Effect of Sequential Facetectomies on Lumbar Spinal Stability under Sagittal Plane Loading Mechanics in a Cadaveric Model

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Introduction: Lumbar facets function to limit forward translation during sagittal movement. Any pathology or surgical intervention that alters the relationship between them may result in spondylolisthesis. Previous in vitro studies have used pure moment (PM) techniques to study facet mechanics. However, this method does not account for the shear force present in vivo, and thus cannot be extrapolated to a clinical situation. A new testing protocol was developed that included a shear force combined with a compressive load and bending moment (CLM). The objective was to analyze the effects of sequential facet resections on facet angle and facet contact surface area, as it relates to their biomechanical stability using two testing protocols. Three surgical conditions were tested and compared to the harvested (H) condition: MIS partial unilateral facetectomy (UF), MIS bilateral facetectomy via unilateral approach (BF) and traditional laminectomy (TL).

Materials and methods: Eight human cadaveric lumbar segments (four L1-L2, two L2-3 and two L4-5) were tested in flexion and extension using a multi-axis robotic testing platform. The testing protocols used were the PM and CLM. The CLM protocol is similar to the PM method with the addition of a shear force and a compressive force. The purpose of this protocol was to simulate a more physiological mode of testing in vitro. For the PM tests, the spines were flexed or extended up to an end limit load of 8Nm. For the CLM tests, a combined (compressive and shear) force vector of 264N was applied along with the 8Nm moment. Measures of segmental rotation and AP translation along the disc plane were analyzed using a non-parametric one-way repeated-measure ANOVA on ranks (Friedman's test) for p< 0.05.

Changes to the facet orientation and surface area were measured from CT images of the H and BF spine conditions using the open source imaging software Osirix. The facet angle and facet contact area measurements were analyzed using a Wilcoxon Signed Rank test (non-parametric paired t-test, p< 0.05) comparing the intact and bi-lateral facetectomy conditions.

Results: CLM testing resulted in the greatest AP translation with the TL condition (Figure 1). Conversely, PM showed no significant changes in AP translation between all spine conditions. The facet angle (in degrees) significantly decreased from the harvested condition (right facet: 36.0±16.5; left facet: 37.3±18.4) when compared to the post facetectomy specimens (right facet: 30.0±17.6; left facet: 33±17.0). A significant reduction also occurred in the facet surface area between the harvested condition (right facet: 0.51±0.09; left facet: 0.52±0.12) and the post-facetectomy condition (right facet: 0.34±0.13; left facet: 0.29±0.07).

Conclusions: Spinal instability was only observed with the traditional laminectomy condition using the CLM mode of testing. PM testing methods were unable to induce any significant changes in AP translation. This draws attention to a limitation of using the PM testing method to study the biomechanical effects of spondylolisthesis in vitro.
Figure 1. AP translation of spinal segments along