Comparison of Functional and Radiological Outcomes Between Two Posterior Approaches in the Treatment of Multilevel Cervical Spondylotic Myelopathy

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Abstract

Background: Posterior cervical decompression is an accepted treatment for multilevel cervical spondylotic myelopathy (CSM). Each posterior technique has its own advantages and disadvantages. In the present study, we compared the functional and radiological outcomes of expansive hemilaminectomy and laminoplasty with mini titanium plate in the treatment of multilevel CSM.

Methods: Forty-four patients with multilevel CSM treated with posterior cervical surgery in Department of Orthopedic Surgery, Beijing Army General Hospital from March 2011 to June 2012 were enrolled in this retrospective study. Patients were divided into two groups by surgical procedure: Laminoplasty (Group L) and hemilaminectomy (Group H). Perioperative parameters including age, sex, duration of symptoms, operative duration, and intraoperative blood loss were recorded and compared. Spinal canal area, calculated using AutoCAD® software (Autodesk Inc., San Rafael, CA, USA), and neurological improvement, evaluated with Japanese Orthopedic Association score, were also compared.

Results: Neurological improvement did not differ significantly between groups. Group H had a significantly shorter operative duration and significantly less blood loss. Mean expansion ratio was significantly greater in Group L ($77.83 \pm 6.41\%$) than in Group H ($62.72 \pm 3.86\%$) ($P < 0.01$).

Conclusions: Both surgical approaches are safe and effective in treating multilevel CSM. Laminoplasty provides a greater degree of enlargement of the spinal canal, whereas expansive hemilaminectomy has the advantages of shorter operative duration and less intraoperative blood loss.

Key words: Expansive Hemilaminectomy; Laminoplasty; Multilevel Cervical Spondylotic Myelopathy; Posterior Cervical Decompression

INTRODUCTION

The optimal surgical approach for cervical spondylotic myelopathy (CSM), especially multilevel CSM, continues to be debated. The goal of surgical intervention for multilevel CSM is to decompress the spinal cord and maintain stability of the cervical spine. In many cases, when stenotic pathology cannot be found at the disk level alone, or is accompanied by ossification of posterior longitudinal ligament (OPLL), a posterior strategy can provide satisfactory cord decompression. Posterior approaches include laminoplasty and laminectomy with or without fusion.[1,2]

Each surgical approach has distinct advantages and disadvantages. In recent years, the satisfactory clinical outcomes achieved with laminoplasty in the treatment of multilevel CSM have received increasing attention,[3] but there are potential postoperative risks associated with this procedure, such as lamina reclosure, which may cause restenosis of the spinal canal, and prolonged operative duration. Posterior laminectomy with decompression is a technique that is relatively simple and safe compared with laminoplasty. However, it can also be impeded by late complications of kyphosis and instability. In 1983, Gui et al.[4] introduced lateral laminectomy for the treatment of cervical myelopathy to avoid the complications that can result from posterior laminectomy, but its ability to achieve canal decompression is limited compared with the posterior approach. Expansive hemilaminectomy was introduced by Xu et al.[5] in 1999 to treat patients with spinal cord injury, and we have been using this technique for more than 10 years to treat multilevel CSM. The present study compared functional and radiological outcomes of two posterior techniques in the treatment of multilevel CSM.

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METHODS

Patient selection

Forty-four patients with multilevel CSM were treated with posterior cervical surgery in Department of Orthopedic Surgery, Beijing Army General Hospital from March 2011 to June 2012 and were recruited for this study. Inclusion criteria consisted of: (1) Consecutive or nonconsecutive multifocal (affecting more than three levels) spinal cord compression on magnetic resonance imaging (MRI); (2) preoperative cervical lordosis >10°; (3) clinical symptoms matching radiographic imaging and MRI; and (4) operated on by one of two appointed surgeons. Exclusion criteria were: (1) Cervical kyphosis; (2) previous cervical injury or operation; (3) other pathological conditions, such as spine deformity, tumor, tuberculosis, infection, or metabolic bone disorders; and (4) mental disorder or heavy opioid or alcohol use. Patients were divided into two groups according to the type of surgery performed: Laminoplasty (Group L) and hemilaminectomy (Group H). Perioperative parameters were also recorded, including age, gender, duration of symptom, operative duration, axial pain, and intraoperative blood loss.

Surgical procedure

Posterior open-door laminoplasty with titanium mini-plate fixation

The surgery was performed following the Hirabayashi technique.[6] General anesthesia was induced, and the patient was placed on the operating table in 30° reverse-Trendelenburg position. The head was immobilized with a Mayfield head clamp. A midline incision was made along the spinous processes of C3–C7 and the paracervical muscles were stripped off the exposed C3–C7 laminae bilaterally. Levels were identified by palpation and visualization of the prominent, bifid C2 spinous process. On the opening side, a high-speed cutting burr was used to create a trough along the lamina-lateral mass junctions. Burring continued until both the dorsal and ventral cortices of the laminae were completely excised. The ligamentum flavum at C2–C3 and C7–T1 was then carefully resected. The muscles attached to C2 were preserved as much as possible to minimize the risk of postoperative kyphotic deformity. On the hinge side, another trough was created along the lamina-lateral mass junctions from C3 to C7 by decorticating the posterior aspects of the laminae. After the adhesions between the dura and ventral surfaces of the laminae were removed with an elevator, a greenstick osteotomy was made by carefully pressing the spinous processes toward the hinge side while elevating the laminae on the open side with a nerve hook. Adequate expansion of the spinal canal, with pulsatile flow in the dura, could usually be achieved with an opening width of 8–10 mm. Skipped levels on the open side were stabilized using mini plates from the Centerpiece™ Plate Fixation System (Medtronic Sofamor Danek, Memphis, TN, USA).

Posterior expansive hemilaminectomy

Patient position and anesthesia were the same as for the open-door laminoplasty procedure. Standard posterior exposure of the cervical spine was achieved. The number of segments and the operated side depended upon the severity of spinal cord compression. The paracervical muscles were stripped from the laminae between C3 and C7 on one side only. The entire posterior element, from the base of the spinous process to the lamina-facet joint junction, was carefully removed unilaterally, over the side of interest, with a high-speed burr. At the base of the spinous process at each operated level, a cross-over, which removed both the base of the spinous processes on the operative side and part of the inner cortex of laminae on the opposite side, was made in order to expand the spinal canal as much as possible, until the opposite nerve roots were noted. After the decompression was complete, an anti-adhesion membrane (ActiveMatrix™, Skye Biologics, Redondo Beach, CA, USA) was applied to prevent tissue adhesion on the decompressed side of the spinal canal postoperatively [Figure 1]. Patients were allowed to sit up or walk on postoperative day 1. A cervical collar was worn for 3 months.

Outcome parameters

Assessment of neurological function

Clinical outcomes were assessed using the Japanese Orthopedic Association (JOA) scoring system.[7] JOA scores were recorded before the operation and 6 months postoperatively. Rate of JOA score improvement (JSI) was calculated as follows: (postoperative score − preoperative score)/(17 − preoperative score) × 100%. Surgical outcome was defined as excellent (JSI ≥ 75%), good (75% > JSI ≥ 50%), fair (50% > JSI ≥ 25%), and poor (JSI < 25%). The proportion of patients with excellent and good results at 6-month follow-up was calculated.

Assessment of spinal canal expansion

Magnetic resonance imaging scan of the cervical spine was performed on a 1.5T system (MAGNETOM® Avanto, Siemens, Germany) preoperatively and at the 6-month follow-up visit. For each pathological level, the T2-weighted coronal slice (repetition time/echo time: 3800/115; flip angle: 150°; excitations: 3; slice thickness: 2 mm; gap: 0 mm; field of view: 300 mm, image matrix: 256 × 512) in which the most severe compression cord area could be confirmed was chosen to represent the involved level. In addition, Adobe
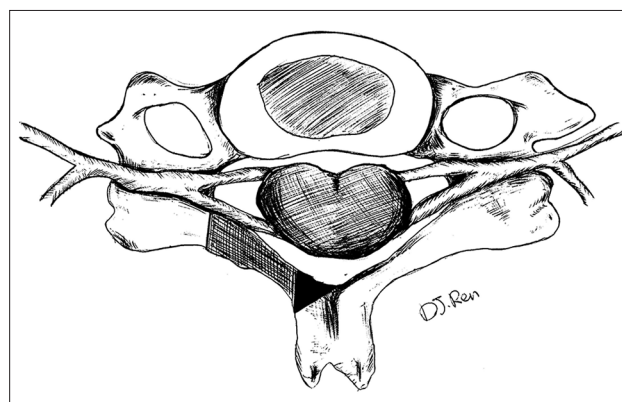

Figure 1: The range of decompression with expansive hemilaminectomy technique.

Illustrator CS6 (Adobe Systems, Inc., San Jose, CA, USA) and AutoCAD® 2014 (Autodesk Inc., San Rafael, CA, USA) were used as follows: The DICOM format of MRI cannot be recognized by AutoCAD®, a software application for two- or three-dimensional computer-aided design and drafting. Therefore, prior to comparing the expansion of the spinal canal in both groups, the MRIs were converted to PNG format using Adobe Illustrator CS6; AutoCAD® was then used to measure the area of the spinal canal. The software enables the user to take precise measurements of an irregular figure. When the selected MRI was opened in AutoCAD®, an enclosed region could be defined by outlining the border of the compressed spinal canal with the mouse pointer. This irregular spinal canal area was calculated using the AREA command. The area and perimeter of the enclosed region appeared at the bottom of the command-line window. The postoperative spinal canal area was defined as the enclosed region between the border of the compression and the dural sac on the decompressed side. For each patient, an average spinal canal area for all involved levels was calculated before the operation and at follow-up [Figures 2 and 3]. Mean expansion ratio of the spinal canal was also calculated at follow-up.

Statistical analysis

Continuous variables were expressed as mean ± standard deviation (SD). Comparisons of quantitative data (operative duration, intraoperative blood loss, and spinal canal area) between groups were analyzed by Student's t-test. The Chi-squared test was performed to compare postoperative recovery of neurological function between groups. Statistical analysis was conducted using GraphPad Prism 5.01 (GraphPad Software, Inc., La Jolla, CA, USA). A $P < 0.05$ was considered as statistically significant.

RESULTS

There were 23 patients in Group L (15 males, eight females; mean age, 66.1 ± 14.8 years [range, 45–72 years]) and 21 patients in Group H (17 males, four females; mean age 68.4 ± 18.1 years [range, 54–81 years]). Duration of symptom was 3–115 months (mean, 28.7 ± 13.2 months) in Group L and 6–102 months (mean, 24.1 ± 11.5 months) in Group H.

Clinical outcomes

In Group L, there was a significant improvement in JOA score from 9.78 ± 6.62 preoperatively to 14.75 ± 3.33 at 6-month follow-up ($P < 0.001$), and 78.2% of Group L patients had excellent ($n = 9$) or good ($n = 9$) results at 6-month follow-up.

There was also significant improvement in JOA score from preoperatively (9.6 ± 3.4) to 6-month follow-up (14.7 ± 3.4) ($P < 0.05$) in Group H, and 66.7% of these patients had excellent ($n = 6$) or good ($n = 8$) results at 6-month follow-up. There was no significant difference in percentage of patients with excellent or good follow-up JOA scores between Group L and Group H. Two patients in Group L (8.6%), but none in Group H, had axial pain at the 6-month follow-up.

Operative duration and intraoperative blood loss

Operative duration was significantly longer in Group L (139.3 ± 35.1 min) than in Group H (100.4 ± 27.1 min) ($P < 0.05$). Mean intraoperative blood loss was significantly greater in Group L (335.7 ± 50.1 ml) than in Group H (221.3 ± 22.5 ml) ($P < 0.05$).

Assessment of spinal canal area

Mean spinal canal area at 6-month follow-up was significantly greater in both groups compared with before surgery. Mean expansion ratio was significantly greater in Group P (77.83 ± 6.41%) than in Group H (62.72 ± 3.86% in Group H which was significantly larger in Group L than in Group H ($P < 0.05$) [Table 1].

DISCUSSION

The primary goals of surgical treatment for multilevel CSM are relief of neurological compression, stabilization of the cervical spine, and restoration of cervical lordosis.[8] Posterior cervical decompression is an accepted treatment of CSM and is the procedure of choice for the patients with multilevel CSM.[9] Since laminoplasty was introduced in 1973 to decrease the rate of late complications associated with laminectomy, various methods for performing cervical laminoplasty, in addition to open-door laminoplasty, have been developed.[10-12] All these variations were designed to widen the spinal canal while retaining the dorsal elements. The development of cervical fixation systems appears to have lowered the incidence of complications in recent years.[13] Open-door laminoplasty has become the preferred posterior procedure for treating multilevel CSM. Nevertheless, there are shortcomings associated with this procedure, such as high cost, long operative duration, potential for reclosing of
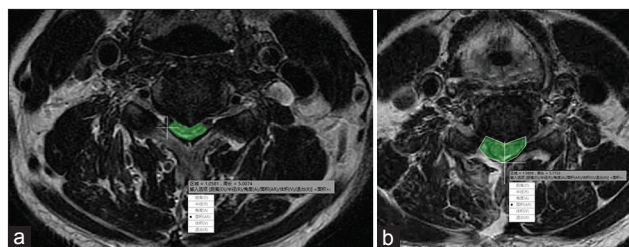

Figure 2: (a) Preoperative and (b) postoperative magnetic resonance imaging images showing measurement of spinal canal areas in Group H using AutoCAD® software.
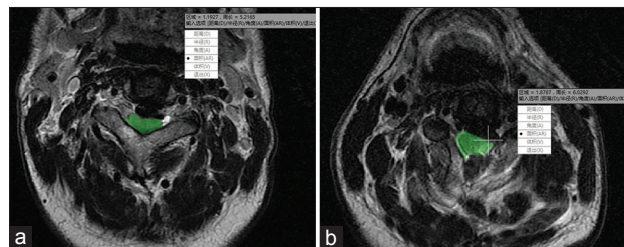

Figure 3: (a) Preoperative and (b) postoperative magnetic resonance imaging images showing measurement of spinal canal areas in Group L using AutoCAD® software.

Table 1: Comparison of spinal canal area preoperatively and at 6-month follow-up

Groups	Preoperative	Follow-up	P	Mean expansion ratio, %
Group L (n=23)	1.1875 ± 0.077	2.2141 ± 0.1178	<0.01	77.83 ± 6.41*
Group H (n=21)	1.1021 ± 0.091	1.987 ± 0.1358	<0.01	62.72 ± 3.86

*P<0.01 compared with mean expansion ratio in Group H.
L: Laminoplasty; H: Hemilaminectomy.

the door, restriction of range of motion, and lack of a truly stable fusion.[14,15]

Cervical laminectomy, which permits adequate decompression of the spinal cord, has long been the treatment for multilevel cervical spondylosis. However, it has been shown that laminectomy may cause instability owing to damage to the posterior elements of the spinal column. Hemilaminectomy is advantageous in preserving spinal structures but provides relatively limited decompression of the spinal canal.[16] Therefore, a modified laminectomy procedure, the expansive hemilaminectomy, was developed to obtain better spinal canal decompression. Because it could widen the spinal canal while preserving the interspinous ligaments and paracervical muscles on the contralateral side, it began to be indicated for the treatment of multilevel CSM.

In this study, we found that there was no significant difference in postoperative neurological improvement, as measured using JOA score, between expansive hemilaminectomy and laminoplasty with mini titanium plate. This suggests that both procedures can achieve similar clinical outcome in the treatment of multilevel CSM. We also found that operation time was shorter, and intraoperative blood loss less, in expansive hemilaminectomy than in laminoplasty with titanium mini-plate fixation. These may theoretically lead to a faster recovery and shorter hospital stay. Axial pain as a postoperative complication after laminoplasty or laminectomy is receiving much attention. Less invasive surgery, reconstruction of the extensor musculature, avoiding detachment of the semispinalis cervical muscles, and early removal of external immobilization have been shown to be effective in preventing axial pain after these procedures.[17] In the present study, no patients in Group H, and 8.6% of patients in Group L, were observed to have postoperative axial pain, suggesting that expansive laminectomy may reduce the incidence of postoperative axial pain compared with laminoplasty. However, because axial pain is influenced by a number of factors, high-quality studies are necessary to investigate this further.

In the present study, MRI, rather than computed tomography or radiographic images, was used to measure the area of the spinal canal because it allows a more detailed view of the spinal cord and compression. Because the shapes of the remnant vertebral canal area were mostly irregular or polygonal, AutoCAD® software was used for precise measurement of spinal canal area. By comparing the areas of the spinal canal before surgery and at 6-month follow-up in both groups, we found that both posterior approaches were able to widen the spinal canal significantly and that, although the mean expansion ratio in Group L was larger than that in Group H, sufficient space for the spinal cord to drift backward was created by both procedures. Our results suggest that laminoplasty may be a better choice for patients with a severely stenotic spinal canal, especially in cases where the spinal canal area is less than half that of the bony spinal canal or in cases of OPLL, because of its ability to achieve a greater degree of enlargement. A variety of factors may affect the surgical outcomes of patients with CSM, and each surgical approach also has its own distinct advantages and disadvantages. Therefore, surgeons should tailor the treatment method to the needs of the patient.[18]

The retrospective design and small sample size of the study group are the main limitations of the present study. Because of the very small sample, we were unable to divide the patients into subgroups according to the severity of the spinal canal stenosis. The lack of mid- and long-term follow-up is another drawback of the study.

In summary, both surgical approaches are safe and effective in the treatment of multilevel CSM; both allow the spinal cord to drift posteriorly in the enlarged spinal canal, and both provide satisfactory neurological improvement at 6-month follow-up. Compared with laminoplasty with mini-titanium plate fixation, expansive hemilaminectomy has the advantages of a shorter operation and less intraoperative blood loss, which theoretically can speed postoperative recovery. In addition, unilateral soft-tissue stripping and preservation of the posterior elements as much as possible can facilitate maintenance of spinal alignment.

REFERENCES

1. Sayana MK, Jamil H, Poynton A. Cervical laminoplasty for multilevel cervical myelopathy. Adv Orthop 2011;2011:241729.
2. Lin D, Zhai W, Lian K, Kang L, Ding Z. Anterior versus posterior approach for four-level cervical spondylotic myelopathy. Orthopedics 2013;36:e1431-6.
3. Casha S, Engelbrecht HA, DuPlessis SJ, Hurlbert RJ. Suspended laminoplasty for wide posterior cervical decompression and intradural access: Results, advantages, and complications. J Neurosurg Spine 2004;1:80-6.
4. Gui L, Davidovits P, Merlini L, Savini R. Cervical myelopathy. Technique and results of spinal cord decompression by lateral laminectomy. Ital J Orthop Traumatol 1983;9:129-38.
5. Xu S, Liu S, Sun T, Liu Z. Cervical spinal cord injury treated by expanded hemilaminectomy (in Chinese). Chin J Surg 1999;37:607-9.
6. Hirabayashi K, Toyama Y, Chiba K. Expansive laminoplasty for myelopathy in ossification of the longitudinal ligament. Clin Orthop Relat Res 1999; 359:35-48.
7. Hirabayashi K, Miyakawa J, Satomi K, Maruyama T, Wakano K. Operative results and postoperative progression of ossification among patients with ossification of cervical posterior longitudinal ligament. Spine (Phila Pa 1976) 1981;6:354-64.
8. Lian XF, Xu JG, Zeng BF, Zhou W, Kong WQ, Hou TS. Noncontiguous anterior decompression and fusion for multilevel cervical spondylotic myelopathy: A prospective randomized control clinical study. Eur Spine J 2010;19:713-9.
9. Satomi K, Nishu Y, Kohno T, Hirabayashi K. Long-term follow-up studies of open-door expansive laminoplasty for cervical stenotic myelopathy. Spine (Phila Pa 1976) 1994;19:507-10.

10. Hirabayashi K, Watanabe K, Wakano K, Suzuki N, Satomi K, Ishii Y. Expansive open-door laminoplasty for cervical spinal stenotic myelopathy. Spine (Phila Pa 1976) 1983;8:693-9.

11. Itoh T, Tsuji H. Technical improvements and results of laminoplasty for compressive myelopathy in the cervical spine. Spine (Phila Pa 1976) 1985;10:729-36.

12. Iwasaki M, Ebara S, Miyamoto S, Wada E, Yonenobu K. Expansive laminoplasty for cervical radiculomyelopathy due to soft disc herniation. Spine (Phila Pa 1976) 1996;21:32-8.

13. Rhee JM, Register B, Hamasaki T, Franklin B. Plate-only open door laminoplasty maintains stable spinal canal expansion with high rates of hinge union and no plate failures. Spine (Phila Pa 1976) 2011;36:9-14.

14. Chiba K, Ogawa Y, Ishii K, Takaishi H, Nakamura M, Maruiwa H, *et al.* Long-term results of expansive open-door laminoplasty for cervical myelopathy – Average 14-year follow-up study. Spine (Phila Pa 1976) 2006;31:2998-3005.

15. Hyun SJ, Rhim SC, Roh SW, Kang SH, Riew KD. The time course of range of motion loss after cervical laminoplasty: A prospective study with minimum two-year follow-up. Spine (Phila Pa 1976) 2009;34:1134-9.

16. Oktem IS, Akdemir H, Kurtsoy A, Koç RK, Menkü A, Tucer B. Hemilaminectomy for the removal of the spinal lesions. Spinal Cord 2000;38:92-6.

17. Wang SJ, Jiang SD, Jiang LS, Dai LY. Axial pain after posterior cervical spine surgery: A systematic review. Eur Spine J 2011;20:185-94.

18. Yamazaki T, Yanaka K, Sato H, Uemura K, Tsukada A, Nose T. Cervical spondylotic myelopathy: Surgical results and factors affecting outcome with special reference to age differences. Neurosurgery 2003;52:122-6.