Life After Graduation: No Final Fusion is a Viable Path for Early Onset Scoliosis Patients Regardless of Implant Type

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INTRODUCTION: Growth-friendly instrumentation has enabled the management of early onset scoliosis (EOS) while delaying surgical fusion, the traditional endpoint of treatment. However, emerging evidence suggests that definitive fusion may be unnecessary in EOS patients with satisfactory alignment at skeletal maturity. There is still limited evidence describing long-term clinical and radiographic outcomes in EOS patients who did not undergo final fusion. This study evaluates long-term outcomes in EOS patients without final fusion and compares outcomes across different types of growth-friendly instrumentation, including vertical expandable prosthetic titanium ribs (VEPTR), MAGnetic Expansion Control (MAGEC) rods, Shilla, and traditional growing rods (TGR). We hypothesized that EOS patients treated without definitive fusion would have satisfactory correction with few complications at final follow-up, regardless of implant type.

METHODS: Using a multi-center EOS database, we retrospectively identified four cohorts of patients treated with growth-friendly instrumentation who graduated without final fusion or implant removal: MAGEC (n=14), TGR (n=94), Shilla (n=10), and VEPTR (n=78). Graduation was defined by cessation of lengthening for MAGEC, TGR, and VEPTR patients and by age sixteen for Shilla patients. Demographics, major curve Cobb angle, trunk height, and post-graduation complication rates were compared across cohorts using chi-square or Fisher-Freeman-Halton tests for categorical variables and ANOVA or Kruskal-Wallis tests for continuous variables. Post-hoc pairwise comparisons for complication rates were performed using Fisher's exact test. For MAGEC, TGR, and VEPTR patients, within-cohort comparisons of Cobb angle and trunk height between graduation and final follow-up were performed using t-tests. Radiographic measurements at graduation were unavailable for Shilla patients. Statistical significance was set at $p < 0.05$ for all analyses.

RESULTS:

Characteristics of EOS patients meeting inclusion criteria are available in **Table 1**. Across all patients, the mean duration of post graduation follow-up was 4.8 years. By instrumentation type, mean post-graduation follow-up was 2.9 years for MAGEC, 5.1 years for TGR, 2.5 years for Shilla, and 4.6 years for VEPTR patients. There were no significant within-cohort differences in major curve Cobb angle ($p = 0.963$, 0.134, 0.432) or trunk height ($p = 0.880$, 0.690, 0.334) between graduation and final follow-up for MAGEC, TGR, and VEPTR patients, respectively. There were also no significant differences in the percent change in Cobb angle ($p = 0.331$) or trunk height ($p = 0.168$) from graduation to final follow-up across cohorts. Post-graduation complication rates were low across all implant types, with no instances of revision or implant migration reported **(Table 2)**. A significant difference in anchor prominence rates was observed between cohorts ($p = 0.005$), driven by a single MAGEC rod patient (7.1%). However, post-hoc pairwise comparisons did not reach statistical significance for any complication.

DISCUSSION AND CONCLUSION: This is the first study comparing long term outcomes of EOS patients treated without definitive surgical fusion by implant type. At mean follow-up of 4.8 years after graduation, all implant types demonstrated satisfactory results. There were few complications and little curve progression after graduation in each assessed cohort, suggesting that avoidance of final fusion is a viable pathway for select EOS patients (i.e. those with satisfactory deformity control at maturity) regardless of implant type. Continued follow-up with larger sample sizes, particularly in patients treated with MAGEC rods or Shilla, is necessary to validate these findings.

	MAGEC Cohort n = 14	TGR Cohort n = 94	Shilla Cohort n = 10	VEPTR Cohort n = 78	p-value
Age at Initiation of Growing-Rod Treatment; years ± SD	8.6 ± 1.9	6.6 ± 2.7	8.6 ± 3.8	6.5 ± 3.5	**0.028**
Years Between Initial Procedure and Final Follow-up; mean ± SD	6.3 ± 1.4	11.0 ± 3.1	9.5 ± 3.6	11.2 ± 3.9	**<0.001**
Years Between Graduation and Final Follow-up; mean ± SD	2.9 ± 1.6	5.1 ± 2.6	2.5 ± 1.6	4.6 ± 2.9	**0.002**
Curve Magnitude (deg); mean ± SD					
Initial	84.7 ± 20.7	74.7 ± 22.6	64.2 ± 15.3	72.3 ± 20.5	0.117
Graduation	57.7 ± 16.8	46.5 ± 18.5	-	62.8 ± 20.2	**<0.001**
Final	58.1 ± 25.5	51.3 ± 21.4	40.6 ± 12.2	65.6 ± 23.0	**<0.001**
% Curve Correction From Initial to Final; median ± SD	28.5% ± 27.5%	27.9% ± 31.3%	31.1% ± 21.4%	8.5% ± 50.0%	**<0.001**
% Curve Progression from Graduation to Final; median ± SD	0.0% ± 47.8%	14.1% ± 43.9%	-	4.0% ± 29.9%	0.331
Trunk Height (cm); mean ± SD					
Initial	27.1 ± 4.6	24.4 ± 4.9	29.8 ± 5.0	24.5 ± 5.1	**0.021**
Graduation	33.7 ± 5.6	34.8 ± 5.8	-	32.0 ± 5.8	**0.013**
Final	34.1 ± 5.8	34.4 ± 6.4	36.1 ± 4.2	30.9 ± 5.8	**0.008**
% Trunk Height Increase From Initial To Final; mean ± SD	30.1% ± 23.2%	42.8% ± 25.8%	24.1% ± 16.9%	30.1% ± 23.9%	**0.014**
% Trunk Height Change from Graduation to Final; mean ± SD	7.5% ± 9.3%	0.5% ± 12.2%	-	-0.9% ± 10.0%	0.168

Table 1. Characteristics of 196 Patients with Early-Onset Scoliosis Treated with Growing Rods Without Final Fusion.

Post-Graduation Complications	MAGEC Cohort n = 14	TGR Cohort n = 94	Shilla Cohort n = 10	VEPTR Cohort n = 78	p-value
Overall Implant Related Complications; n(%)	1 (7.1%)	6 (6.4%)	0 (0.0%)	2 (2.6%)	0.550
Rod Breakage	0 (0.0%)	5 (5.3%)	0 (0.0%)	2 (2.6%)	0.582
Implant Migration	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Screw Failure, Rupture, or Displacement	0 (0.0%)	1 (1.1%)	0 (0.0%)	0 (0.0%)	0.779
Anchor Prominence	1 (7.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	**0.005**
Deep Wound Infection; n (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (1.3%)	0.6775
Revision; n (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-

Table 2. Post-Graduation Complications in 196 Patients with Early-Onset Scoliosis Treated with Growing Rods Without Final Fusion.