EFFECT OF UNI- AND BI-CORTICAL SCREW ANGULATION ON THE STABILITY OF MULTI-LEVEL CORPECTOMY CONSTRUCT – A FINITE ELEMENT MODEL STUDY

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INTRODUCTION

Cervical corpectomy and fusion with an anterior screw-plate system is a common surgical technique to treat spondylotic disorders. The dynamic plates are load-sharing in nature that requires bi-cortical screws. In comparison, the rigid plates are load-bearing device that requires uni-cortical screws. Despite excellent immediate-postoperative results, clinical failures of such multi-level construct and adjacent segment disease have been observed due to the load-bearing nature of rigid plates during late-postoperative stages. The objective of the present study was to investigate the stability of the construct using the rigid plates by placing the uni- and bi-cortical screws at an oblique angle with respect to the endplates. Furthermore, the direction of propagation of the adjacent segment disease was determined.

METHODS

A three-dimensional finite element (FE) model of a healthy C3-T1 segment was developed from the CT scan of a 38-year old woman. Two-level corpectomy was performed and a graft was centrally placed in between the C4 and C7 covering up to 50% area of the opposing endplates. An anterior plate with rigid screw trajectory was used. Five models were built with the screws at an oblique cephalad-caudal screw angle with respect to the endplates. Four of these models were built with an oblique cephalad-caudal screw angle of 0°, 5°, 10°, and 15°, while the fifth model was built with an oblique cephalad screw angle of 15° and a caudal screw angle of 0°. Uni- and bi-cortical screws of 16 and 18 mm length with an outer and inner diameter of 3.5 and 2.5 mm were used. The material properties were adopted from the literature. The moment loads were created by applying equal and opposite loads on the superior surface of C3 keeping the inferior surface of T1 fixed. A constant preload of 73.6 N was applied using two temperature truss elements connecting the lateral edges of the vertebral bodies to mimic the follower load technique. The analysis was performed using the commercial FE software, ADINA. The stability of the construct and adjacent segments using uni- and bi-cortical angulated screws were compared under a moment of 1.5 Nm with preload.

RESULTS AND DISCUSSION

The healthy C3-T1 model was validated with the *in vitro* study (Panjabi *et al* 2001 and Wheeldon *et al* 2006) under a moment of 1.0 Nm with preload (figure 1). Some motion results over predicted the *in vitro* data, but they were within the *in vivo* range of motion (Penning *et al* 1978). Moreover, Panjabi *et al* 2001 did not mention the age group of cadavers, while Wheeldon *et al*

2006 used the cadavers with an age range 20-51 years. The above *in vitro* studies using the cadavers represented some degenerative pathology due to the older specimens, while the FE model used the material data of the healthy spine. The two-level corpectomy construct with parallel, uni-cortical screws and anterior rigid plate was validated with the *in vitro* study (Cagli *et al* 2004) during immediate-postoperative condition under a moment of 1.5 Nm with preload (figure 2).

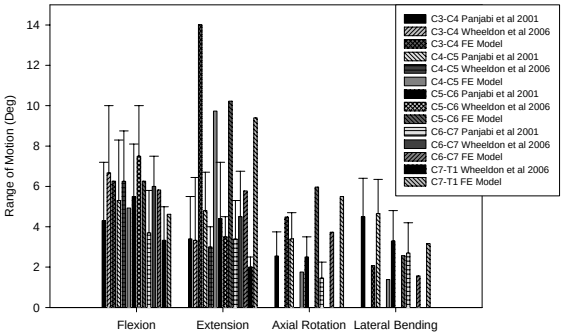

Figure 1: Validation of a healthy C3-T1 intact model with the *in vitro* studies.

The range of motion was not dependent upon screw angulations and types of screws. Although bi-cortical screws provided a negligible enhanced stability as compared to the uni-cortical screws during immediate-postoperative condition, but no such effect was observed during late-postoperative condition. Lehmann *et al* 2004 observed the similar results.

Higher percentage reduction in the range of motion of the superior motion segment was observed as compared to the inferior motion segment except for the lateral bending motion. The corpectomy construct was more stable during late- than immediate-postoperative condition due to progressive fusion of the bone graft with the endplate. This stable state of fusion was achieved with the reduction in range of motion of the adjacent segments (figure 3).

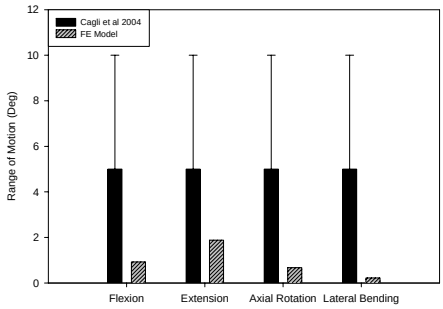

Figure 2: Validation of the C4-C7 corpectomy construct with the *in vitro* study.

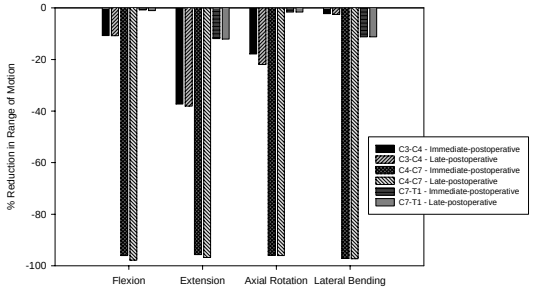

Figure 3: Percentage reduction in the range of motion of the corpectomy construct and adjacent segments.

SUMMARY

The stability of the corpectomy construct and adjacent segments are independent of the angular placement and types of screws. The adjacent segment degeneration was found to propagate superior to the corpectomy construct.

REFERENCES

Panjabi, M.M., Crisco, J.J. et al. (2001). *Spine,* **26,** 2692-2700.

Wheeldon, J.A., Pintar, F.A. et al. (2006). *J. Biomech,* **39,** 375-380.

Penning, L. (1978). *Am J. Roentgenol,* **30,** 317-326.

Cagli, S., Chamberlain, R.H. et al. (2004). *Spine,* **29,** 1420-1427.

Lehmann, W., Blauth, M. et al. (2004). *Eur Spine J.*, **13,** 69-75.