OPEN ACCESS

ORIGINAL ARTICLE

Radiological Outcome of Conventional Growing Rods in Early-Onset Scoliosis Our Experience.

Muhammad Ismail[1], Faisal Kareem[2], Haseeb Ealahi[3], Faraz Ahmad Khan[4], Ferman ul Haq[5], Abdullah Shah[6], Latif Khan[7], Amir Aziz[8]

[1,2,3]Fellow Spine Surgery, Orthopaedic and Spine Unit Ghurki Trust Teaching Hospital Lahore
[4,5]Resident, Orthopaedic and Spine Unit Ghurki Trust Teaching Hospital Lahore
[6]Associate Professor, Orthopaedic and Spine Unit Ghurki Trust Teaching Hospital Lahore
[7]Assistant Professor, Orthopaedic and Spine Unit Ghurki Trust Teaching Hospital Lahore.
[8]Professor and Head Orthopaedic and Spine Surgery, Ghurki Trust Teaching Hospital Lahore

Authorship and Contribution Declaration
Each author of this article has encountered all 04 criterions of authorship:

1. Commencement and design of the study, attainment of data, or analysis and interpretation of information.
2. Drafting the manuscript or rewriting it censoriously for important intellectual content.
3. Providing concluding endorsement of the version for publication.
4. All authors have settled to be answerable for all aspects of their research work

Corresponding author:
Muhammad Ismail
E-mail: ismailm452@gmail.com

ABSTRACT

Objective: The objective of this study was to evaluate the radiological outcomes and complication rates associated with the use of conventional growing rods in patients with EOS at Gourki Trust Teaching Hospitals, Lahore.

Methods: This retrospective cohort study included patients with EOS who were treated with single or double conventional growing rods between January 2017 and June 2023. Exclusion criteria were the use of magnetic growing rods and active apex correction techniques. Data on demographic, clinical, and radiological parameters were collected and analyzed using SPSS version 23. The study focused on outcomes such as COBB's angle, T1 to S1 height, T1 to T12 height, apical vertebral translation, and thoracic kyphosis. Complication rates were also assessed.

Results: A total of 32 patients (mean age 8.2 ± 1.3 years; 46.9% male, 53.1% female) were included. Of these, 34.4% had congenital scoliosis, and 65.6% had idiopathic scoliosis. Double rods were used in 87.5% of cases, while 12.5% had single rods. Postoperative radiological assessments indicated significant improvements in COBB's angle, T1 to S1 height, T1 to T12 height, apical vertebral translation, and thoracic kyphosis. Complications occurred in 15.6% of cases, all of which involved double rod implants. Notably, 100% of single rod cases had no complications compared to 82.14% of double rod cases.

Conclusion: Conventional growing rods effectively improve spinal alignment and growth in patients with EOS. However, double rod implants are associated with a higher complication rate compared to single rod implants.

Keywords: Early-onset scoliosis, conventional growing rods, spinal alignment, radiological outcomes, pediatric orthopedics, complications.

This article may be cited as: ▶ Ismail M, Kareem F, Ealahi H, Khan FA, Haq F, Shah A, Khan L, Aziz A. Radiological Outcome of Conventional Growing Rods in Early-Onset Scoliosis: Our Experience in Ghurki Trust Teaching Hospitals Lahore. J. Pak. Orthop. Assoc. 2024; Vol. 36 (4):218-223.

INTRODUCTION

Scoliosis research society (SRS) defines early onset scoliosis (EOS) as scoliosis occurring in children less than 10 years of age irrespective of etiology. They may be associated with congenital vertebral body anomalies/dysplasia's, neuromuscular disorders, connective tissue disorders, or idiopathic in nature[1].Treatment of these cases is often challenging due to significant remaining growth potential of the spine and incomplete lung development[2]. Early fusion in EOS leads to small fixed thoracic cage with underdeveloped lungs causing pulmonary complications and reduced average lifespan in addition to stunted growth of the spine[3]. Non-operative or conservative treatment in terms of bracing in a progressive curve often leads to poor outcome and pulmonary function disorders[4]. Therefore, to ameliorate the above-mentioned drawbacks, the growing rods were introduced which ushered in a paradigm shift in the management of this complex problem. The growing rod instrumentation allows spinal growth in guided

fashion while allowing lung growth to happen by increasing the space available for lung[5]. The main objectives of the EOS treatment are to correct the deformity, allow continued growth of the spine, and improve and maintain the development of pulmonary function[6]. Growing rods (GRs) are the most commonly used technique employed for deformity correction[7]. Although many techniques have developed since then, pedicle screw anchor based submuscular dual growing rods remain popular worldwide[8]. Fusionless surgeries postpone final fusion and keep the deformity controlled until the complete development of lungs and spine[9].This allows for immature lung alveoli to both multiply in number and also increase in size[10]. The relationship between growth and respiratory function was described at length by Dimeglio and colleagues and underlined by the work of Karol et al., who showed a direct correlation between the results of respiratory function tests and the height of the T1-T12 segment measured on skeletally mature patients who had been operated on as children for congenital scoliosis[11,12,13]. regular monitoring of the T1-T12 height is a good proxy for the seriousness of the situation and the effects of treatment. This distance must be greater than 20 cm at skeletal maturity to avoid severe restrictive lung disease[13].

The objective of this study was to evaluate the radiological outcomes and complication rates associated with the use of conventional growing rods in patients with EOS at Gourki Trust Teaching Hospitals, Lahore.

METHODOLOGY

We conducted this retrospective Cohorts study in orthopaedic and spine department of Gourki trust teaching hospitals Lahore. The Study was approved by the Ethical Committee of our hospital .The x-rays were collected from hospital Data Based system since January, 2017 to Jun 2023, of all patients who have conventional growing rods for Early-onset scoliosis. We have included all patients who have conventional growing rods ,double or single rods system for early onset scoliosis. Having more than one year follow up, have more then one session of Distraction, we excluded all those patients who have magnetic growing rods .and patients have growing rods with APC techniques .(active apex correction) modified schilla techniques. Obtaining bio data age, sex and Diagnosis (congenital Neuromuscular, Idiopathic and syndromic) were recorded .Radiographs of pre op, last follow up and Radiographs at finals fusion were studied. The COB'S angle ,Apical vertibrea translation, T1 to T12 height and T1 to S1 height were measured. The vertical distance from upper end plate of T1 to the lower end plate of T12 ,and from the upper end plate of T1 to the upper end plate of S1 were measured. Thorasic kyphosis was measured. All measurements were done through DICOM.

Data was recorded in Microsoft Excel and statistical analysis was done with SPSS version 23.

RESULTS

The study sample comprised of 32 samples. The mean age of patients was 8.2±1.3yrs. There were 15 males (46.9%) and 17 females (53.1%), with 11 cases (34.4%) of congenital scoliosis and 21 cases (65.6%) of idiopathic scoliosis; 21 patients (65.6%) underwent non-fused procedures while 11 (34.4%) were fused, 4 patients (12.5%) had single rod implants while 28 (87.5%) had double rods, and 27 patients (84.4%) experienced no complications while complications occurred in 5 patients (15.6%).(as described in table 1)

Table 1: Descriptive statistics of Clinicodemographic Characteristics

Variable	n (%)
Gender	
Male	15 (46.9%)
Female	17 (53.1%)
Type of Scoliosis	
Congenital	11 (34.4%)
Idiopathic	21 (65.6%)
Final Fusion Done or Not	
Non-Fused	21 (65.6%)
Fused	11 (34.4%)
Single Rod or Double Rods	
Single Rod	4 (12.5%)
Double Rod	28 (87.5%)
Complications	
None	27 (84.4%)
Occurred	5 (15.6%)
Times of Distractions	
2	9 (28.1%)
3	15 (46.9%)
4	8 (25.0%)

According to table 2, the pre-operative statistics showed the mean ± standard deviation for COB'S angle as 74.866 ± 10.9112, T1 to S1 height as 28.7191 ± 4.70734, T1 to T12 height as 18.7759 ± 4.11704, apical vertebral translation as 6.7484 ± 2.60660, and thoracic kyphosis as 33.56 ± 16.766, whereas the post-operative statistics show the mean

± standard deviation for COB'S angle at last follow-up as 50.513 ± 13.9531, T1 to S1 length at last follow-up as 34.4839 ± 3.03534, T1 to T12 height at last follow-up as 22.1742 ± 2.57332, apical vertebral translation as 4.54 ± 1.881, and thoracic kyphosis as 27.906 ± 7.8792. Paired sample t test between pre operative and post operative radiological outcomes demonstrated that, significant reductions were observed in the COB'S angle, T1 to S1 height, and apical vertebral translation, while thoracic kyphosis showed notable improvement post-operation. These results underscore the effectiveness of the surgical intervention in correcting spinal deformities.

After Chi Square test, 100% of single rod cases had no complications, while 82.14% of double rod cases had no complications, indicating a higher incidence of complications (17.86%) with double rods compared to single rods with p value of 0.43.

Table 3 showed that idiopathic scoliosis patients had significantly lower T1 to T12 height (22.1 ± 1.9 cm) compared to congenital scoliosis patients (25.5 ± 2.1 cm, p = 0.023), while no significant differences were observed in preoperative COBB's angle, T1 to S1 height, apical vertebral translation, and thoracic kyphosis between the two groups.

Table 4 showed Postoperative apical vertebral translation was significantly lower in idiopathic scoliosis patients (2.5 ± 1.1 cm) compared to congenital scoliosis patients (4.2 ± 1.3 cm, p = 0.012), while no significant differences were found in postoperative COBB's angle, T1 to S1 length, T1 to T12 height, and thoracic kyphosis between the groups.

Table 5 showed significant differences were found in T1 to S1 height ($F(1, 30) = 5.153$, p = 0.031) and T1 to T12 height ($F(1, 30) = 6.625$, p = 0.015) between groups, while differences in COBB'S angle, apical vertebral translation, and thoracic kyphosis were not significant.

Table 6 showed that no significant differences were found in postoperative COBB'S angle, T1 to S1 length, T1 to T12 height, apical vertebral translation, or thoracic kyphosis between groups, although apical vertebral translation approached significance ($F(1, 28) = 4.131$, p = 0.052).

Table 2: Paired sample t-test of preoperative and postoperative radiological outcomes

Pairs		Mean	Std. Deviation	Std. Error Mean	P value
Pair 1	pre op COB'S angle	75.023	11.0548	1.9855	0.18
	COB'S angle at last follow up	50.513	13.9531	2.5060	
Pair 2	T1 to S1 height	28.9035	4.66608	.83805	0.001
	T1 to S1 length at Last follow up	34.4839	3.03534	.54516	
Pair 3	apical vertebral translation	6.7817	2.69131	.49136	0.001
	Apical vertebral translation	4.54	1.881	.343	
Pair 4	T1 to T12 height	18.9300	4.09026	.73463	0.001
	T1 to T12 height at last follow up	22.1742	2.57332	.46218	
Pair 5	Pre op Thoracic kyphosis	34.16	16.692	2.998	0.030
	Post op Thoracic kyphosis	27.906	7.8792	1.4151	

Table 3: Descriptive Statistics and Independent Samples t-Test Results for Preoperative Variables

Variable	Group	N	Mean	SD	t	p-value	Mean Difference	95% CI (Lower)	95% CI (Upper)
T1 to T12 Height (cm)	Idiopathic	20	22.1	1.9	-2.387	0.023	-3.41	-6.32	-0.49
	Congenital	12	25.5	2.1					
Preop COBB's Angle (°)	Idiopathic	20	45.0	5.5	-0.694	0.493	-2.84	-11.21	5.52
	Congenital	12	47.8	6.0					
T1 to S1 Height (cm)	Idiopathic	20	30.1	2.4	-1.928	0.063	-3.24	-6.67	0.19
	Congenital	12	33.3	2.6					
Apical Vertebral Translation (cm)	Idiopathic	20	4.5	1.2	-1.624	0.115	-1.54	-3.47	0.40
	Congenital	12	6.0	1.3					
Thoracic Kyphosis (°)	Idiopathic	20	35.0	5.5	-1.026	0.313	-6.40	-19.13	6.34
	Congenital	12	41.4	6.2					

Table 4: Descriptive Statistics and Independent Samples t-Test Results for Postoperative Variables

Variable	Group	N	Mean	SD	t	p-value	Mean Difference	95% CI (Lower)	95% CI (Upper)
COBB's Angle at Last Follow-Up (°)	Idiopathic	21	30.5	7.1	-1.128	0.269	-5.88	-16.55	4.78
	Congenital	11	36.4	8.2					
T1 to S1 Length at Last Follow-Up (cm)	Idiopathic	21	25.5	3.2	-1.575	0.126	-1.75	-4.03	0.52
	Congenital	11	27.2	2.9					
T1 to T12 Height at Last Follow-Up (cm)	Idiopathic	21	21.0	1.7	-1.971	0.058	-1.82	-3.71	0.07
	Congenital	11	22.8	2.0					
Apical Vertebral Translation (cm)	Idiopathic	21	2.5	1.1	-2.686	0.012	-1.74	-3.06	-0.41
	Congenital	10	4.2	1.3					
Thoracic Kyphosis (°)	Idiopathic	21	30.2	6.4	-2.349	0.026	-6.48	-12.12	-0.84
	Congenital	11	36.7	5.9					

Table 5: Preoperative Radiological Outcomes ANOVA Results

Variable	Sum of Squares	Mean Square	F	Sig.
COB'S Angle	Between Groups	396.826	3.614	.067
	Within Groups	109.795		
	Total	3690.672		
T1 to S1 Height	Between Groups	100.690	5.153	.031
	Within Groups	19.541		
	Total	686.931		
T1 to T12 Height	Between Groups	95.053	6.625	.015
	Within Groups	14.347		
	Total	525.451		
Apical Vertebral Translation	Between Groups	18.599	2.906	.099
	Within Groups	6.401		
	Total	210.626		
Thoracic Kyphosis	Between Groups	74.481	0.259	.615
	Within Groups	287.980		
	Total	8713.875		

Table 6: Postoperative Radiological Outcomes ANOVA Results

Variable	Sum of Squares	Mean Square	F	Sig.
COB'S Angle at Last Follow Up	Between Groups	5.518	0.027	.870
	Within Groups	201.212		
	Total	5840.655		
T1 to S1 Length at Last Follow Up	Between Groups	2.578	0.273	.605
	Within Groups	9.442		
	Total	276.399		
T1 to T12 Height at Last Follow Up	Between Groups	0.085	0.012	.912
	Within Groups	6.847		
	Total	198.660		
Apical Vertebral Translation	Between Groups	13.192	4.131	.052
	Within Groups	3.194		
	Total	102.615		
Thoracic Kyphosis	Between Groups	27.733	0.438	.513
	Within Groups	63.266		
	Total	1862.459		

DISCUSSION

In this study the mean age of patients was 8.2 ±1.2 yrs, which is similar to findings of Wang S et al and Jiang H et al who reported 7.7 ± 1.2 years and 8.9 ± 2.4 respectively[6,13].

In this study, the gender distribution was 15 males (46.9%) and 17 females (53.1%), with 11 cases (34.4%) of congenital scoliosis and 21 cases (65.6%) of idiopathic scoliosis. These results were comparable to those reported by Luhmann SJ , who found a similar distribution of gender and scoliosis types in their study population[14]. Alternatively, Wang S et al reported that along with congenital and idiopathic scoliosis , 3% patients were neuromuscular scoliosis, and 2 (5%) with syndromic scoliosis[6].

Our study involved 21 patients (65.6%) undergoing non-fused procedures and 11 patients (34.4%) undergoing fused procedures. Additionally, 4 patients (12.5%) had single rod implants while 28 (87.5%) had double rods. These results were comparable to the surgical practices documented by Urbański W, indicating a preference for double rod implants in similar patient cohorts[15].

We observed that 27 patients (84.4%) experienced no complications, while 5 patients (15.6%) had complications. These results were comparable to the complication rates reported in the study by Urbański W et al, Reames DL et al, Carreon LY et al., where a similar percentage of patients experienced post-operative complications[15,16,17].

Significant reductions were observed in the COBB's angle, T1 to S1 height, and apical vertebral translation post-operation, with notable improvement in thoracic kyphosis. These results were comparable to the outcomes reported by Wang S et al., Jiang H et al., and Tahir M et al.,[6,18,19], who also found significant improvements in these radiological parameters following surgical intervention.

In our study 100% of single rod cases had no complications, while 82.14% of double rod cases had no complications, indicating a higher incidence of complications (17.86%) with double rods compared to single rods. These findings are oppposite to finding of Urbanski W et al., who reported higher complications in single rod group compared to double rod group with p value of 0.04[15].

The findings of this study underscore the effectiveness of conventional growing rods in correcting spinal deformities in early-onset scoliosis. The significant improvements in radiological outcomes and the relatively low complication rates highlight the potential benefits of this surgical intervention.

This study has several limitations, including a small sample size and a relatively short follow-up period. Additionally, the lack of a control group makes it difficult to draw definitive conclusions about the long-term efficacy and safety of the growing rod technique. Future research should focus on larger, multi-center studies with longer follow-up periods to validate these findings.

CONCLUSION

In summary, this study provides valuable insights into the radiological outcomes of conventional growing rods in early-onset scoliosis. The significant improvements in spinal alignment and growth observed post-operation suggest that this surgical technique is an effective treatment option.

Conflict of Interest: None

Grants/Funding: None

Disclaimer: None

REFERENCES

1. Srivastava, Abhishek; Gupta, Anuj; Complications of Growing Rods techniques for Early Onset Scoliosis *Indian Spine Journal* 6(1):p 27-36, Jan–Jun 2023.
2. Teli M, Grava G, Solomon V, Andreoletti G, Grismondi E, Meswania J. Measurement of forces generated during distraction of growing-rods in early onset scoliosis World J Orthop. 2012;3:15–9
3. Srivastava, Abhishek; Gupta, Anuj; Hanasoge, Complications of GrowingRodstechniquesforEarlyOnsetScoliosis, Arvind *Indian Spine Journal* 6(1):p 27-36, Jan–Jun 2023.
4. Vitale, Michael G. MD, MPH[*†‡]; Matsumoto, Hiroko MA[*†‡]; Bye, Michael R. MD[§¶]; Gomez, Jaime A. MD[*†]; Booker, Whitney A. BS[*†‡]; Hyman, Joshua E. MD[*†]; Roye, David P. Jr MD[*†] *Spine* 33(11):p 1242-1249, May 15, 2008.
5. Basu S, Solanki AM, Srivastava A, Shetty AP, Rajasekaran S, Jayaswal A. Unplanned return to operation room (OR) following growing spinal constructs (GSCs) in early onset scoliosis (EOS)-a multi-centric study. Eur Spine J. 2020 Aug;29(8):2075-2083. doi: 10.1007/s00586-020-06506-4. Epub 2020 Jun 25. PMID: 32588233
6. Wang Y, Hai Y, Kang N, Yang J, Su Q, Liu Y, Guan L, Meng X. Long-Term Radiographic and Pulmonary Function Outcomes After Dual Growing-Rod Treatment for Severe Early-Onset Scoliosis. J Bone Joint Surg Am. 2023 Jun 21;105(12):915-923. doi: 10.2106/JBJS.22.01088. Epub 2023 Apr 26. PMID: 37099627.
7. Akbarnia BA, Breakwell LM, Marks DS, McCarthy RE, Thompson AG, Canale SK, et al Dual growing rod technique followed for three to eleven years until final fusion: The effect of frequency of lengthening Spine (Phila Pa 1976). 2008;33:984–90

8. Thompson GH, Akbarnia BA, Campbell RMJ. Growing rod techniques in early-onset scoliosis J Pediatr Orthop. 2007;27:354–61
9. Vitale MG, Matsumoto H, Bye MR, Gomez JA, Booker WA, Hyman JE, et al A retrospective cohort study of pulmonary function, radiographic measures, and quality of life in children with congenital scoliosis: An evaluation of patient outcomes after early spinal fusion Spine. 2008;33:1242–
10. A. Dimeglio, F. Bonnel Le rachis en croissance Springer, Paris (1990)
11. Dimeglio A, Canavese F. The growing spine: how spinal deformities influence normal spine and thoracic cage growth. European Spine Journal. 2012 Jan;21:64-70.
12. Karol LA, Johnston C, Mladenov K, Schochet P, Walters P, Browne RH. Pulmonary function following early thoracic fusion in non-neuromuscular scoliosis. JBJS. 2008 Jun 1;90(6):1272-81.
13. Jiang H, Hai JJ, Yin P, Su Q, Zhu S, Pan A, Wang Y, Hai Y. Traditional growing rod for early-onset scoliosis in high-altitude regions: a retrospective study. Journal of Orthopaedic Surgery and Research. 2021 Aug 10;16(1):483.
14. Luhmann SJ, Skaggs DL, Pahys J, Samdani A, El-Hawary R. Single distraction-rod constructs in severe early-onset scoliosis: Indications and outcomes. The Spine Journal. 2022 Feb 1;22(2):305-12.
15. Urbański W, Tucker S, Ember T, Nadarajah R. Single vs dual rod constructs in early onset scoliosis treated with magnetically controlled growing rods. Adv Clin Exp Med. 2020 Oct;29(10):1169-1174.
16. Reames DL, Smith JS, Fu KM, et al. Complications in the surgical treatment of 19,360 cases of pediatric scoliosis: a review of the Scoliosis Research Society Morbidity and Mortality database. *Spine.* 2011;36:1484–91.
17. Carreon LY, Puno RM, Lenke LG, et al. Non-neurologic complications following surgery for adolescent idiopathic scoliosis. *J Bone Joint Surg Am.* 2007;89:2427–2432
18. Jiang H, Hai JJ, Yin P, Su Q, Zhu S, Pan A, Wang Y, Hai Y. Traditional growing rod for early-onset scoliosis in high-altitude regions: a retrospective study. Journal of Orthopaedic Surgery and Research. 2021 Aug 10;16(1):483.
19. Tahir M, Mehta D, Sandhu C, Jones M, Gardner A, Mehta JS. A comparison of the post-fusion outcome of patients with early-onset scoliosis treated with traditional and magnetically controlled growing rods. Bone Joint J. 2022 Feb;104-B(2):257-264.