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Distraction-Based Treatment Maintains Predicted Thoracic Dimensions in Early-Onset Scoliosis

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Abstract

Study Design: Retrospective cohort study.
Objective: Examination of distraction-based treatment effect on thoracic dimensions in patients compared to predicted individual normal values, at initial treatment and subsequent follow-up after lengthenings.
Summary of Background Data: Change in thoracic dimensions and spine length is an important outcome measure in treatment of children with early-onset scoliosis; however, it is difficult to use to make comparisons between patients and the normal population because of the heterogeneous nature of early-onset scoliosis.
Methods: Early-onset scoliosis patients treated with distraction-based therapy who had radiographic parameters (pelvic inlet width, chest width, and thoracic height) preoperatively, immediately postoperatively, and at a minimum 5-year follow-up were included. Individual thoracic measurements were compared with predicted normal measures based on pelvic inlet width, and expressed as a percentile of predicted measure.
Results: Comparisons were made in 41 patients; mean age at time of primary surgery was 4.5 years, and median follow-up was 6.5 years. Thoracic height percentile increased from a mean preoperative value of .78 to a postoperative percentile of .88 ($p < .001$); at long-term follow-up, it was .85. Absolute thoracic height increased at all 3 time points: 141.6, 159.79, and 203.45 mm, respectively Mean chest width was similar preoperatively (170 mm) and immediately postoperatively (166.5 mm) but increased at latest follow-up (206.9 mm). Chest width percentile was similar at all 3 times (.93, .90, and .91).
Conclusions: Distraction-based treatment increases absolute thoracic height over time. There is significant improvement in the thoracic height percentile normalized after initial surgery, which was maintained over time. Measuring expected gains as a percentile normalized for pelvic width may be a more relevant outcome measure compared with measuring only absolute values.

Keywords: Early onset scoliosis; Distraction-based therapy; Pulmonary outcomes

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Introduction

Patients with early-onset scoliosis (EOS) may have significant spinal deformity and altered pulmonary function. When severe, patients may have thoracic insufficiency syndrome [1]. Cardiopulmonary dysfunction is the most common cause of morbidity and mortality in patients with EOS [2,3].

Although early spinal fusion can control spinal deformity, it does so at the expense of spinal height and pulmonary function over time [4]. Typical distraction-based therapies (growing spinal rods or Vertical Expandable Prosthetic Titanium Rib) therefore attempt to control spinal deformity while allowing spinal growth and maintaining thoracic dimensions. The impact of interventions on thoracic dimensions is particular interesting because it directly affects pulmonary function.

Outcome measures in the treatment of EOS are poorly defined; and the most commonly reported of these include thoracic height or spine length [5-7]. Unfortunately, in this population, understanding the significance of absolute measured change in individual patients over time is difficult because EOS encompasses multiple diagnoses (congenital, neuromuscular, syndromic, and idiopathic). These patients may have variable growth rates, nutritional status, and statures, and therefore comparing outcomes of this population with values expected for normal growth may not apply [8-10]. Five centimeters of spine growth over 5 years in a patient with Beal syndrome with naturally tall stature may be much less than normal growth, whereas 5 cm of spine growth in a patient with metatropic dysplasia may be much more than normal.

Pelvic inlet width has been used to provide individualized disease- and age-independent standards in predicting thoracic dimensions [11]. The purpose of this study was to examine whether distraction-based treatment in patients with EOS can improve on thoracic dimensions compared with predicted values normalized for pelvic width, and whether treatment can maintain these improvements over time.

Materials and Methods

The researchers completed a retrospective review of the Growing Spine Study Group database. All participating institutions had institutional review board approval. A total of 125 patients were initially identified as having at least 5 years of follow-up after initial surgical implant of growth-friendly procedure (growing rods or Vertical Expandable Prosthetic Titanium Rib). All etiologic diagnoses were included. Five sites participated in sending the additional data needed, which included measurements of pelvic inlet width, maximum chest width, and T1–T12 height from a coronal radiograph at 3 time points: preoperatively, immediately postoperatively, and at least 5-year follow-up. Forty-six patients met inclusion criteria. Four patients were missing immediate postoperative data and 1 was missing follow-up measurements. Missing data were assumed to be missing at random for analysis purposes.

Table 1
Outcome measurements.

	Preoperative	Postoperative	Most recent follow-up
Maximum chest width	170.01±18.59	166.55±20.22	206.91±38.09
Thoracic height	141.63±24.98	159.79±24.19	203.45±42.79
Pelvic inlet width	76.12±12.37	77.16±11.14	107.46±22.41

Data are means ± standard deviations (in mm).

The authors calculated summary statistics for pelvic inlet width, maximum chest width, and thoracic spine height at each time point for all patients. Individual thoracic height and chest width were compared with predicted thoracic height and chest width, respectively, based on pelvic inlet width at that time, and expressed as a percentile of predicted thoracic height for that pelvic width. Because the change in these measurements is confounded by other factors such as age and gender [10], normalized predicted percentiles for both maximum chest width and thoracic height, based on pelvic inlet width, were calculated using previously developed normalizing equations [11]. Normalizing equations estimate the expected value of thoracic height and maximum chest width based on gender and pelvic inlet width. Measurement percentiles were obtained by calculating the ratio of the actual thoracic height measurement to the expected value of the measurement computed based on the normalizing equations. A percentile greater than 1 implies that the patient was above the expected measurement, a percentile equal to 1 implies that the patient was equivalent to the expected measurement, and a percentile less than 1 implies that the patient was below the expected measurement.

Piecewise linear mixed models were used to evaluate the change in normalized maximum chest width percentile and normalized thoracic height percentile during the study period. These models take into account the varied baseline

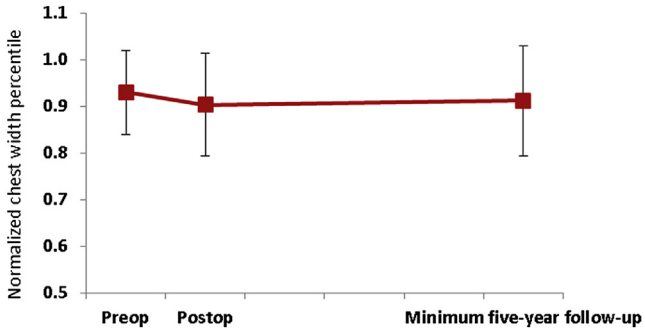

Fig. 1. Linear mixed model for chest percentile at each time point. Squares represent the mean chest percentile at the time point (Table 2), the line represents the slope estimated by the linear mixed model (Table 3), and I-bars represent the standard error of the linear mixed model at each point (Table 3). Preop, preoperatively; Postop, postoperatively.