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Surgical management of early onset scoliosis using a new type of growing rods called GSP system

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Abstract
The goal of the treatment of early onset scoliosis (EOS) is to correct the deformity while allowing for spinal growth. The aim of this study was to determine the safety and effectiveness of a new type of growing rod system the growing spine profiler or GSP that may be used in single or dual technique.
From 2012 to 2016, 15 patients underwent growing rod surgery for correction of EOS as follow. 5 single and 10 dual growing rod procedures using the growing spine profiler system (GSP).
The etiology of the patients' spinal deformities were as follows idiopathic (5), congenital (4) and neuromuscular (6).
Clinical evaluation included age, sex, diagnosis, follow-up, number and frequency of lengthenings, and complications. Radiographic evaluation included changes in Cobb's angle, kyphosis, coronal and sagittal balance, space available for the lung (SAL) ratio, apical vertebral translation, shoulder and pelvic obliquity and T1-S1 height.
Overall 46 lengthening procedures were performed, the average number of lengthening procedures being 3 per patient.
The average time between two lengthening procedures was 6 (5-7) months. non-lengthening surgeries were about 30 and was done mainly to correct a complication that had happened during the course of surgical correction these surgeries include debridement for deep infection. replacement of broken rods.....etc and will be listed below
Average follow-up time was 20 months. The mean coronal Cobb angle was improved from 81.8° to 39°.
One patient underwent fusion surgery. his age was 9 years, with a follow-up of 6 months. The Cobb's angle before fusion was 100° that improved to 61°. There were about 2 complications per patient, Dual growing rods results in better deformity correction and stability of correction with an acceptable complication rate.

Keywords: surgical management, growing rods, GSP

1. Introduction
Management of early onset scoliosis (EOS) is a challenging problem. Infantile and juvenile idiopathic scoliosis, neuromuscular deformities and congenital scoliosis are grouped under EOS by Akbarnia [1]. Several treatment modalities have been described. Initial treatment, involves observation, bracing and serial casting [2-6].
The success of each type of treatment modality varies greatly according to multiple factors including pathology, cobb's angel, rigidity of the main curve and its location, associated kyphosis and patient compliance.
Surgical treatment is indicated for a congenital deformity, progressive deformity or when the other treatment modalities fail to control the deformity [7-10-18]. Correction and maintenance of a deformity requires solid fusion. This has been the standard surgical approach for a patient who has completed spinal growth. Some authors have proposed solid fusion for EOS as well. However, early fusion will affect the development of the thorax negatively and a crankshaft will probably occur at follow-up [15]. The goal of the treatment in EOS is correction of the deformity and allow spinal growth at the same time. Surgery without fusion can maintain sagittal balance and correct the deformity without impairment of spinal growth [6, 7, 9-18]. It is the most common treatment for EOS despite requiring more surgeries resulting in more surgical scars. Variable success rates have been reported. The growing rod is a common and useful technique for EOS. Several studies report the growing rod to be effective, with some advantages and complications [7-9, 11, 12, 14, 18]. We performed single and double growing rod procedures, without fusion, using a new version of the growing rod systems called the growing spine profiler or GSP that consists of pedicle screw construct caudally and a rib clamp proximally fig (1) each connected to a stainless steel rod these rods fig (2) connected by a rod connector through which lengthening is done

Fig 1: Rib Clamps

Fig 2: stainless steel rods

initially a single rib is included in the rib clamp and as our vision become clear we used to include two rib in a single larger rib clamp for better proximal anchoring point. The aim of this study was to determine the safety and effectiveness of single fig (3) and dual GSP rod techniques in terms of achieving and maintaining scoliosis correction for the growing spine and see which technique was more effective in the management of EOS.

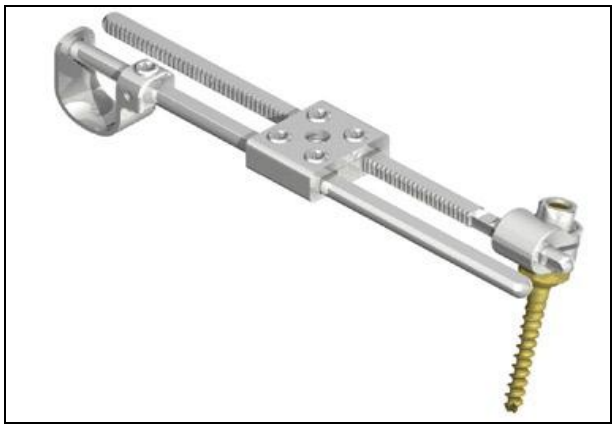

Fig 3: single GSP system

2. Materials and Methods

From 2012 to 2016, 15 patients (nine (60%) female and 6 (40%) male) Fig. (4) underwent single or dual growing rod procedures in assuit university hospital department of orthopedic and Traumatology We performed 5 single and ten dual growing rod operations

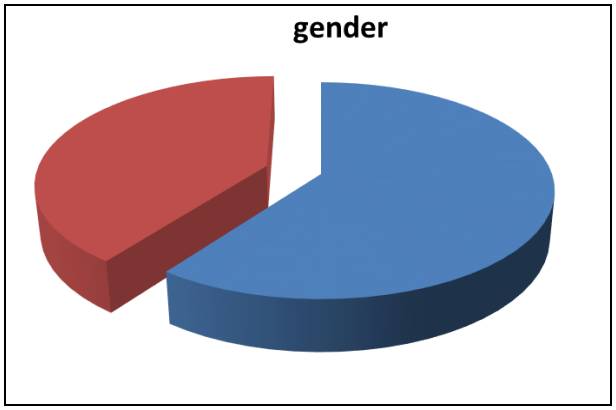

Fig 4: male to female ratio

The average age was 4.8 years for both groups. The etiology of the etiology of patient's spinal deformities were as follows four idiopathic, four congenital three neuromuscular and four neurofibromatosis scoliosis. Fig, (5)

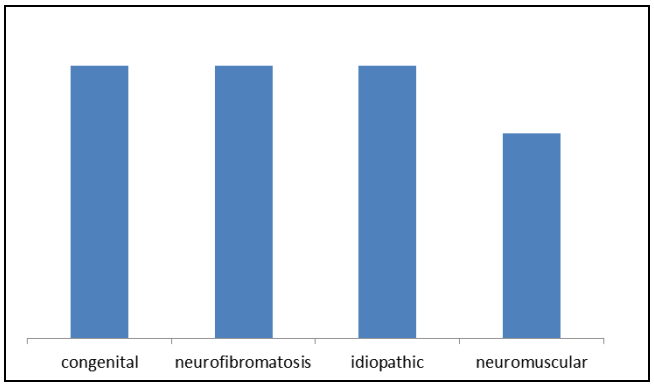

Fig 5: etiology of the deformity

Only Two patients had prior surgery for EOS. Curve types were thoracic in four, thoracolumbar in six, double major in three and lumbar in two. Standard standing AP radiographs of the spine were used to determine the end vertebrae for pedicle screw constructs. There was no difference between single or dual rod groups in the determination of the instrumentation levels. The most distally instrumented vertebra was determined according to the stable vertebra criteria. Only the concave side of the main curve was instrumented in the single rod group.

The proximal anchoring point was single rib in our early cases but soon we used to include two rib in a single large rib clamp we used to anchor the second and third rib if both are suitable. we usually use two separate incision caudal one for the pedicle screw which is inserted under fluoroscopic guidance one screw in each side of the distally instrumented vertebra that is put through a wiltse approach to minimize subperiosteal dissection and hence premature bony fusion another proximal incision is used in the midline and dissection proceeds on both sides to reach the target rib in which the rib clamp is applied. initially we used to include one rib in a small rib clamp but later on we found that it is much better to include two ribs in a single larger rib clamp. We did not use any bone graft to obtain a solid fusion at the foundation site. A stainless steel rod is anchored proximally to the rib clamp and distally to the pedicle screw and connected together in the rod to rod connector that has four locking nuts and central distraction nut were inserted through the paravertebral muscles using the Submuscular plane finally first lengthening is done at the index surgery that may obtain up to 50% correction.

Subsequent Lengthening was performed under fluoroscopy through a small incision at the connector site every six months. Clinical evaluation included age, sex, diagnosis, follow-up, number and frequency of lengthening, and complications. Postero-anterior and lateral radiography were performed initially and during the follow- up period. Radiographic measurements included changes in Cobb angle, kyphosis, frontal and sagittal balance, SAL ratio, T1-S1 height and apical vertebral translation. The data were collected before the index surgery, after the index surgery and also after each lengthening procedure also all surgical details are recorded including length of skin incision, blood loss, operative time

and complication during surgery. Patients were mobilized on the first postoperative day, with no brace or other orthosis. Only strenuous activities were restricted, allowing regular daily activities.

3. Results

Overall 46 lengthening procedures were performed, the average number of lengthening procedures being 3 per patient. The average time between two lengthening procedures was 6 (5-7) months. Average follow-up time was 20 months. L5 hemivertebrectomy was performed in one case and detethering was done in another case Overall, at the initial examination, the mean coronal Cobb angle was 81.8, the mean global kyphosis was 63° Post-operatively the Cobb angle improved to 62.5°, after the index surgery and to 58.2° after the first lengthening and to 55.2° after the second lengthening and to 53.6° after the third lengthening and to 49.1° after the fourth lengthening. Kyphosis improved from 59° preoperatively to 58.2° after the index surgery and to 56.7° after the first lengthening and to 55.1° after the second lengthening and to 54.1° after the third lengthening and to 52° after the fourth lengthening. There was no significant difference between male and female groups in the measurements of correction in the coronal plane.

Fusion surgery was performed via a posterior approach in one patient whose initial cobb's angle was 100°that improved finally to 60° with satisfactory overall coronal and sagittal balance in general correction in the coronal plane was much more than that in the sagittal plane and sever kyphosis was one of the most important causes of failure in addition to rigidity of the curve or early or premature bony fusion

4. Complications

In our series we have many complications that ranges from mild to severe but never catastrophic complications include

- superficial infection in 6 cases
- deep infection in 4 cases
- rod breakage in 6 patients
- screw pull out in 4 patients
- rib fracture in 4 patients
- premature bony fusion in 2 patients
- skin complications in 3 patients

5. Discussion

Scoliosis surgery without fusion was first described by Harrington in 1962 [16]. Harrington and Luque reported a high complication rate that included implant failure and spontaneous fusion [15, 16, 1]. The growing rod technique without fusion has been popular in treating EOS while allowing for spine growth. In the literature, dual or single growing rod instrumentation has been reported with varying rates of success [7-18]. Klemme *et al.* reported a coronal Cobb angle improvement from 67° to 47°, with a satisfactory sagittal curve management in a study of 63 patients with early onset scoliosis treated with a single growing rod. They recommended using an external support [18]. Blakemore *et al.* report that a single growing rod is useful in the managing of EOS, although it has a high complication rate [9]. Minerio *et al.* reported a 40% improvement in the measurement of the initial curve, using a single rod [11]. It appears from the literature. that a single rod is useful in the management of EOS. In our study, however, a single rod corrected the deformity early, but it did not maintain this correction and had a high complication rate, which is also consistent with the literature as metal failure was repeated so we transformed all initial single rod group to a dual rod. Akbarnia *et al.* advised a dual growing rod in the treatment of EOS [1, 7, 8]. They showed that a dual growing rod can provide better correction and maintenance of correction compared to a single rod. A dual growing rod also had a lower complication rate than a single rod [1, 19].

Minerio *et al.* and Blakemore *et al.* reported that they performed a lengthening after approximately Cobb angle increase of 20° [9, 11]. Akbarnia *et al.* recommended to perform a lengthening at 6 month intervals [1, 19]. Subsequently we adopted this protocol and started performing lengthenings at 6 month intervals on a routine basis.

The average T1-S1 length increase was reported to be 1.2 cm per year in a multicentric study [1]. rib clamp complication, rod breakage, implant prominence and skin irritation were the major complications of the growing rod techniques [7-9, 11, 12, 18, 19, 20]. Surgery without fusion has a high complication rate regardless of the surgical technique [20, 21]. We used a pedicle screw foundation to decrease the number of implant related complications. Mahar *et al.* showed in a biomechanical study that a pedicle screw construct provides better strength and stability compared to other implant constructs [22]. Some authors recommend foundation site fusion to decrease implant related complications [1, 17, 21]. We had 4 complications with pedicle screws. This seems to be an acceptable rate We had 10 implant related complications that required surgical revision. There were 2 complications per patient that seems reasonable and accepted.

6. Recommendations

The GSP system is a good choice for correcting EOS with proper patient selection. Proper surgical technique and proper follow up

7. References

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