



## Age at Initiation and Deformity Magnitude Influence Complication Rates of Surgical Treatment With Traditional Growing Rods in Early-Onset Scoliosis

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### Abstract

**Study Design:** Multi-center retrospective review.

**Objective:** The purpose of this study was to identify preoperative variables associated with postoperative complications in early-onset scoliosis (EOS) patients treated with traditional growing rods (TGR); and to develop a model to predict the incidence of postoperative complications based on preoperative variables.

**Summary of Background Data:** TGRs are commonly used to treat progressive EOS. Prior research has demonstrated a high rate of postoperative complications using this technique; however, few studies have identified preoperative factors that contribute to such complications.

**Methods:** A total of 110 patients who initiated TGR treatment before 10 years of age and completed final treatment were identified from a multi-center database. Overall treatment effect was calculated for major curve size, thoracic kyphosis, thoracic height, and total spine height. Univariable and multivariable logistic regression identified preoperative predictors of complications. An algorithm was developed and validated to calculate the probability of complications based on preoperative data.

**Results:** All patients completed TGR treatment (average follow-up 8.1 years). The overall treatment effect was a significant decrease in major curve magnitude, increase in thoracic height, increase in spine height, and no significant change in thoracic kyphosis. There were 263 total complications in 87 patients (79%) resulting in 84 unplanned surgeries. The most common complications were implant-related (49%), surgical site infection (23%), medical (19%), alignment (6%), and neurologic (3%). The significant independent preoperative predictors of complications were age at implantation and preoperative thoracic kyphosis. Multivariable regression showed that age less than 7.6 years,

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Ethical approval: All participating institutions obtained IRB approval prior to study initiation.

The medical devices mentioned in this paper have been cleared by the US Food and Drug Administration.

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thoracic kyphosis greater than 38 degrees, or major curve magnitude greater than 84 degrees significantly increased the probability of complications.

**Conclusions:** Earlier age at implantation, greater thoracic kyphosis, and larger major curves increased the probability of complications following TGR instrumentation. These findings provide a valuable tool for predicting complications that may aid in surgical planning and shared decision making with patients and their families.

**Level of Evidence:** IV.

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**Keywords:** Early-onset scoliosis; Traditional growing rods; Postoperative complications; Deformity magnitude

## Introduction

Early-onset scoliosis (EOS) is defined as a spinal deformity developing in patients 10 years old or younger [1]. Deformity progression is associated with multiple complications, with the majority involving pulmonary compromise [2]. Additionally, multiple late complications are common even with appropriate management, including infection, premature spinal fusion, and deformity progression [3]. Nonsurgical options include orthotic bracing and casting. The effectiveness of these techniques are often limited by thorax and spine compliance, rib cage plasticity, pulmonary compromise, and skin breakdown. Surgical management can improve chest wall and pulmonary development; however, complications including surgical site infection, implant failure, and curve progression are frequent.

Various growth-friendly surgical options have been studied in EOS patients to both preserve spinal growth and control deformity. As suggested by Skaggs et al., these techniques may be broadly grouped into three main categories: distraction-based, tension-based, and guided-growth [4]. The most common distraction-based technique is the use of traditional growing rods (TGR), in which instrumentation is placed and sequentially lengthened as the child grows until skeletal maturity is approached and a final fusion performed. Prior research has shown the efficacy of such instrumentation [5,6], but has also reinforced the high incidence of complications (48%-90%) associated with initial instrumentation and subsequent repeated surgical lengthenings [7,8].

Few prior studies have investigated specific factors contributing to postoperative complications. Bess et al. reported a 58% overall complication rate in 81 of 140 EOS patients treated with TGR [9]. The authors found significantly more unplanned procedures due to implant complications in patients treated with single rather than dual rods but no overall difference in complication rate. Further, they showed that the complication risk increased with younger age at initial surgery and subsequent lengthening procedures. In a later commentary, Karol underscored the fact that many patients in this study had not yet undergone final fusion; thus, true complication rates are likely to even be higher [10]. The primary purpose of this study was to identify preoperative variables associated with postoperative complications in EOS patients treated with TGR. The secondary

goal was to develop a model to predict the incidence of postoperative complications based on preoperative variables.

## Materials and Methods

A multicenter international database of EOS patients treated with single and dual TGR was retrospectively reviewed following Institutional Review Board approval. Patients who initiated TGR treatment before 10 years of age or less and completed treatment were included. Patients with incomplete preoperative medical records, inadequate imaging studies, or without completion of treatment were excluded. A total of 110 patients (49 male and 61 female) met our inclusion criteria.

Demographic, radiographic, and complication data were recorded for each patient. Demographic data included diagnosis, age, date and details of index surgery (single or dual GR), American Society of Anesthesiologists (ASA) Physical Status Classification System at index surgery, dates and details of subsequent surgeries, and date of most recent follow-up. Radiographic data included measurement of the major and secondary curve magnitudes, sagittal plane measures (T5–T12 thoracic kyphosis, thoracolumbar kyphosis, lumbar lordosis, and maximum thoracic kyphosis), T1–T12 thoracic spine height (measured from the superior endplate of T1 to the inferior endplate of T12), and T1–S1 spinal height (measured from the superior endplate of T1 to the inferior endplate of S1). Time points analyzed included preoperative, initial postoperative, and most recent follow-up visits. Complication data included complication type and date.

## Statistical Analysis

Complication rates along with 95% confidence intervals were estimated for surgical site infection, implant, alignment, neurological, and medical complications. Each complication rate was defined as the number of patients who experienced at least one complication out of the total number of patients in the study. All tests were two-sided, and *p* values less than .05 were considered significant. All analyses were conducted using SAS software, version 9.3 (SAS Institute, Inc., Cary, NC).

Paired *t* tests were used to analyze the change in thoracic dimensions, including major curve magnitude, thoracic

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