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The Lumbar Gap Measurement in Lenke 1−4C Curves

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Abstract

Study Design: Retrospective review.
Objectives: To assess whether the lumbar gap (LG) measurement, which is the distance between the center sacral vertical line and the concave edge of the apical vertebra of the lumbar curve, would be a useful tool to predict the need for lumbar curve fusion in the Lenke 1−4C curves.
Summary of Background Data: The current treatment guidelines of selective thoracic fusion in the Lenke 1−4C curves are not routinely accepted.
Methods: One hundred three adolescent idiopathic scoliosis (AIS) patients had undergone either selective thoracic fusion (STF) or both thoracic and lumbar curves fusion (TLF) for Lenke 1−4C curves. The correlations between the fusion decision making and preoperative LG, coronal balance, thoracic and lumbar Cobb, apical vertebra translation, and rotation were analyzed. The radiographic outcomes and SRS-30 of a minimum 2-year follow-up were reviewed in each group.
Results: A total of 51 patients (49.5%) underwent an STF, and 52 patients (50.5%) underwent a TLF. The mean LG was 22.0 ± 8.8 mm in the TLF, which was 2.3 times greater than the STF (9.6 ± 3.9 mm) ($p < .0001$). Only 5% of the lumbar curves were fused when the LG was 10 mm or less. Ninety percent of the lumbar curves were fused when the LG was 16 mm or greater, and 100% lumbar curves were fused with an LG of 21 mm or greater. The preoperative coronal imbalance to the left in the TLF was significantly greater than the STF. A mean 47% thoracic correction corresponded to a mean 39% spontaneous correction of the lumbar curve obtained in the SFT, which was significantly different from the TLF (56% and 65%). There were no differences in the SRS-30 scores at 2 years postoperatively between the STF and the TLF.
Conclusion: The lumbar curve should not be fused when the LG was 10 mm or less, and very likely should be fused when the LG exceeds 20 mm in the Lenke 1−4C AIS patients.
Level of Evidence: Level III

Keywords: Lenke lumbar C modifier; selective thoracic fusion; lumbar gap

Introduction

The Lenke classification system for adolescent idiopathic scoliosis (AIS) evaluates curve patterns, lumbar apical vertebral translation, and sagittal alignment and has been helpful in facilitating surgical decision making [1-3]. In general, for curves in which the lumbar apical vertebral body is touched by the center sacral vertical line (CSVL), termed lumbar modifier A or B, the recommendation is to fuse the main thoracic curve fusion only. The more challenging decision rests with double curves in which the lumbar apical vertebra is totally translated from the CSVL, termed lumbar modifier C. These double curves could also be treated with a selective thoracic fusion (STF) but are considered to be at greater potential for subsequent decompensation. In surgical AIS patients whose deformities include lumbar modifier C curves, the decision to include the lumbar curve in the fusion remains controversial [4-6].

IRB/Research Advisory Panel Approval: This study was reviewed and approved by the UT Southwestern Institutional Review Board, approval # 022011-127, and the Texas Scottish Rite Hospital for Children Research Advisory Panel, approval # 10-03-670.

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Performing an STF for lumbar modifier C double curves requires radiographic and clinical information. Clinical evaluation with the Adam's forward bending test assesses the severity of the lumbar prominence. Radiographic evaluation of the curve magnitude, apical vertebral translation (AVT), apical vertebral rotation (AVR), and their respective ratio are important [7,8]. A successful STF can often be achieved if their ratios are greater than 1.2. However, this guideline is not routinely adhered to. Previous studies reported that only 6% to 67% of patients with the Lenke 1C curve type underwent STF [6,7,9].

The purpose of this study was to retrospectively review the radiographic results and patient-reported outcomes of the Lenke 1C, main thoracic curve; 2C, double thoracic curve; 3C, double major; and 4C, triple major curves in order to determine which modifier C curves should not be treated by an STF. We hypothesized that the preoperative distance between the CSVL and the concave edge of the apex of the lumbar curve, termed the lumbar gap (LG), would be a predictive indicator of whether or not to include the lumbar curve in the fusion for those curves with a modifier C.

Materials and Methods

Inclusion criteria and grouping

A total of 1,068 AIS cases surgically treated at a single institution between July 2005 and October 2014 were retrospectively reviewed. For this study, inclusion criteria were Lenke 1C, 2C, 3C, and 4C AIS patients surgically treated with a posterior pedicle screw−only constructs with a minimum 2 years' postoperative follow-up. Those who were treated by all-hook constructs or hybrid constructs (combination hook and screw), and those who had less than 2 years' follow-up were eliminated. Details of the clinical deformities, radiographic features, and postoperative outcomes was collected on those who qualified for this study. A total of 103 patients were divided into two groups based on the fusion pattern. In the STF group (n = 51), patients underwent selective thoracic fusion. In the thoracic and lumbar fusion (TLF) group (n = 52), patients underwent both thoracic and lumbar curve fusion.

Skeletal maturation status

The triradiate cartilage, Risser sign, and menarchal status (females) were assessed in each patient. The status of the triradiate cartilage was defined as open, closing (nonfused remnant is incompletely visualized), and closed. The Risser sign was measured in the standard manner from grade 0 to 5. The menarchal history was recorded as premenarchal or postmenarchal (in years).

Radiographic measurements

All radiographs were evaluated digitally using the Synapse analysis system (Fujifilm Medical Systems, Stamford, CT). Measurements were determined on preoperative and follow-up postoperative radiographs. In the standing posterior-anterior (PA) radiograph, the coronal parameters included (Figs. 1 and 2) 1) thoracic (T-Cobb) and lumbar Cobb (L-Cobb) angle; 2) thoracic (T-AVT) and lumbar apical vertebral translation (L-AVT); 3) thoracic (T-AVR) and lumbar (L-AVR) Nash-Moe apical vertebral rotation; 4) coronal balance, which was defined as the distance between a plumb line from the centroid of C7 (C7PL) and the CSVL (C7PL-CSVL), and coronal imbalance, defined as a C7PL-CSVL >20 mm; 5) thoracic trunk shift, which was calculated by measuring the distance between the vertical trunk line and the CSVL; 6) shoulder level, which was measured by the clavicle angle, and shoulder imbalance, defined as a clavicle angle $>2^{\circ}$; and 7) coronal position of the lowest instrumented vertebra (LIV), which was the distance between the centroid of LIV and the CSVL (LIV-CSVL), was measured 2 months postoperatively and at the final follow-up. The LIV-CSVL change between the 2 months postoperatively and final follow-up was calculated. In the sagittal plane, thoracic kyphosis from T5 to T12, thoracolumbar junction alignment from T10 to L2, and lumbar lordosis from T12 to the sacrum were measured. For the coronal plane radiograph measurements, a positive value indicated either distance translation to the right of the CSVL or left up the tilt angle. A negative value indicated a distance translation to the left of the CSVL or right up the tilt angle. For the sagittal plane measurement, kyphosis was a positive number and lordosis was a negative value.

On the preoperative supine bending radiographs, the thoracic and lumbar curves were measured. The thoracic (T-FI) and lumbar flexible index (L-FI) was then calculated: FI = standing coronal Cobb angle−supine bending Cobb angle/standing coronal Cobb angle $\times$ 100%.

Lumbar gap measurement

On the standing PA radiograph, the distance between the CSVL and the concave edge of the apex of the lumbar or thoracolumbar curve, termed the lumbar gap (LG), was measured (Fig. 1). To do this, the CSVL was first drawn. The lumbar or thoracolumbar apex, which was the most horizontal and most laterally deviated vertebra or disc from the CSVL, was then identified. The LG was measured from the CSVL to the concave edge of the apex. The LG in which the CSVL touches the apex is defined as zero. The LG was divided into four sections: LG $\leqslant$ 10 mm; LG = 11−15 mm; LG = 16−20 mm; and LG $\geqslant$ 21 mm. The patient distribution was evaluated according to the LG. A possible cut-off value of the LG was analyzed to determine whether or not to include the lumbar curve in the fusion for these patients.

Patients outcomes

The patients completed the Scoliosis Research Society Questionnaire (SRS-30) before and after surgery. Mean