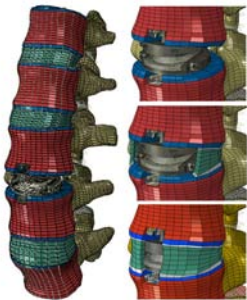


Partial Annulus Fibrosus Preservation Facilitates Restoration of Biomechanics in Lumbar Spinal Segments Treated with Artificial Disc Replacement

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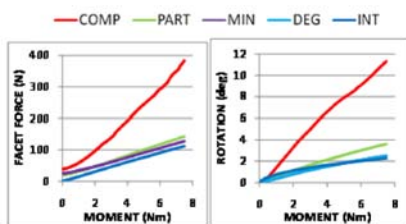
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To date, the effects of partial preservation of native intervertebral disc tissue (specifically annulus fibrosus) during implantation of an artificial disc on the biomechanics of lumbar spinal segments has not been assessed. To address this, a finite element model of the human lumbar spine (L1-L5) was created. The mechanical behavior of the annulus fibrosus was simulated with a continuum approach utilizing an orthotropic strain energy function. The predictions were validated under pure moments up to 7.5 Nm in three principal directions (flexion/extension, lateral bending and axial rotation) over the complete nonlinear loading range. The validated model was implanted with the ProDisc-L at the L3/L4 level. In addition to intact (INT), three implantation conditions were tested: complete annular wall resection (COMP), partial annular wall resection (PART) and minimal (MIN) resection of the annulus (implantation through a 12mm-wide anterior cavity) (Figure-1). The MIN condition was also simulated by alteration of the annular material properties in order to model significant annular degeneration (DEG).



[Figure-1]

The range of motion (ROM) predictions at the operated level increased in all loading scenarios except for flexion. The MIN condition most closely approximated the ROM INT predictions. On the other hand, ROM predictions in the COMP condition, in all loading scenarios except for flexion, were substantially higher than the values predicted in other conditions. For example, axial rotation ROM was predicted to be 11.2°, 3.61°, 2.5°, 2.51° and 2.27° in the COMP, PART, MIN, DEG and INT variants, respectively (Figure-2).



[Figure-2]

In extension loading, the superior endplate and the polyethylene core of the prosthesis were observed to disarticulate as a result of the applied moment in COMP and PART conditions. ROM predictions at the adjacent levels and the nonlinearity of the moment-rotation curves at L3/L4 level were observed to be reduced as a result of disc implantation; this is most likely because the inherent resting compressive forces due to implantation were 15N, 130N, 221N and 201N in COMP, PART, MIN and DEG conditions, respectively. The DEG condition did not yield appreciable differences in force or ROM predictions as compared to the MIN condition. Finally, treatment increased the force transmission in the facets under axial rotation in all conditions (Figure-2). In conclusion, maximum preservation of the annulus fibrosus tissue during implantation of the artificial disc was found to be a critical component for obtaining restoration of the intact condition biomechanics of the treated and adjacent levels.