INTRODUCTION:
The treatment of early onset scoliosis with posterior hook constructs and fusion is often complicated by the crankshaft phenomenon, which is the gradual increase in rotational deformity due to continued anterior growth in the presence of a solid posterior fusion. The combination of a posterior hook construct and an anterior fusion is considered the gold standard for prevention of the crankshaft phenomenon.

It has been hypothesized however, that a pedicle screw fixation alone can provide similar results in torsional rigidity to posterior hooks with anterior fusion. If this holds to be true, it would provide a simple one step procedure to correct a patient’s scoliotic curve and prevent the crankshaft phenomenon. Additionally, it is well recognized that the deformity in idiopathic scoliosis has an important torsional component. Although early results suggested hook constructs could correct the torsional component and sustain it, more recent data has refuted this. Clinical data suggests pedicle screws allow for improved correction of the torsional component, however, there is little biomechanical data to support this.

In this study torsional rigidity of scoliotic constructs were tested in two phases. The first phase was to validate the claim that the pedicle screw fixation provides as much stiffness, if not more, than anterior fusion coupled with the hook fixation. Cross-connectors were then added to both fixation constructs at T4-T5 and T10-T11 to determine if they provide any significant additional rigidity. The second phase of this study looked at the screw construct and the consequence of having a pedicle screw on one side compared to both sides of T7, the usual apex of a scoliotic curve. Clinical data demonstrates the pedicle screw construct provides more torsional stiffness than with two screws and no cross-connectors (p=0.0019).

METHODS:
Cadaver spines from T4-T11 were used in this study; five for phase one and six for phase two. Each spine was potted at T4 and T11 with the distal end being held in an angle vise to accommodate for the natural curvature of the spine. A 20 N compression force was maintained in load control, while a torque of +/- 2 N-m was applied sinusoidally at 0.25 Hz.

In phase one, each spine was initially tested intact, then with the hook fixation construct, followed by the pedicle screw fixation construct; both constructs were tested with and without cross-connectors. Subsequently, both fixation constructs were tested after fusing T6-T9; again with and without cross-connectors.

In phase two, only the pedicle screw construct was used, and each spine was tested with one screw at T7 and then with two screws at T7; both times with and without cross-connectors. Figure 1 shows a diagram of all the fixation constructs.

RESULTS:
In phase one, our hypothesis was validated with results showing a significant increase of 58.52% in torsional stiffness with the pedicle screw fixation over the anterior hook construct, both without cross-connectors (p=0.0170). The addition of cross-connectors to the fusion and hooks construct increased its by 8.56% though it was found not to be significant (p=0.1179). The pedicle screw construct without cross-connectors also had a significantly greater stiffness of 54.64% over the anterior fusion and hooks construct with cross-connectors (p=0.0199). When cross-connectors were applied to both constructs, the pedicle screw construct again showed an increase in torsional stiffness over the fusion and hook construct by 61.64% (p=0.0234).

DISCUSSION:
Through this study we were able to obtain biomechanical data that demonstrates the pedicle screw construct provides more torsional rigidity than the former “gold standard” of anterior fusion and hooks. This seems to reinforce the premise that pedicle screws have purchase across all three columns of the spine, passing closer to the center of vertebral rotation, thus providing better torsional rigidity. These findings, having important clinical implications, support the use of pedicle screws and posterior fusion for treating early onset scoliosis and preventing the crankshaft phenomenon. A single posterior procedure theoretically would decrease morbidity of young patients, decrease overall costs, and improve outcomes. Additionally, pedicle screws can maintain rotational correction better than hooks, which is considered essential both from a functional and cosmetic perspective.

This study also confirmed that the placement of one or two screws at T7, the usual apex of a scoliotic curve, had no significant effect on overall torsional rigidity. Our findings are reassuring for clinical scenarios that can sometimes occur when one of the pedicles is considered too small or dysplastic to be instrumented or after failed pedicle screw placement. Also, the addition of cross-connectors was found to play a major role in increasing torsional rigidity. Cross-connectors limit the relative vertical shearing motion of each long rod, which thus causes limited torsional movement, endorsing the use of cross connectors to prevent crankshaft and to maintain rotational correction in idiopathic scoliosis.

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