A FINITE ELEMENT INVESTIGATION INTO THE BIOMECHANICAL EFFECTS OF MINIMIALLY INVASIVE TREATMENT FOR CERVICAL SPONDYLOTIC MYELOPATHY

Lacey E. Bresnahan [1], Mozammil Hussain [2], Richard G. Fessler [1], Raghu N. Natarajan [2], and Gunnar B.J. Andersson [2]

[1] The University of Chicago, Chicago, IL, USA
[2] Rush University Medical Center, Chicago, IL, USA

INTRODUCTION

Cervical spondylotic myelopathy is 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 moment 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 was compared between a cervical MEDS and open laminectomy at C4-6 to an intact control using finite element analysis. The open procedure resulted in an overall increase in motion at all segment levels for each of the three loading conditions (Figure 1), with the largest overall increases in axial

rotation and lateral bending. Increased motion in the axial plane ranged from 100% at C7-T1 to 141% at C6-7. The range of increase in motion during lateral bending was from 26% at C3-4 to 108% at C4-5.

MEDS resulted in minimal increased motion at all segment levels for each of the three loading conditions. The most significant changes were seen in axial rotation and flexion-extension with no significant change in lateral bending. Motion for the MEDS in the axial plane increased in the range of 0% at C7-T1 to 20% at C6-7. Flexion-extension increased from less than 1% at C3-4 to 29% at C6-7.

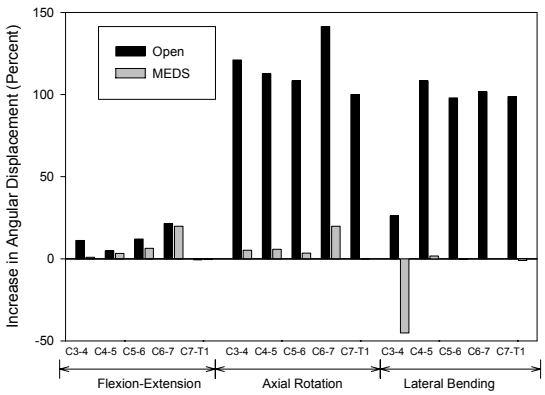

Figure 1. Change in percent segmental rotation for open and MEDS normalized to control under flexion, extension, lateral bending and axial rotation.

Axial rotation resulted in the most significant increases in motion for both the open and MEDS with a maximum of 1% and 20% at C6-7 respectively. Lateral bending resulted in the second largest overall increase in motion with the maximum occurring at C4-5 with a 108% and 2% increase for open and MEDS. The total motion (C3 with respect to T1) of the open was increased relative to the MEDS in flexion-extension (10% and 5%), axial rotation (115% and 6%) and lateral bending (101% and -1%). A comparison of the segments directly adjacent to the operative site resulted in a consistent maximum increase in motion at the caudal end (C6-7) for both open and MEDS (Table 1).

SUMMARY/CONCLUSIONS

The limitations of the 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 results seen clinically (1). The data show that the posterior elements of the cervical spine provide resistance to segmental rotation in the three anatomic planes. Surgical manipulation of these elements can lead to substantially increased motion as can be seen by the results of the open data. Minimization of bone and ligament removal associated with MEDS results in greater preservation of the normal motion of the cervical spine after surgery.

REFERENCES

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Table 1: Percent increase in segmental rotation of levels adjacent to operative site (C4-6).

	Flexion-Extension		**Axial Rotation**		**Lateral Bending**	
Level	**Open**	**MEDS**	**Open**	**MEDS**	**Open**	**MEDS**
C3-4	11	1	121	5.	26	-45
C6-7	21	20	141	20	102	0