BIOMECHANICS OF ADJACENT SEGMENTS WITH NUMBER OF INTER-BODY BONE GRAFTS AND SPINAL INTRUMENTATIONS FOR A MULTI-LEVEL FUSION CONSTRUCT USING A FINITE ELEMENT MODEL

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INTRODUCTION

Cervical fusion is a traditional procedure for the treatment of single- and multi-level spondylotic myleopathy or radiculopathy. The stand-alone graft has been shown to be less effective in providing the stability to construct especially with multi-level decompression. Additional stabilization of stand-alone grafting with anterior instrumentation (plate and screws), posterior instrumentation (rods and screws) or a combination of anterior and posterior instrumentation helps in achieving better fusion rates and reduces the possibility of graft dislodgement or subsidence. With the addition of spinal instrumentation and increase in the stiffness of the construct level, the adjacent levels are subjected to increased motion. In spite of previous *in vivo* and *in vitro* studies, the biomechanics of degeneration of adjacent segments after a multi-level fusion procedure is poorly understood. To date, no study exists in the literature showing the influence of number of inter-body grafts and instrumentations used for multi-level cervical decompression on the biomechanics of adjacent segments.

The objective of the present study was to compare the biomechanical response of the levels adjacent to the multi-level fusion construct by varying the number of inter-body grafts (corpectomy and/or discectomy) and spinal instrumentations (anterior and/or posterior). The rotational motion, stresses in the disc, and loads on the articulating facets of the adjacent levels were studied.

METHODS

A three-dimensional finite element (FE) model of a C3-T1 segment of the cervical spine was developed from the CT scan of a 38-year old normal female subject. The intact model was previously validated with the published specimen studies. Five surgical fusion models from C4 to C7 were developed from the intact model – discectomy with anterior fixation, corpectomy-discectomy with anterior fixation, corpectomy with anterior fixation, corpectomy with posterior fixation and corpectomy with anterior-posterior fixation. The discectomy fusion was performed with three inter-body grafts placed at C4-C5, C5-C6 and C6-C7 levels. The corpectomy fusion was performed with a single strut graft placed in between C4 and C7. The corpectomy-discectomy fusion was built with two grafts (C4-C6 corpectomy and C6-C7 discectomy). The grafts were centrally placed covering up-to 50% endplate area. The anterior fixation was created by using an anterior plate with rigid screw trajectory from C4 to C7. Two uni-cortical screws each at the cephalad and caudal ends of the anterior plate were placed parallel to the endplates. The posterior fixation was built by using a vertical rod with rigid screw trajectory from C4 to C7. Two uni-cortical screws at each segment were placed in the posterior lateral mass. The anterior-posterior fixation was built by using an anterior screw-plate together with the posterior screw-rod system. The anterior and lateral mass screws of 16 mm long with an outer and inner diameter were 3.5 and 2.5 mm were used. The material properties of the spinal structures and instrumentations were adopted from the literature. The physiologic rotations based on literature data were prescribed on the C3 vertebra (flexion=45°, extension=35°, axial rotation=20°, lateral bending=25°). The inferior surface of the T1 vertebra was fixed. A constant pre-load of 73.6 N was applied using two isotropic truss elements connecting each of the lateral edges of the vertebral bodies to mimic the follower load technique. The analysis was performed using the commercially available FE code, ADINA.

RESULTS AND DISCUSSION

The results of the present study showed an increased motion of the adjacent levels with surgical interventions as compared to the intact case (Figure 1). Also, the stresses in the discs and loads on the facets of the levels adjacent to the fusion construct were higher than the intact values.

By decreasing the number of inter-body grafts for multi-level fusion (discectomy to corpectomy-discectomy to corpectomy) and increasing the number of spinal instrumentations (anterior to posterior to anterior-posterior) for stabilizing the construct, an increased motion was observed at the adjacent segments (Figure 1). Previous studies have reported a similar increase in the motion at levels adjacent to fusion construct. The same trend was seen with the stresses in the discs and loads on the facets of the adjacent non-operated levels. Lee *et al*[1] and Yang *et al*[2] observed increased stresses in the discs and facet loads at the levels adjacent to the fusion level when the posterior instrumentation was used as compared to the anterior fixation.

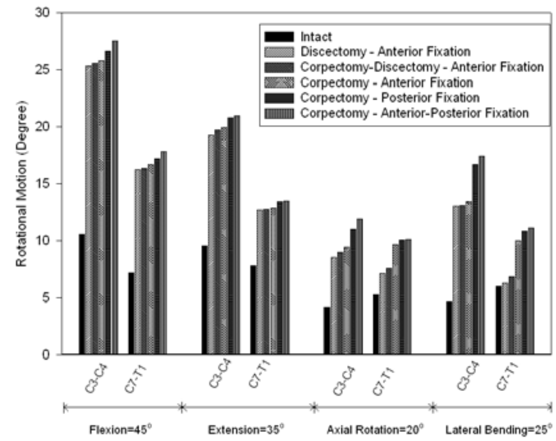

Figure 1: Rotational motion of adjacent segments with various fusion procedures added with different fixation techniques

SUMMARY

The levels adjacent to the multi-level fusion construct were affected by the number of inter-body grafts and the type of fixation technique used. The results of this study should help surgeons to appropriately choose the fusion procedure and the type of fixation to avoid the degeneration of adjacent segments and at the same time, to achieve a better fusion at the construct level.

REFERENCES

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