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Clinical Article

Axial Neck Pain after Cervical Laminoplasty

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Objective : It has been demonstrated that cervical laminoplasty is an effective and safe method of treating multi-level cervical spondylotic myelopathy and ossification of the posterior longitudinal ligament. However, recent reports have suggested that axial neck pain is frequently encountered after cervical laminoplasty. The aim of the present study was to determine clinical significance of the C7 spinous process on axial neck pain after cervical laminoplasty.

Methods : A total of 31 consecutive patients that underwent cervical laminoplasty between March 2002 and December 2008 were reviewed. The authors evaluated and compared axial neck pain and lordotic angle in patients that underwent C7 spinous process preserving surgery (group 1, n = 16) and in patients in which the C7 spinous process was sacrificed (group 2, n = 15).

Results : Severe or moderate early axial pain occurred in 56.2% of patients in group 1 and in 86.6% in group 2. Severe or moderate late axial pain occurred in 12.5% in group 1 and in 73.3% in group 2. Eighty-Six percent of patients in group 2 and 43% in group 1 experienced aggravation of their axial neck pain during the early postoperative period. Aggravation of axial neck pain during early postoperative period was less common in group 1 but not statistically significant ($p = 0.073$). Sixty-six percent of patients in group 2 and 12% in group 1 had aggravated axial neck pain at late postoperative period and aggravation of late axial neck pain was significantly less common in group 1 ($p = 0.002$).

Conclusion : The present study demonstrates that C7 spinous process preserving laminoplasty decreases the incidence of aggravated axial neck pain after cervical laminoplasty.

KEY WORDS : Cervical laminoplasty · Axial neck pain · C7 spinous process.

INTRODUCTION

Cervical laminoplasty was first described by Hirabayashi et al.[7] as a means of avoiding the delayed sequelae of laminectomy without fusion, and has since been used to treat a variety of lesions, such as, cervical ossification of the posterior longitudinal ligament and cervical spondylotic myelopathy. Furthermore, in East Asia, cervical laminoplasty is increasingly replacing cervical laminectomy with instrumented fusion because of the longer operative times, the higher incidence of more blood loss, pseudoarthrosis and the greater costs of spinal instrumentation, especially in elderly patients. Moreover, cervical laminoplasty is considered to be relatively safe and to present a low complication risk[6,13].

In terms of range of laminoplasty, C3-C7 laminoplasty is performed based on the concept of providing extensive posterior decompression[8]. Nevertheless, it has been reported that axial symptoms, such as pain and stiffness, are common complaints after cervical laminoplasty[10,34]. Axial pain after cervical laminoplasty has been reported to be due to neck muscle disruption, especially because of detachments of muscle insertions to the C2 or C7 spinous processes, or deep extensor muscles[12,30,31]. Pal and Routal[27] demonstrated that the C7 lamina plays a critical role in maintaining the stability of the cervical spine. The incidence of axial symptoms has been reported to be as great as 30-60% in patients that have undergone laminoplasty[10,17].

We have performed C3-6 laminoplasty on most patients with compression myelopathy since 2002, excepting patients with cord compression at C6-7 or a lower level. The purpose of this study was to investigate axial neck pain after C7 preserving and non-preserving laminoplasty.

MATERIALS AND METHODS

Thirty-one patients who underwent laminoplasty for cervical myelopathy between January 2002 and December

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2008 and with a minimum follow-up of 6 months after surgery were enrolled in this retrospective study. The main indication for surgery were evidence of myelopathy by physical examination with spinal cord compression by computed tomography (CT) or magnetic resonance imaging. During physical examinations, patients complained of numbness of the extremities, clumsy hands and difficulty of walking.

Operative technique

All operations were performed by the same surgeon. Under endotracheal general anesthesia, the patient was placed in the prone position, with the head secured in a three-point, rigid, cranium-fixation device and the neck in slight flexed position. A standard midline incision was made to expose the cervical laminas from the caudal edge of C2 to the cranial edge of C6 or C7, and was continued laterally to the medial aspect of the facet joints, preserving the spinous process and the inter- and supra-spinous ligaments. Care was taken to preserve the facet capsules and soft tissue attachments to the lateral masses. Two channels were drilled using a 3 mm cutting burr avoiding damage to facet joints until the ventral cortex of the lamina is identified. On the side to be opened, the channel was completed through the ventral cortex of the lamina with a diamond burr or 1 mm Kerrison upcutting rongeur. On the hinge side, the ventral cortex of the lamina was thinned until the lamina can be rotated dorsally to decompress the spinal cord. The ligamentum flavum and dural adhesions were released on the opening side and posterior elements are elevated en bloc. After adequate decompression, the dura was typically pulsatile, indicating satisfactory decompression. The open door was stabilized with a titanium miniplate (Low profile, Solco Medical, Korea). We usually used a straight five-hole plate bent in an "open Z" configuration, so that one hole was available for fixation into the lamina and its corresponding lateral mass. No formal attempt was made to graft to the operative site.

Patients were permitted to get out of bed wearing a Philadelphia collar within a week of surgery. At 2 months after surgery, collars were removed after checking X-rays and CT scans of the cervical spine.

Clinical assessments

Neurologic statuses were assessed using the Japanese Orthopedic Association scoring system (JOA, highest score = 17) before and after surgery[33]. JOA scores were recorded before surgery and at 1, 6 and 12 months postoperatively, and at latest follow-up assessments.

Axial symptoms included neck pain with neck stiffness, shoulder stiffness, or both. Axial symptoms were graded according to the criteria of Hosono et al.[9], as follows : severe (a pain killer or local injection regularly required), moderate (physiotherapy or compress regularly required), or mild (no treatment required). Early axial pain during the first postoperative month and late axial pain, which was evaluated at 12 month follow-up visits, were investigated. However, one patient who was followed up for less than a year was investigated at 6 months postoperatively for late axial pain.

We hoped to determine by comparing axial pain in the group 1 and 2 (the C7 preserving group and the C7 non-preserving group, respectively), whether C7 plays an important role in axial neck pain.

Radiographic assessments

Radiographic assessments involved determining lordotic angles of cervical spines. Lordotic angle was used as a measure of lordotic curvatures, and was defined as the angle between a line parallel to the inferior aspect of the C2 body and a line parallel to the inferior aspect of the C7 body. Cervical lordosis was measured from C2 to C7 preoperatively and at final follow-up visits.

We hoped to determine by comparing cervical lordotic angle in the group 1 and 2, whether C7 plays an important role in cervical lordotic angle.

Statistical analysis

Statistical analyses were performed using SPSS version 12.0 (SPSS Institute, Inc., Chicago, IL, USA). Because the number of patients was small, nonparametric statistical methods were used to ascertain the statistical significance of intergroup differences. Fisher's exact probability test was used to compare early and late axial pain between group 1 and 2. Mann-Whitney U test was used to compare preoperative axial pain, JOA score, recovery rate and radiologic results of cervical laminoplasty between group 1 and group 2. Statistical significance was accepted for p values of < 0.05.

RESULTS

Patient demographics

Of the 31 patients, 25 were men and 6 were women. The primary diseases were cervical spondylosis (15 cases), ossification of the posterior longitudinal ligament (13 cases), and calcification of the ligamentum flavum (3 cases). Mean age at surgery was 60.94 years (range, 31-79 years), and average length of follow-up was 28.90 months (range 6-84 months). Average preoperative and postoperative JOA scores and average recovery rate for all cases were 10.91 ± 4.10, 14.26 ± 2.90 points and 65.51 ± 21.12%, respectively (Table 1).

Clinical assessments

Average JOA score in group 1 improved from 10.76 ± 4.85 preoperatively to 14.06 ± 3.57 points at follow-up and in group 2, it improved from 11.97 ± 3.21 to 14.50 ± 1.91 points. Recovery rates in terms of JOA scores in group 1 and 2 were 69.00 ± 25.14% and 61.29 ± 14.72% in the group 2, respectively (Table 2). There was no statistical difference in postoperative JOA score and the rate of recovery between the two groups.

The difference between group 1 and group 2 with regard to preoperative axial pain was not statistically significant (p = 0.953).

Severe or moderate early axial pain occurred in 56.2% of patients in group 1 and in 86.6% in group 2. Severe or moderate late axial pain occurred in 12.5% in group 1 and in 73.3% in group 2 (Table 3).

Eighty-six percent (13 of 15 patients) of patients in group 2 and 43% (7 of 16 patients) in group 1 experienced aggravation of their axial symptoms during the early postoperative period. Aggravated early axial pain was less common in group 1 but not statistically significant (p = 0.073). Sixty-six percent (10 of 15) of patients in group 2 and 12% (2 of 16 patients) in group 1 had aggravated axial symptom at late postoperative follow-up and aggravated late axial pain was significantly less common in group 1 (p = 0.002).

We also investigated the effect of number of decompressed lamina on axial pain by comparing the group of patients who had 4 or less laminae decompressed and the group of patients who had 5 or more laminae decompressed. However, numbers of decompressed lamina were not found to be associated with the aggravation of axial pain during early postoperative period and at late postoperative follow-up (p = 0.507, and 0.486, respectively).

Radiographic assessments

Radiographically, mean cervical lordosis measured from C2 to C7 on lateral radiographs were 22.3 ± 11.8 and 11.9 ± 8.0 in group 1 and 2 at final follow up visits, respectively which were statistically significant different (p = 0.041). However, the difference between group 1 and group 2 with respect to postoperative loss of cervical lordosis was not statistically significant (p > 0.05) (Table 4).

Table 1. Patient demographics

Parameters	
Age_{Total}	31-79 years (60.94 ± 10.68 years)
$Age_{Group\ 1}$	31-79 years (61.00 ± 12.05 years)
$Age_{Group\ 2}$	47-73 years (60.86 ± 9.08 years)
Sex	M : F = 25 : 6
Primary disease	
cervical spondylosis	15
OPLL	13
Calcification of the ligamentum flavum	3
Follow up period	6-84 months (28.90 ± 23.99 months)
Number of decompressed $lamina_{Total}$	3-6 (4.26 ± 0.82)
Number of decompressed $lamina_{Group\ 1}$	3-5 (3.78 ± 0.71)
Number of decompressed $lamina_{Group\ 2}$	4-6 (4.86 ± 0.51)
Preoperative JOA score	3-16 (10.91 ± 4.10)
Postoperative JOA score	7-17 (14.26 ± 2.90)
Recovery rate of the JOA score (%)	28-100% (65.51 ± 21.12%)

OPLL : ossification of posterior longitudinal ligament, JOA score : Japanese Orthopaedic Association score

Table 2. JOA score and recovery rate for each group

	Preoperative JOA score	Postoperative JOA score	Recovery rate (%)
Group 1 (n = 16)	10.76 ± 4.85	14.06 ± 3.57	69.00 ± 25.14
Group 2 (n = 15)	11.97 ± 3.21	14.50 ± 1.91	61.29 ± 14.72
p value	NS	NS	NS

NS : not significantly, JOA score : Japanese Orthopaedic Association score

Table 3. Severity axial symptoms for each group

	Group 1 (n = 16)	Group 2 (n = 15)
Preoperative		
Mild	13	12
Moderate	3	3
Severe	0	0
Early postoperative		
Mild	7	2
Moderate	8	8
Severe	1	5
Late postoperative		
Mild	14	4
Moderate	1	6
Severe	1	5

DISCUSSION

Cervical myelopathy results from spinal cord compression due to various degenerative spinal changes. Although the surgical treatment of multilevel cervical myelopathy due to cervical spondylosis and OPLL remains controversial, cervical laminoplasty has now almost replaced laminectomy as a method of posterior decompression for cervical myelopathy in Japan and Korea, because cervical instability and kyphotic deformity are common after cervical laminectomy.

A considerable number of laminoplasty technique have been described[4,13,20,23,25,26,29]. Nevertheless, axial neck pain

Table 4. Comparison of radiologic results of cervical laminoplasty between Group 1 and Group 2

	Group 1 (n = 16)	Group 2 (n = 15)	*p* value
Cervical lordotic angle (degree)			
Preoperative	29.6 ± 11.0	19.9 ± 11.3	0.023
Postoperative	22.3 ± 11.8	11.9 ± 8.0	0.041
Δ C2-C7 lordotic angle (degree)*	7.3 ± 9.3	7.9 ± 9.4	NS

* Δ C2-C7 lordotic angle = preoperative C2-C7 lordotic angle - postoperative C2-C7 lordotic angle. NS : not significantly

remains the most important problem of cervical laminoplasty. Hosono et al.[10], reviewed a series of 72 laminoplasties conducted to treat cervical spondylotic myelopathy, and found a 60% incidence of axial pain. Kawaguchi et al.[16], reported significant axial neck pain in 44% of their patiensts. Other authors have reported incidence of axial neck pain after laminoplasty of about 30%[5,28,32]. The possible causes of axial neck pain after cervical laminoplasty are ischemia of the shoulder muscles, atrophy of nuchal muscles, and delayed union in the facet joints[10].

Relatively few studies have addressed C7 preserving surgery in the context of reducing the incidence of axial neck pain, and in fact, there is no definitive evidence regarding the anatomic importance of C7. Nevertheless, the incidence of axial neck pain aggravation after C7 non-preserving laminoplasty deserves consideration. The ligamentum nuchae is a triangular sheet of fibroelastic tissue that is located centrally between the dorsal musculature of the cervical spine[21]. It is composed of the dorsal raphe and the ventral midline septum. The dorsal raphe is formed by the interweaving of the right and left upper trapezius, splenius capitis, and rhomboid minor, and is a narrow but thick strip of collagenous tissues flattened in the coronal plane, centered over the midline of the back of the neck. It is firmly attached to the external occipital protuberance above and to the tip of the seventh cervical spinous process below, and less firmly attached to the tip of the sixth cervical spinous process[22]. According to Johnson et al.[14], the obvious advantage of the connective tissue organization in the ligamentum nuchae is that it must (by virtue of its direct attachments to the C6 and C7 vertebrae) serve to direct forces to the lower part of the cervical spine, thus sparing the middle and upper cervical spines from excessive loading. The ligamentum nuchae act as a strong tendon to control head balance, and in this context, its attachments to spinous processes are important[2]. Furthermore, because it represents the site of transition from the flexible and lordotic cervical spine to the rigid and kyphotic thoracic spine, the cervicothoracic junction is a structurally unstable region[3,11]. This abrupt change from mobility to stability predisposes this region of the spine to trauma and degeneration. In addition, the transition from smaller cervical vertebrae to larger thoracic vertebrae also occurs in this region. As a result, a higher incidence of postoperative kyphotic deformity exists in this region.

Although cervical laminoplasty has taken over from laminectomy in an effort to decrease the incidence of postoperative kyphotic deformity, a tendency toward kyphotic deformity still exists[1,6,24]. Maeda et al.[19] suggested that cervical lordosis after laminoplasty is preserved by dynamic factors, such as muscles and ligaments, which means that less kyphotic alignment development, is related to greater preservation of cervical spine flexibility after laminoplasty. Therefore, minimal violation of ligamentum nuchae at C7 insertion which is the main structure of neck motion is important to prevent the postoperative progression of kyphosis of cervical spine.

Cervical myelopathy is most common at the C5-6 disc level followed (in order) by C4-5, C3-4 and C6-7 disc level. Furthermore, the C6-7 disc level accounts for only 5% of patients with cervical myelopathy. This difference in frequency can be explained by the fact that cervical enlargement of the spinal cord is located at the C4-5 and C5-6 levels[18]. Retrolisthesis of the cervical spine seen in extension (dynamic stenosis) seldom occurs at the C6-7 disc because of its anterior tilt[15]. In other words, routine inclusion of C7 lamima as a standard expansive cervical laminoplasty is not recommended based on the consideration of lower incidence of myelopathy and possibility of instability at cervicothracic region.

According to our radiologic result, postoperative lordotic angle of cervical spine is closely related to preoperative lordotic angle of the cervical spine and there is no significant difference between group 1 and group 2 with regard to loss of cervical lordosis after laminoplasty. This result suggests that C7 preserving laminoplasty to reduce the incidence of axial neck pain cannot provide the benefit of the preservation of lordotic angle after laminoplasty.

CONCLUSION

This study shows that axial neck pain after cervical laminoplasty is significantly correlated with the preservation of the C7 spinous process. Therefore, performing C7 non-preserving laminoplasty routinely as a standard expansive cervical laminoplasty is not to be recommended. We suggest that surgeons should preserve the C7 spinous process to prevent axial neck pain after cervical laminoplasty when it is possible.

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