Spine Deformity
www.spine-deformity.org

Spine Deformity 3 (2015) 560–565

# Sagittal Alignment Two Years After Selective and Nonselective Thoracic Fusion for Lenke 1C Adolescent Idiopathic Scoliosis

Paul C. Celestre, MD[a], Leah Y. Carreon, MD, MSc[b,*], Lawrence G. Lenke, MD[c], Daniel J. Sucato, MD[d], Steven D. Glassman, MD[b]

[a]*OrthoVirginia, 1400 Johnston-Willis Drive, Suite A, Richmond, VA 23235, USA*
[b]*Norton Leatherman Spine Center, 210 East Gray St. Suite 900, Louisville, KY 40202, USA*
[c]*Department of Orthopaedic Surgery, Washington University School of Medicine, 660 S Euclid Ave, Campus Box 8233, St. Louis, MO 63110, USA*
[d]*Department of Orthopaedics, Texas Scottish Rite Hospital for Children, 2222 Wellborn Street, Dallas, TX 75210, USA*

Received 25 June 2014; revised 21 April 2015; accepted 2 May 2015

## Abstract

**Study Design/Setting:** Matched cohort.
**Objective:** To evaluate thoracic and thoracolumbar sagittal Cobb angles in patients undergoing either selective thoracic fusion (STF) or nonselective thoracic fusion (NSTF) for Lenke 1C adolescent idiopathic scoliosis (AIS).
**Summary of Background Data:** The Lenke classification is used to guide fusion levels in AIS. For some curve types, including 1C, there is a disparity in practice regarding whether the thoracolumbar/lumbar curve should be included in the arthrodesis. The impact of performing an NSTF on sagittal parameters has not been adequately evaluated.
**Methods:** A multicenter database of AIS was queried for patients with right-sided 1C curves treated with posterior correction and fusion. A matched cohort for each group was created based on age, gender, preoperative Cobb angles, and Scoliosis Research Society–22R domain scores. Independent *t* tests for continuous variables and Fisher exact test for categorical variables were used to compare the STF and NSTF groups.
**Results:** Thirty-eight patients who underwent NSTF were matched to 38 patients in the STF. An average of 8.0 levels were fused in the STF group and 11.6 in the NSTF group ($p < .001$). Preoperative and radiographic variables were similar between the two groups. Postoperatively, there was a statistically significant difference between the STF and NSTF sagittal Cobb in the thoracic spine, 26.9° and 21.7° ($p = .013$). The greatest difference was in the thoracolumbar sagittal Cobb, which increased to 4.3° kyphosis in the STF group and decreased to 9° of lordosis in the NSTF group ($p < .001$). Residual thoracolumbar/lumbar scoliosis was 25.5° in the STF group and 14.5° in the NSTF group ($p < .001$).
**Conclusions:** STF in 1C curves preserves lumbar motion segments but may be associated with an increase in thoracic and thoracolumbar kyphosis compared to NSTF. As expected, residual thoracolumbar/lumbar scoliosis was less in the NSTF group compared to the STF group. Although the long-term implications of these changes are unknown, consideration of sagittal balance is critical. Following these patients in the medium and long term will provide important information to guide fusion levels.
**Level of Evidence:** II.


*Keywords:* Sagittal alignment; Adolescent idiopathic scoliosis; Selective thoracic fusion; Spine fusion

## Introduction

Sagittal alignment is recognized as the single most important factor in determining quality of life in adults with scoliosis [1,2]. Although the Lenke [3] classification of adolescent idiopathic scoliosis (AIS) includes a sagittal modifier, little is understood about the long-term sequelae of spinal arthrodesis for AIS on sagittal balance. Furthermore, patients undergoing fusion for AIS may not lose the

Author disclosures: PCC (none); LYC (none); LGL (none); DJS (receives royalties from AAOS YOC, outside the submitted work); SDG (none).

Institutional Review Board approval for all institutions was obtained before data collection.

*Corresponding author. Norton Leatherman Spine Center, 210 East Gray Street, Suite 900, Louisville, KY 40202, USA. Tel.: (502) 992-0488 x4139; fax: (502) 589-0849.

*E-mail address:* leahcarreon@nortonhealthcare.org (L.Y. Carreon).

2212-134X/$ - see front matter © 2015 Scoliosis Research Society.
http://dx.doi.org/10.1016/j.jspd.2015.05.002

ability to compensate for increased positive sagittal spinal balance by pelvic retroversion until many decades after their index operation.

In AIS, Lenke 1C curves are defined as those with only one major structural (main thoracic) curve, but are accompanied by a large, flexible thoracolumbar/lumbar curve in which the central sacral vertebral line passes lateral to the pedicle of the most rotated lumbar vertebra [3]. The appropriate surgical treatment for Lenke 1C curves is an area of debate within the literature. On the basis of the Lenke classification [3], Lenke 1C curves are amenable to a selective thoracic fusion (STF). However, there is a substantial variation (6% to 67%) in rates of selective versus nonselective thoracic fusion (NSTF) for such curves [4-6].

Multiple clinical factors have been identified as reasons to choose NSTF over STF for Lenke 1C scoliosis, including control of the thoracolumbar kyphosis [3], large lumbar curves, large apical lumbar vertebral deviation, and prevention of distal adding on [4,6].

NSTF, that is, arthrodesis of all or part of the thoracolumbar/lumbar curvature, sacrifices motion segments in the lumbar spine in order to restore coronal balance and potentially prevent subsequent distal adding-on. However, little attention has been paid in the literature to changes in sagittal alignment and balance in patients undergoing fusion into the lumbar spine. The purpose of this study was to compare the thoracic and thoracolumbar sagittal alignment after STF versus NSTF in Lenke 1C AIS curves.

## Materials and Methods

A multicenter database of patients with AIS who underwent surgical correction of their spinal deformity from December 2002 to December 2009 was queried for patients with right-sided main thoracic AIS Lenke 1C curves. Eighteen sites with 21 surgeons participated in this database with a total 4,075 patients enrolled. Criteria for inclusion in the database were a diagnosis of thoracic, thoracolumbar, and/or lumbar AIS, patient age between 8 years and 17 years 11 months at the time of diagnosis and surgery performed before age 21. Because idiopathic scoliosis is a diagnosis of exclusion, patients had a history, physical exam, and radiographs consistent with this diagnosis. Patients with congenital, neuromuscular, juvenile, or infantile scoliosis were excluded. Patients who had a revision spine surgery or had a staged or concurrent anterior procedure were also excluded. Twelve percent of eligible patients were excluded from the study because of language barriers, patient refusal, or inability to follow-up. A total of 3,535 subjects reached a 2-year follow-up. Of these, 1,568 (44%) patients had radiographic follow-up, 2,039 (58%) had clinical follow-up, and 2,024 (57%) completed a 2-year Scoliosis Research Society–22R (SRS-22R) questionnaire [7-10].

Patients were classified into two groups, those who had STF and those that did not. STF was defined as a lower instrumented vertebra (LIV) of L1 or above, whereas NSTF was defined as those patients with an LIV of L3 or L4 (Figs 1 and 2). The decision to perform STF versus NSTF

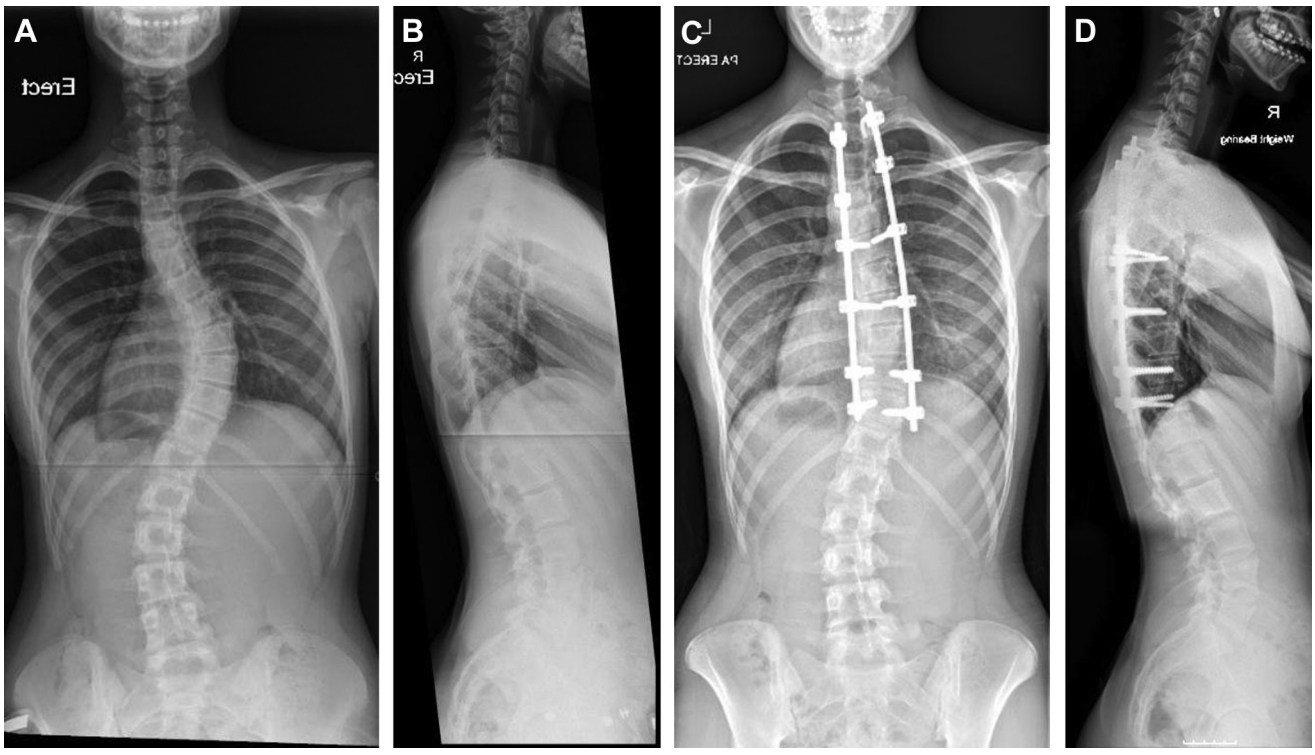


Fig. 1. Example of a patient with a Lenke 1C curve who underwent selective thoracic fusion. Distal fusion level is at T11. (A) Preoperative posteroanterior radiograph; (B) preoperative lateral radiograph; (C) posteroanterior radiograph taken 2 years postoperative; (D) lateral radiograph taken 2 years postoperative.