

A Retrospective Study on Dual Growing Rod at the End of Treatment

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Abstract

Study design: Retrospective review of patients affected by Early Onset Scoliosis (EOS), treated with dual growing rod (GR) and reached final posterior arthrodesis.

Objective: To evaluate the trend of main thoracic and kyphotic curves during treatment with GR until final fusion.

Background context: Previous studies analysed the effect of GR implantation and lengthening during treatment of patients affected by EOS. The sagittal balance has not been previously evaluated.

Methods: 52 patients affected by EOS, treated with growing implants from 2007 to 2017 at our Institution were reviewed. We considered 10 consecutive patients treated with dual mechanical GR and reached final arthrodesis. The lengthening are made every 10-12 months. The minimum follow-up was 2 years and the minimum number of lengthening was 2. Every patients were monitored with periodic anteroposterior and lateral X-Ray. Measurements of the main thoracic curve and of kyphosis were performed according to Cobb method at different stages of treatment.

Results: Both main thoracic and kyphotic curves had similar trends during treatment. The main thoracic curve improved from a mean pre-op value of 63,8° Cobb to a mean value of 39° Cobb after placement of GR. During lengthening, there was a loss of correction. After final arthrodesis, the average angle of main thoracic curve was 47,6° Cobb. The kyphosis changed from a mean pre-op angle of 62°, to a mean angle of 40,2° after the treatment with GR. The measure at the end of lengthenings was 49,9° and after the final arthrodesis the average angle of the kyphosis was 49,6° Cobb.

Conclusion: Both main thoracic and kyphotic curves show a fluctuating trend. The first implant represents the most corrective system, instead lengthening shows a partial loss of correction. The final correction obtained by definitive arthrodesis is comparable to the first correction. The main reason for this trend could be the progressive autofusion of the spine during treatment, which causes a progressive stiffness of the spine.

Keywords: Early onset; Scoliosis; Growing rod; Lengthening; Spine; Arthrodesis

Abbreviations: EOS: Early Onset Scoliosis, GI: Growing Implants, GR: Growing Rods, VEPTR: Vertical Expandable Prosthetic Titanium Rib Device

Introduction

Early Onset Scoliosis (EOS) is defined as a condition occurring in patients younger than 5 years old. The appearance of thoracic curves before this age is associated with an increased mortality rate compared to the general population because of the impairment of cardiopulmonary reserve [1]. The EOS are classified based on the etiology, the magnitude of the major curve, the kyphosis and an annual progression ratio modifier [2,3].

Severe EOS, which can no longer be controlled by conservative treatment because of their severity, requires surgical treatment. Standard method of final fusion used in older patients is less effective in very young children [4-8]. New surgical methods such as Growing Implants (GI) for the treatment of EOS gain popularity in recent years. The GI are valid systems that limit the progression of the scoliotic curve during growth and allow to reach an appropriate age to perform a definitive treatment [9,10]. The most used types of implants are the vertical expandable prosthetic titanium rib (VEPTR) device and mechanical and magnetic Growing rod (GR) implants. The VEPTR consists of a single bar and a proximal rib coupling; GR is a distraction-based system with single or dual rods, typically used in older patients.

The aim of this retrospective cohort study is to evaluate the results of final fusion with posterior arthrodesis in patients with EOS firstly treated with mechanical GR implant with dual rods.

Materials and Methods

A retrospective review of all the 52 patients affected by EOS treated with GI from 2007 to 2017 at our Institution has been performed. We excluded the patients treated with single GR, magnetic GR and VEPTR, making the group consisting only of patients treated with dual mechanical GR and finally treated with definitive arthrodesis. Inclusion criteria were a minimum of two lengthening procedures (in addition to primary implantation) and a minimum follow up of 2 years.

The clinical data collected included age at every surgeries, sex and diagnosis. The surgical data comprised total number of surgeries and lengthening, lengthening intervals and complications.

All the patients were treated with dual mechanical GR according to Akbarnia Technique [11]. All surgical procedures, both initial and final surgery and every lengthening were performed using SSEP and MEP neuromonitoring. The lengthening was made every 10-12 months. Each patient received from 2 to 6 lengthening during treatment. Every patient was monitored with antero posterior and lateral X-Ray. Main

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thoracic curve measurement was performed according to Cobb method in a anteroposterior view. The Cobb angle measurement on the lateral view has permitted to quantify the thoracic kyphosis, considering the superior endplate of T1 and the inferior endplate of T12. In few cases, in which the detection of T1 was difficult, the superior endplate of T4 has been considered.

The measurements were done at different stages of treatment: before the first surgical treatment (pre-initial), after the treatment with GR (post-initial), at the end of lengthening (pre-final), after the definitive treatment (post-final). In the cases in which we considered T4 as the superior limit of the kyphotic, we measured it in every stages of treatment. Two observers measured each radiograph independently. Descriptive statistics were used to determine means and ranges.

Results

Ten patients met our initial inclusion criteria. The baseline patient's characteristics are reposted in Table 1. The main thoracic curve improved from a mean pre-op value of 63.8° Cobb (range 83° - 53°) to a mean value of 39° Cobb after placement of GR (range 48° - 16°). During lengthening we observed a loss of correction to a mean angle of 53.8° (75°- 31°) despite lengthening procedures (pre-final). After final arthrodesis, the average angle of main thoracic curve was 47.6° Cobb (71° - 24°). The growing implant provided an average correction of 38.9% (45-27%), instead final arthrodesis provided an average correction of the main thoracic curve of 25.4% (38-18%) (Figure 1).

The kyphosis showed these changes: From a mean pre-op value of 62° (95°-31°), it reached a mean angle of 40.2° (83°-18°) after the treatment with GR. The measure at the end of lengthening was 49.9° (76° - 26°) and after the final arthrodesis, the average angle of the kyphosis was 49.6° Cobb (72° - 33°). About the kyphotic curve, the growing implant provided an average correction of 33% (12-41.9%), instead final arthrodesis provided an average correction of 17% (6-24.2%).

The definitive arthrodesis was performed with posterior instrumented technique with pedicle screws and a derotative method according to direct vertebral derotation in 9 cases [12,13]. In one case the patient developed a spontaneous arthrodesis therefore no instrumentation has been implanted.

We had seven complications: 3 single rod breakages (2 in the same patient and 1 in another one); 2 aseptic mobilization of the proximal screw; 1 proximal junctional kyphosis that needed the proximal extension of the instrumentation; 1 septic mobilization of the instrumentation developed after the planned final lengthening. In this case the GR has been removed and an antibiotic treatment has been performed. No instrumentation has been implant because of spontaneous arthrodesis. All mechanical complications have been treated during lengthening or definitive surgery.

Discussion

The EOS treatment represents a challenge for spine surgeons. Surgical treatment is indicated for progressive curves superior to 45° in an immature child [14]. In the last years GI gains popularity and actually represents the gold standard for the surgical treatment of EOS, when the definitive arthrodesis is not yet indicated. This method should be considered as a "bridge" until the definitive treatment, ensuring growth as close as possible to normal growth, decreasing the progression of deformity and preventing complications [15]. Dual GR shows a better results than single GR in terms of curve correction and trunk growth, thanks to the greater control and strength offered by dual rods

compared than a single one [16]. Our purpose was to evaluate the trend of both main thoracic scoliotic and kyphotic curve during lengthening until final arthrodesis. From the data we collected, the pattern of the main thoracic curve and the kyphosis were similar and fluctuating: we detected an improvement of both curves after the surgical treatment with GR, a progressive loss of correction despite lengthening and finally a further little improvement with the definitive treatment (Figure 2).

The first implant represents the most corrective system. During lengthening we obtain a partial loss of correction before the final fusion, as a progression of the deformity without an effective improvement from the elongations performed.

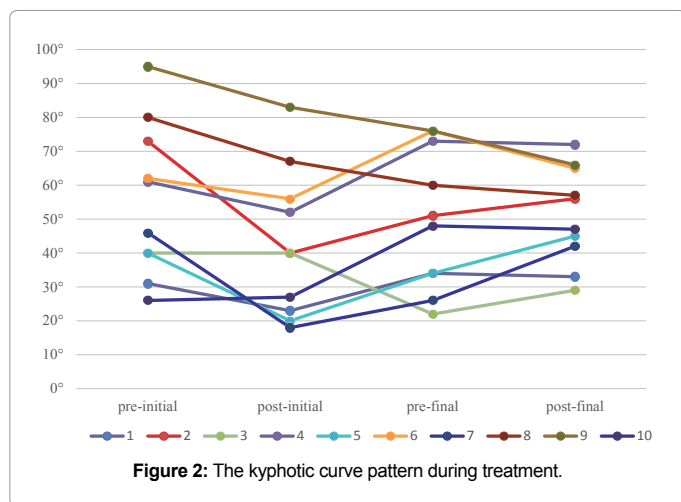
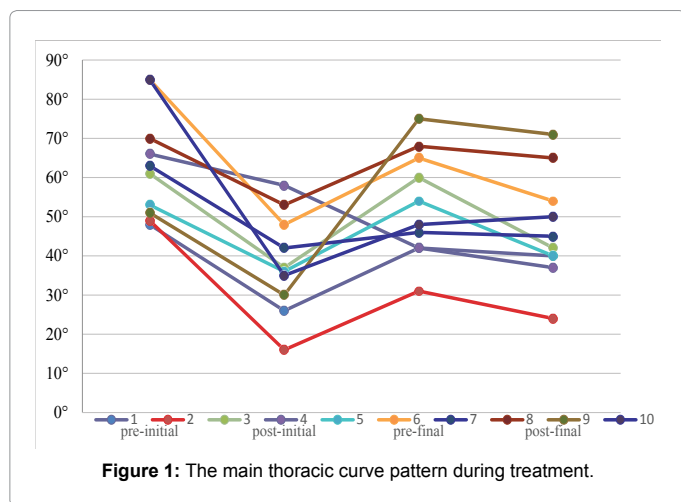
Our data confirmed the reports of Akbarnia and co-authors, that showed that variations in the main thoracic curves depended on the intervals between the elongations. They compared patients who received lengthening at intervals inferior to 6 months with patients whose lengthening interval was superior to 6 months. In the first group the curve improved over lengthening, instead in the second one it showed a fluctuating trend similar to that reported in our data [17]. Cahill and co-authors reported that auto-fusion of the spine caused by a combination of repeated surgical procedures and spontaneous bone bridging in the immobilized spine may occur in 89% of children treated with growing rod [9]. Sankar et al. explained this phenomenon reporting a progressive stiffness of the spine with repeated distractions and coining the "law of diminishing returns" [18]. With this law they described the trend of the T1S1 length which progressively decreased during elongations. In our opinion, this rule could be also valid in the description of the trend of the main thoracic curve and of the kyphotic curve when elongations are performed over 6 months.

We decided to perform the elongation every 10-12 months (mean 11) because we believe that the incidence of complications (especially infective) is lower and that a longer interval is more accepted by the patient and his family. The risk of complication increases for each additional surgery performed during the treatment. Furthermore, to undergo young children to surgical interventions every 6 months (or less) represents a considerable suffering and pain for the patient and his family, a factor that should certainly not be underestimated.

To our knowledge this is the first study that evaluates the trend of the kyphotic curve. We believe that the scoliosis is a 3D deformity and that a correct sagittal balance could significantly increase the functional outcome of the patients. The kyphotic curve showed the same trend of the scoliotic one: a great improvement after the first surgical treatment with GR, a progressive loss of correction during lengthening and finally a further little improvement with the definitive treatment. The main reason for this trend could be the progressive auto fusion of the spine during treatment, which causes a progressive stiffness of the spine. Also the minor correction of the definitive treatment in comparison with

Demographics	n=10
Male/Female	4/6
Type of GI	10 dual growing rods
Deformities aetiologies	3 idiopathic
	4 syndromic
	1 neuromuscular
	2 congenital
Mean Age at the time of first surgery	8 y, 8 m (range 6 y, 8 m – 12 y, 9 m)
Mean Age at the time of final surgery	13 y, 10 m (range 11 y, 7 m – 19 y)
Average duration of treatment	4 y, 8 m (range 2 y – 7 y, 1 m)

Table 1: The baseline patient's characteristics are reposted in this table.



the GR positioning surgery could be explained by the progressive auto fusion of the treated spine.

Limitations of this study include its retrospective nature and the small size of the cohort. Another bias is represented by the inhomogeneity of the kyphotic curve measurements on x-ray that may increase the inaccuracy of the results.

Conclusion

In conclusion, the purpose of the treatment of EOS with GI is to grant a “normal” lengthening of the spine during growth period in order to perform final surgery with lesser complications due to spine and chest growth. Our study confirms other scientific reports about treatment with GR. The GR technique is safe and effective [11]. The fluctuating trend of the curves should not preclude the family and discourage the surgeon. In recent years we are dealing an increasing number of patients with magnetic GR, which allows furthering reducing the number of surgical interventions, of complications and pain for the patient. The data in our possession are still too small to allow a proper evaluation and comparison between the various types of instruments, but we hope to have a satisfactory number of data available soon. Treatment of childhood spinal deformities is a challenge for the surgeon, for the patient and its family. The path to be taken is long and different from patient to patient.

Key points

- Treatment of early onset scoliosis with dual growing rod and lengthening >6 months shows a fluctuating trend of the main thoracic and the kyphotic curve.
- It is important to consider the kyphotic curve because scoliosis is a 3D deformity.
- The fluctuating trend of the curves should not preclude the family and discourage the surgeon.

Conflicts of Interest

None.

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