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Regression of anterior disc-osteophyte complex following cervical laminectomy and fusion for cervical spondylotic myelopathy

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Abstract

Study Design—Retrospective case control study

Objective—To investigate whether posterior cervical laminectomy and fusion modifies the natural course of anterior disc-osteophyte complex in patients with multilevel CSM

Summary of Background Data—Dorsal migration of the spinal cord is the main purported mechanism of spinal cord decompression following cervical laminectomy and fusion but other potential mechanisms have received scant attention in the literature. This study was conducted to investigate whether cervical laminectomy and fusion affects the size of anterior disc osteophyte complex.

Methods—The medical records and radiographical imaging of 44 patients that underwent cervical laminectomy and fusion for CSM between 2006 and 2013 were analyzed. The size of the anterior disc osteophyte complex was measured pre and postoperatively on MR images taken at an interval of > 3 months apart. A control group consisted of 20 non-operatively treated advanced cervical spondylosis patients. Patients in the control met the same inclusion and exclusion criteria and also had sequential MRI taken at an interval of > 3 months apart.

Results—The nonoperative and operative groups were statistically similar in the pertinent patient demographics and characteristics including gender, age, time to second MRI, size of anterior disc-osteophyte complex on baseline MRI, mean number of levels affected, and percentage of patients with T2 signal change. As expected the mJOA scores were significantly lower in the operative versus nonoperative cohort (13.6 vs. 16.5, $P < 0.01$). A significant decrease in the size of anterior disc osteophyte was observed in the operative group postoperatively ($P < 0.01$). In comparison, there was no statistically significant change in the size of the anterior disc osteophyte complex in the control group ($P > 0.05$). The magnitude of the change in disc size between the two groups was statistically significant ($P < 0.01$).

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Conflicts of interest

The authors do not have any conflict of interest regarding this manuscript.

Conclusion—The findings of this study suggest that regression of anterior-disc osteophyte complex occurs following cervical laminectomy and fusion, and likely provides another mechanism of spinal cord decompression.

Keywords

cervical; myelopathy; fusion; regression; disc

Introduction

Cervical spondylotic myelopathy (CSM) is a potentially devastating neurological disorder resulting from spinal cord injury related to degeneration of the intervertebral discs and other supporting spinal column structures. This condition is the most common acquired spinal cord disorder in patients over age 55 and its incidence is expected to rise as the general population ages^{1, 2}. The natural history of CSM is characterized by stepwise neurologic deterioration in many patients, therefore, surgical intervention is frequently advocated^{3,4}.

There are various surgical procedures used in the treatment of patients with CSM including anterior cervical discectomy and fusion (ACDF) or corpectomy, cervical laminoplasty, cervical laminectomy, and cervical laminectomy and fusion⁵⁻¹¹. Each of these procedures has been demonstrated to be efficacious in the management of CSM, and in many cases it is likely that one of several approaches could yield satisfactory outcomes in an individual patient.

Cervical laminectomy and fusion has become an increasingly popular surgical technique for the treatment of CSM. The most salient purported beneficial effects of this procedure are the direct spinal cord decompression and dorsal drift of the spinal cord away from anterior compressive structures^{12,13}. However, a less recognized benefit of this procedure is the regression of the anterior located disc osteophyte complex, which, in addition to spinal cord drift, can serve to alleviate spinal cord compression. The phenomenon of osteophytic resorption following anterior interbody fusion has been described previously by both Bohlman¹⁴ and Robinson¹⁵. To our best knowledge, the regression of anterior compressive pathology has not been previously described following posterior fusion. In this manuscript, the authors investigate the occurrence of anterior disc-osteophyte complex regression following cervical laminectomy and fusion for CSM.

Materials and Methods

The medical records and radiographical imaging of all patients that underwent laminectomy and fusion for CSM by the senior author (LTH) between 2006 and 2013 were analyzed. Postoperative MRI was routinely ordered in this patient population as part of another clinical study. Inclusion criteria for the study included clinical signs and symptoms of CSM, confirmatory preoperative cervical spine imaging demonstrating a ventral disc herniation of 3mm in antero-posterior diameter, and a comparable postoperative MRI at least 3 months after surgery without metallic artifact in the region of measurement (Figure 1, 2). Exclusion criteria included patients with a history of cervical trauma, previous cervical spine surgery, and the simultaneous presence of another neurological disorder (e.g. multiple sclerosis,

normal pressure hydrocephalus, etc.). Cervical laminectomy and fusion using lateral mass screws and local autograft without discectomy was performed in each patient.

A control group consisted of nonoperatively treated advanced cervical spondylosis patients that were either completely asymptomatic or had mild CSM (Figure 3). The patients in the control group each fulfilled the inclusion and exclusion criteria, most notably repeat cervical spine imaging at an interval > than 3 months apart. The Office for the Protection of Research Subjects at our Institution approved the protocol for this study.

Radiographic Analysis

Radiographic analysis of pre-operative and post-operative MRI was performed using a single PACS viewer and imaging software (Centricity, GE Medical Systems, Milwaukee, WI). Anatomical measurements were performed using digital calipers at uniform magnification (200%). Central spinal canal stenosis was most often secondary to a combination of degenerative ventral disk-osteophyte complexes in conjunction with varying degrees of ligamentum flavum hypertrophy. For each analyzed disc level, the exact area of maximum disc herniation was first confirmed on both T2-weighted sagittal and axial images. A digital straight line was then drawn from the midpoint of the posterior aspect of the superior vertebrae to the midpoint of the inferior one on the sagittal cut corresponding to the point of maximal herniation. The measurement recorded by digital caliper between the posterior vertebral line and the point of maximal disc herniation was the recorded size of the herniated disc osteophyte complex. Only cervical levels with greater than 3mm of disc osteophyte complex protrusion on initial MRI were included in the analysis. The presence or absence of parenchymal T2 signal hyper-intensity was documented in all reviewed images.

Statistical analysis

The operative and control groups were analyzed on the basis of number of levels affected, displacement per cervical disk, modified Japanese Orthopedic Association score (mJOA), time to second MRI, and cord signal. The two-tailed paired samples t-test was used to assess changes over time within either group and Welch's t-test was used to compare differences between groups. An α level of 0.05 or less was deemed statistically significant.

Results

Forty four patients were identified as meeting criteria for the operative group and 20 patients for the control group. Baseline characteristics are demonstrated in Table 1 with $P > 0.05$ indicating no significant difference between groups. There were 29 (65.9%) males in the operative group and 12 (60.0%) in the control group ($P > 0.05$). The mean age of the operative group was 65.1 ± 10 years as compared to 59.8 ± 15.3 in the control group with ($P > 0.05$). There was no significant difference in the time to second MRI between the operative and the control group at 9.6 and 14.4 months respectively ($P > 0.05$). Twenty eight of the forty four patients (65%) in the operative group had T2 spinal cord signal change compared to 13 of 20 patients (64%) in the control group ($P > 0.05$). Baseline mJOA scores were different between the groups with 13.6 ± 1.56 in the operative patients and 16.5 ± 1.43

in the controls ($P < 0.01$). In the operative group, patient mJOA scores improved by 2.4 from 13.6 ± 1.56 to 15.9 ± 1.35 ($P < 0.01$) after surgery.

Baseline disc displacement was not significantly different between these groups with $4.70 \pm 1.02\text{mm}$ (range 3.00 to 7.89mm) in the operative group and $5.03 \pm 1.17\text{mm}$ (range 3.00 to 8.14mm) in the control group. In the operative group, the mean cervical disc displacement per level decreased 1.71mm from $4.70 \pm 1.02\text{mm}$ to $2.99 \pm 1.32\text{mm}$ (range 0 to 5.53mm) ($P < 0.01$). The control group however, increased slightly by 0.17mm from $5.03 \pm 1.17\text{mm}$ to $5.20 \pm 1.48\text{mm}$ (range 2.40 to 8.40mm) ($P > 0.05$) (Figure 4). The change in disc size herniation between the two groups was statistically significant ($P < 0.01$).

When analyzing only the level with the maximum initial disc-osteophyte complex size per patient, the mean complex size in the operative group decreased 2.31mm from $5.38 \pm 1.10\text{mm}$ to $3.07 \pm 1.64\text{mm}$ ($P < 0.01$).

Discussion

The natural history of CSM is frequently characterized by stepwise neurologic deterioration, with many patients ultimately requiring surgical intervention due to significant neurologic impairment^{3,16,17}. There is considerable debate about the optimal surgical management of patients with cervical myelopathy. Multiple surgical options exist, and large randomized studies have demonstrated satisfactory outcomes from either anterior or posterior approaches¹⁸⁻²⁰.

Cervical laminectomy and fusion has become an increasingly popular technique in the treatment of CSM. This is demonstrated by a recent survey of Academy of North American Spine Surgeons which revealed that cervical laminectomy and fusion is the most commonly used (70%) posterior procedure to treat multilevel CSM, followed by laminoplasty (23%), and laminectomy (7%)²¹. Dorsal migration of the spinal cord away from compressive ventral structures is the most widely accepted mechanism of spinal cord decompression following cervical laminectomy, and several published studies have emphasized the importance of this phenomenon^{12,13}. However, other mechanisms likely assist in the achievement of spinal cord decompression following cervical laminectomy and fusion. Regression of the anterior disc-osteophyte complex following cervical laminectomy and fusion represents an example of such mechanism, but has received comparatively scant attention in the literature.

The present study was designed to investigate whether posterior decompression and fusion modifies the natural course of the anterior disc-osteophyte complex in patients with multilevel CSM. We hypothesized that posterior fusion would result in a significant decrease in size of the anterior disc-osteophyte complex. The size of the anterior disc-osteophyte complex was measured pre and postoperatively in a cohort of CSM patients that underwent cervical laminectomy and fusion. In addition to pre and postoperative comparisons, the study cohort was compared to a group of nonoperatively treated patients with advanced spondylosis that were asymptomatic or had only mild CSM. The control group also underwent MRI at two separate time points, and provided context for the expected changes

in disc-osteophyte complex size in the absence of surgical intervention. The two groups were comparable and statistically similar in many of the key variables, most notably the size of the anterior disc-osteophyte complex as well as the mean interval between radiographical imaging.

The study group demonstrated a significant decrease in size of the anterior disc-osteophyte complex following posterior decompression and fusion: the mean decrease in disc size was 36% across all operative levels. When analyzing only the single largest anterior disc-osteophyte complex, the decrease in size was 43% of the preoperative baseline. In contrast, the control patients demonstrated an increase in the mean size of anterior disc-osteophyte complex although this did not reach statistical significance. Therefore it seems apparent that regression of the anterior disc-osteophyte complex occurs secondary to cervical laminectomy and fusion, and this likely represents another mechanism of spinal cord decompression following this procedure. As expected, there was some variation in the degree of disc-osteophyte complex regression through the cohort. This may be a function of the composition of the complex, as it would make sense that the softer components would more readily reabsorb, whereas the hard or heavily calcified components would remain more resistant to reduction. The process leading to this occurrence is unclear, but we speculate that reduction in size of disc osteophyte complex was accomplished via modulation of abnormal segmental motion in the fused segments of the surgery group. Biomechanical studies, and more recently kinetic MRI studies have elucidated the cyclical link between disc degeneration and abnormal motion^{22,23}. Furthermore, disc degeneration has been associated with changes in vertebral force distribution causing spondylotic changes and even fractures in the thoracic spine²⁴. Such changes may also occur in the cervical spine. This is supported by the observation that osteophytes are rarely present at sites of congenital or spontaneous fusions in the cervical spine²⁵. Reducing or eliminating abnormal motion therefore may prevent further disc degeneration and reverse some of these processes. Similar processes are frequently encountered in other spinal pathologies with abnormal motion such as synovial cysts, or craniovertebral pannus formation. Akin to the patients in our series, cessation of motion is associated with regression of the cysts or pannus in many cases²⁶⁻²⁹.

Several early investigations also support and correlate with our observations, and are consistent with the proposed mechanism of disc-osteophyte regression. In these reports, resorption of osteophytes occurred following anterior interbody fusion performed without osteophytectomy. Robinson et al¹⁵ first described this phenomenon in a series of 56 patients that underwent anterior cervical discectomy and fusion for advanced cervical spondylosis. This observation was subsequently echoed by Bohlman¹⁴ who detailed a similar occurrence in a cohort of 17 CSM patients that underwent anterior cervical discectomy and fusion. In both investigations the resorption of osteophytes was thought to be directly related to bony remodeling following fusion, and significant neurological improvement was achieved postoperatively.

The findings of this study have clinical impact and relevance. The decision to perform an anterior or posterior approach for a given patient with CSM is highly surgeon dependent and frequently debated. Commonly, surgeons prefer to perform an anterior approach in cases with significant anterior compression given concern that the spinal cord may be inadequately

decompressed from a posterior approach. In some of these cases, anterior disc-osteophyte complex regression, in addition to spinal cord drift, may provide enough decompression to obtain satisfactory clinical results via the posterior approach. This could be particularly advantageous in the elderly population as they may require multi-level surgery and are at high risk to develop swallowing-related problems following an extensive anterior approach.

Conclusion

Cervical laminectomy and fusion is a commonly performed surgery for the treatment of cervical spondylotic myelopathy. The main purported mechanism of spinal cord decompression following this procedure is spinal cord drift. The findings of this study suggest that regression of the anterior-disc osteophyte complex also occurs following laminectomy and fusion, and likely provides another mechanism of spinal cord decompression.

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Figure 1.

(A(A) Preoperative T2 weighted sagittal MRI demonstrating severe spinal cord compression in an 80 year old gentleman with significant upper and lower extremity weakness as well as gait difficulty. (B) Postoperative MRI demonstrates regression of the anterior disc herniation and spinal cord decompression following laminectomy and fusion.)

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Figure 2.

(A) 68 year old woman with progressive gait difficulty and hand incoordination. MRI demonstrated significant C3-4 spinal cord compression. (B) She underwent C3-4 laminectomy and fusion and postoperative MRI demonstrated regression of the anterior disc herniation.

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Figure 3.

51 year old gentleman with a history of neck pain and finger numbness, but denies any myelopathic symptoms. MRI revealed evidence of spinal canal stenosis from the anterior disc herniations. Due to his mild symptomatology the patient was treated nonoperatively.

Figure 4.

Graph demonstrating that the size of the anterior disc osteophyte complex significantly decreased in size following cervical laminectomy and fusion. The size of the anterior disc osteophyte complex did not sequentially change in the nonoperative group. significantly change in size on

Table 1

Patient demographics and characteristics

	Operative	Control	P-value
Patients	44	20	
Gender	29 males (65.9%)	12 males (60.0%)	> 0.05
Age (years)	65.1 ± 10	59.8 ± 15.3	> 0.05
Time to second MRI (months)	9.6 ± 11.5	14.4 ± 7.2	> 0.05
Size of disc osteophyte complex on baseline MRI (mm)	4.70 ± 1.02	5.03 ± 1.17	> 0.05
Baseline mJOA scores	13.6 ± 1.56	16.5 ± 1.43	< 0.01
Mean # of levels affected	2.77±0.96	2.95±1.23	> 0.05
T2 Cord signal (patients)	28 (64%)	13 (65%)	> 0.05