SIX VS FOUR SCREWS: A BIOMECHANICAL ANALYSIS OF SHORT SEGMENT FIXATION OF THE THORACOLUMBAR SPINE

*Chen, J; *Chiappetta, G; *Valdes, MA; *,**Milne, EL; *,**Latta, LL; *Eismont, FJ
*University of Miami, Miami & Coral Gables Campuses, FL;
**Max Biedermann Institute for Biomechanics, Miami Beach, FL

INTRODUCTION:

Unstable burst fractures of the lumbar spine continue to be treated with various modes of fixation. Indications for posterior fixation include complete neurologic injury and neurologically intact but unstable. This latter includes burst fractures with posterior injuries, ligamentous flexion distraction injuries and fracture dislocations. The use of pedicle screws continues to gain support over traditional hook-rod constructs and sublaminar wiring. Its advantages include increased rigidity, fixation through all three columns of the spine, increased fusion rates and the ability to use shorter fusion segments.1,2 Biomechanical studies have been performed comparing different instrumentation techniques.3

The standard configuration for posterior short segment fixation involves pedicle screws placed above and below the fracture. However loss of correction and hardware failure have been reported.4 In a series of 19 patients treated with short segment fixation, bending of the screws occurred in 6 patients, progressive kyphosis in 3 patients, and screw breakage in 1 patient.5

We hypothesize that placing additional pedicle screws at the level of the fracture achieves "three-point fixation" and can improve the rigidity of the fixation.

METHODS:

Nine fresh human cadaver spines from T12 to L2 were used for the testing. An L1 corpectomy was performed to remove all anterior column support. The specimens were instrumented with 6.25mm posted Isola pedicle screws connected to quarter inch rods using standard Isola lateral connectors (DePuy, Raynham, MA). Set screws in the lateral connectors were tightened to 60 in-lb and right-hand nuts were tightened to 100 in-lb.

To test the six screw construct, all six lateral connectors were tightened to the screws. To test the four screw constructs, the lateral connectors were detached from the screws in L1.

Selspot LED sensors were implanted in the vertebral bodies of T12 and L2 to measure the movements of the vertebral bodies. Uniaxial strain gages were bonded to the quarter inch rods to monitor strain. To maintain the integrity of the bone and soft tissues, all specimens were cyclically loaded to 5 N-m flexion, extension and axial rotation, well within their elastic range. This ensured that the biomechanical properties of the specimens did not alter after testing. A 400 N follower preload was employed to simulate the stabilizing forces produced by abdominal musculature. Paired t-test was utilized to analyze the differences between the constructs.

FIGURE 1. Test setup with 6 screws and transverse rod

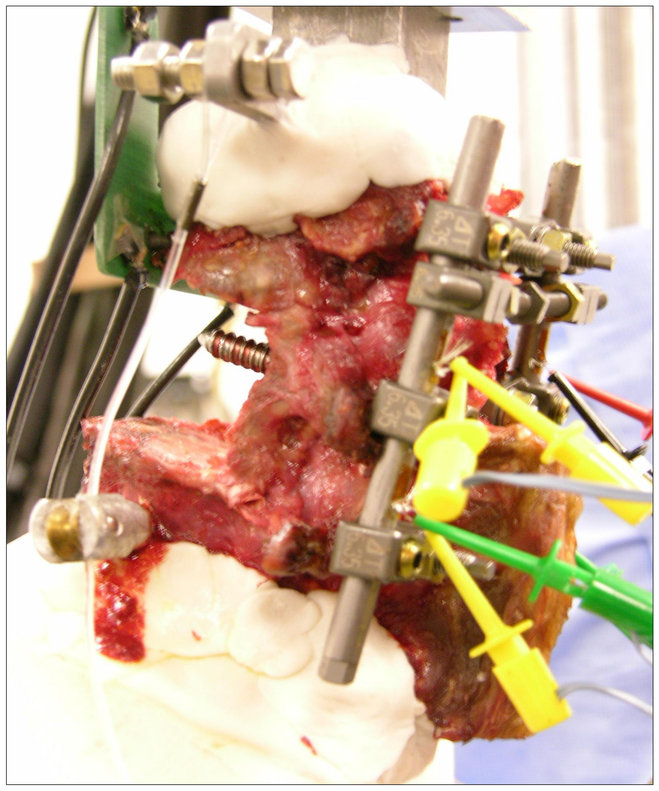

Table 1 – Structural rigidity, in N/mm & N·m/º

	4 screws	6 screws	change	P <
Flexion	18.03	20.05	10%	0.026
Extension	38.38	32.47	-18%	0.153
Axial rotation	2.27	2.53	10%	0.035

Table 2 – Torsional rigidity in N·m/º

Transverse connector	4 screws	6 screws	change	P <
No	2.265	2.526	10%	0.035
Yes	2.902	2.975	2%	0.327

Table 3 – Increase in relative motion between T12 and L2 for 4 vs. 6 screws for full flexion to full extension

	Mean	SD	N	P <
Sagittal rotation	18.5%	25.7%	9	0.05
Vertical translation	20.1%	28.6%	9	0.05

RESULTS SECTION:

The additional screws at L1 significantly stiffened the construct in flexion and torsion. With the 2 additional screws, stiffness of the constructs increased by an average of 9% and 11%, respectively, for flexion (p=0.02) and torsion (p=0.03). The flexion to extension total range of motion between T12 and L2 increased by almost 20% when only 4 screws were used.

With the addition of a transverse connector, the torsional rigidity of the constructs increased by an average of 16% for the 6 screw construct (p=0.006). The relative movement between T12 and L2 increased by 33.3% and 27.7% for 6 and 4 screw constructs, respectively, when the transverse rods were removed.

There was no significant difference in the rod strains between the six and the four screw constructs.

DISCUSSION:

This is the first study to evaluate the effects of instrumentation in the fractured level. Adding pedicle screw fixation at the level of an L1 burst fracture significantly increases the rigidity of the construct in flexion and torsion. This 6-pedicle screw construct also benefits from the use of a transverse connector. This has clinical implications for cases in which short segment fixation is considered.

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