Biomechanical Evaluation of Lateral-Access Anterior Instrumentation for Thoracolumbar Instability

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Introduction: The optimal surgical approach to the treatment of thoracolumbar (TL) junction instability resulting from fracture and/or neoplasm remains controversial. An anterior approach is useful in certain clinical scenarios. Expandable implants with an apophyseal footprint designed for delivery via a lateral approach are now widely available. No prior study has evaluated the biomechanical profile of constructs utilizing these implants to treat thoracolumbar instability.

Purpose: The purpose of this study was to compare the fixation strengths and biomechanical properties of five different fixation techniques all with anterior cage placement. The variables were number of pedicle screws/rods, with or without transverse plate.

Methods: Ten grossly and radiographically normal fresh-frozen human cadaveric spine segments T12-L2 were thawed and stripped of the paraspinal muscles, leaving the facet joints, capsules, and interspinous ligaments intact. An L1 corpectomy model was then created by resecting the L1 vertebral body and adjacent intervertebral discs.

Each construct configuration was cyclically loaded at a frequency of 0.25 hertz to 5 Newton-meters in flexion-extension in a non-destructive manner using a servohydraulic testing machine. Once a steady state was obtained, the load/displacement curve was recorded. Displacement measurements were made during loading using brackets with three retroreflective markers fixed to the vertebral body of T12 and L2. Total displacement was measured as the vector sum of displacement in the axial, coronal, and sagittal planes in millimeters (mm). A 400 N follower preload was employed to simulate the stabilizing forces produced by paraspinal musculature.

The initial construct was composed of a Nuvasive X-core expandable cage + two 6 mm SpheRx polyaxial pedicle screws with 5.5 mm Ti rods + one Nuvasive traverse lateral plate (2RPC) (Figure 1). One of the rods was removed for the second construct leaving the ipsilateral rod, the cage and the lateral plate (1RPC). The third construct removed the remaining rod leaving the cage and plate (PC). The fourth construct was with the two rods repositioned and the lateral plate removed (2RC). The fifth construct was with one ipsilateral rod and the cage (1RC).

Figure 1 - 2RPC construct

Differences between the five groups were statistically compared by ANOVA with Bonferroni correction for multiple comparisons. Structural stiffness in flexion/extension and vertical translation were evaluated.

Figure 1 – 2RPC construct

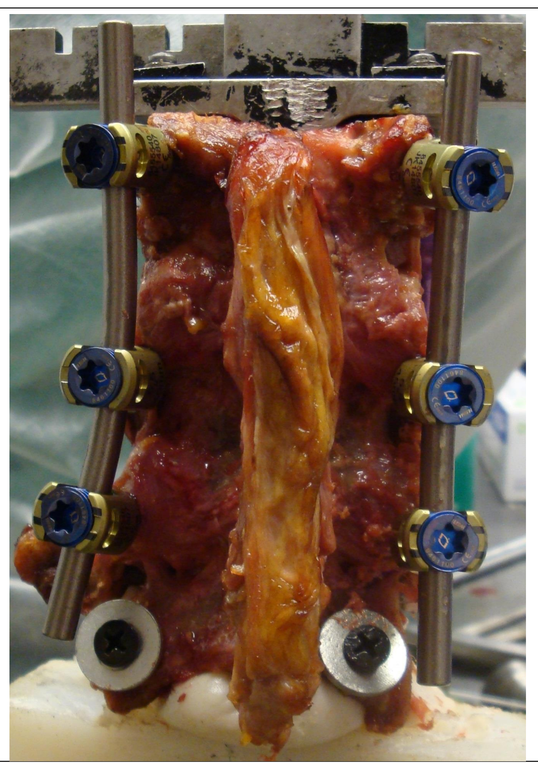

Figure 2 – 2RPC construct, posterior view

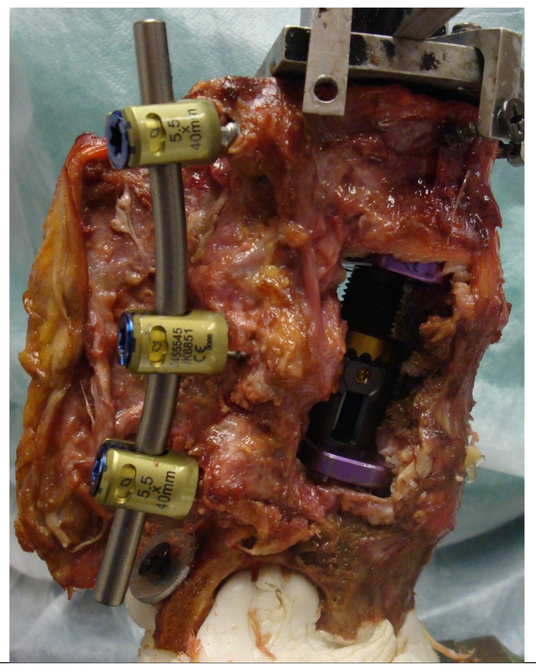

Figure 3 – 2RPC construct, lateral view

Results: The 2RPC construct exhibited the least total displacement under load of all constructs. The average total displacement observed for the 2RPC construct was 1.0 ± 0.4 mm, followed by 1.4 ± 0.4 mm, 1.8 ± 1.0 mm, and 1.5 ± 1.1 mm for the 2RC, 1RC, and PC constructs, respectively (Figure 2). A significant difference in total displacement was observed when comparing the 2RPC and 1RC groups (1.0 ± 0.4 mm vs. 1.8 ± 1.0 mm, $p = 0.04$). The removal of the plate from the initial construct (2RC) increased the overall translation by 66% and reduced the stiffness by 3%. The removal of the contralateral rod and the plate (1RC) from the initial construct resulted in the greatest increase in translation, 107% and reduction in stiffness, 25%.

Results … continued
Replacing the plate with the one rod (1RPC) connected resulted in an overall increase of translation of only 16% and reduction of stiffness by 8%. Removing the remaining rod (PC) resulted in a 56% increase in overall translation but the greatest reduction in stiffness, 29%.

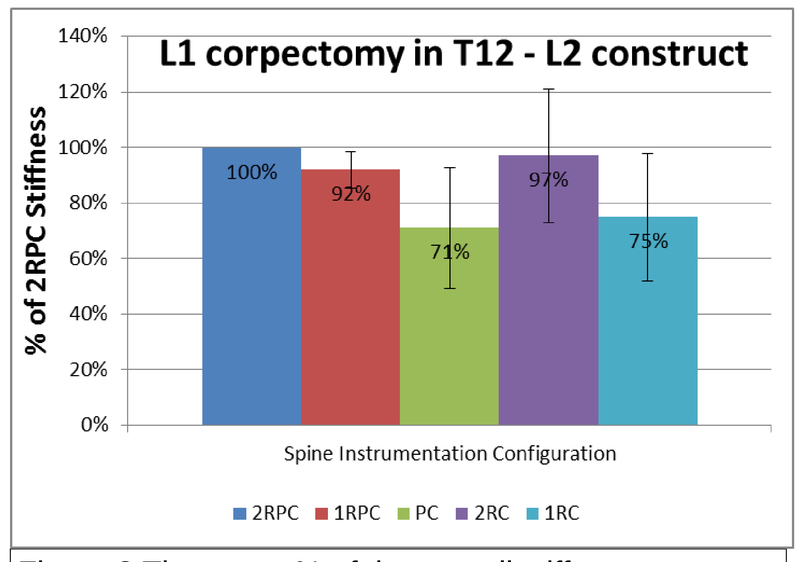

Figure 2 The mean % of the overall stiffness measured for each parameter compared with to the stiffest construct - 4 pedicle screws/2 rods + anterior cage + transverse plate.

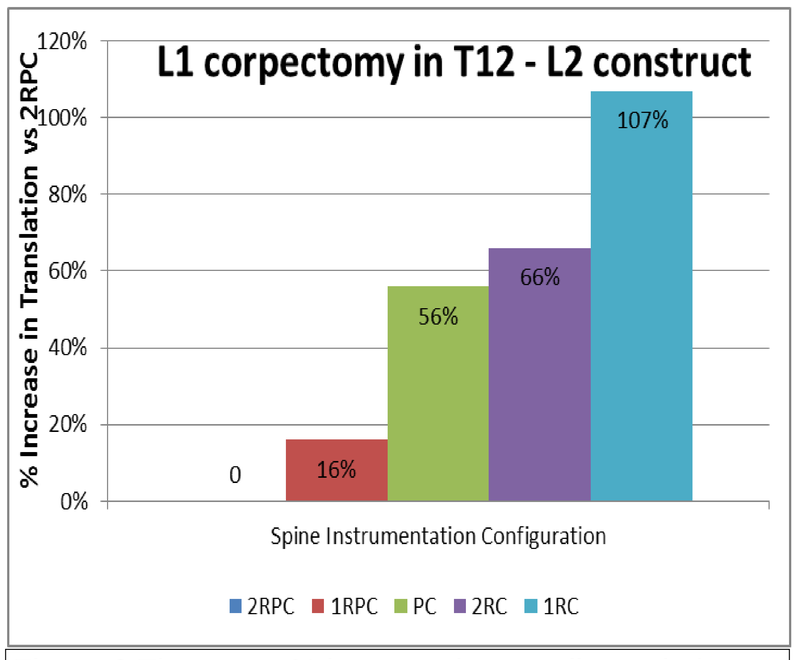

Figure 3 The mean % increase in overall translation measured for each parameter compared to the construct with the least overall translation - 4 pedicle screws/2 rods + anterior cage + transverse plate.

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Discussion & Conclusions: Use of a lateral plate appears to offer gains in construct stability comparable to that of bilateral pedicle screw fixation. While sample size prevented all construct comparisons from achieving statistical significance, the 2RPC construct allowed least motion, with 2RC, 1RC, & PC constructs allowing sequentially more displacement. A 1RC construct allowed statistically more motion than a 2RPC construct in an L1 corpectomy model. Surgeons treating TL instability with an expandable cage and unilateral posterior fixation may wish to consider a more stable construct.

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