Introduction: Despite advances in surgical techniques, failure to achieve solid arthrodesis of the lumbosacral junction, hardware failure, loss of sagittal balance and other complications continue to be a significant clinical problem, especially in long fusions to the pelvis. While some studies have shown mechanical advantages to utilizing bilateral iliac screws, recent clinical reviews have reported better outcomes with unilateral iliac fixation. Surprisingly, there are no previous biomechanical studies comparing the stability of constructs when using bilateral versus unilateral iliac screws.

Materials and Methods: Sixteen skeletally immature porcine spines from L2 through the pelvis were obtained. Spines were randomized to either L6-S1 interbody graft groups or intact L6-S1 disc groups (n=8 per group). For the specimens with an L6-S1 interbody cage, complete discectomies were performed at L6-S1. A measuring template was then used to select a proper sized polyethylethylketone, thick walled vertical ring type, interbody cage (Novel PEEK Space, Alphatec Spine, Carlsbad, CA). All spines were then fully instrumented from L2 to S1 with bilateral pedicle screws connected by 5.5mm titanium alloy rods (Zodiac System, Alphatec Spine, Carlsbad, CA). The superior endplate of the L2 vertebral body, and the pedvis were rigidly fixed in custom designed fixation rigs using two-part epoxy resin. Instrumented spines were then placed within a bi-axial servohydraulic MTS858 load frame (MTS, Co., Eden Prairie, MN). Four 4mm retro-reflective non-collinear markers were attached to the L6 and S1 vertebra using 0.062” K-wires for the measurement of rigid body motion using a four camera non-contact motion measurement system. (Qualisys AB, Goteborg, Sweden) A custom dual gimbal cantilever bending apparatus applied pure moments through the length of the spine. Moments were applied between + 7.0Nm at 0.5 deg/sec for flexion, extension and lateral bending. Spines were also tested in axial torsion between + 7.0Nm while applying a 100N axial load. For each test, mechanical data was collected at 10Hz for the test duration. For kinematic data, three-dimensional coordinates for each marker were sampled at 30Hz for the test duration. From this information, rigid body rotation of L6 relative to S1 was calculated using a custom written analysis program (Matlab, Mathworks, Inc, Natick, MA). Bilateral iliac fixation was tested first, followed by unilateral and finally sacrum only fixation. Construct stiffness (N/mm/deg) was calculated from the end of the neutral zone to peak load. Total range of motion (ROM) (degrees) of L6-S1 rotation was calculated from motion data from the marker sets. These data were analyzed using a two-way ANOVA (p<0.05). A Tukey's post-hoc correction test for multiple comparisons was employed when significant differences were reported from the two-way ANOVA.

Results: Mechanical Data

For flexion testing, both the type of instrumentation (p<0.01) and the use of an interbody cage (p<0.03) were found to be statistically significant (Figure 1). For extension testing, both the type of instrumentation (p<0.01) and the use of an interbody cage (p<0.001) were found to be statistically significant. For lateral bending testing, both the type of instrumentation (p<0.0001) and the use of an interbody cage (p<0.0001) were found to be statistically significant. For the specimens with an L6-S1 interbody cage, complete discectomies were performed at L6-S1. A measuring template was then used to select a proper sized polyethylethylketone, thick walled vertical ring type, interbody cage (Novel PEEK Space, Alphatec Spine, Carlsbad, CA). All spines were then fully instrumented from L2 to S1 with bilateral pedicle screws connected by 5.5mm titanium alloy rods (Zodiac System, Alphatec Spine, Carlsbad, CA). The superior endplate of the L2 vertebral body, and the pelvis were rigidly fixed in custom designed fixation rigs using two-part epoxy resin. Instrumented spines were then placed within a bi-axial servohydraulic MTS858 load frame (MTS, Co., Eden Prairie, MN). Four 4mm retro-reflective non-collinear markers were attached to the L6 and S1 vertebra using 0.062” K-wires for the measurement of rigid body motion using a four camera non-contact motion measurement system. (Qualisys AB, Goteborg, Sweden) A custom dual gimbal cantilever bending apparatus applied pure moments through the length of the spine. Moments were applied between + 7.0Nm at 0.5 deg/sec for flexion, extension and lateral bending. Spines were also tested in axial torsion between + 7.0Nm while applying a 100N axial load. For each test, mechanical data was collected at 10Hz for the test duration. For kinematic data, three-dimensional coordinates for each marker were sampled at 30Hz for the test duration. From this information, rigid body rotation of L6 relative to S1 was calculated using a custom written analysis program (Matlab, Mathworks, Inc, Natick, MA). Bilateral iliac fixation was tested first, followed by unilateral and finally sacrum only fixation. Construct stiffness (N/mm/deg) was calculated from the end of the neutral zone to peak load. Total range of motion (ROM) (degrees) of L6-S1 rotation was calculated from motion data from the marker sets. These data were analyzed using a two-way ANOVA (p<0.05). A Tukey's post-hoc correction test for multiple comparisons was employed when significant differences were reported from the two-way ANOVA.

Discussion: Bilateral iliac screw fixation did not significantly increase construct stiffness or limit L6-S1 motion compared to unilateral iliac screw fixation.

Unilateral fixation may provide adequate stability, supporting previous reports of similar arthrodesis rates between bilateral and unilateral fixation. Placement of an interbody cage following complete discectomy demonstrated lower construct stiffness compared to the intact disc data. This data supports the idea that anterior intervertebral cages in the presence of full discectomy, reduce the stiffness of the motion segment in which they are placed.

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