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Clinical Study

Change in spinal height following correction of adolescent idiopathic scoliosis

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Abstract

BACKGROUND CONTEXT: Corrective surgery for adolescent idiopathic scoliosis (AIS) leads to vertical growth arrest of the instrumented spine. This might be offset by the immediate gain in spinal height (SH) as a result of correction of the curvature.

PURPOSE: This study aimed to identify predictors of gain in SH following corrective surgery for AIS. We present a unique model to predict postoperative height prior to intervention, which could contribute to the preoperative counseling and consenting process.

STUDY DESIGN: This was a retrospective case series. All surgeries were performed by one of four substantive pediatric spinal surgeons within a single regional center over a 3.5-year period.

PATIENT SAMPLE: There were 104 patients who had instrumented posterior spinal fusion for AIS included. There were 93 females, and the age range was from 11 to 17 years. All patients had posterior instrumented fusion using rods and anchors (pedicle screws±hooks).

OUTCOME MEASURES: Postoperative SH was the primary outcome measure. The SH (C7–L5) and Cobb angles were measured from a pre- and postoperative standing X-ray of each patient.

METHODS: Variables associated with patients (demographic and radiological) and the surgical constructs were analyzed for predictability of height gain. A model was derived including only significant predictors of substantive importance using hierarchical regression methods. Cross-validation procedures verified the adequacy of the model fit. Analysis was performed using IBM SPSS Statistics for Windows version 20.0 (IBM Corp. Armonk, NY, USA).

RESULTS: The major curve was thoracic in 90% of cases. The number of vertebrae fused ranged from 5 to 15. The average preoperative Cobb angle was 66°, with an average correction of 45°. The average change in SH was 4.66 cm (SD 2.13 cm). The model presented included preoperative height, preoperative Cobb angle, and number of vertebrae within the construct, with coefficients of 1.00 (95% CI: 0.90, 1.09), 0.067 (95% CI: 0.039, 0.095), and 0.26 (95% CI: 0.11, 0.41), respectively. This model had an adjusted-R^2 value of 0.83 and a R^2 for prediction of 0.79, and can be shown to have similar predictive capability as a model comprising a wider range of predictors.

CONCLUSION: The greatest postoperative height values following posterior spinal fusion for AIS could be expected from a patient with greater preoperative height and Cobb angle, and whose construct spans a large number of vertebrae.

Keywords: Adolescent; Correction; Gain; Height; Idiopathic; Scoliosis

Introduction

Patients with adolescent idiopathic scoliosis (AIS) are known to have abnormal anthropometric measurements [1–8]. For instance, females with AIS are taller than age-matched healthy controls, and a surgical procedure which is likely to increase their height suddenly and significantly could therefore have an unwanted psychological effect on a patient who is likely to be body conscious already [9–11]. It is not surprising that the cosmetic concern caused by this deformity

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is a reason for patients to seek corrective surgery [12–14]. However, correction involves fusion which does halt vertical growth [15]. Winter [16] proposed a formula to determine the amount of remaining spinal growth (which would be lost) within the fused segments (0.7 mm/segment per year of remaining growth). Growth arrest must therefore be a concern, especially in the young where fusion would have a significant effect on final height [6]. It is therefore reassuring that publications have confirmed height gain as a result of curve correction [17–20], but none have predicted this gain ahead of intervention. If AIS patients are concerned with their appearance, then preoperative advice regarding expected change in appearance is important, if not essential. This is emphasized by one of the authors' experience of an AIS patient asking "How much taller will I be after the operation?". We looked at predictors of height gain that would be available to the surgeon ahead of intervention and thereupon present a predictive model.

EVIDENCE & METHODS

Context

The authors present results of a study intended to evaluate predictors for gain in height following surgical correction for idiopathic scoliosis. This was a retrospective review of 104 patients treated at a single center.

Contribution

The authors employed hierarchical regression modeling to address confounders in this analysis. They ultimately conclude that greater preoperative height, preoperative Cobb angle and number of vertebrae within the construct were all associated with postsurgical height.

Implications

Findings from this study may be used to counsel patients and their family regarding expected gains in height following correction of AIS. That being said, this remains a study potentially impaired by a relatively limited number of patients treated at a single center. Therefore, results may not be comparable among individuals treated in other clinical settings. The findings in this analysis cannot be viewed as greater than Level IV evidence.

—The Editors

Method

Patients

Surgery was performed by four substantive pediatric spinal surgeons within a specialist children's hospital. Patients were selected for inclusion if they met the following criteria:

1. Instrumented posterior spinal fusion for AIS.
2. A preoperative and postoperative whole spine X-ray performed within 6 months of each other.

However, if either of a patient's preoperative or postoperative X-rays were lacking in reference points for measurement (radiopaque ruler, indistinct vertebral body), he or she was excluded.

Radiological measurement

Our standard whole spine radiographic study comprises a standing posterior-anterior and lateral X-ray of a patient standing alongside a radiopaque ruler. The authors have measured spinal height (SH) between the center of the C7 and L5 bodies on the lateral X-ray (Figure). The center of the vertebral body is the intersection of the diagonals through the body. T1 body was not reliably visible owing to variable shoulder height, and therefore C7 was chosen. Spinal height between C7 and L5 was measured to the millimeter. Change in height was the difference in SH between the preoperative and postoperative X-ray. Cobb [21] angles were measured on the posterior-anterior X-ray. Scoliotic curves were classified according to the Lenke [22] method.

Statistical analysis

Development of predictive model

Analysis was conducted on the sample to investigate possible predictors of change in SH. The following variables were initially considered: age at operation; gender; screw density (the percentage of the maximum number of screws the construct would allow if all pedicles within the construct contained a screw); system design (related to the design of the rod-screw connectors and classified as side or top loading systems); number of cross-links between rods; number of vertebrae included in the construct; Lenke classification of curve type (categorized as thoracic or thoracolumbar/lumbar); preoperative Cobb angle; and preoperative height (C7–L5).

Postoperative height (C7–L5), to be adjusted for preoperative height and other factors, was considered to be the primary outcome for the model.

A sequential (hierarchical) regression procedure was used to derive an optimum set of predictors. Following standard procedures, variables considered to be of greater importance were entered on later steps. Four blocks were devised. The first block comprised the demographic variables: age and gender. The second block comprised procedural variables, including screw density, system design, number of vertebrae included in the construct, and number of cross-links. The third block comprised variables relating to the patient condition, including Lenke classification and preoperative Cobb angle. Preoperative height was entered individually in the final block. Within each of the first three blocks, all variables were entered using a backward elimination modeling strategy. Forced entry was used for the final block. The sensitivity of the blocking to the selection of the set of variables remaining in the presented model was tested by varying the composition of the