A Finite Element Investigation into the Effects of Minimally Invasive Treatment for Cervical Spondylotic Myelopathy

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INTRODUCTION

Cervical spondylotic myelopathy one of the most common diseases of the vertebral column frequently caused by degenerative processes (1). The degenerative changes that occur in the cervical spine result in compression of the spinal cord and nerve roots leading to radicular pain and numbness. Posterior surgical approaches for the management of cervical spondylosis are well established and among the oldest spinal procedures known. Recent advancements in minimally invasive surgical techniques have produced the same surgical result while minimizing bone and ligament resection as well as preserving the surrounding tissue (1). These surgical advancements have shown clinical improvements such as a decrease in post operative pain and improved clinical outcomes (2) however, the biomechanical impact of cervical microendoscopic decompression for stenosis (MEDS) is unknown. In this study we will quantify the change in intersegmental motion of the cervical spine in response to a decompressive laminotomy at C4-6 using the standard open procedure and the new MEDS technique.

METHODS

A three dimensional finite element model of an intact C3-T1 cervical spine motion segment was developed from the CT scan of a 38 year-old female normal subject. The model was previously validated with the *in vivo* study under diurnal compressive load of 40 – 350N (3). A compressive pre-load of 150N was simulated using the follower load technique. Two additional C3-T1 models with a C4-C6 laminectomy were developed one with traditional open posterior approach and the other a cervical MEDS approach. The open procedure was modeled by removal of the spinous process, a bilateral laminectomy and removal of the ligamentum flavum and interspinous ligaments. The cervical MEDS was modeled by unilateral removal of the right lamina and the ligamentum flavum. Moment loads were created by applying appropriate equal and opposite loads on the superior surface of C3 keeping the inferior surface of T1 fixed. A 1.5 Nm flexion, extension, axial rotation and lateral bending moments were applied to the model. The values selected represent the mean motion generated in the three principle planes computed from the *in vivo* studies. Rotation of the vertebral body was studied for the three FE models using the commercially available software ADINA.

RESULTS AND DISCUSSION

Rotation of the vertebral bodies in the sagittal, axial and coronal planes were compared between a cervical MEDS and open laminectomy at C4-6 and an intact control using finite element analysis. There was a general increase in motion at each level under all loading conditions using the open technique (Figure 1).

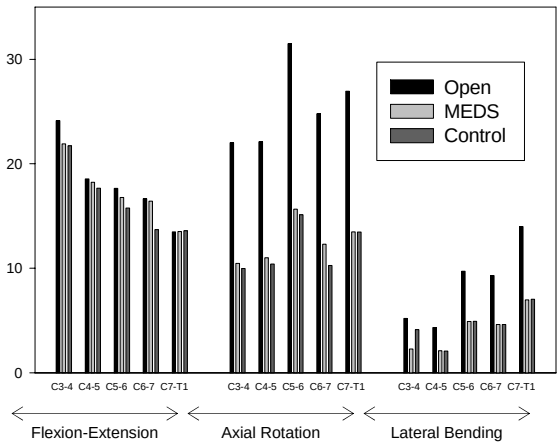

Figure 1. Change in segmental rotation for open, MEDS and control models under flexion, extension, lateral bending and axial rotation.

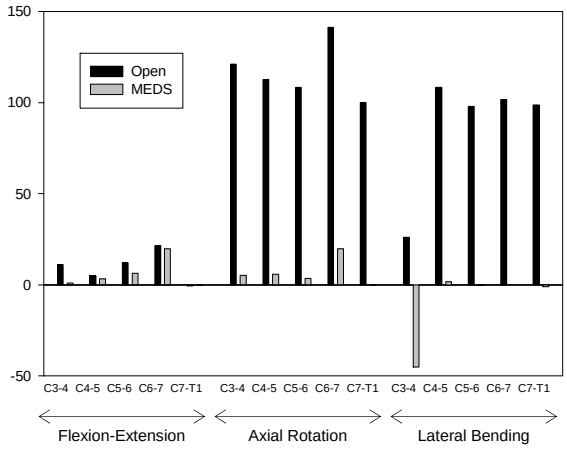

Figure 2. Change in percent segmental rotation for open and MEDS normalized to control under flexion, extension, lateral bending and axial rotation.

MEDS resulted in minimal increased motion with the most significant change at C6-7 in axial rotation and flexion-extension. Figure 2 shows the percentage change in rotation for the open and MEDS procedures standardized to an intact control model under all loading conditions. Again, there was an overall increase in motion for the open relative to the MEDS group with the largest increase in axial rotation and lateral bending. The largest increases in motion under lateral bending were seen at C4-5 for both open and MEDS resulting in a 108% and 2% change respectively relative to the control. The largest motion for axial rotation was seen at C6-7 for both groups and resulted in an increase of 141% and 20% for open and MEDS respectively. An over 100% increase in motion during axial rotation was found for each segment for the open model.

SUMMARY/CONCLUSIONS

The limitations of finite-element analysis are known. However, our application of the finite element method for comparison of segmental motion as a result of two different surgical treatments for cervical spondylotic myelopathy provide biomechanical data to verify the results seen clinically (1). Our data show that the MEDS procedure results in significant preservation of motion control compared to the open procedure for a cervical laminectomy at C4-6.

REFERENCES

1. Santiago P, Fessler RG (2007) *Neurosurgery*,**60 (Suppl 1),** S160-5.
2. Fessler RG, Khoo LT (2002) *Neurosurgery*, **51 (Suppl 5)**, S37-45.
3. Natarajan RN et al. (2000) *Spine*, **25(8)**, 955-61.