Biomechanical Analysis of Short Segment Fixation in an Unstable Thoracolumbar Flexion-Distraction Injury Model: 6-Screw Construct with and without Facet Compression

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PURPOSE:

Flexion-distraction injuries (FDI) typically result in compression failure of the anterior column and tension failure of the posterior column, most commonly with a combination of both osseous and ligamentous involvement. Unstable injuries with disruption of the posterior ligamentous complex (PLC) are best managed with posterior fusion, however, the length and type of construct is debatable. Furthermore, there have been no biomechanical studies evaluating these constructs in a FDI cadaveric model.

Prior biomechanical studies at our institution evaluating 4 vs. 6-screw constructs in a compression fracture model have already demonstrated the superior construct rigidity with the added fixation level. This study aims to describe for the first time in the known English literature the biomechanical effects of 6-screw constructs with and without facet compression in a cadaveric L1 FDI model.

METHODS:

Seven fresh human cadaver spines from T12 to L2 were used for testing. A compression fracture with loss of at least 50% height was produced at L1. The PLC was transected with a scalpel. The specimens were instrumented from T12 to L2 with 6 mm pedicle screws connected to 5.5 mm titanium rods.

Selspot LED emitters were fixed to T12 and L2 to measure the 3 D movements. From those measures, 6 DOF of motion, and relative movement between T 12 and L2 could be calculated. Uniaxial strain gages were bonded to the open segment of the rods between T12 and L1, and also between L1 and L2, to monitor longitudinal strain. A 200 N follower preload was employed to simulate the stabilizing forces produced by paraspinal musculature. Specimens were cyclically loaded from 5 N·m extension to 5 N·m flexion and then ±5 N·m in axial rotation, well within their elastic range. The differences caused by locking the facet joints were statistically compared by paired Student's t-test.

Two conditions were tested: 1) 6-screw construct without compression (unlocked facets) and 2) 6-screw construct with compression between T12-L1 and L1-L2 (locked facets). Structural stiffness in flexion and extension, rod strain, vertical translation and sagittal rotation were all evaluated.

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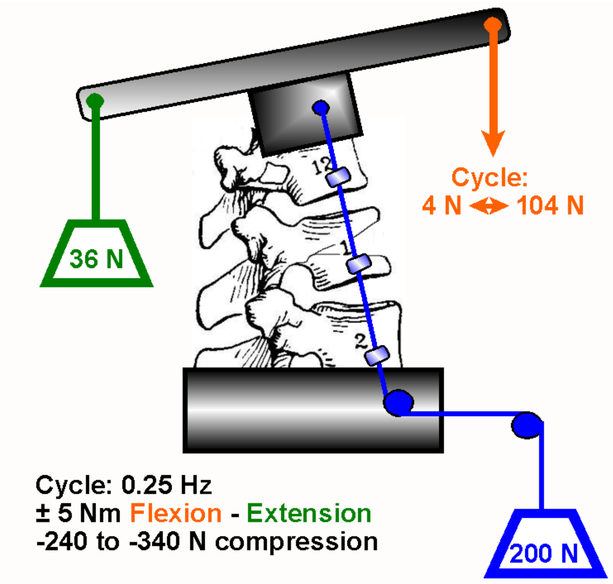

Figure 1 – Each spine was mounted at the proper anatomic angle. Follower and extension preloads were applied, then the spine was cycled in flexion – extension.

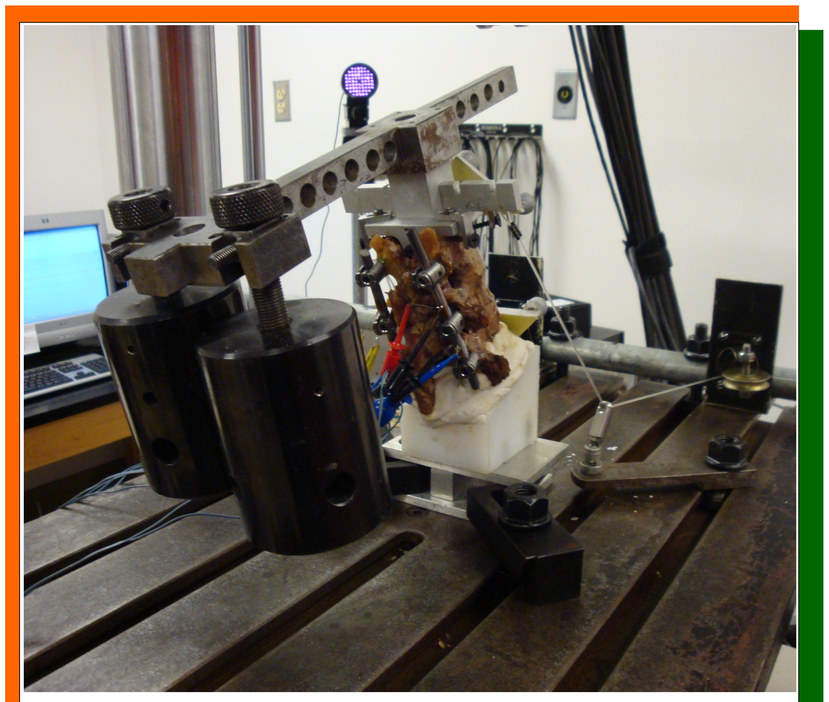

Figure 2 – After compressing the facets, the preloads are applied and the spine is ready for cyclic loading.

RESULTS:

Facet locking in the 6-screw construct resulted in a 54.5% increased structural rigidity ($p<0.005$), a 34.9% reduction in vertical translation ($p<0.0005$), a 48.2% reduction in sagittal rotation ($p<0.005$), and a 25.7% reduction in L1-L2 rod strain ($p<0.02$).

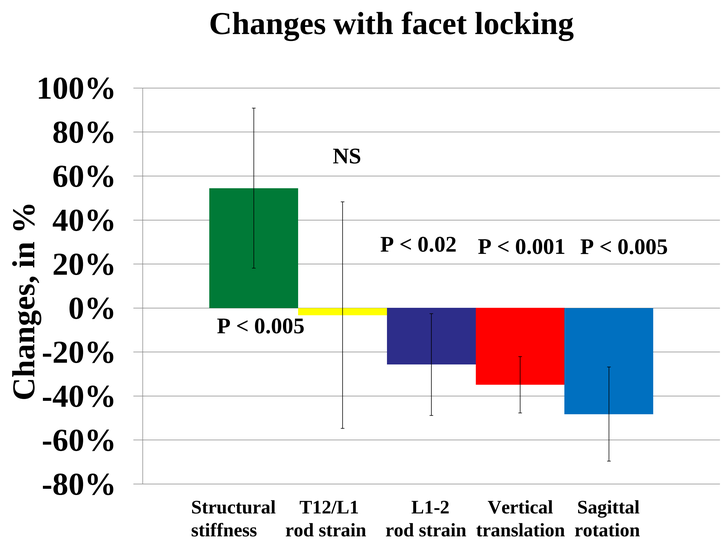

Figure 3 - The mean and standard deviation of % change measured for each parameter in each specimen comparing fixation with vs. without compression (locking) of the facet joints.

DISCUSSION:

This is the first biomechanical study to evaluate the effects of instrumentation in a cadaveric flexion-distraction injury model. Compression of the posterior instrumented construct significantly improves construct rigidity and may improve alignment and stability in the setting of an unstable flexion-distraction injury.

SIGNIFICANCE:

When both the anterior and posterior columns are unstable, achieving rigid fixation is much more difficult. The facet joints which articulate with the "floating" segment at L1 provide the best opportunity to achieve a mechanical connection to the T12 and L2 segments. By compressing the facet joints with the posterior rod and pedicle screw construct, one can re-establish some stability to the posterior column, and improve the possibility of achieving fusion.

ACKNOWLEDGEMENTS:

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