ORIGINAL ARTICLE

Traditional versus magnetically controlled growing rods in early onset scoliosis surgical treatment

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Abstract

Purpose Growing rod surgeries are common methods in the treatment of early onset scoliosis. Magnetic growing rod (MGR) surgery, in particular, has become more widespread in the last 10 years. The aim of this study was to compare the effects of traditional and magnetically controlled growing rod techniques on efficacy, safety, spinal growth, and lung development.

Methods A retrospective analysis was made of 24 TGR and 17 MGR patients. Inclusion criteria were patients aged < 10 years, curvature $> 40°$ or a progression of $> 10°$ in the 4–6 month follow-up for curves between 25 and 40°.

Results There were 9 males and 15 females in the TGR cohort and 7 males and 10 females in the MGR cohort. The mean age at first surgery was 6.1 years and 7.1 years, respectively. Major curve Cobb angles of TGR were preop. 51.5°, postop. 21.4° and 18.1° at the final follow-up. In the MGR cohort, these values were 60.4°, 41.8°, and 36.4°, respectively. The mean T1-S1 lengthening velocity was calculated as 1.12 cm/year (0.9318 mm/month) in the TGR group and 1.27 cm/year (1.0571 mm/month) in the MGR group. In the TGR cohort, a total of 99 procedures were performed as 24 initial surgeries and 75 additional procedures (5 lengthening during unplanned surgery due to complications; 4 revision, 1 debridement). In the MRG cohort, a total of 25 surgical procedures were performed as 17 initial surgeries and 7 additional procedures (3 debridements, 5 revisions).

Conclusion The results of this study showed that the TGR system provided better correction in the coronal plane and was superior in kyphosis restoration than the MGR system. Both methods were successful in lengthening, but complication rates were slightly higher in the MGR cohort. The most common complication was the pullout of the proximal anchors, and this was more common in the MGR. Both TGR and MGR were found to be effective treatments. Lengthening without surgery is a significant advantage of the MGR system, but it has a high revision rate, and Cobb angle correction was found to be less effective than with TGR.

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Introduction

Regardless of its etiological diagnosis, scoliosis before the age of 10 years is defined as early onset scoliosis (EOS). The course of severe, progressive EOS in the growing child is complex and challenging to manage. In addition, these patients may have syndromic and pathological conditions associated with cardiopulmonary and gastrointestinal diseases that increase morbidity. The aim of treatment in EOS is to correct the curvature or prevent progression while at the same time allowing the vertebrae to grow and the vertebral column to remain mobile, allowing the cardiovascular and respiratory systems to develop.

Although many different growth friendly implant systems have been described in the treatment of early onset scoliosis, traditional growing rod (TGR) techniques are among the most widely used. In the last 10 years, magnetically controlled growing rod (MGR) systems have become more widespread as fewer surgical interventions are required.

The aim of this study was to compare the effects of traditional and magnetic controlled growing rod techniques on the efficacy, safety, spinal growth, and lung development in the treatment of early onset scoliosis.

Methods

The study included 24 patients treated with TGR in the Orthopedics and Traumatology clinic of SBU Ankara Training and Research Hospital between July 2009 and January 2012, and 17 patients treated with MGR in the Orthopedics and Traumatology clinic of SBU Şişli Hamidiye Etfal Training and Research Hospital between January 2016 and December 2021. Inclusion criteria were patients aged < 10 years, curvature exceeding 40° or progression of > 10° in the 4–6 month follow-up for curves between 25° and 40°. Only patients with double growing rods were included in the study.

In the TGR group, the pediatric spinal system of Tasarımmed (Istanbul, Turkey) was used. In the MGR group, the MAGEC system was used (MAGEC; Ellipse Technologies, Irvine, CA, USA).

Demographic information (gender, etiology, age at first operation), follow-up times, and the number of lengthenings were recorded for all patients. Standing posteroanterior and lateral radiographs of all patients were used. Preoperative, early postoperative, and end of follow-up period radiographs were evaluated.

The patients were divided into 4 groups according to the etiology: congenital, idiopathic, neuromuscular, and syndromic. Three independent observers evaluated all the radiographs by measuring Cobb angle, thoracic kyphosis angle (T4-T12), T1-S1 length, coronal and sagittal balance, and SAL index. The mean of the measurements was recorded as the value for analysis.

T1-S1 distance was calculated as the length measured perpendicular to the ground between the midpoints of the T1 upper endplate and S1 upper endplate. The monthly T1-S1 segment growth rate for each patient was calculated individually by dividing the difference between the postoperative and final measurements by the follow-up time. The velocities were calculated by taking the numerical average of all the values. Coronal balance was calculated by measuring the distance between the line drawn perpendicular to the ground from the center of the C7 vertebral body and the central sacral vertical line on the posteroanterior radiograph. Sagittal balance was evaluated according to the distance of the line drawn perpendicular to the ground from the middle of the C7 vertebral body to the posterosuperior corner of the S1 vertebral body on the lateral radiograph. If this line passes posteriorly to the S1 posterosuperior corner, it is considered negative, and if it passes anteriorly, it is considered positive. The SAL index (Space Available for Lung) was calculated to compare the lung range of motion of the patients. The lengths of the lines descended from the most proximal costa to the middle of the diaphragm were measured. The ratio of the concave side to the convex side was taken as the SAL index.

Data obtained in the study were analyzed statistically using SPSS vn.26.0 software (SPSS Inc., Chicago, IL, USA). Mean, standard deviation, and minimum and maximum values were used in descriptive statistics. In the comparisons of numerical data (age at first surgery, follow-up time), the Independent t test was used as the parametric test if the data were normally distributed. The Mann–Whitney U test was used as the nonparametric test if the data were abnormally distributed. The Dependent t test was used as the parametric test if the change in Cobb angles and length measurements were normally distributed, and the Wilcoxon matched-pairs test was used as the nonparametric test if the data were abnormally distributed. Pearson chi-Square tests were used to compare categorical data (sex distribution, scoliosis type, scoliosis etiology, complications…). A value of $p < 0.05$ was accepted as statistically significant.

Results

The traditional growing rod system (TGR cohort) was applied to 24 of 41 patients in the study. There were 9 males (32.5%) and 15 females (62.5%), of which 11 patients (45.8%) had idiopathic, 9 (37.5%) had congenital, 3 (12.5%) had syndromic, and 1 (4.2%) had neuromuscular scoliosis.

A magnetic controlled growing rod system (MGR cohort) was applied to the remaining 17 patients. This group comprised 7 (41.2%) males, and 10 (58.8%) females, of which 6 patients had idiopathic scoliosis (35.3%), 5 had congenital (29.4%), 5 had syndromic (29.4%), and 1 had neuromuscular scoliosis (5.9%) (Table 1).

Both groups were similar in respect of the etiological type of scoliosis, gender distribution, mean age at first surgery, and follow-up period. One Make-Up Syndrome and one Campomelic Dysplasia were other pathologies accompanying scoliosis in the TGR patients.

One patient had previous surgery in another center due to congenital heart disease (mitral valve insufficiency + AVSD). Intraspinal pathology was detected in 3 patients (12.5%) during preoperative examinations. One of the patients with intraspinal pathology had syringomyelia + diastematomyelia, one had syringohydromyelia, and one had syringomyelia + tethered cord + intraspinal lipoma. No preoperative neurological deficit was detected in the first two of the abovementioned patients, 40% paresis was seen in the left lower extremity preoperatively in the third patient.

One patient with achondroplasia, two with neurofibromatosis, and one with osteogenesis imperfecta were in the MGR group. There was a history of intraspinal pathology in 2 patients (12%). One of the patients was diagnosed with astrocytoma–syringomyelia and had a ventriculoperitoneal shunt. Hydrocephalus–meningocele–lipoma was detected in the other patient, and a ventriculoperitoneal shunt was performed. A growing rod was used as revision surgery for only 1 patient in the TGR group. All MGR patients underwent primary surgery.

The mean age at first surgery was 6.1 years (1.3–10.9) in the TGR group, and 7.1 years (3.1–10.4) in the MGR group. The mean follow-up time was calculated as the time from the initial surgery to the final follow-up. It was calculated as 23.9 months (11–40 months) in the TGR group and 30.2 months (5–65 months) in the MGR group. The mean lengthening interval was 8.1 months in the TGR group and 3.5 months in the MGR group.

Table 1 Demographic data and comparisons of the two groups (chi-square test for gender and scoliosis type, Independent t test for age at first surgery and follow-up, and the Mann–Whitney U test was used to compare the number of lengthenings

		Magnetic		Traditional		p
Gender	Male	7 (41.2%)	Male	9 (32.5%)		
	Female	10 (58.8%)	Female	15 (62.5%)		0.812
Diagnosis	Idiopathic	6 (35.3%)	Idiopathic	11 (45.8%)		
	Congenital	5 (29.4%)	Congenital	9 (37.5%)		
	Syndromic	5 (29.4%)	Syndromic	3 (12.5%)		
	Neuromuscular	1 (5.9%)	Neuromuscular	1 (4.2%)		0.577
Follow-up time		30 ± 15		23.9 ± 8.0		0.131
Age		7.1 ± 1.90		6.1 ± 2.81		0.199
Number of lengthenings		9.2 ± 4.9		3.1 ± 1.2		0.000

$p < 0.05$ indicates a statistically significant difference

Fig. 1 Change of Cobb angle of the main curvature during treatment
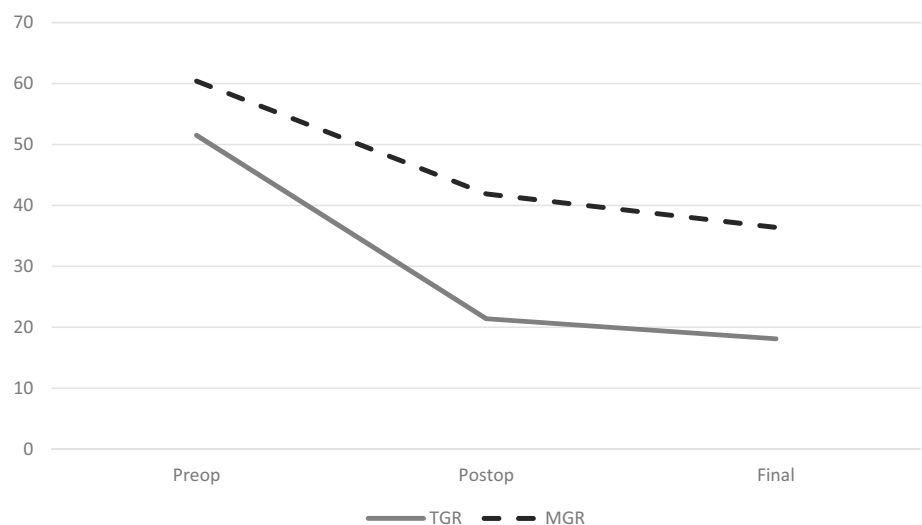
Correction of spinal deformity

The mean Cobb angles of the main curve in the TGR group were 51.5° (16°–86) preoperatively, 21.4° (0°–46°) postoperatively, and 18.1° (4°–36°) at the final follow-up (Fig. 1). Accordingly, 58.4% correction was obtained in the deformity during the first surgery. At the final follow-up, a 64.9% improvement was detected in the deformity compared to the initial value. A statistically significant difference was found between the preoperative–postoperative-final follow-up Cobb angles of the patients in the statistical evaluation ($p < 0.05$) (Table 3).

The mean Cobb angles of the main curve in the MGR group were 60.4° (31°–91°) preoperatively, 41.9° (21°–79°) postoperatively, and 36.4° (15°–55°) at the final follow-up. Correction of 30.6% was obtained in the deformity during the first surgery. At the final follow-up, a 39.7% improvement was detected in the deformity compared to the initial value. A statistically significant difference was determined between the preoperative–postoperative-final follow-up measurements of the patients ($p < 0.05$) (Table 3; Fig. 2).

The mean kyphosis angle in the TGR group was calculated as preoperative 48.3° (6°–98°), postoperative 26.2° (6°–66°), and at the final follow-up as 26.9° (8°–60°). The correction rate of kyphotic deformity calculated after the first surgery was 47.8%, while the rate at the final follow-up was 47.7%. A statistically significant difference was determined between the preoperative and postoperative kyphosis angles ($p = 0.000$). No significant difference was found between the postoperative kyphosis angle and the final follow-up kyphosis angle ($p = 0.495$) (Table 3).

In the MGR group, the mean kyphosis angle was measured as 29.9° (9°–70°) preoperatively, 18.4° (3°–47°) postoperatively, and 25.5° (9°–58°) at the final follow-up. The correction rate of kyphotic deformity calculated after the first surgery was 38.5%, while the rate at the final follow-up was 14.7%. A statistically significant difference was determined between the preoperative and postoperative kyphosis angles ($p = 0.002$), but no significant difference was found between the postoperative kyphosis angle and the final follow-up kyphosis angle ($p = 0.608$) (Table 3).

Coronal balance measurements of the TGR group were 15.4 mm (0–30) preoperatively, 10.1 mm (0–30) postoperatively, and 9.6 mm (0–30) at the final follow-up. Statistically, the difference between the coronal balance preoperative, early postoperative, and final follow-up measurements were insignificant ($p = 0.924$) (Table 3).

In the MGR group, it was calculated as 23.9 mm (2–61) preoperatively, 24.5 mm (4–52) postoperatively, and 18.8 mm (1–55) at the final follow-up. The difference between preoperative and early postoperative measurements in coronal balance was statistically insignificant ($p = 0.903$).

The change between early postoperative and final follow-up values was not significant ($p = 0.205$) (Table 3). When the preoperative, postoperative, and final coronal balance averages were compared between the groups, with the exception of the early postoperative coronal balance values, no similarity was found between the groups. (p values of 0.200, 0.000, and 0.064, respectively) (Table 2; Fig. 3).

The mean sagittal balance measurements of the TGR group were found to be -3.3 mm (-60–60) preoperatively, -4.4 mm (-52–40) postoperatively, and -6.5 mm (-60–60) at the final follow-up. Statistically, there was no difference between preoperative–postoperative ($p = 0.819$) and postoperative-final follow-up ($p = 0.555$) values.

In the MGR group, the mean sagittal balance was measured as 19.5 mm (-60–50) in the preoperative period, 29.1 mm (5–54) postoperatively, and 27.2 mm (-10–73) at the final follow-up. Statistically, the difference between preoperative–postoperative ($p = 0.492$) and postoperative-final

**Fig. 2** Change of thoracic kyphosis angle during treatment
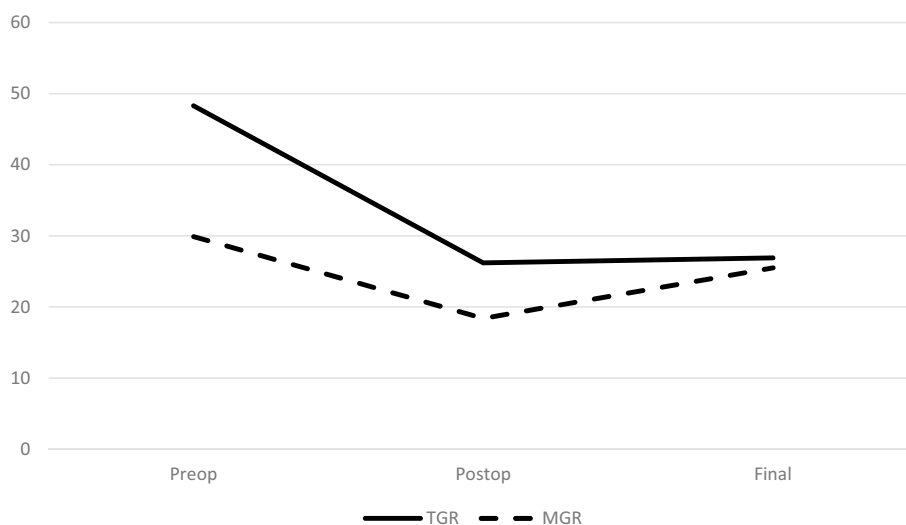
Table 2 Comparisons of the measurements of the TGR and MGR groups

	Magnetic			Traditional			p
	Mean ± SD	Min–max	Median	Mean ± SD	Min–max	Median	
Age*	7.1 ± 1.90	3.1–10.4	7.2	6.1 ± 2.81	1.3–10.9	6.1	0.199
Follow-up time*	30 ± 15	5–68	28	23.9 ± 8.0	12–40	22.5	0.131
Number of lengthenings	9.2 ± 4.9	1–19	9	3.1 ± 1.2	1–5	3	0.000
Preop. Cobb*	60.4 ± 17.8	31–91	57	51.5 ± 19.7	16–86	52	0.150
Postop. Cobb*	41.8 ± 14.6	21–79	44	21.4 ± 11.2	0–46	20	0.000
Final Cobb*	36.4 ± 11.3	15–55	36	18.1 ± 1.7	4–36	18	0.000
Preop.*	29.9 ± 17.4	9–70	25	48.3 ± 24.7	6–98	44	0.012
Postop. kyphosis	18.4 ± 11.4	3–47	15	26.2 ± 13.1	6–66	24.5	0.032
Final kyphosis*	15.5 ± 12.9	9–58	23	26.9 ± 12.7	8–60	24	0.722
Preop. T1-S1*	256 ± 35	195–330	257	261 ± 42	173–341	263	0.725
Postop. T1-S1*	274 ± 35	216–335	270	288 ± 43	198–362	290	0.284
Final T1-S1*	304 ± 44	224–394	298	309 ± 42	212–386	308	0.791
Elongation velocity*	1.06 ± 0.57	0.20–2.00	0.970	0.93 ± 0.5	0.17–2.29	0.830	0.475
Preop. K. Bal*	23.9 ± 19.9	2–61	20	15.4 ± 10.1	0–30	13	0.090
Postop. K. Bal	24.5 ± 14.4	4–52	23	10.1 ± 8.9	0–30	8	0.001
Final K. Bal	18.7 ± 16.2	1–55	12	9.6 ± 8.9	0–30	9	0.097
Preop. S. Bal	19.5 ± 26.1	−60–50	20	−3.3 ± 32	−60–60	−3	0.009
Postop. S. Bal*	29.1 ± 15.6	5–54	29	−4.4 ± 31	−52–40	−6	0.000
Final S. Bal*	27.2 ± 23.1	−10–73	25	−6.5 ± 30	−60–60	−7	0.000
Preop.	0.846 ± 0.148	0.548–1.081	0.861	0.897 ± 0.076	0.773–1.017	0.914	0.302
Postop. SAL*	0.910 ± 0.119	0.689–1.113	0.931	0.957 ± 0.058	0.842–1.066	0.961	0.155
Final SAL*	0.938 ± 0.085	0.764–1.074	0.950	0.982 ± 0.058	0.825–1.092	0.992	0.058

$p < 0.05$ indicates a statistically significant difference

*The data distribution was normal, and the Independent t test was used. The data were abnormally distributed when unmarked, and the Mann–Whitney U test was used

Fig. 3 Change of coronal balance values in the patients
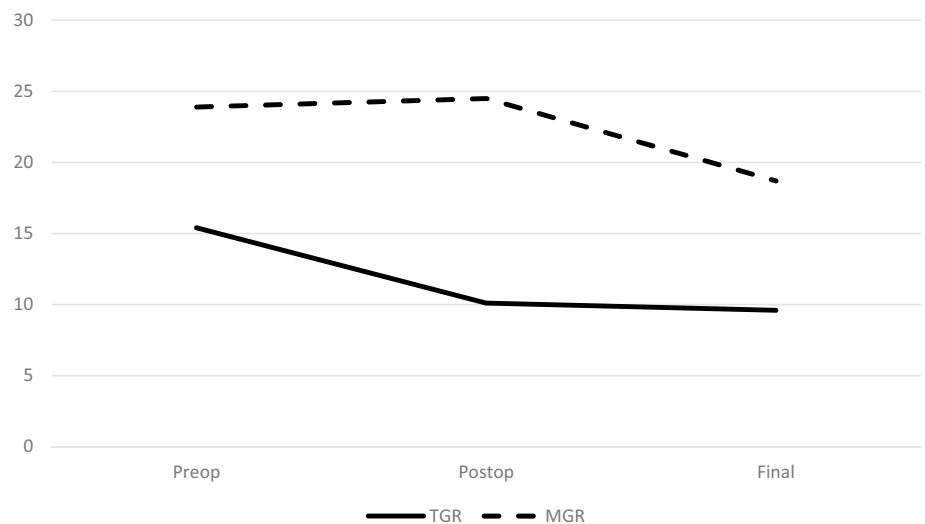
follow-up ($p = 0.962$) in sagittal balance was not significant (Table 3). When the preoperative, postoperative, and final sagittal balance average values were compared between the groups, a significant difference was found in all three categories. (p values of 0.009, 0.000, and 0.000, respectively) (Table 2; Fig. 4).

Table 3 Evaluation of the efficacy of the treatment

Pairs	Groups	p
Preop.–postop. Cobb*	TGR	0.000
	MGR	0.000
Postop-final Cobb	TGR	0.008
	MGR	0.008
Preop.–postop. Kifoz*	TGR	0.000
	MGR	0.001
Postop-final Kifoz*	TGR	0.495
	MGR	0.001
Preop.–postop. K. Bal*	TGR	0.052
	MGR	0.903
Postop-final K. Bal	TGR	0.932
	MGR	0.205
Preop.–postop. S. Bal	TGR	0.819
	MGR	0.492
Postop-final S. Bal	TGR	0.555
	MGR	0.962
Preop.–postop. T1-S1	TGR	0.000
	MGR	0.000
Postop-final T1-S1	TGR	0.000
	MGR	0.000
Preop.-final SAL	TGR	0.000
	MGR	0.004

The treatment was evaluated as effective if $p < 0.05$

*Paired samples t test was applied. Wilcoxon test was used for the rest

Spinal growth

The mean T1-S1 distance of the patients in the TRG group was found to be 261 mm (173–341) preoperatively, 288 mm (198–362) postoperatively, and 309 mm (212–386) at the final follow-up. The average increase in T1-S1 distance from preoperative to postoperative was 26.5 mm (7–59), while the increase until the final follow-up was 47.2 mm (21–85). A statistically significant difference was found between the mean T1-S1 values measured in the preoperative–postoperative-final follow-up of the patients ($p = 0.000$).

In the MRI group, the mean T1-S1 distance was measured as 257 mm (195–330) preoperatively, 274 mm (216–335) postoperatively, and 304 mm (224–394) at the final follow-up. The average increase in T1-S1 distance from preoperative to postoperative was 17.2 mm (5–55), while the increase until the final follow-up was 38 mm (8–82). In the statistical evaluation, a significant difference was found between the mean T1-S1 values measured in the preoperative–postoperative-final follow-up of the patients ($p = 0.000$). There was an average increase of 10% in T1-S1 distance after instrumentation in the TGR group, while this increase was 6.7% on average in the MGR group.

The growth rate of the patients was calculated as mm/month by dividing the difference between the final and the early postoperative measurements by the follow-up times of the patients. T1-S1 elongation rates were calculated as 1.12 cm/year (0.9318 mm/month) in the TGR group and 1.27 cm/year (1.0571 mm/month) in the MGR group. The T1-S1 segment constitutes approximately 50% of the sitting height and consists of 2/3 of the thoracic vertebrae and 1/3 of the lumbar vertebrae. It is widely known in the literature that the T1-S1 segment grows 10 cm in the first 5 years of life (2 cm/year), 10 cm between the ages of 5 and 10 years (1 cm/year), and 10 cm over the age of 10 years (1.8 cm/year) [1].

The mean age of the patients was 6.1 years in the TGR group and 7.1 years in the MGR group, and there was

Fig. 4 Change of sagittal balance values in the patients
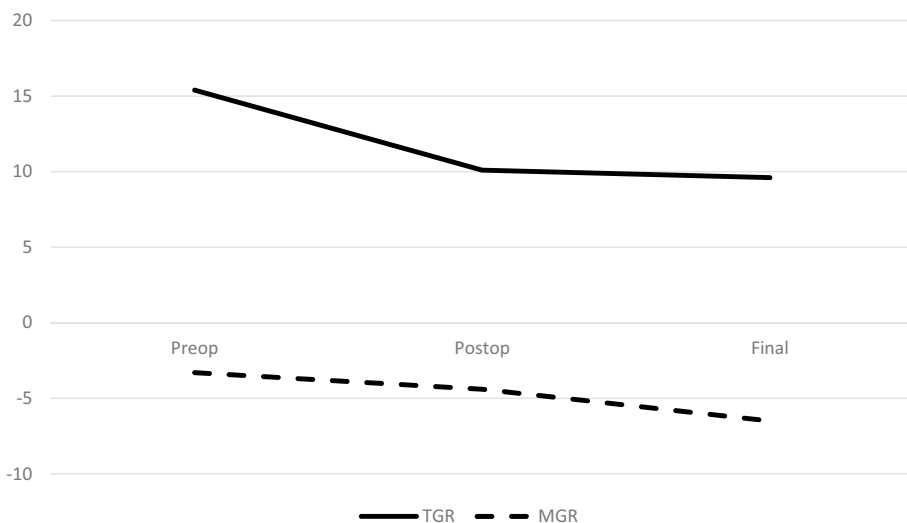
no significant difference between the groups in respect of patient age. Both groups were compared at the rate of 1 cm/year, as stated in the literature. The One-Sample t test was used, and 1 cm/year was converted to 0.84 mm/month, and results were calculated as $p = 0.136$ in the MGR group and $p = 0.408$ in the TGR group. Thus no statistically significant difference was determined between the height increase rate of the groups and the known average rate.

Correction of the thoracic cavity

The preoperative and final measured SAL index variation in the same group were evaluated with the Wilcoxon signed-rank test. The results were calculated as $p = 0.04$ in the MGR group and $p = 0.00$ in the TGR group. These values of $p < 0.05$, showed that the effect of treatment on the SAL index was statistically significant in both groups (Table 3). When the preoperative, postoperative, and final measured SAL index averages were compared between the two groups, no significant difference was determined (Table 2). These results indicate that the indices were similar between groups and successfully increased during treatment (Fig. 5).

Complications

No final fusion was performed in any patient in the TGR group. A total of 99 procedures were performed on the entire patient group, as 24 initial surgeries and 75 lengthening procedures (5 lengthenings during unplanned surgery due to complications). There were 3 wound infections and 4 implant-related complications. While two of the wound infections were resolved with antibiotic therapy alone, one was resolved with surgical debridement and antibiotic treatment.

Implant-related complications were rod breakage in 1 patient, pullout of the screw in 1 patient, rod breakage and pullout of the screw in 1 patient, and loosening of the screw cap (end cap) in 1 patient. Correction loss due to implant failure did not occur in any patient. Unplanned surgery was performed 5 times for these complications. Neurological complications did not develop in any patient. Patients underwent an average of 3.1 (1–5) lengthenings during this period.

In the MGR group, 17 initial surgeries were performed on the patients. In addition, 1 patient underwent debridement, 1 patient underwent debridement and implant extraction in the same session and the final fusion in another session. Implant replacement was performed in 5 patients. Screw revision was performed in 3 patients due to screw pullout, and magnetic rod replacement was performed in 1 patient due to rod failure in the second lengthening. In 1 patient, rod revision was performed after rod breakage in the 3rd lengthening, followed by material extraction and debridement due to skin problems and infection. Final fixation was applied in another session.

A total of 25 surgical interventions were performed. Patients underwent an average of 9.2 (1–19) lengthenings during this period. Superficial infections were treated with antibiotic treatment (Table 4).

Table 4 Comparison of complications between the groups

	TGR ($N = 24$)	MGR ($N = 17$)
Superficial infection	2 (8%)	1 (6%)
Deep infection	1 (4%)	3 (18%)
Implant failure	4 (17%)	5 (29%)
Unplanned surgery	5 (21%)	8 (47%)
Total complications	7 (29%)	9 (53%)

**Fig. 5** Change of SAL index in the patient groups
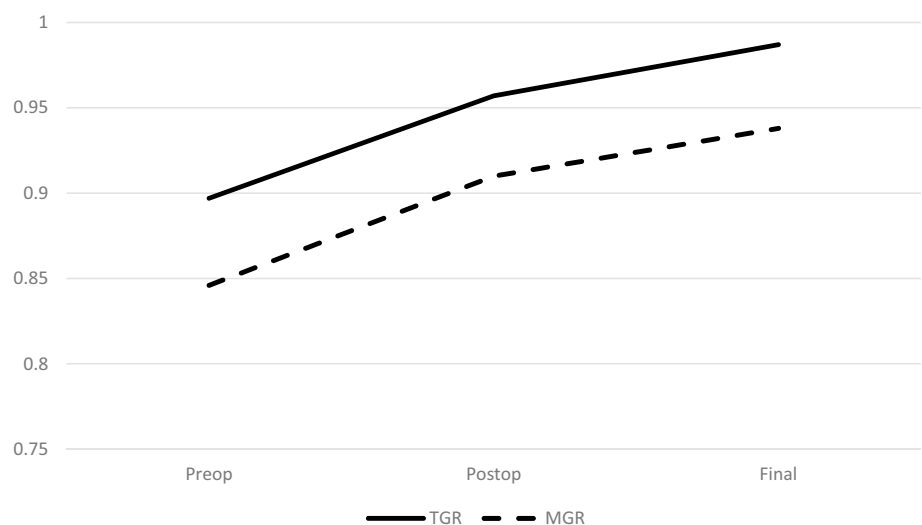
Implant placement

In both groups, braces were not used routinely in the postoperative period. However, bracing was applied to 4 patients (14.8%) in the TGR group: To 2 patients due to syndromic scoliosis (Campomelic dysplasia, Kabuki Make-Up Syndrome) after primary surgery and to 2 after revision surgery, as bone quality was poor. One of the patients was applied with a brace because of rod fracture, and the other was a revision due to the pullout of the screw. A Minerva brace was used in 1 patient, and TLSO in 3 patients. At the end of the 3 months, the brace use was terminated as no problems were observed during the follow-up. A brace was used for one patient in the MGR group postoperatively. The patient was being followed up with the diagnosis of osteogenesis imperfecta, and the brace use was discontinued after 3 months of follow-up.

In the primary instrumentation of all patients in the TGR group, only a polyaxial transpedicular screw was used. However, in 2 patients with pullout of proximal pedicle screws, the pullout pedicle screw was replaced with a hook. The most common pedicle screw application levels were T3 (34%) and T4 (33%) levels in the proximal, L3 (33%), and L4 (33%) levels in the distal. The most common screw configuration was the instrumentation of 2 segments (2 + 2) (63%) proximally and distally (Figs. 6, 7).

A polyaxial transpedicular screw was used for primary instrumentation, with the exception of 2 patients in the MGR group, where a hook was used. In 3 patients, proximal pedicle screws were replaced with hooks due to pullout. The most common pedicle screw application levels were T2 (34%) and T3 (41%) levels in the proximal, L4 (26%), and L3 (25%) levels in the distal segment. The most commonly

Fig. 6 Distribution of anchors in the thoracic vertebral segments
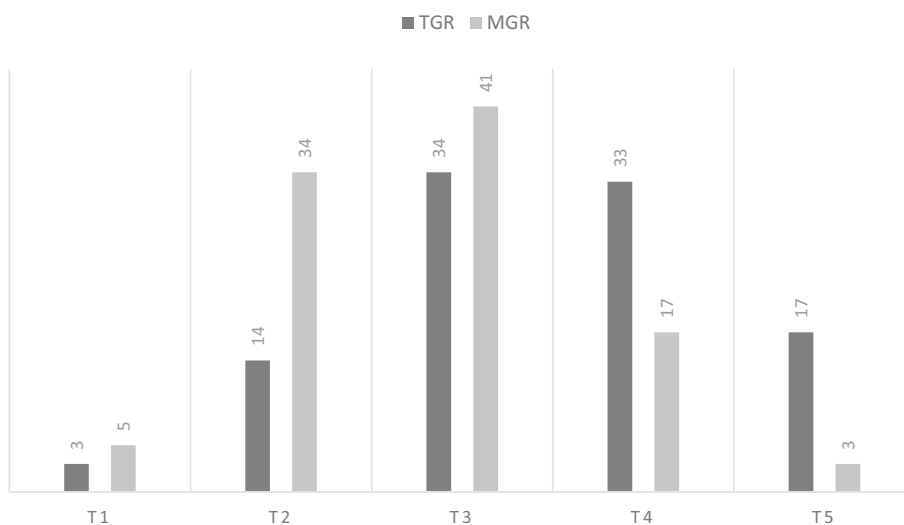
Fig. 7 Distribution of anchors in the lumbar vertebral segments
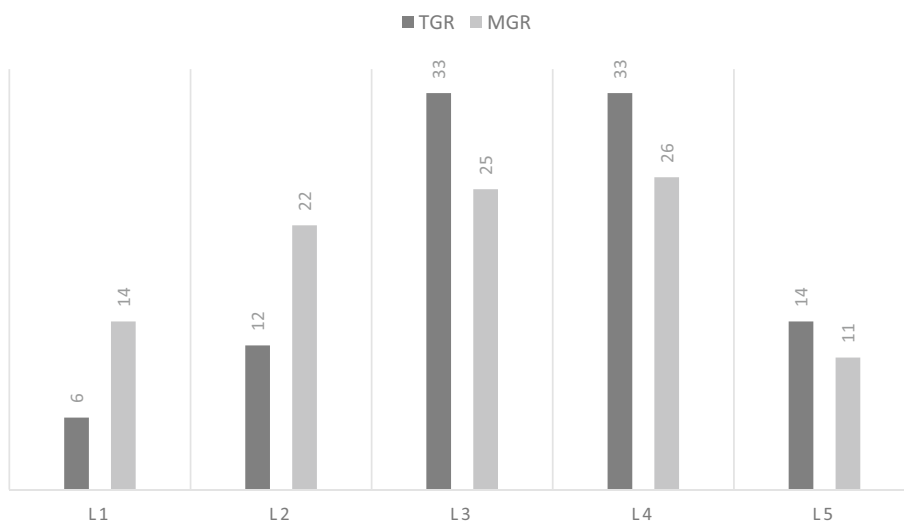
used screw configuration was the instrumentation of 2 segments (2 + 2) (64.7%) proximally and distally.

Discussion

The first study comparing magnetic controlled and traditional growing rod systems was published by Akbarnia et al. in 2013 as a case-match study with a 2-year follow-up of a cohort of 12 MGR patients. There was reported to be no significant difference between the two groups regarding major curve angle and T1-S1 distances [2].

In the current study, the TGR system was found to provide better correction in the coronal plane and was superior in kyphosis restoration than the MGR system. Cobb angles were corrected by 64.9% in the TGR cohort and 39.7% in the MGR cohort. The correction rate was similar to other studies in the MGR cohort, but was slightly higher in the TGR cohort. However, the mean preoperative kyphosis angles were higher in the TGR cohort, and the mean final kyphosis angles were similar. Consequently, both systems were seen to be prone to hypokyphosis, but the TGR was more successful in kyphosis correction.

Similarities were observed between the groups in terms of preoperative and final follow-up coronal balance values. The coronal balance values decreased with treatment in both groups, which was compatible with the literature [3, 4].

When the preoperative, postoperative, and final sagittal balance averages were compared between the groups, there was no similarity. In addition, the preop–postop and final values were not affected by the treatment. It has been shown in the literature that success in correcting the coronal balance is seen mainly in the TGR system. However, it has been reported that growing rod treatments cannot provide effective correction in the sagittal plane [4]. This problem is considered an unsatisfactory aspect of growing rod surgery [3]. Recent studies have stated that the long-term clinical and radiological results of idiopathic scoliosis surgery are severely affected by the restoration of sagittal balance and the correction in the coronal plane [5]. Therefore, new ideas and further research are needed to solve this problem.

No statistical difference was found in the T1-S1 growth rate compared to that of the healthy population. Both systems were successful in lengthening, successfully reaching the elongation rate required for the age group, and there was no difference between the elongation rates of the groups.

While applying lengthening and correction of the deformity with growing rod treatment, it is also aimed to prevent deformity and loss of chest wall function that starts to occur in the thoracic wall. Especially a restrictive deformity occurs in the hemithorax on the convex side, and it is aimed to equalize the volume and height of the two hemithoraces. Both growing rod systems effectively increased the SAL ratio, thus equalizing the hemithoraces, creating a more functional thoracic wall. When the SAL rates of the two groups were compared, no significant difference was found.

While the most common complication was found to be the pullout of the proximal anchors, this complication was more common in the magnetic rod system. A higher rate of proximal anchor pullout is thought to be due to the MGR system's hypokyphotic effect and the implant's wide actuator area. Complications other than pullout were rod breakage, magnetic rod lengthening failure, screw cap loosening, and soft tissue infection.

Strong aspects of this study were the homogeneity of the groups in terms of age, follow-up period, male–female ratio, etiological diagnosis rate, some significant preoperative values (Cobb angel, T1-S1, SAL index, coronal balance values) and the fact that all patients were operated on by the same surgeon, even in different centers, and strengthen the results. The negative aspects of the study were the retrospective, 2-centered design and that patients were not classified according to curve pattern. In a previous multicentric analysis of patients undergoing MGR surgery, 46.7% of the patients underwent unplanned surgery at 2 years of follow-up. It was also observed that the number of complications increased as the lengthening interval became shorter [6]. Another meta-analysis of 336 patients reported an average of 44.5% complications, and 33% required unplanned surgery at a mean follow-up of 29.7 months [7]. The unplanned surgery rate of 47% in the MGR cohort of the current study supports these data.

The advantage of MGR is that it reduces the length of hospitalization and eliminates the need for repeated lengthening surgeries. On the other hand, the fact that the index surgery cost of using MGR is significantly higher than TGR may make it difficult to choose [8]. In a study published in 2014, the total cost spent on TGR and MGR treatments equalized in the 3rd year of patient follow-up, and in the 4th year of TGR treatment outstripped by significant volume [9]. In another study of 44 patients, the economic burden scores and overall satisfaction in the MGR group were significantly superior to those in the TGR [10].

Its high performance and relatively low complication rates show that TGR is the most effective implant in early onset scoliosis surgery. MGR, on the other hand, is a safe and effective alternative, promising, and may become the treatment standard in the future.

Declarations

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