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Magnetically controlled growing rod in 13 patients with early-onset scoliosis and spinal improvement

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ABSTRACT

Objective: The aim of this study was to examine the use of magnetically controlled growing rods as a method of providing spinal improvement while preventing thoracic insufficiency in patients with early-onset scoliosis (EOS).
Methods: Of a total of 13 patients, 4 patients underwent a dual magnetic rod implantation, while 9 patients had a single magnetic rod procedure. The study group comprised 12 (93%) female and 1 (7%) male patients. Six patients (46%) had an idiopathic form of scoliosis, in 4 (30%) it was congenital, and in 3 (23%) it was neuromuscular scoliosis. The patients' Cobb angles, thoracic kyphosis, T1-T12 and T1-S1 distance prior to and following the treatment were compared.
Results: The mean Cobb angle before surgery was 53.78^0, whereas it decreased to 39.29^0 postoperatively ($p < 0.001$). The mean thoracic kyphosis angle was 40^0 before and 29.79^0 after surgery ($p < 0.001$). The mean T1-S1 distance was 32.14 cm before and 36.36 cm after surgery ($p < 0.001$). The mean T1-T12 distance was 18.69 cm before and 20.64 cm after surgery ($p < 0.001$).
Conclusion: The use of magnetic rods is an effective method of EOS treatment. It allows for spinal growth while managing the progression of the scoliosis.
Level of evidence: Level IV, therapeutic study.

Introduction

Early-onset scoliosis (EOS) is defined as scoliosis that develops between birth and the age of 10 years.[1] The use of a growing rod system allows for the continuation of spinal growth while containing the progression of scoliosis until skeletal maturation at the age of 11–13 years. If uncorrected before adolescence, EOS causes growth delay, short stature, and thoracic insufficiency as a result of damaged pulmonary alveolar development.[2] In cases with a mature spinal column and a T1–T12 distance shorter than 18 cm,[3] pulmonary function may be reduced by 45%.

Between birth and adulthood, growth of the spinal thoracic cage follows a pattern. The T1-T12 height at birth is 110 mm on average, and reaches an average of 180 mm at age 5 in both sexes. The mean measurement goes up to 220 mm at age 10 (monthly growth of 1.16 mm, and yearly growth of 14 mm at age 0–5, and monthly growth of 0.67 mm and yearly growth of 8 mm at age 5–10). Furthermore, the T1-S1 distance grows 2 mm until the age of 5, and 1.2 mm monthly between the ages of 5 and 10.[4]

Treatment methods for skeletally immature patients with severe, progressive spinal deformities include the vertical expandable prosthetic titanium rib (VEPTR; DePuy Synthes, Raynham, MA, USA) implant or the Shilla growth guidance system (Medtronic, Dublin, Ireland), as well as single or dual growing rods. All growing rod systems are extended at 6- to 9-month intervals to produce spinal growth, and spinal fusion surgery is performed once mature. Traditional techniques of growing rod surgery have disadvantages, such as increased surgical complications as a result of repeated surgical procedures, potential wound site infection, and extended hospitalization. Therefore, externally controlled magnetic growing rod systems were developed.

The aim of this study was to compare the results of patients who had single magnetic rod with the results of patients who underwent a dual magnetic rod procedure.

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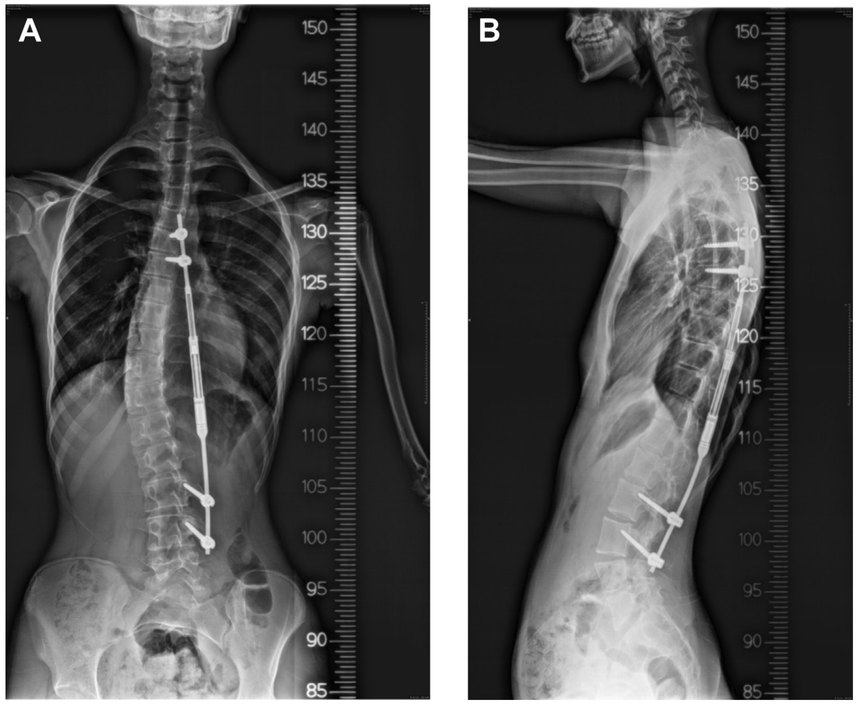

Fig. 1. Antero -posterior (A) and lateral (B) X-ray of a 9 year old patient with a single magnetic rod after the last distraction.

Statistical analysis

The statistical analysis of the data was performed using the statistical software package IBM SPSS Statistics for Windows, Version 23.0 (IBM Corp., Armonk, NY, USA). Whether or not the data were normally distributed was determined using the Shapiro–Wilk test. The Mann–Whitney U test was used for the comparison of 2 groups with data that did not demonstrate normal distribution. The dependent variables of normally distributed data were compared using a paired t-test. Descriptive statistics were presented as mean $\pm$ SD or median (minimum–maximum). The level of significance was alpha = 0.05.

Patients and methods

Patients with magnetic rod implants were observed between January 2012 and January 2014. This study included children aged between 5 and 10 years who had never undergone any spinal deformity surgery and who had a Cobb angle of 40^0 or greater. The mean follow-up time was 37.7 months.

The study group comprised 13 patients, 12 (93%) female and 1 (7%) male, whose lengthening process was completed between the aforementioned dates. Six patients (46%) had idiopathic scoliosis, 4 (30%) had congenital, and 3 (23%) had neuromuscular scoliosis. The patients' Cobb angles, thoracic kyphosis, T1-T12, and T1-S1 distance, and thoracic kyphosis angles prior to and following the operation were compared.

Of 10 (76%) patients who had a single magnetic rod, 2 (15%) had complications. One patient who initially had a single rod later had dual rods implanted. In total, a dual magnetic rod procedure was performed on 4 (30%) patients (Figs. 1–3).

Two stable vertebrae were determined using traction and bending radiographs from the beginning and end of the curvature and pedicle screws were inserted. The rods were fixed to the screws by applying distraction/compression and derotation on the top and bottom of the growing rod. Decortication was performed in order to ensure fusion to the vertebrae. Neuromonitoring was employed during surgery.

The patients were examined at 3-month intervals and while in the prone position, each rod was lengthened by 4 mm using a non-invasive magnetic remote control. The radiographs taken before and after rod expansion were used to compare the length with the previous follow-up and recovery measurements.

Results

The patients' mean age was 11.3 years (range: 8–14 years) at the last follow-up. After the expansion was completed, the mean follow-up was 11 months (range: 8–13 months). No orthesis device was used post operation, and no neurological deficits were detected.

The Cobb angle was measured based on the basic curve. Compensatory curves were not included in the study. Of these curves, 11 (84.6%) were thoracic, and 2 (15.3%) were thoracolumbar curves. The mean thoracic kyphosis angle was 40^0 before and 29.79^0 after the surgery ($p < 0.001$). The mean T1-S1 distance was 32.14 cm before and 36.36 cm after the surgery ($p < 0.001$). The mean T1-T12 distance was 18.69 cm before and 20.64 cm after the surgery ($p < 0.001$).

	Preoperative	Postoperative	p
T1-S1 distance	32,14 ± 3,87	36,36 ± 4,36	**<0,001**
Cobb angle	53,78 ± 10,74	39,29 ± 13,26	**<0,001**
Thoracic kyphosis angle	40,00 ± 17,60	29,79 ± 17,88	**<0,001**
T1-T12 distance	18,69 ± 3,18	20,64 ± 4,14	**<0,001**

There was no significant difference in the 4 parameters when the single magnetic rod and dual magnetic rods were compared.

	Magnetically controlled growing rods						p
	Single rod			Double rod			
	Median	Minimum	Maximum	Median	Minimum	Maximum	
Preoperative T1-S1 distance (mm)	31,27	28,00	39,17	30,96	25,38	32,64	0,454
Postoperative T1-S1 distance	0,13	0,06	0,21	0,13	0,08	0,19	1000
Preoperative Cobb angle (degrees)	55,50	37,00	78,00	49,00	42,00	55,00	0,240
Postoperative Cobb angle (degrees)	−0,26	−0,43	−0,05	−0,28	−0,63	−0,17	0,733
Preoperative thoracic kyphosis angle (degrees)	40,50	11,00	72,00	37,00	26,00	56,00	0,839
Postoperative thoracic kyphosis angle (degrees)	−0,26	−0,55	0,06	−0,44	−0,50	−0,34	0,106
Preoperative T1-T12 distance (mm)	18,58	13,66	26,57	18,59	14,66	19,92	0,733
Postoperative T1-T12 distance (mm)	0,09	−0,03	0,24	0,10	0,05	0,21	0,733

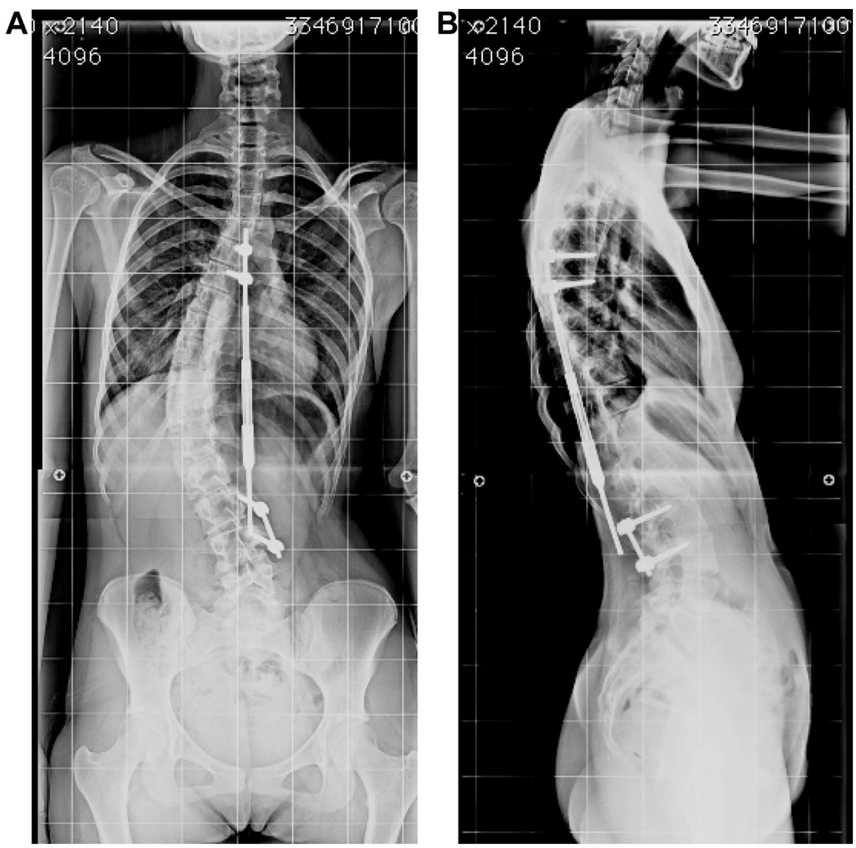

Fig. 2. Implant failure in an 11-year-old patient following trauma.

Discussion

When compared with traditional growing rod systems in terms of cost, although expansion with magnetic rods is more expensive in the early period, magnetic growth rod systems are more cost-effective after the third year.[4,5] The required, regular surgical procedures, related complications, and revision surgeries make the traditional methods much more expensive. Caniklioglu et al[6] reported similar results, noting that repeated invasive surgical procedures often lead to spinal or extra-spinal complications.

Bess et al[7] reported a 58% rate of complication in 140 patients. A key factor in the complication rate was reported to be the need for additional surgical procedures. Choi et al[8] also found that 23 of 54 patients had at least 1 complication. Fifteen of the 23 patients required at least 1 revision surgery, primarily due to rod breakage or rod-related problems. We switched to dual magnetic rods in 1 patient who had a break in the rod after a trauma, and another patient had a proximal screw pullout.

Dual magnetic rod implants are often preferred, as there appear to be fewer complications and failures. Despite the fact that dual rods proved to be more effective in recovering deformity, the difference found in our study was not significant. Perhaps a larger number of patients with dual rods would have led to significant results. Teoh et al[9] first applied revision to patients with a single magnetic rod and reconstructed with dual rods. Yang et al[10] reported that use of a single rod was an important factor in rod breakage in their 327-case study. Dannawi et al[11,12] demonstrated that recovery was more frequent in the patients with dual rods compared with the patients with a single rod implant.

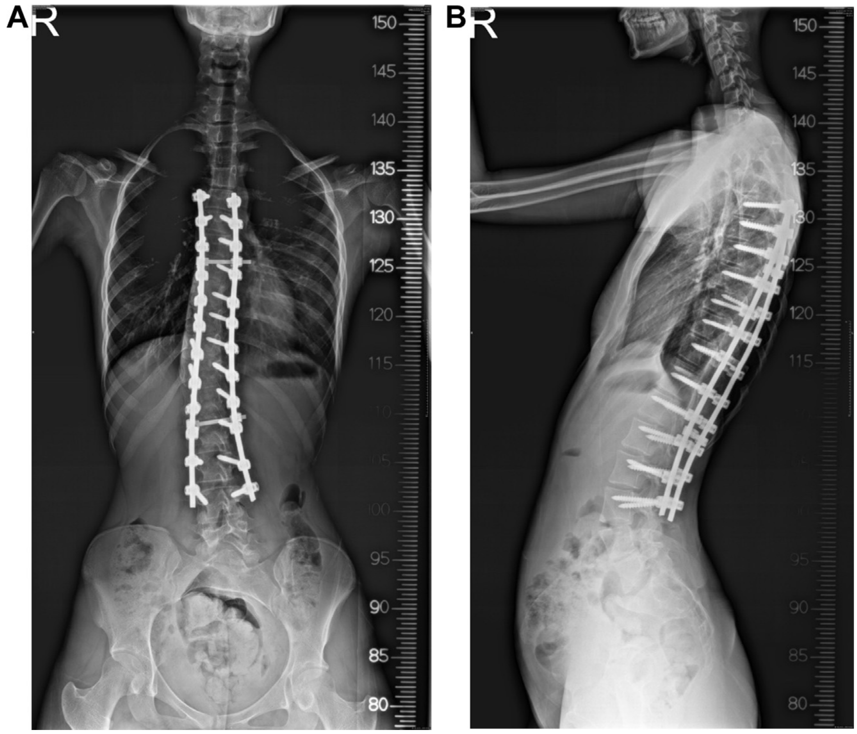

Fig. 3. Spinal fusion surgery after the revision at the lastest follow-up.

Limitations

There was no significant difference between the types of scoliosis in terms of the correction achieved in our study, though the preoperative bending graphs showed that the idiopathic scoliosis patients had greater flexibility and better scoliosis reduction. There could be significant difference between the types of scoliosis, however, in studies with a larger number of patients.

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