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OUTCOMES OF DEFINITIVE SPINAL FUSION USING ALL PEDICLE SCREW FOR A BORDERLINE IMMATURE PATIENT WITH IDIOPATHIC EARLY ONSET SCOLIOSIS

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ABSTRACT

This prospective study endeavors to prove that Definitive Spinal Fusion (DSF) as a method for the management of progressive Idiopathic Early Onset Scoliosis (IEOS) in cases aged 8-11 years old represents a good option. Growth-friendly surgeries such as Growing Rods (GR) which are the trend now for the management of EOS aim to preserve spinal growth and lung development while correcting the curve, but at the expense of a high risk of complications such as loss of fixation, infection, progressive kyphosis, as well as inadvertent fusion. DSF offers better curve correction, avoids the complications associated with growth-sparing techniques, and prevents further curve progression with no more growth for the fused segments. Twenty IEOS patients with a major coronal curve angle of between 50 and 90 degrees in the age group of 8-11 years were included in this study. The mean age at the time of surgical intervention has been found to be 9.8 years, with a standard deviation (SD) of 0.8 years, encompassing a range of 8 to 11 years. A subsequent observational period spanning a duration of three years was conducted, during which pertinent data was collected. The mean age of the subjects at the conclusion of said follow-up period was determined to be 13 years, with a standard deviation of 0.8 years. The mean coronal Cobb angle demonstrated a statistically significant improvement ($p<0.001$), decreasing from an initial value of 62 ± 12 degrees prior to the surgical intervention to a final value of 14 ± 6 degrees following the procedure. The average increase in spinal and thoracic height from preoperative to last monitoring was 4.5 cm and 2.9 cm, respectively. BIDQ (Body Image Disturbance Questionnaire) score differed significantly ($p<0.001$) from a preoperative mean of 2.6± 0.7 to a postoperative mean of 1.1 ± 0.2. No unplanned surgeries were required due to complications. The primary concern in the past with earlier fusion techniques in

a skeletally immature case was the risk of loss of height increase or curve progression (either adding on or crankshaft). Using pedicle screws for definitive fusion resulted in better curve correction, adding to the height with no reported curve progression or significant complications. Therefore, the motivation for using growing rods in the age group 8-11 will decrease.

KEYWORDS: Idiopathic EOS Scoliosis, Definitive Spinal Fusion.

1. INRODUCTION

Early-onset scoliosis (EOS) denotes a pathological condition characterized by a spinal curvature that arises prior to the attainment of ten years of age, irrespective of the etiological factors involved. Within the realm of EOS, four different types exist. namely idiopathic, neuromuscular, syndromic, and congenital (1).

Children with idiopathic EOS (IEOS) who are between 8 and 11 years old pose a challenge for surgical treatment, as they are in a transition phase from growth-friendly methods to fusion methods. The growth-friendly methods have high complication rates (2), including metal failure, premature fusion, repeated surgeries, psychological stress, and the risk of repeated anesthesia on the developing brain. These complications were the motivation to conduct this study to address the argument against using growing rods in this group of patients and to advocate for definitive spinal fusion as the preferred method, as the benefits of growth-sparing methods may not outweigh the risks in some cases.

1.1. Patients and Method

The present study encompasses a cohort of twenty patients diagnosed with idiopathic early-onset scoliosis (IEOS), with ages ranging from 8 to 11 years at the moment of operation. All cases were managed by posterior spinal fusion at Al Zahra university hospital, Misr Children's Hospital for Health Insurance, and Cairo International Spine Center (CISC). Before beginning, the research has been approved by the Research and Ethical Committees at the Faculty of Medicine for Girls at Al Azhar University. The parents (or the relevant attendant) of all participants has been informed about the research's goal and gave written consent for participation.

Patients were chosen according to the following criteria:

1. Patients with idiopathic EOS.
2. Age at the time of the first presentation: from 8 years to 11 years with open triradiate cartilage.
3. Cobb's angle from 50 to 90.
4. No previous spinal surgery.

Patient's assessment: Major coronal and sagittal Curve angles, spinal and thoracic height (all radiographs were measured preoperative, ten days post-op, and three years after surgery by two pediatric spine surgeons), The SRS-22r Arabic version questionnaire and the BIDQ-S questionnaire were filled by the patients prior to their surgical intervention as a means of establishing a baseline, and subsequently at the three-year postoperative follow-up. The patients were available for clinical and radiological follow-up at regular visits (immediately post-operative: two months, six months, one year, two years, and three years, correspondingly). The same team did DSF in all cases.

Stat data analysis: The data analysis package used was SPSS version 21. Data were coded and entered on an Excel sheet and then extracted for SPSS. Qualitative information was expressed by number and percentage; quantitative information was represented by mean and standard deviation. Statistical tests were done for parametric (paired student t-test for numerical values) and non-parametric information, Fischer exact test, and chi-square test for qualitative data. Spearman correlation tests were used. The significance level was considered if p was not above 0.05.

2. RESULTS

The research comprised 20 cases (16 females and four males) with a mean age at the time of definitive fusion was 9.8 years with 0.8 standard deviations (range 8-11). All patients were riser grade 0 at surgery time (fig 1). The mean operative time was 124.00± 36 minutes, with a mean of 528 ± 268 ml intraoperative blood loss in 20 patients. No postoperative drain was used. The intrathecal morphine injection for pain relief was done for all patients. Coronal angle correction rate: mean coronal Cobb angle enhanced significantly (p under 0.001) from 62 ± 12 to 14 ± 6 after surgery. Comparison between 10 days post-operative and after three years (t=1.9, p=0.06) indicates insignificant change. Sagittal angle correction rate: A statistically insignificant change has been observed in sagittal angle pre and postoperatively p equal 0.6. Comparison between 10 days post-operative and after three years (t=0.4, p=0.6) indicates insignificant change. Spinal and thoracic height: The mean initial rise in spinal height (T1-S1) after surgery was 3.1cm. The observed arithmetic mean of the overall increase in spinal height, as measured from the preoperative baseline to the most recent follow-up, was determined to be 4.5 cm. The observed mean initial increase in thoracic height, specifically spanning from the first to the twelfth thoracic vertebrae (T1-T12), after surgical intervention, was quantified at 2.2 cm. Furthermore, the mean cumulative rise from the preoperative baseline measurement to the most recent postoperative evaluation was determined to be 2.9 cm. SRS-22r scores: Responses collected and interpreted according to the score sheet key. The

questionnaire measures five aspects. Scores range from 1 to 5, as five means best and one means worst. Total SRS-22 r significantly improved p<0.001, from a total pre-op mean of 2.8± 0.1 to a post-op mean of 4.1 ± 0.2. p under 0.001. A significant enhancement was seen in all domains. BIDQ scores: Total BIDQ scores differ significantly p<0.001, from a total pre-op mean of 2.6± 0.7 to a post-op mean of 1.1 ± 0.2. Significant changes were seen in all questions. P< 0.001 for all questions and the total score (table 1).

Table 1: Demographic and Radiographic Information: Preoperative, Post-operative, and at Last Monitoring.

Characteristics		Mean ± SD (Range)	p-value
Age (Years)	At surgery	9.80 ± 0.89 (8 – 11)	
	At last follow-up	13 ± 0.86 (11 – 14)	
Sex, Female: male		16(80.0%) : 4 (20.0%)	
Risser Preoperative	Grade 0	20 (100.0%)	
Risser, at last follow-up	Grade 0	2 (10.0%)	
	Grade 1	5 (25.0%)	
	Grade 2	7 (35.0%)	
	Grade 3	4 (20.0%)	
	Grade 4	2 (10.0%)	
Major coronal curve	Preoperative	61.65°±12.21° (50°–84°)	<0.001
	Immediate post-operative	14.05° ± 5.55° (7°- 24°)	
	At last follow-up	15.00°±5.89° (8°-26°)	
Thoracic kyphosis	Preoperative	36.72° ± 17.38° (12°-63°)	0.656
	Immediate post-operative	34.89° ± 9.65° (18°- 57°)	
	At last follow-up	34.28° ± 9.60° (18°- 55°)	
Thoracic height (mm)	Preoperative	211.80±24.70 (185-270)	<0.001**
	Ten days Post-operative	233.95±24.33 (200-290)	
	Three years Post-operative	240.05±22.82 (208-295)	
T1S1 height (mm)	Preoperative	331.25±40.67 (240-420)	<0.001**
	Ten days Post-operative	362.05±44.78 (265-430)	
	Three years Post-operative	376.90±45.80 (273-445)	

2.1. Complications

One patient showed post-operative shoulder imbalance that did not require surgery. None of the cases illustrated infection, neurological or pedicle screw-related complications, or progression of the deformity.

3. DISCUSSION

In the case of pediatric patients below the age of eight who are afflicted with progressive idiopathic early-onset scoliosis (IEOS), optimal management entails the implementation of techniques that prioritize the preservation of spinal growth. In the context of pediatric patients ranging from 8 to 11 years of age who present with IEOS, the decision-making process becomes notably intricate when contemplating the selection between growth-sparing methodologies and fusion techniques. In research carried out by Bess et al., it has been discovered that each lengthening surgery for the growing rods was associated with a notable escalation in the complication rate, amounting to a substantial 24% increase. Furthermore, the majority of the patients, surpassing the halfway mark, experienced the occurrence of at least one complication (2). A systematic review of a magnetically controlled GR reported a mean complication rate of 44.5 percent and an unplanned revision rate of thirty-three percent (3). The high rate of complications associated with growth-sparing techniques, such as metal failure, early auto fusion, psychological effects of repeated surgeries, and the risk of repeated anesthesia on the developing brain, motivated us to start this study as the complications outweighed the benefits in some cases. In the present investigation, our primary objective was to attain optimal correction while minimizing progression and mitigating the frequency of complications associated with prevailing growth-sparing methodologies, which currently stands at 44.5%. This was accomplished by implementing a novel management paradigm for patients with borderline immaturity who exhibit IEOS. All patients in this study were aged between (8-11) years and had a thoracic height of over 18 cm. Alveolar multiplication stops by the age of 8 years as proved by studies on lung development and alveolar formation. Furthermore, it is worth noting that individuals exhibiting a thoracic height exceeding 18 cm demonstrated unremarkable pulmonary function, as indicated by previous research (4). The impact of definitive fusion on the reduction of lung space has been studied before, but only in a very young demographic with an average

age of three to five years. It is, therefore, inappropriate to draw conclusions from these findings for patients who are eight years or older (5). To limit the results in a single group of patients diagnosed with EOS, researchers have chosen to focus their study on the idiopathic group. By utilizing the pedicle screw technique, the progression of deformities caused by growth is prevented, and the crankshaft phenomenon commonly seen with older implants is avoided. This leads to a decrease in the necessity for additional surgeries. Moreover, this technique results in improved correction and a reduction in the number of fusion levels required (6). In our research, we selected the highest instrumented vertebra based on the level of the shoulders, and the lowest instrumented vertebra has been chosen according to the stability of the vertebra. In our study, we chose the uppermost instrumented vertebra based on the shoulder level, and the lowest instrumented vertebra based on the stable vertebra. A mean significant coronal curve (MCC) correction of 75.7% was achieved, surpassing the mean correction rates of 44% documented in a comparative study examining the radiographic findings of the Shilla growth guidance system and conventional growing rods (7). The findings of our study align with contemporary research, which highlights the merits of implementing early definitive fusion as a means to reduce complication rates and enhance correction percentages among individuals in the age group (8-11) diagnosed with early-onset scoliosis (EOS). Pawelek et al. conducted a comparative study between SF and GR in cases with moderate idiopathic EOS. It was observed that patients diagnosed with scoliosis who underwent spinal fusion surgery exhibited superior curve correction outcomes throughout the final monitoring interval in comparison to cases who received GR then final fusion (8). Keil et al., in a comparative research between growing rods (magnetic and traditional) and early definitive fusion in juvenile EOS, reported that the median coronal curve correction rate was 37% for the GR group and 62% for the PSF group. (9)

A research by Soliman et al. examined the outcomes of early DSF in young cases (8–10 years old) with severe EOS and followed them for an average of 4.1 years. They reported that the average correction of the main coronal curve was 70.5%. (10) In research performed by Tauchi et al., a comprehensive examination was undertaken to compare the outcomes of definitive fusion and growing rods in individuals diagnosed with neurofibromatosis type 1 and early-onset dystrophic scoliosis. The findings of this investigation revealed that definitive fusion exhibited superior correction rates, amounting to 59%, as opposed to growing rods, which achieved a correction rate of 41% during the final follow-up. Furthermore, it was observed that the employment of definitive fusion necessitated a reduced number of fused segments in comparison to the employment of growing rods. In addition, the spinal height was almost equal in both groups at the last follow-up. (11) The study conducted by Xu et al. has provided compelling evidence to support the superiority of definitive fusion overgrowth-friendly surgeries in the management of long-spanning congenital scoliosis among kids within the age range of 9 to 11 years. The findings of this research indicate that definitive fusion not only yields more substantial correction but also entails a reduced incidence of complications. Moreover, it is worth noting that the growth-friendly group exhibited a comparatively greater number of fusion levels when compared to the posterior spinal fusion group. (12)

Our study showed that thoracic and spinal heights increased by 2.9 cm and 4.5 cm, respectively, during the latest follow-up. These results are consistent with recent comparative studies between early DSF and growing rods for EOS in young children, indicating slightly lower gains in thoracic and total spine height than growth-friendly techniques. Nevertheless, it is imperative to acknowledge that the utilization of growth-friendly techniques has been associated with a greater frequency of complications, suboptimal deformity correction, and an increased likelihood of requiring subsequent surgical interventions when juxtaposed with alternative approaches.

Keil et al documented that in comparison to the utilization of posterior spinal fusion (PSF) in isolation, the sequential implementation of growth rods (GR) followed by PSF has yielded a notable increase of 2.3 centimeters in thoracic height gain. However, it is important to note that this approach has also exhibited a reduction of 25% in deformity correction efficacy, accompanied by an additional occurrence of 1.2 complications and 2.2 surgical procedures per patient. Moreover, PSF alone led to an average of two centimeters of thoracic height gain, with a mean complication of 0.5 among 25 patients (9).

Soliman et al. observed a mean increase of 4.2 cm in thoracic height and 8.7 cm in spinal height at the end of the mean 4.1-year monitoring (10).

Our study demonstrated a significant improvement (P below 0.001) in the total SRS-22r score, with the highest rises in the self-image and satisfaction domains, and this was consistent with

the findings in a study by Uehara et al. (13)

3.1. Limitations

There are few patients, short-term follow-up, all patients are still immature (no Risser 5 patients at follow-up while 12 patients were Risser 0-2), and a lack of data on pulmonary function (none of the patients were evaluated with pulmonary function tests preoperatively or postoperatively). Therefore, there may be a probability of additional loss of curve correction.

4. CONCLUSION

The ideal study on this topic should contain age and gender-matched controls treated with magnetically controlled growing rods (MCGR) or traditional growing rods (TGR) for comparison purposes. But this may be challenging due to the limitations of this patient population. Definitive fusion resulted in good curve correction without significant progression, adding to the height. Therefore, we expect definitive spinal fusion to replace the motivation for using growing rods in ages 8-11.

4.1. Figure Legends:

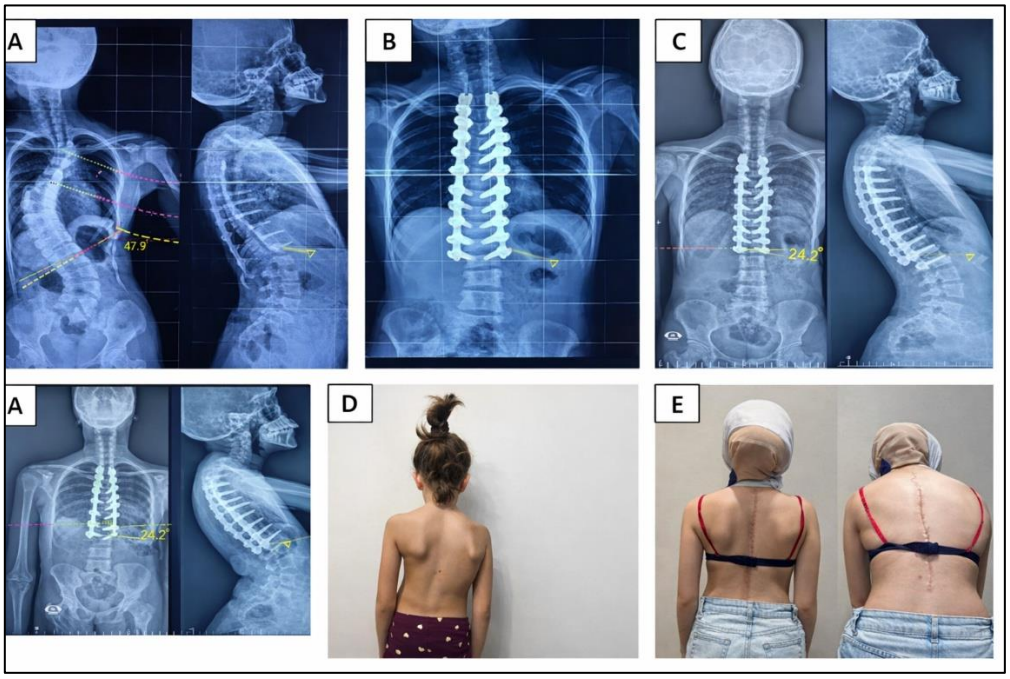

Figure 1: Whole spine radiographs and clinical images of a nine-year-old girl. A is a preoperative x-ray. B is an initial post-operative x-ray, C is a three-year follow-up x-ray, and D and E are pre- and post-operative photos, respectively. The patient's Risser stage altered from 0 to 4.

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