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Risk factors for predicting complications associated with growing rod surgery for early-onset scoliosis

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ABSTRACT

Objective: To identify risk factors for postoperative complications associated with growing rod surgery for early-onset scoliosis (EOS).
Methods: A total of 55 consecutive patients underwent growing rod surgery for EOS were examined from database. Data included age at initial surgeries, sex, diagnosis, body mass index (BMI), duration of follow-up, initial and final measure of major curve, T2–5, T5–12, T10–L2, and T12–S1 kyphosis angles, levels and type of instrumentation, total number of surgeries, number of rods inserted, number of lengthenings, lengthening intervals and rod location were studied. Risk factors for postoperative complications were analyzed using binomial multiple logistic regression analysis.
Results: Postoperative complications were associated with 37 of 272 procedures (14%) and affected 23 patients (42%). Complications included 25 implant-related failures (66%), 4 alignment complications (11%), 4 infections (11%), 1 neurological impairment (3%), 3 respiratory problems, 2 gastrointestinal problems, 1 urinary problem, and 1 dural tear. The most frequent implant-related failure was dislodged implant (76%) and 92% of the dislodgements occurred at the proximal foundation. Binomial multiple logistic regression analysis demonstrated that curve magnitude in last follow-up (OR: 1.042; $P = 0.036$), duration between growing-rod lengthening procedures (OR: 1.121; $P = 0.003$) and duration of follow-up (OR: 1.079; $P = 0.001$) maintained its significance in predicting likelihood of postoperative complications.
Conclusion: The occurrence of postoperative complications in growing rod surgery for EOS is most likely multifactorial and is related to curve magnitude in last follow-up and duration between growing-rod lengthening procedures.

Early-onset scoliosis (EOS), defined as scoliosis starting at the age of 5 years or less, regardless of etiology [8,9], is at risk for rapid curve progression and pulmonary insufficiency [6,13,16]. Children with EOS may also have associated syndromic pathological conditions with cardiopulmonary and gastrointestinal anomalies that can exacerbate the impact of EOS on pulmonary function [10]. Thus, compared with children with adolescent idiopathic scoliosis, children with early-onset scoliosis demonstrate greater mortality rates, independent of curve magnitude [6,7,16]. When treating EOS that does not respond to brace or cast treatments, growth-sparing fusionless surgery is preferable to fusion surgery because it interferes less with the normal development of the patient's thoracic cage. It has been reported that single growing rod for EOS demonstrated unacceptably high complication rate [1,14], motivating some authors to question the value of growing rod treatment because of the unacceptable risk–benefit ratio. Akbarnia et al. [4], utilized dual rods attached to solid proximal and distal foundations. Initial reports on the dual rod technique have demonstrated superior deformity correction and predicted growth maintenance during the treatment period compared with those associated with the single rod technique. However, postoperative complication rates remain high, in the range of 29%–58% [2–5,18]. Therefore, the identification and quantification of risk factors for postoperative complications associated with growing rod surgery for EOS are of paramount importance to the patient and the clinician.

This retrospective cohort study was undertaken to investigate (1) the overall incidence of postoperative complications associated with growing rod surgery for EOS, (2) the predictive factors

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of development of postoperative complications associated with growing rod surgery for EOS.

1. Materials and methods

We examined data with institutional review board approval obtained. A total of 55 consecutive patients underwent growing rod surgery for EOS between January 1999 and July 2013, at 1 academic hospital: a university-based medical center, were examined from database. Inclusion criteria were an age of 10 years or younger at the time of treatment with a growing rod construct for early-onset scoliosis and a minimum of 1 year of follow-up after the initial growing rod implantation. Exclusion criteria were treatment with any method other than a growing rod construct, an age of over 10 years, incomplete follow-up data, and less than 1 year of follow-up from the initial implantation. The mean age of patients at time of initial surgery was 6.8 ± 2.5 years with mean follow-up of 38.4 ± 17.3 months. There were 16 male patients and 39 female patients. The indications for surgery were congenital scoliosis in 28 patients, idiopathic scoliosis in 6 patients, syndromic scoliosis in 8 patients, neuromuscular scoliosis in 6 patients and miscellaneous disorders in 7 patients. At the final follow-up, 45 of the 55 patients were still undergoing growing rod treatment, 10 had undergone final fusion surgery, and spinal implants had been removed from 1 patient without final fusion because of uncontrollable surgical-site infections.

A retrospective review of collected clinical data and radiographs was performed. The clinical data collected included age at initial surgeries, sex, diagnosis, body mass index (BMI), duration of follow-up and complications. Radiographic data included initial and final measure of major curve, and T2–5, T5–12, T10–L2, and T12–S1 kyphosis angles were measured before surgery and at the latest follow-up. For patients who underwent final correction and fusion surgery, the final follow-up data were obtained from radiographs taken just before fusion surgery. The surgical data collected included levels and type of instrumentation, total number of surgeries, number of rods inserted, number of lengthenings, lengthening intervals and rod location (submuscular vs. subcutaneous). Complications were categorized as wound, implant, alignment, and general (surgical or medical). Wound problems were classified as superficial or deep infections, and other wound-related problems such as painful scars. Implant complications included rod breakage, loss of foundation fixation such as hook or screw pullout, and implant prominence. General complications included dural tears, an estimated operative blood loss of >500 mL, hematomas, and postoperative cardiopulmonary and gastrointestinal complications.

The database was divided into a non complication group and a complication group. The data analysis was performed using SPSS version 19.0 (Chicago, IL, USA). Continuous data were compared between the 2 groups using the student t test, whereas discontinuous data were analyzed using the Chi-squared test. Fisher's exact test was used for small data subsets ($n < 5$). All significance tests were 2-tailed, with $P < 0.05$ representing statistical significance. In addition, a multivariate logistic regression analysis was performed to identify which factors helped predict the probability of postoperative complications associated with growing rod surgery for EOS.

2. Results

2.1. Demographic data

A summary of the demographics and surgical data for the two groups are presented in Table 1. Patients underwent a mean of 4.3 ± 1.9 rod-lengthening procedures (range, 1–8 times) at a mean interval of 9.3 ± 2.1 months (range, 6–12.8 mo) in the complication group and 3.4 ± 1.2 rod-lengthening procedures (range, 2–6 times) at a mean interval of 7.9 ± 1.7 months (range, 5.5–12.0 mo) in the non-complication group. Patients in postoperative complications group had a higher mean curve magnitude at the time of the last follow-up (42.8° vs. 29.3°, $P = 0.013$), although preoperative mean curve magnitude was similar between the two groups (74.0° vs. 70.2°, $P = 0.492$). Of the patients with postoperative complications, a significant higher proportion of patients underwent surgery with single rod technique, 8 (34.8%) vs. 3 (9.4%) ($P = 0.038$).

Table 1
Demographic Characteristics and surgery related factors of the patients.

Characteristics	Patients with postoperative complications		*P*
	Yes ($n = 23$)	No ($n = 32$)	
Age at initial growing-rod implantation (years)	6.45 ± 2.59	7.04 ± 2.48	0.393
Sex, *n* (%)			0.852
Male	7 (30.4)	9 (28.1)	
Female	16 (69.6)	23 (71.9)	
BMI (kg/m^2)	23.94 ± 2.19	24.16 ± 2.87	0.760
Duration of follow-up (month)	48.60 ± 18.91	31.03 ± 11.50	0.000
Instrumented vertebral levels per patient	7.78 ± 1.68	8.22 ± 2.15	0.421
Surgical procedures per patient	5.61 ± 1.80	4.47 ± 1.22	0.007
Lengthening procedures per patient	4.26 ± 1.91	3.41 ± 1.24	0.049
Duration between growing-rod lengthening procedures (month)	9.28 ± 2.12	7.92 ± 1.71	0.011
Curve magnitude (°)			
Initial	74.00 ± 21.00	70.16 ± 19.83	0.492
Last follow-up	42.83 ± 21.75	29.31 ± 17.42	0.013
Diagnosis, *n* (%)			0.829
Congenital scoliosis	17 (56.7)	11 (44.0)	
Idiopathic scoliosis	3 (10.0)	3 (12.0)	
Neuromuscular scoliosis	3 (10.0)	3 (12.0)	
Syndromic scoliosis	3 (10.0)	5 (20.0)	
Miscellaneous disorders	4 (13.3)	3 (12.0)	
No. of rods, *n* (%)			0.038
Single	8 (34.8)	3 (9.4)	
Dual	15 (65.2)	29 (90.6)	
Placement of Growing Rods, *n* (%)			0.418
Subcutaneous	1 (4.3)	0 (0)	
Submuscular	22 (95.7)	32 (100)	

Note: BMI: body mass index.