Cervical Paraspinal Muscle Atrophy Rates Following Laminoplasty and Laminectomy with Fusion for Cervical Spondylotic Myelopathy

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BACKGROUND: **Cervical spondylotic myelopathy (CSM) is a disorder that can cause neurologic deterioration. Studies on paraspinal muscular atrophy (PMA) in the lumbar spine have shown that these changes are caused by several perioperative factors. It is possible that PMA in the cervical spine could behave similarly. In this retrospective study, we compared the degree of PMA after laminoplasty versus laminectomy and fusion (LF) using a standard posterior approach to the cervical spine.**

METHODS: **18 laminoplasty and 43 LF patients were included in this study. For each patient, preoperative and postoperative MRI files were obtained and transferred into OsiriX imaging software. Atrophy rate was obtained and reported as percentage change in cross-sectional area of the cervical paraspinal muscles from preoperative to postoperative imaging.**

RESULTS: **Mean cross-sectional cervical muscle atrophy rates were 6% and 13.1% for laminoplasty and LF, respectively, representing a 2.19 times increase in the degree of atrophy ($P < 0.001$). Independently, LF was associated with a 5.84% increase in the rate of PMA ($P = 0.03$). Involvement of C3 as the cephalad surgical level was associated with a 5.78% decrease in the rate of PMA ($P = 0.03$). For each degree increase in postoperative Cobb angle, there was a 0.66% decrease in the rate of PMA ($P = 0.02$).**

CONCLUSION: **PMA should be part of the decision making process when a posterior approach is considered, inasmuch as this study demonstrates that cervical laminoplasty was associated with significantly lower rates of PMA compared with cervical laminectomy and fusion. Additionally, these results suggest that minimizing PMA may help preserve cervical lordosis.**

INTRODUCTION

Cervical spondylotic myelopathy (CSM) is a debilitating disorder that can potentially cause significant and progressive neurologic deterioration. CSM remains the leading cause of spinal cord pathologic conditions worldwide.[1] Surgery is the standard of care for progressive CSM, and a posterior approach is frequently used in the management of multilevel disease in the absence of rigid cervical kyphosis.[2] However, atrophy of the paraspinal musculature after the posterior approach is common after spinal surgery.[3] Studies on paraspinal muscular atrophy (PMA) in the lumbar spine have shown that these changes are caused by mechanical injury, ischemia, denervation, retraction time, a midline approach, and disuse secondary to bracing.[4-9] PMA has been shown to lead to poor outcomes after lumbar spine surgery, contributing to postoperative pain, instability, and failed back syndrome.[3]

Comparatively fewer studies have investigated PMA in the cervical spine, but the available research suggests that limiting exposure to the medial two thirds of the lateral masses may decrease PMA.[10] More importantly, there is a scarcity of literature comparing the relative impact of different posterior procedures on cervical PMA. The authors of this study postulate that the choice of procedure could alter the incidence of PMA. In this retrospective

Key words
- Atrophy
- Cervical spine
- Laminectomy fusion
- Laminoplasty
- Paraspinal muscle

Abbreviations and Acronyms
CI: Confidence interval
CSA: Cross-sectional area
CSM: Cervical spondylotic myelopathy
LF: Laminectomy and fusion
MRI: Magnetic resonance imaging
PMA: Paraspinal muscular atrophy

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Citation: World Neurosurg. (2017) 107:445-450.
http://dx.doi.org/10.1016/j.wneu.2017.07.173

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

study, we compared the degree of PMA after laminoplasty versus laminectomy and fusion (LF) using a standard posterior approach to the cervical spine.

METHODS

The study was reviewed and approved by the institutional review board at our institution. The medical records, preoperative and postoperative radiographs, and magnetic resonance imaging (MRI) of the cervical spine were reviewed on all patients undergoing laminoplasty or LF by the senior author at more than 1 consecutive level for CSM between 2006 and 2015. Significant kyphosis and instability were contraindications to laminoplasty, and fixed severe kyphosis was a contraindication for LF. Postoperative MRI was routinely obtained in these patients as part of another clinical study.

Inclusion and Exclusion Criteria

Inclusion criteria for the study included clinical signs and symptoms of CSM. Exclusion criteria for this study included a history of previous cervical spine surgery; concomitant anterior cervical spine surgery; a diagnosis of infection, tumor, central cord syndrome, or other acute traumatic event; the simultaneous presence of another diagnosed neurologic disorder (such as normal pressure hydrocephalus, Parkinson disease, polio, or multiple sclerosis); postoperative MRIs less than 3 months from surgery; significantly degraded MRIs secondary to metallic artifact or patient movement; and MRIs that were incompatible with the imaging analysis software. Based on the above inclusion and exclusion criteria, 61 patients were enrolled in the study and divided into 2 groups. The laminoplasty group (A) consisted of 18 patients, and the LF group (B) consisted of 43 patients.

Surgical Management

All patients in the laminoplasty group underwent a modified open-door laminoplasty technique with titanium miniplates with or without allograft bone, as previously described.[8] Briefly, the spinous processes, lamina, and lateral masses on the open side of the laminoplasty were exposed. On the hinge side, only the hemi lamina and the very medial portion of the facet joints were exposed. Patients in the LF group underwent a posterior instrumented fusion in addition to decompressive laminectomy. The spinous processes and the entirety of the bilateral lateral masses were exposed. The fusion procedures were performed with the use of bilateral lateral mass screws and rods with local autograft bone. All surgical procedures were conducted by the same senior surgeon (L.T.H.). Both laminoplasty and LF were performed at similar relative rates during the entire inclusion period. The primary diagnosis and pathologic condition, CSM, was the same between the 2 groups. The decision on whether to perform laminoplasty or LF was based on several factors, including cervical alignment, the presence of mechanical neck pain, and patient preference.

Postoperative Protocol

Patients in both groups were treated with a hard cervical collar postoperatively. Patients in the laminoplasty group were treated in the hard collar for 4 weeks, compared to with 6 weeks for the LF patients. Physical therapy involving cervical range of motion and strengthening exercises was initiated at 6 weeks for patients in both groups.

Radiographic Analysis

For each patient, preoperative and postoperative MRI files were obtained from our institution's picture archiving and communication system. These files were then transferred into OsiriX (version 3.8.1, Pixmeo, Geneva, Switzerland), an imaging analysis software on an encrypted computer. Paraspinal cervical muscle groups were manually outlined and encircled to generate a cross-sectional area (in cubic centimeters) as seen in **Figure 1**.

Muscle groups in C2–C3 included multifidus and semispinalis cervicis.[1] Each section thereafter would generally include some component of the aforementioned group. The muscle group in C3–C4 was predominantly semispinalis capitis.[1] The added muscle group in C4–C5 was splenius capitis.[1] In section C5–C6, the trapezius was the predominant muscle group.[1] In section C6–C7, muscle groups were indistinguishable but consisted of all nuchal muscles.[1]

To assess for PMA, the average cross-sectional area (CSA) of all operated cervical levels was obtained on preoperative and postoperative images. Two independent researchers collected all radiographic data points for CSA. Atrophy rate was obtained by the following formula as previously described: 100 × (1- postoperative average paraspinal muscle cross-sectional area/preoperative average paraspinal muscle cross-sectional area).[2]

Additionally, preoperative cervical alignment was measured by the Cobb angle (C2–C7). Lordotic sagittal alignment was defined as Cobb angle >10°, straight as 0°–10°, and kyphotic as <0°.

Statistical Analysis

Patients in the laminoplasty and LF groups were analyzed on the basis of demographic factors (such as age and gender), clinical factors (such as number of levels affected, time between preoperative and post-operative MRI, time between surgery and postoperative MRI), and radiographic factors (such as Cobb angle, sagittal alignment, and paraspinal muscle cross-sectional area). Differences in continuous variables (such as age, number of levels affected, time between preoperative and postoperative MRI, time between surgery and postoperative MRI, and Cobb angle) between both groups were analyzed with unpaired samples t test. Differences between the paraspinal muscle CSA within each group were assessed by a 2-tailed paired samples t test. Categoric variables, such as gender and sagittal alignment, were analyzed by the Fisher exact test. Interobserver variability coefficients were obtained using correlation functions on CSA data obtained by the 2 independent researchers.

Additionally, data were assessed for normality and skewedness. Ordinary least squares regression was used to determine the association between paraspinal muscle atrophy rate and procedural technique, age, gender, number of levels fused, time between preoperative and postoperative MRI, time between surgery and postoperative MRI, cephalad surgical level involving C3, and sagittal alignment. The variables chosen for each model were determined based on availability of the data and on the authors' initial hypotheses about the effects of each variable size reduction. The model was assessed for multicollinearity and