Biomechanical Comparison of Rigid vs. Semi-rigid Rods in Spinal Fusion Constructs: A Finite Element Study
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Introduction: While fusion success rate has been reported to be as high as 95%, we have learned from rigid fixation systems that either screw or rod breakage or screw loosening is observed if no fusion is achieved. It is therefore hypothesized that the use of semi-rigid rods may increase the load on the anterior column, promoting fusion while protecting the instrumentation from failure by reducing the screw-bone loading. The purpose of this study was to evaluate the load sharing characteristics, the screw-bone loading and the segment stabilization using rigid vs. semi rigid rods in spinal fusion constructs.

Methods: A three-dimensional ligamentous L1-S1 FE-Model with muscles load was used in this study. The FE-Model was validated based on in-vivo data. Fusion constructs were simulated by PLIF or PLF approach with posterior instrumentation at L4-L5 (Fig 1.) Pure moment of ±7.5 Nm was applied in flexion/extension, axial rotation and lateral bending. The ROM, load sharing and screw loading were determined at the index level for the following modalities:
- Intact (control)
- instable (L4 laminectomy with 25% medial facetectomy)
- PLIF cages at L4-L5 with 5.5mm PEEK(semi-rigid) and titanium(rigid) rod instrumentation
- PLF with 5.5mm PEEK and titanium rod instrumentation

Results: The ROM results are shown in Fig 2. Decompression produced more flexible segment, while implantation of either titanium or PEEK rod systems stabilized the segment equally.
Load Sharing - Under 400N upper thoracic load, 335 N was transferred through the anterior column support and 68 N through the semi-rigid rod. The corresponding load sharing for the rigid rod was 300 N and 104 N respectively. The semi-rigid rod shifted 10% of the upper thoracic load from the posterior to anterior, thus reducing loading on the posterior instrumentation by approximately 34% compared to the rigid rod.

Bone-Screw Loading - The screw bending moment for the semi-rigid rod construct was 0.3 Nm for both flexion and extension. The corresponding load for rigid rod construct were 1.0 Nm and 0.4 Nm. The bending moment acting on the bone-screw interface is reduced by 70% and 25% in flexion and extension respectively when compared to titanium rod.

Conclusions: These results show that there is no difference between rigid and semi-rigid rods for stabilization in spine in fusion construct. However, the semi-rigid has an advantage by shifting the load from posterior instrumentation to anterior column support thus promoting fusion in accordance to Wolff's law, while reducing loads on the bone screw interface. Thereby may be ideal for fusion in the aging spine and poor osteoporotic bone quality.