# Crankshaft Phenomenon After Definitive Spine Fusion in Pre-Teens: Should We Be Concerned with Pedicle Screw Constructs?

Jake Goldfarb, Eshan Shriniwas Sane, Christian E Wright, Nicholas Speller, Ling Chen, Simon Tang, Keith H Bridwell, Blake K Montgomery

INTRODUCTION: As disillusionment with growing constructs increases, many surgeons are opting for delaying surgical intervention with growing rods and leaning towards earlier definitive spinal fusion. However, early spinal fusion can have consequences due to remaining growth, one being the crankshaft phenomenon. This occurs when the anterior spine continues to grow after posterior spinal fusion, resulting in increased rotation and curve progression. This project aims to further understand the impact of early fusion by exploring the crankshaft phenomenon and modern pedicle screw characteristics.

METHODS: A retrospective analysis was conducted of idiopathic scoliosis patients aged ≤12 treated with posterior spinal fusion. Inclusion criteria were a diagnosis of idiopathic scoliosis, thoracic fusion, and ≥ 2 years of follow-up. The thoracic curve magnitude was measured at pre-operative, first post-operative follow-up, and final follow-up, with the crankshaft phenomenon defined as a change in ≥ 10°. The rib vertebral angle difference (RVAD) was assessed as a component of crankshaft and was measured at first and final follow-up. Patient-Reported Outcomes Measurement Information (PROMIS) scores, screw density, and screw length were recorded. Student's paired t-test and linear regression were used with significance set at $p < 0.05$.

RESULTS:

33 patients met the inclusion criteria, with a mean age of 12.1 (range 10.3– 12.9) and mean follow-up of 3.3 years (range 2.0 - 6.1). 23 patients (70%) were Risser 0, and 11 patients (33%) had open triradiate cartilages. The mean preoperative thoracic curve was 63.8° ± 16.3. The mean fusion construct density was 1.6, with a periapical density 1.4. 93.9% of the screws reached the anterior 50% of the vertebral body (zone 3 or 4). The thoracic curve did not significantly increase from first to final follow-up (20.2° ± 9.1 first follow-up vs 19.5° ± 7.8 at final follow-up, $p = 0.42$). Only one patient experienced thoracic curve increase over 10°. The RVAD was only slightly larger at final follow-up compared to first follow up (mean difference of 4°, standard deviation (SD) 1.4°, $p < 0.01$). There was no significant association between RVAD and self-image which was measured by PROMIS peer relations. No patients underwent anterior release.

DISCUSSION AND CONCLUSION:

Posterior spinal fusions in idiopathic scoliosis patients aged 10-12 may experience minimal crankshaft exhibited by worsening rib rotation, but the rates are low. Surgeons may council families about these anticipated changes preoperatively, with reassurance that there is no difference in outcome measures.

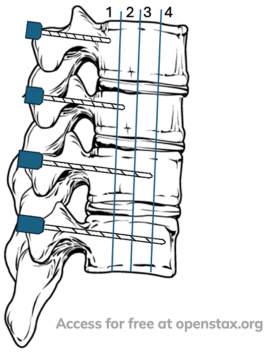


**Figure 1.** Depiction of the methodology for obtaining screw length scores. The vertebral body was divided into quartiles on the standing lateral radiograph, (0-25% of vertebral body length = 1, 25-50% of vertebral body length = 2, 50-75% of vertebral body length = 3, 75-100% of vertebral body length = 4).

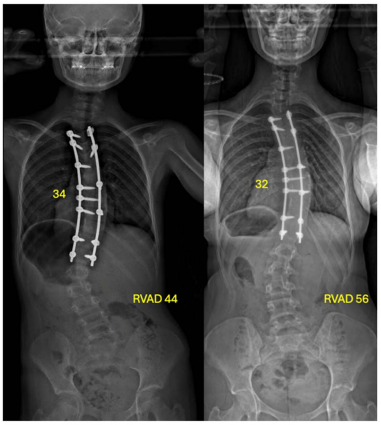


**Figure 2.** PA Whole Spine Radiograph of 12F Risser 0/closing triradiate cartilages who underwent posterior spinal fusion. A) First post-operative follow-up with thoracic curve of 34° and RVAD of 44°. B) Six-year post-operative follow-up with thoracic curve of 32° and RVAD of 56°.

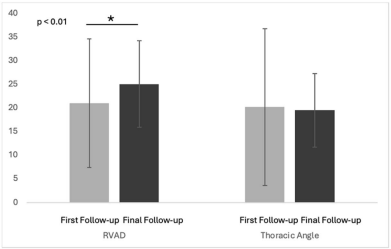


**Figure 3.** Change in Rib Vertebral Angle Difference (RVAD) and Thoracic angle from first to final follow-up.