a total of 51 patients (47F, 4M) who met the inclusion criteria. The mean age was 15 (12-17) years and the mean follow-up was 84 months (24-120). It was observed that the UIV was T9 in the most proximal and T12 in the most distal. LIV was L2 in 2 patients; L3 in 40 patients and L4 in 9 patients.

Coronal Plane Parameter Analysis

TL/L structural curve Cobb angle was mean 42.8° (38°-71°) preoperatively, and 6.3° (0°-20°) at the last follow-up, with an 85% improvement rate. The mean upper thoracic curve (UTC) Cobb angle was 20.2° (6°-36°) preoperatively, and 7.8° (0°-20°) at the last follow-up, and the spontaneous recovery rate was 57% (Figure 1). Normality tests were applied and preoperative and postoperative comparison of spine parameters were performed with paired t-test. There were statistically significant diffrence between preoperative and postoperative main TL/L and non-structural thoracic curve Cobb angles (p=0.001). There was no statistical difference between postoperative and last follow-up TL/L curve Cobb angle (p>0.05). Dw angle below LIV was >5° in 21 patients (41%). Preoperative LIV tilt angle was mean 24.9° (13°-40°) and at last follow-up LIV tilt angle improved to a mean

3.5° (0°-9°) with a 86% correction rate. At the last follow-up coronal decompansation was not observed (Table 1).

Sagittal Plane Parameter Analysis

Mean thoracic kyphosis was 37.3° (12°-56°) preoperatively and 45.3° (24°-58°) at the last follow-up. Preoperative mean lumbar lordosis was 55.6° (32°- 84°), and 61.1° (40°-74°) at the end of follow-up. Preoperative thoracolumbar transition kyphosis (T10-L2) was >5° in 18 patients with a mean 13.4° (5°-33°), and it was measured mean 2.7° (-2°-11°) at the end of the follow-up. Mean preoperative sagittal sacral vertical line was -19.14 mm (-76 -45), it was measured as -6.5 mm (-34 -25) at the end of the follow-up.

Table 1. Patients demographic data, scoliosis research society-22r (SRS22r) outcome scores of the patients

	Patients
N	51
Age	14 (12-16)
Gender	47F, 4M
Follow-up (year)	7.5 (2-10)
SRS-22r scores at F/up [mean (range)]	
Pain	4.3 (2.4-5)
Self-image	4.1 (3-5)
Function	4.6 (3.6-5)
Mental health	3.9 (2.4-4.8)
Satisfaction	4.62 (3-5)
Sub-total	4.3 (3.6-4.9)

Clinical Outcome

SRS-22r evaluation improved from mean 3.7 (3.2-4.1) to 4.3 (3.6-4.9). One patient underwent a screw revision surgery because of loosening which was evaluated pseudoarhrosis. In the uninstrumented upper thoracic curve, curve progression did not detected. None of the patients underwent additional surgeries for superficial or deep infection and wound complications (Table 2).

DISCUSSION

Surgical goal of AIS aims to provide a well-balanced spine with more mobile segments. For this purpose Cobb to Cobb fusion became standart approach in selective conditions. Here we present long term results of Lenke type 5 AIS curves who underwent posterior Cobb to Cobb selective TL/L fusion. Our results with high satisfaction of patients were compatible with literature knowledge. Selective TL/L posterior Cobb to

Table 2. Radiologic spine parameters at preoperative and last follow-up

	Preoperative	Follow-up
Upper thoracic curve	20.2° (6-36°)	7.8° (0-20°)
Main TL/L curve	42.8° (38-71°)	6.3° (0-20°)
LIV tilt	24.9° (13-40°)	3.5° (0-9°)
Thoracic kyphosis	37.3° (12-56°)	45.3° (24-58°)
Lumbar lordosis	55.6° (32-84°)	61.1° (40-74°)
Thoracolumbar junction kyphois (T10-L2)	13.4° (5-33°)	2.7° (-2-11°)

TL/L: Thoracolumbar/lumbar, LIV: Lower instrumented vertebra

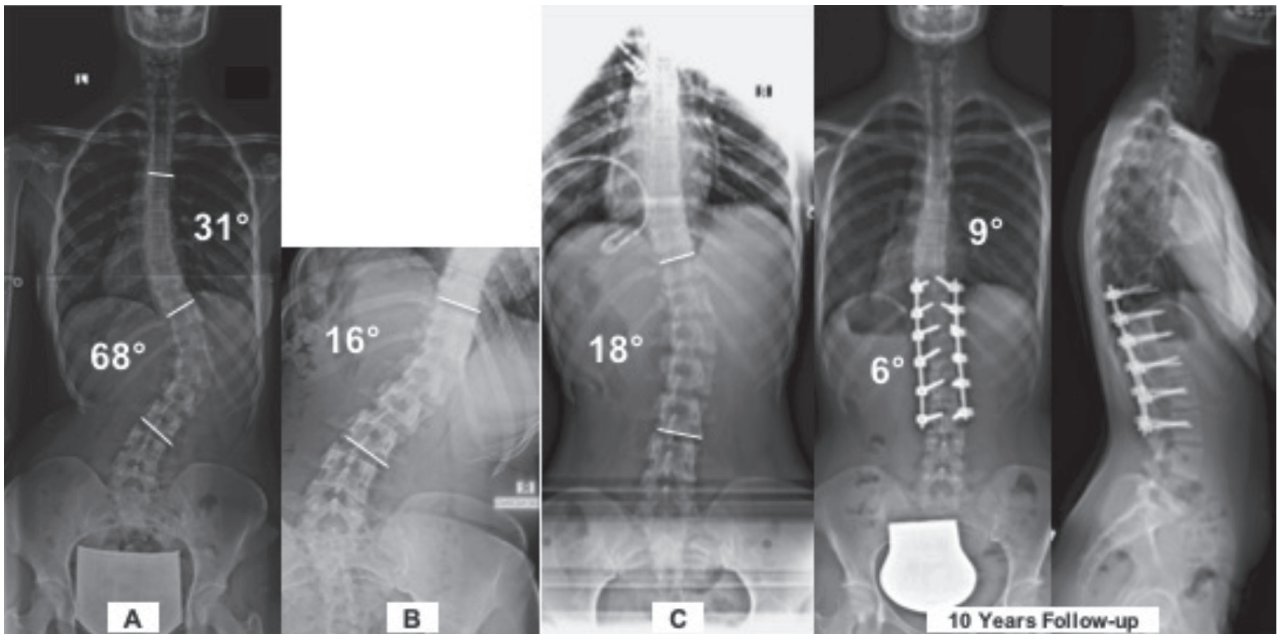

Figure 1. A patient with a 10 years follow-up. The patient was 16 at the age of surgery. A: Standing full spine anteroposterior X-ray; B: Preoperative supine bending X-ray; C: Traction anteroposterior X-ray under general anesthesia and last follow-up anteroposterior and lateral standing spine X-rays

Cobb fusion resulted well TL/L correction and spontaneous correction of uninstrumented upper thoracic curve early and last follow-up[5,19]. Up to date, many authors have published the results of fusion surgery with the anterior approach for the treatment of Lenke type 5 curvatures and have shown its effectiveness in providing coronal balance. Advantages such as requiring shorter level of fusion and excluding paralumbar muscle problems that occur with posterior approach have been reported as superiority of anterior surgery to posterior surgery[20,21]. Problems such as the development of kyphosis and high rates of non-union, respiratory problems after thoracoabdominal approaches, vascular injury and scarring that are more difficult to tolerate cosmetically have created the disadvantages of anterior approach[6,7]. Shufflebarger et al.[4] firstly reported the satisfactory clinical and radiologic results of of TL/L curve treatment with posterior approach using pedicle screw systems. In the comparison of anterior and posterior approaches, it was concluded that there are advantages such as more correction rate of the coronal curvature (84%) and less correction loss afterwards (2.4% at the end of 2 years of follow-up) and shorter hospital stay in patients who underwent posterior spinal fusion (PSF) using a pedicle screw. In the literature, 63-84% improvement rates in structural TL/L curvature have been reported with posterior selective fusion. This improvement with anterior spinal fusion (ASF) has been reported to be up to 66-87% in the early postoperative period, and it has been reported to decrease to 67% as a result of long-term follow-up[6,7]. In our study, the 85% improvement rate of the main curve after at least a mean follow-up of 2 years and the absence of correction loss support the effectiveness of Cobb to Cobb fusion with the posterior approach.

While it is recommended to add the structural TL/L curvature to the fusion in order to preserve more mobile segments in Lenke type 5 curves with posterior segmental fusion using pedicle screw, it has been stated that non-structural thoracic curvature does not progress and improves spontaneously[5,8,22,23]. Spontaneous thoracic curvature resolution after ASF in Lenke type 5 curves was found to be 19-34%, and improvement rates close to these rates (30-51%) were reported with PSF[9,20,21]. Wang et al.[15] reported a 51.8% spontaneous correction rate of nonstructural UTC. In our study, the rate of spontaneous recovery of the curvature that was not included in the fusion was found to be 57% with a minimum follow-up of 2 years. Numerous studies have been conducted to reveal which radiological parameters are associated with postoperative global coronal balance in terms of CIB development. LIV tilt, LIV translation and Dw below LIV parameters were found to be associated with local and global coronal balance after surgery with PSF[13-15]. It was concluded that if the LIV tilt, which was up to 25° preoperatively, could not be reduced to below 8° postoperatively, it was an important risk factor for the development of postoperative CIB[15]. In the present study preoperative LIV tilt was mean 23.7° and improved to mean 3.3° at the follow-ups with a 87.6% correction rate. CIB was not observed in our patients. Satake et al.[24], reported that the most important factors affecting the postoperative Dw under LIV in Lenke type 5 curvatures treated with the anterior approach are a near-horizontal position of the disc under LIV and choosing LIV as LEV-1 short segment fusion. Banno et al.[25] reported in their study when L3 was selected as LIV in Cobb to Cobb fusion, Dw under LIV was seen at a rate of 27% but they did not reveal a relation with CIB in their cases. The authors concluded that subjacent disc wedging could be a compensatory mechanism for UTC and fractional lumbar curve segments that are not included in the fusion.

Study Limitations

In our study there were certain limitations. First of all this study was conducted in a retrospective manner. All patients received selective Cobb to Cobb fusion so control group could not be added to study. More studies with different designs and comparison of the selective group with non-selective group and also with comparison of anterior and posterior spine fusion group with long term follow-up are needed to clarify this issue.

CONCLUSION

In conclusion, satisfactory results are obtained with Cobb to Cobb fusion in AIS lenke type 5 curves in the correction of both the main curve and the compensatory curve. There is no loss of correction in long-term follow-ups. LIV tilt and sub-LIV disc angulation, which are postop radiological inference markers, are important markers for coronal balance. Based on the radiological markers of our patients, it was concluded that the development of CIB can be prevented by keeping LIV tilt and Dw under LIV within the target values.

Ethics

Ethics Committee Approval: Ethics committee approval was obtained from İstanbul Bilim University Clinical Research Ethics Committee (date no: 21/01/2016, approval no: 44140529/2016-05).

Informed Consent: Retrospective study.

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Authorship Contributions

Surgical and Medical Practices: O.L.U., S.K., M.E., A.H., Concept: Ö.K., T.Ş., H.S.C., R.D., S.K., M.E., A.H., Design: Ö.K., S.K., M.E., A.H., Data Collection or Processing: Ö.K., T.Ş., H.S.C., O.L.U., R.D., Analysis or Interpretation: T.Ş., H.S.C., O.L.U., R.D., Literature Search: Ö.K., H.S.C., O.L.U., R.D., Writing: Ö.K., H.S.C., R.D., S.K., M.E., A.H.

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