In vitro Comparison of One and Two Level Posterior Dynamic Stabilization Device: Inferences from Kinematic Tracking of Device Components Based on Interpedicular Travel and Spherical Joint Rotation

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Background: Posterior dynamic stabilization devices have become of interest due to the potential for these implants to provide controlled interpedicular travel coupled with intervertebral rotation, a necessary requirement for optimal, stable intervertebral motion. Ideally, dynamic lumbar implants should mitigate extraneous motion for the instrumented functional spinal unit (FSU) to prevent further degeneration of the pathologic FSU. The ability for the Stabilimax device to control the kinematic response and appropriate posterior load through the FSU should be fully characterized for both one and two-level constructs in order to understand the potential clinical implications of the device.

Methods: Six fresh frozen-human lumbar cadaveric specimens were stripped of all soft tissue excluding the osteoligamentous structures. Each specimen was subjected to pure moment flexion extension, lateral bending and axial torsion loading protocols with load limits equal to +/- 7.5Nm in the intact condition, after destabilization, implantation with a one-level Stabilimax at L4-L5, a two-level Stabilimax extended to L5-S1 and a hybrid construct consisting of a one-level Stabilimax at L4-L5 and rigid rod fixation at L5-S1. The motion of each vertebra was recorded during each test using an optoelectric motion tracking system (Optotrak, Waterloo Canada). Furthermore, the relative motion of pertinent components of the device was tracked during testing using the same technique. Interpedicular Travel (IPT) was defined as the magnitude of the vector describing the translation of adjacent pedicles between peak loading conditions. The rotation of each pedicle screw on the left side of each spine within its spherical joint was also calculated.

Results: A statistically significant reduction in IPT at L4-L5 during flexion extension and lateral bending of each of the instrumented conditions with respect to both the intact and destabilized conditions was found (p< 0.01).

At L5-S1 significant reductions, with respect to intact, in flexion extension IPT were found in both the two-level and hybrid conditions (p< 0.006). Furthermore, a significant reduction, with respect to two-level, in flexion extension IPT was found in the hybrid condition (p=0.011). The hybrid condition showed a decrease in IPT during lateral bending when compared to both the intact and two-level conditions (p=0.006 and 0.025 respectively).

The flexion extension spherical joint rotation at L5 was significantly less for the two-level condition than for both other instrumented conditions, one-level (p=0.042) and hybrid (p=0.022). In addition, the lateral bending spherical joint rotation at L5 was significantly less for the two-level condition compared to the hybrid condition.

Conclusions: The results indicate that implantation of each construct results in a significant reduction in IPT but that IPT is greater for the two-level Stabilimax than for rigid fixation at the index level. This is particularly interesting given that range-of-motion did not indicate a difference between these two treatments in this study.

The spherical joint rotation results indicate that the two-level device is more constrained at the middle screw (L5) than the one-level device. This result makes intuitive sense given that this is where the top and bottom halves of the device are coupled.