Effect of Different Grades of Facetectomy on Biomechanics of Lumbar Spine Stabilized with Dynesys System: A Finite Element Based Study

INTRODUCTION:
Spinal stenosis is a painful degenerative condition that occurs due to facet joint arthritis. Various degrees of facetectomy are often recommended for nerve decompression to alleviate radicular and arthritic pain. The excision of the facet joints however affects the kinematics of the index level, possibly leading to additional stresses in the remaining structures. Spinal fusion systems or posterior dynamic stabilization systems such as the Dynesys (Zimmer, MN), provide stability to the affected motion segment [1] after decompression. The Dynesys surgical technique recommends performing a decompression that preserves at least 50% of the facet joints. The objective of this finite element study was to evaluate the biomechanical performance of the Dynesys dynamic stabilization system as a function of graded facetectomies and ascertain with our hypothesis that the performance of the device is altered at 50%+facetectomy.

MATERIALS AND METHODS:
An experimentally validated, three dimensional ligamentous finite element (FE) model of the L3-S1 segment [Fig.1A] was used [2]. The intact model was modified to simulate decompression at L4-L5 with: 1) 50%, 2) 75% and 3) total bilateral medial facetectomy. A three dimensional model of the Dynesys implant was then simulated at the L4-L5 level [Fig.1B]. The Dynesys is a posterior stabilization device consisting of titanium alloy pedicle screws and polycarbonate urethane (PCU) spacers that surround tensioned polyethylene terephalate (PET) cords. A recommended preload of 150 N was applied to the cord in each implanted case. A friction less contact interaction was defined between the contact surfaces of the spacer and pedicle screws. The stiffness of the spacer and the cord were taken as 63 N/mm and 414 N/mm respectively using a 0.2% offset method. A 400 N compressive follower load plus a 10 Nm bending moment were applied to the models to simulate extension (Ext), flexion (Flex), lateral bending (LB) and axial rotation (AR). Range of motion, pedicle screw stresses and center of rotation (COR) at the implanted level were computed and compared for different models.

RESULTS:
Total facetectomy increased the motion in Ext (8.7° vs. 2.7 ° for intact) and AR (8.4 ° vs. 2.4 ° for intact) at the L4-L5 level, as expected. The percent decrease in motion after placement of the Dynesys implant across L4-L5 ranged from 65% in AR to 80% in Flex for all graded facetectomies except in the total facetectomy AR case [Fig.2A]. The motion in this case was higher than the intact case.

The maximum stress on the pedicle screws were quite high in Ext, LB and AR in all implanted models with graded facetectomy, as compared to intact. However, this increase was more pronounced in the total facetectomy case with very high stresses in AR [Fig.2B].

CONCLUSION:
The Dynesys dynamic stabilization system constrains the motion of the decompressed segment similar to a rigid system. Our results suggest that multiple grades of facetectomy show minimal effects on the kinematics of the stabilized segment in all loading cases except AR. In total facetectomy case, increased motion and elevated pedicle screw stresses were observed in AR as compared to the intact-stabilized case. Higher screw stresses in AR for 50%+ facetectomies may accelerate screw loosening/failure especially in combination with other motions like flexion/extension during daily activities. Furthermore, the COR for the stabilized segment shifted away from the intact-in vivo location.

REFERENCES:

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