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Assessment of Lowest Instrumented Vertebra Tilt on Radiographic Measurements in Lenke "C" Modifier Curves Undergoing Selective Thoracic Fusion in Adolescent Idiopathic Scoliosis

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Abstract

Study Design: Multicenter, retrospective cohort study.
Objectives: The purpose of this study is to determine how the amount of residual lowest instrumented vertebra (LIV) tilt correlates with radiographic measurements.
Summary of Background Data: When performing a selective thoracic posterior spinal fusion for adolescent idiopathic scoliosis (AIS), the LIV may be tilted into the lumbar curve or made horizontal.
Methods: This is a multicenter retrospective study of 33 consecutive patients with AIS, Lenke types 1 to 4, lumbar modifier C, and a minimum follow-up of 2 years, who underwent selective thoracic posterior spinal fusions. Measurements obtained from pre- and postoperative radiographs were correlated with postoperative LIV tilt.
Results: At final follow-up, less postoperative LIV tilt significantly correlated with less thoracic apical translation ($p = .023$) when controlling for the position of the LIV relative to the stable vertebra and preoperative thoracic and lumbar curve flexibility. LIV tilt was not significantly associated with thoracic Cobb angle, lumbar Cobb angle, lumbar apical translation, coronal balance, sagittal balance, or the amount of correction obtained compared to their preoperative measurements ($p > .05$).

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Conclusion: Decreased LIV tilt was significantly associated with decreased thoracic apical translation. LIV tilt did not significantly correlate with coronal balance or any other radiographic measurement. We caution that these findings may only be applicable in C modifier curves and when the correct LIV is chosen.
Level of Evidence: Level III, Therapeutic study.

Keywords: Lowest instrumented vertebra; Adolescent idiopathic scoliosis; Selective thoracic posterior spinal fusion; Decompensation; Cobb angle

Introduction

According to a 2011 review of selective thoracic fusion for adolescent idiopathic scoliosis (AIS), the goals of surgical intervention are to "(1) halt curve progression and correct deformity, (2) maintain a balanced spine in the coronal and sagittal planes, (3) preserve as many mobile spinal segments as possible, and (4) prevent surgical complications such as junctional kyphosis, adding-on, and revision surgery" [1].

By performing a selective fusion of the thoracic curve and leaving the lumbar curve unfused, the surgeon can correct spinal deformity while reducing the total number of levels fused. This technique does not sacrifice immediate correction or long-term stability of the spine [2-4]. Selective thoracic fusions (STFs) appear to work best in patients with a structural thoracic curve, and a flexible, compensatory lumbar curve. These curves were initially classified as King Type II curves [5], and later as Lenke 1C, 2C, 3C, and 4C curves [2,6,7]. Multiple studies have demonstrated that the compensatory lumbar curve found in these types will spontaneously correct following fusion of the structural thoracic curve [2,5,8-12]. Additional advantages of selective fusions over multicurve fusions include decreased operating time and decreased blood loss [3].

Identifying the correct level as the lowest instrumented vertebra (LIV) is an important factor in preventing decompensation and possibly progression of deformity in STFs. Multiple studies have identified the neutral and stable vertebra as the ideal LIV for preventing adding-on of scoliosis, and lumbar decompensation. The stable vertebra (SV) takes precedence over the neutral vertebra when the two are not the same vertebrae [4,5,10,13].

One factor that remains unknown in STFs is the effect of LIV tilt on radiographic outcomes. In theory, a horizontal LIV restores the vertebra to a normal anatomic position, which allows for better correction of the thoracic and lumbar curves. Alternatively, a tilted LIV may align more harmoniously with the unfused vertebra immediately inferior, which may prevent decompensation. No studies have examined the effect of postoperative LIV tilt on curve correction, coronal decompensation, or other radiographic outcome measurements in posterior STFs in AIS.

Materials and Methods

This was an institutional review board–approved, multicenter, retrospective cohort study that included consecutive surgical cases from three tertiary referral pediatric orthopedic centers undergoing surgery between August 6, 1992, and December 30, 2009. Patients were included if they were diagnosed with AIS, had a lumbar curve modifier of C, underwent selective thoracic posterior spinal fusion (LIV = L1 or higher), and had at least 24 months of documented clinical and radiographic follow-up. Patients who had previously undergone spine surgery, including tethered cord release, spinal cord decompression, or previous scoliosis correction were excluded.

Patient demographic and surgical information, including age, gender, Lenke class, lumbar modifier, and length of fusion were collected from paper and electronic medical records. Preoperative standing anterior-posterior (AP) plain films were evaluated to determine if the center sacral vertebral line (CSVL) did not touch the body of the lumbar apical vertebra, indicating a lumbar modifier of C [14].

The preoperative neutral vertebra was defined as the "most cephalad vertebra below the apex of the major curve whose pedicles are symmetrically located within the radiographic silhouette of the vertebral body," and the SV was defined as the "most cephalad vertebra at or immediately below the end vertebra (EV) of the major curve that is most closely bisected by the CSVL." The C7 plumb line (C7PL) was defined as a vertical line bisecting C7. The center sacral vertebral line was defined as a vertical line bisecting S1 (CSVL) [14].

Radiographic outcome variables were measured on digital or hardcopy standing films taken postoperatively; at 3, 6, 12, and 24 months postsurgery; and at the last recorded follow-up visit. LIV tilt was measured as the angle between the horizontal line of the film and a line parallel to the lower endplate of the LIV. Standard thoracic and lumbar Cobb angles were measured on preoperative standing and side-bending AP films, and on postoperative standing AP films [15].

Decompensation, also known as coronal balance, was defined as the horizontal distance between the C7PL and the CSVL on a standing AP radiograph. Sagittal balance was defined as the horizontal distance between the C7PL and the posterior-superior corner of S1 on a standing lateral radiograph. Thoracic apical translation was defined as the horizontal distance from the center of the thoracic apical vertebra to the C7PL, and lumbar apical translation was defined as the distance from the center of the lumbar apical vertebra (LAV) to the CSVL. Both thoracic and lumbar apical translation was measured on standing PA radiographs.

A visual representation of select radiographic measurements can be seen in Figure 1.