BIOMECHANICAL TESTING OF MULTI-LEVEL LAMINOPLASTY AND LAMINECTOMY PROCEDURES

Swathi Kode, Anup A Gandhi, Joseph D Smucker, Douglas C Fredericks, Nicole M Grosland

Department of Biomedical Engineering, Center for Computer Aided Design, Department of Orthopaedics and Rehabilitation

The University of Iowa, Iowa City, IA
Email: nicole-grosland@uiowa.edu, web: http://www.ccad.uiowa.edu/mimx

INTRODUCTION

Cervical spinal stenosis is a medical condition caused by the narrowing of the spinal canal, possibly leading to the compression of the spinal cord or other nerve roots [1]. The traditional posterior method of decompression, laminectomy, involves removal of the lamina and associated ligaments. Laminoplasty, considered an alternative to laminectomy, is a procedure intended to relieve pressure on the spinal cord while maintaining the stabilizing effects of the posterior elements of the vertebrae. Open door laminoplasty (ODL) involves “hinging” one side of the lamina and cutting the other side to form a door. The lamina is then opened and held in place with plates and screws.

The number of lamina to be opened to fully release the spinal cord has always been a question and it depends on the existing pathological conditions. In order to see the longitudinal effects of ODL, a 2-level and 4-level laminoplasty was performed on cervical spinal segments. The current study is an experimental approach, addressing the multidirectional flexibility of the cervical spine in response to both laminoplasty and laminectomy procedures.

METHODS

A total of 3 fresh-frozen human cadaveric cervical specimens (C2-T1) were used in this study. Specimens were cleaned of all residual musculature and were potted using Bondo (Bondo Corp, Atlanta, GA). The specimens were tested in the following sequential order: (a) Intact (b) Laminoplasty at C5-C6 (LP_C56) (c) Laminoplasty at C3-C6 (LP_C3456) (d) Laminectomy at C3-C6 (LT_C3456)

ODL on C5-C6 levels: After testing the intact specimens, ODL was first performed on the C5 and C6 levels. A 3mm high speed burr was used to create a hinge on the right lamina and lateral mass junction by removing the dorsal cortex and cancellous layer. A cut of approximately 4-5mm was made on the contralateral side by using the same high speed burr. Thereafter, the spinous process of C5 and C6 was resected. Interspinous ligaments (C4-C5, C5-C6 and C6-C7) and unilateral ligamentum flavum on the open side (C4-C5, C6-C7) were resected with a scalpel to aid in laminar opening. The lamina of the involved vertebrae were then opened gently towards the hinge and stabilized with plates and screws (Medtronic Sofamor Danek, Memphis, TN). A 10 mm plate was secured with 2 screws on lateral mass and one on the open end of lamina. Care was taken to preserve the facet capsules.

ODL on C3-C6 levels: After the C5-C6 laminoplasty was tested, the procedure was extended to the C3 and C4 levels. The additional ligaments resected include interspinous ligaments (C2-C3, C3-C4) and unilateral ligamentum flavum on the open side at C2-C3.

Laminectomy on C3-C6 levels: Following the laminoplasty study at C3-C6, a laminectomy was performed (levels, C3-C6) by drilling through the hinge on the right lamina and lateral mass junction. The plates and screws on the contralateral side were removed. The preserved ligamentum flavum at C2-C3 and C6-C7 was then resected for the complete removal of posterior elements.

Experimental Testing Protocol: Specimens were tested using servo hydraulic materials testing...
machine (858Mini Bionix II, MTS Corporation, Eden Prairie, MN) retrofitted with 2 spine-loading fixtures. Custom made rigid body sensors consisting of 3 IREDs were rigidly attached to the anterior part of each vertebra and the top and bottom gimbals. The motion of the sensors was then tracked with an optical motion capture system (Optotrak 3020, Northern Digital Inc., Waterloo, Ontario, Canada). The cervical spinal segments were evaluated under a pure moment of 2Nm in flexion/extension, right/left lateral bending and right/left axial rotation at a loading rate of 4Nm/min. To precondition the specimen and to minimize the viscoelastic effects; each test was repeated for two cycles, with the data from the third cycle used for analysis.

RESULTS AND DISCUSSION

Since the preliminary study is limited to 3 spines, the specimens will be analyzed for statistical significance after testing additional specimens. Figure 1 and Figure 2 show the average range of motion (± standard deviation) data during flexion and extension respectively. During flexion, laminoplasty resulted in 8% increase in the motion while laminectomy resulted in 55% increase in the motion. It can be observed from figure 2 that laminoplasty showed a trend towards decreased range of motion during extension while no major changes were observed after laminectomy.

Both left lateral bending and left axial rotation showed a 13% and 12% increase in the range of motion respectively after open door laminoplasty (LP_C3456). This inclination towards increased range of motion after left lateral bending and left axial rotation can be attributed to the open door laminoplasty being performed on left side. Laminectomy resulted in profound increase in the motion during left (21%) and right (13%) axial rotation.

Compared to 4-level laminoplasty, 2-level laminoplasty resulted in decrease of motion during flexion and extension. After 2-level laminoplasty, during extension, it was observed that the C4 spinous process touched the opened lamina of C5 thereby resulting in decreased motion at C4-C5.

Lateral bending and axial rotation did not result in any major changes in motion after 2-level laminoplasty.

CONCLUSION

Earlier in vitro studies after ODL show discrepancies in the type of stabilization technique used for holding the lamina in the open position [2]. The plates and screws used in the current study were found to be intact throughout the testing of specimens. The range of motion data shows that laminoplasty resulted in minimal changes while laminectomy resulted in substantial increase during flexion and axial rotation. These results correspond well with existing in vitro laminoplasty and laminectomy studies [3]. Our goal is to compare the experimental results to the finite element predictions after ODL and laminectomy.

REFERENCES