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Original Article

Combined expansive open-door laminoplasty with short-segment lateral mass instrumented fusion for multilevel cervical spondylotic myelopathy with short segment instability

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ABSTRACT

Objectives: Expansive open-door laminoplasty (EOLP) is an effective procedure for multilevel cervical spondylotic myelopathy (MCSM). It preserves a higher range of cervical motion than laminectomy with fusion and reserves more posterior elements than laminectomy alone. MCSM with short-segment instability or correctable local kyphosis often requires long-segment decompression and adequate segment fusion.
Materials and Methods: We retrospectively reviewed 20 patients who received EOLP with short-segment posterior lateral mass instrumented fusion at our institution from 2008 to 2011. The follow-up period was at least 36 months. Postoperative functional and radiographic outcomes were collected and analyzed.
Results: Japanese Orthopedic Association scores improved significantly 36 months after surgery and the average recovery ratio was 85.3 ± 14.7%. Nurick disability scores and neck pain visual analog scale scores considerably decreased 3 years after surgery. No patients had aggravated neck pain or C5 nerve palsy during follow-up. The preservation of range of motion was approximately 60% after 36 months. No implant loosening or laminar collapse was reported on radiographic follow-up.
Conclusion: EOLP with concomitant lateral mass instrumented fusion yields favorable short-term clinical results for MCSM with short segment instability.

1. Introduction

Expansive laminoplasty is an effective procedure for treating multilevel cervical spondylotic myelopathy (MCSM). It can preserve segmental motion and protect posterior elements [1]. However, performing a laminoplasty alone is not sufficient for multilevel cervical stenosis with segmental instability and kyphosis [2]. Local kyphosis of cervical alignment is a critical factor associated with unsatisfactory surgical outcomes. It likely occurs because of incapacity of the spinal cord to expand posteriorly after decompression [3]. The choices for MCSM with obvious segmental pathologies include long level anterior corpectomied or discectomied fusion and long-level posterior laminectomy with instrumented fusion. We have reported that expansive open-door laminoplasty (EOLP) with concomitant anterior decompression and fusion is a good choice for MCSM patients who have segmental kyphosis, obvious anterior pathology, and segmental instability because the procedure has the advantage of motion preservation of a laminoplasty [4]. However, combined anterior and posterior procedures are associated with extended surgical times, increased blood loss, and a possible doubling of postoperative complications. For MCSM patients with segmental instability, laminoplasty combined with short-segment posterior instrumented fusion is considered a good alternative because the resulting stabilization can facilitate maintaining the cervical spine in an enhanced stable

Conflict of interest: none.

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position. This is expected to enable the spinal cord to adequately expand posteriorly after decompression. A previous report explored the increased incidence of C5 nerve palsy when combined posterior procedures were used [5]. The aim of the current study was to describe our surgical method of EOLP with short-segment lateral mass instrumentation and report surgical outcomes in a consecutive series of 20 patients with MCSM involving short-segment correctable kyphosis or instability.

2. Materials and Methods

Research ethics committee of Hualien Tzu Chi hospital, Buddhist Tzu Chi medical foundation authorized this retrospective study (IRB101-100). A consecutive series of 20 patients in whom MCSM with short-segment instability or correctable local kyphosis treated by laminoplasty with short-segment posterior lateral mass instrumentation was diagnosed from 2008 to 2011 at the authors' institution were reviewed. The follow-up period after surgery was at least 36 months.

Multilevel spinal cord compression was diagnosed using magnetic resonance imaging (MRI), and segmental instability or kyphosis was confirmed using dynamic plain radiography. Clinical cervical instability is defined as an axial neck pain visual analog scale (VAS) score ≥ 4 with one of the following three criteria: (1) static lateral radiograph translation distance > 3.5 mm; (2) angle of motion >20° on dynamic sagittal plain radiographs; and (3) static lateral radiographs showing angulation of the vertebrae > 11° greater than the angulation of either normal adjacent vertebrae [6]. Japanese Orthopedic Association (JOA) scores, Nurick scores, and VAS scores were used to assess preoperative neurological function and axial neck pain. All patients underwent routine and dynamic radiographs and MRI before surgery, and the preoperative cervical curvature was evaluated using the angle between the lower endplate of C2 and the upper endplate of C7. Range of motion (ROM) was evaluated by analyzing dynamic views of the cervical curvature. Correctable local kyphosis was confirmed when a lateral radiograph of the cervical spine showed a difference exceeding 5° between the adjacent vertebrae that could be corrected by extending the neck [3]. Segmental instability was determined by a horizontal displacement of > 10% of the sagittal diameter of the vertebral body in relation to the adjacent vertebra [7]. Twelve of the 20 patients had correctable local kyphosis confirmed by dynamic radiographs and the remaining eight patients had short-segment instability. Preoperative MRI showed no posterior disc herniation compressing the anterior spinal cord in any of the 20 patients. The characteristics of the participants are shown in Table 1.

The intended instrumented levels were decided preoperatively as segments of reducible local kyphosis or instability. Other stenotic levels were treated with EOLP. Somatosensory-evoked potentials were monitored using stimulation through the median nerve at the wrist during surgery to record basic data and any evidence of iatrogenic spinal cord injury [8]. After patients were placed in the prone position, Gardner-Wells skull traction tongs were used to induce relative kyphosis on the cervical spine. EOLP was performed using the techniques described by Hirabayashi et al [9] and O'Brien et al [10]. After bilateral channels were created using a cutting bur, the skull traction was released. Lateral mass instrumentation of the short segment was applied over the hinged side and fixed in an expected cervical alignment. After opening the lamina and using titanium miniplates to keep the lamina elevated, the lateral mass instrumentation was finally fixed over the open side ((Fig. 1)). Titanium reconstruction plates and screws were used with the Magerl technique [11] in 12 patients and a Synthes pedicle screw-rod system was used in the other eight patients.

After surgery, it was recommended that the patients wear hard neck collars (Vista, Aspen Medical Products Inc., Irvine, CA, USA) for protection for 3 months and perform adequate neck extension exercises. VAS scores were used to assess the severity of axial pain after surgery. JOA scores and Nurick scores were used to assess neurological function, and the JOA recovery rate was calculated

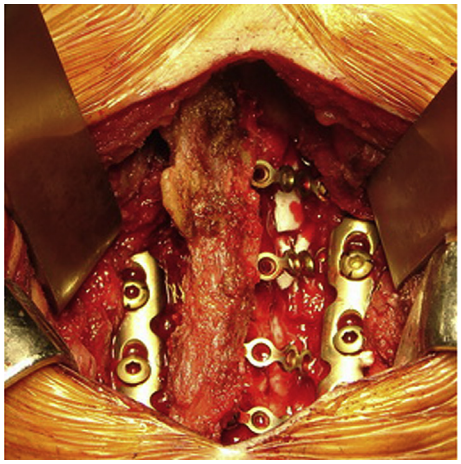

Fig. 1. Final intraoperative photograph of expansive open-door laminoplasty and concomitant posterior instrumentation with titanium reconstruction plates.

Table 1
Demographic data of the case series.

	Male ($n = 10$)	Female ($n = 10$)	Total ($n = 20$)
Age (y)	67.4 ± 9.8	66.0 ± 7.8	66.7 ± 8.4
Posterior instrumentation segment			
1	8	4	12
2	2	6	8
Sagittal compression ratio	0.54 ± 0.03	0.51 ± 0.02	0.53 ± 0.03
Axial compression ratio	0.33 ± 0.02	0.31 ± 0.01	0.32 ± 0.02
Symptom persistence period (mo)	11.6 ± 7.0	15.6 ± 5.4	13.6 ± 6.2
Symptom aggravation period (mo)	2.0 ± 0.7	2.6 ± 1.7	2.3 ± 1.3
Pavlov ratio	0.65 ± 0.05	0.64 ± 0.05	0.64 ± 0.05
Cobb angle (°)	10.5 ± 2.2	16.8 ± 4.8	13.6 ± 4.8
ROM (°)	36.8 ± 9.7	40.1 ± 7.3	38.4 ± 8.3
Nurick score	2.2 ± 0.5	3.0 ± 0.7	2.6 ± 0.7
VAS score	6.0 ± 0.0	5.2 ± 1.1	5.6 ± 0.8
JOA score	11.2 ± 1.8	10.4 ± 1.1	10.8 ± 1.5

Data are presented as *n* or mean ± standard deviation.
JOA = Japanese Orthopedic Association; mo = month; ROM = range of motion; VAS = visual analog scale; y = year.

from JOA score data evaluating the improvements [12]. The formula was as follows:

(postoperative score − preoperative score) × 100/[17 (full score) − preoperative score].

During postoperative follow-up, cervical spine plain radiographs with dynamic views were analyzed to observe changes in cervical curvature and ROM every 3 months. MRI was performed at 12 months, 24 months, and 36 months postoperatively to verify enlargement of the spinal canal and the decompression effect on the spinal cord. After the 1st postoperative year, patients were followed up yearly at the orthopedic outpatient department for at least 3 years.

SPSS version 17.0 software package was used for statistical analysis (SPSS Inc., Chicago, IL, USA). To assess statistical significance, unpaired Student *t* test was also performed, and the level of statistical significance was set at $p < 0.05$.

3. Results

This study involved 10 men and 10 women. Their mean age was 66.7 ± 8.4 years. Twelve patients received one level of posterior instrumentation (PI) and the remaining eight patients received two levels of PI. The average myelopathic-symptom aggravation time was 2.3 ± 1.2 months, the mean surgical time was 2.1 ± 0.5 hours, and the mean blood loss was 116.2 ± 33.8 mL.

The mean JOA score improved from 10.8 ± 1.5 months to 16.1 ± 0.6 12 months after surgery (Table 2), and the mean recovery rate was 85.3 ± 14.7%. The mean Nurick disability score decreased from 2.6 ± 0.7 to 0.4 ± 0.7. The mean neck pain VAS score 36 months after surgery decreased from 5.6 ± 0.8 to 1.6 ± 1.3. The results of neurogenic recovery and neck pain decrease were significant ($p < 0.05$); moreover, there were no complications such as aggravated neck pain or C5 nerve palsy.

The mean Pavlov ratio at the C5 level improved from 0.64 ± 0.05 to 1.12 ± 0.04, 3 years after surgery (Table 3). The cervical curvature lordotic angle increased from 13.6 ± 4.8° to 18.8 ± 6.7°, and cervical ROM changed from 38.4 ± 8.3° to 22.7 ± 4.5°; thus, about 60% of preoperative ROM was preserved at 36 months. No implant loosening or laminar collapse was reported during radiographic follow-up.

Table 2
Comparison of preoperative/postoperative functional outcomes.

	Preoperative	Postoperative 36 mo	*p*
Nurick score	2.6 ± 0.7	0.4 ± 0.7	< 0.001*
VAS score	5.6 ± 0.8	1.6 ± 1.3	< 0.001*
JOA score	10.8 ± 1.5	16.1 ± 0.6	< 0.001*
JOA recovery rate (%)		85.3 ± 14.7	
C5 nerve palsy (%)		0	

Data are presented as mean ± standard deviation.
*$p < 0.05$ was considered statistically significant after test.
JOA = Japanese Orthopedic Association; VAS = visual analog scale.

Table 3
Comparison of preoperative/postoperative radiographic outcomes.

	Preoperative	Postoperative 36 mo	*p*
Pavlov ratio	0.64 ± 0.05	1.12 ± 0.04	< 0.001*
Cobb angle	13.6 ± 4.8	18.8 ± 6.7	0.066
ROM	38.4 ± 8.3	22.7 ± 4.5	< 0.001*

Data are presented as mean ± standard deviation.
*$p < 0.05$ was considered statistically significant after test.
JOA = Japanese Orthopedic Association; ROM = range of motion; VAS = visual analog scale.

3.1. Case presentation

A 68-year-old man who worked as a farmer presented with bilateral hand clumsiness, numbness in the four limbs, and an impaired tandem gait. The patient's JOA and Nurick scores before the surgical procedure were 10 and 3, respectively, and the neck pain VAS score was 4. C5-6 segmental ROM before the surgery was 26° (Fig. 2A and 2B). The difference between the C5-6 segmental angle and the average ROM of C4-5 and C6-7 was > 11°. C3-4 retrolisthesis was noted but the translation was < 3.5 mm and not unstable based on lateral and dynamic plain radiographs. MRI in the sagittal view showed C3–7 stenosis with obvious compression of the spinal cord (Fig. 2C). Multilevel cervical stenosis with C5–6 instability was noted. EOLP was performed over C3–7 with concomitant C5–6 PI with bilateral titanium reconstruction plates. The neck pain VAS score was 1 36 months after the surgical procedure. Two years after surgery, the JOA score was 17 and the Nurick score was 0; the JOA recovery rate was 100%. The cervical curvature was 12° lordosis and ROM was 16° (Fig. 2D and 2E). MRI of the patient's spinal cord 3 years after surgery showed a patent spinal canal with smooth cerebrospinal fluid flow (Fig. 2F).

4. Discussion

Laminoplasty is a valuable surgery for multilevel cervical stenotic myelopathy [13,14]. We have also reported good surgical results with EOLP for patients with MCSM without local kyphosis, segmental instability, or an observable major anterior compressive lesion [15]. Local kyphosis and segmental instability are both associated with unsatisfactory MCSM outcomes after expansive laminoplasty [3,16]. Only anterior diskectomy or corpectomy for MCSM has been noted to have a high incidence of nonunion, pseudarthrosis, and fusion site collapse; therefore, further extended anterior fusion with long-level PI might be indicated during the surgery or as a subsequent staged procedure [17,18]. Using laminoplasty with short-level fusion to treat multilevel cervical stenosis associated with instability or misalignments can save motion segments with minimal fusion-related complications [19,20]. In this study, we performed EOLP with short-segment PI for 20 patients with segmental correctable kyphosis or instability, and the neurogenic recovery outcomes were satisfactory. In addition to preserving nearly 60% of the patients' preoperative ROM, increased lordotic cervical curvature and significantly decreased axial neck pain were observed postoperatively.

Postoperative segmental C5 palsy and aggravated axial neck pain are both recognized complications after expansive laminoplasty. The incidence rate of C5 palsy after laminoplasty is approximately 4.6% (range, 0–30%) [21]. Takemitsu et al [22] reported a 50% complication rate in EOLP combined with posterior lateral mass instrumented fusion and attributed the incidence to aggravated foraminal stenosis after reduction of spondylolisthesis and asymmetrical spinal cord posterior expansion. Aggravated axial neck pain after laminoplasty has also been reported as a result of destruction of the C2 and C7 spinous processes [5,23,24]. In our study, none of the 20 patients had postoperative deltoid weakness or exacerbated neck pain according to the VAS scores.

Short-segment stabilization appears to extend the indications for EOLP for MCSM. Instead of long-level decompression fusion, short-segment anterior decompression combined with EOLP provides an alternative in treating multilevel stenosis with prominent short-segment anterior compression lesions, kyphosis,

Fig. 2. (A,B) Preoperative dynamic radiographs show C5/6 instability. (C) Magnetic resonance imaging (MRI) shows C3-7 stenosis compression of the spinal cord. (D,E) Postoperative anteroposterior and lateral X-rays at 36 months show better cervical curvature. (F) MRI 36 months postoperatively shows a patent spinal canal with smooth cerebrospinal fluid flow.

and instability [4]. However, a combined anterior and posterior approach might extend the surgical time and increase the incidence of spinal cord injury because two procedures are performed. For MCSM without prominent anterior compressive lesions but with local instability or kyphosis, expansive laminoplasty with posterior short-segment stabilization appears to be another appropriate surgical method. The mean age of patients in this study was 65 years or older. Performing all posterior procedures through one wound and in one surgical position may lessen complications from multiple procedures for patients in this age group.

The limitations of the current study were the small sample and the short duration of follow-up. In future studies, we will compare EOLP combined with anterior decompression fusion with the method explored in this study.

Because EOLP with concomitant short-segment lateral mass instrumented fusion yielded favorable short-term clinical results, the method is adequate for treating cases of MCSM with short segment correctable local kyphosis or instability.

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