Characterizing Disc Bulge in Three Different Regions of the Outer Annulus Subjected to Biomechanical Testing Including Pure Moment Protocols

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Introduction: Due to the proximity of the neural elements, the occlusion potentially created by the outer annulus is an important clinical attribute to characterize. Isolating the effects on the anterior column from the posterior column would allow direct comparisons between native and treated conditions. Moreover, nucleus augmentation devices would have more exacting performance parameters to meet. In order to gauge the efficacy of hydrogel augmented nucleus pulposus relying on the otherwise plenary intervertebral disc, the disc bulge at the outer annulus of functional spinal units (FSU) with resected posterior columns was measured in vitro using human lumbar specimen.

Materials and methods: Based on the radiographic grading of over 30 lumbar levels by the surgeon, severely degenerated FSU were excluded, leaving 25 qualified levels. Individual FSU with the posterior columns removed, were subjected to ±5.0Nm in pure moment flexion extension bending, lateral bending, and axial torsion. Both the native and polymer augmented nucleus treatments were tested. Disc bulge was measured in three distinct regions on the surface of the annulus. In the figure shown below, the hollow circles indicate the approximate locations of each of the LED in the neutral position at the beginning of each test cycle. The method to determine disc bulge was calculated from the neutral position at three separate locations on the outer annulus with the posterior marked as region I, the posterolateral as region II, and the lateral marked as region III. An analysis of variance (ANOVA) statistical model was used to detect differences amongst the treatment groups with a Bonferroni post hoc test to specify the different groups.

Results: The mean±stdev disc bulge for the native anterior column in flexion extension bending was 0.55±0.32mm, 0.84±0.60mm, and 0.58±0.40mm at the posterior, posterolateral and lateral regions respectively. Similarly, the mean±stdev disc bulge for the augmented condition was 0.55±0.46mm, 0.60±0.44mm, and 0.47±0.34mm in the same regions. The mean bulge for the native condition in lateral bending was 0.37±0.30mm, 0.59±0.34mm and 0.87±0.45mm while the nucleus augmented condition measured 0.22±0.30mm, 0.46±0.30mm, and 0.65±0.30mm. The mean disc bulge for the native condition in axial torsion was 0.27±0.33mm, 0.16±0.34mm and 0.09±0.40mm compared to 0.13±0.16mm, 0.08±0.25mm, and 0.25±0.57mm in the augmented condition. The disc bulge was statistically reduced at all three measured regions of the outer annulus (p=0.008 for posterior, p=0.021 for posterolateral, p=0.017 in lateral) only in lateral bending.
Discussion: Nucleus augmentation appears to dramatically reduce the disc bulge in all three measured regions of the outer annulus in lateral bending. Significant influences on disc bulge in any location in flexion extension bending and axial torsion were not detected. In conclusion, nucleus augmentation may have a significant effect on the disc bulge in lateral bending however other modes of loading did not exhibit significant reductions in bulge.