Spine

CLINICAL OUTCOMES FOLLOWING CERVICAL LAMINOPLASTY FOR 204 PATIENTS WITH CERVICAL SPONDYLOTIC MYELOPATHY

Michael Y. Wang, M.D.,* Sachin Shah, M.D.,† and Barth A. Green, M.D.†
*Department of Neurological Surgery, University of Southern California, Los Angeles and California;† and Department of Neurological Surgery, University of Miami, Miami, Florida


BACKGROUND
Laminoplasty is a well-recognized technique for decompressing the cervical spine in cases of spondylotic myelopathy and ossification of the posterior longitudinal ligament. This technique, originally popularized in Asia, is becoming more widespread, but to date there have been few reports of clinical series from North American centers.

METHODS
Retrospectively we reviewed (1986-2001) 204 cases of open door laminoplasty. All patients presented with symptoms and magnetic resonance imaging (MRI) findings consistent with myelopathy secondary to multisegmental cervical stenosis with spondylosis and underwent decompression from C3 to C7. Improvement in myelopathy was assessed with the Nurick Score.

RESULTS
Average age was 63 years (range 36 to 92). Follow-up averaged 16 months. Postoperatively, Nurick scores improved by 1 point in 78 patients, 2 points in 37 patients, 3 points in 7 patients, and 4 points in 5 patients; 74 patients experienced no improvement, and 3 patients deteriorated by one point. There was no statistical difference in myelopathy outcomes when comparing patients older and younger than 75 years of age. In two patients there was radiographic progression of kyphosis, but in no case was subsequent fusion required. 6 patients without neck pain preoperatively developed new intractable neck pain after surgery.

CONCLUSIONS
Open door expansile laminoplasty is a safe and effective method for treating cervical spondylotic myelopathy. Laminoplasty is thus an alternative to anterior surgery that can be accomplished quickly with minimal blood loss, minimizing risks in elderly patients. © 2004 Elsevier Inc. All rights reserved.

KEY WORDS
Laminoplasty, laminectomy, myelopathy, cervical spine, radiculopathy.

INTRODUCTION
The optimal surgical treatment for cervical spondylotic myelopathy remains controversial (13,18). Multilevel laminectomy without fusion has been largely supplanted by anterior surgery, and proponents of anterior approaches stress the advantages of direct decompression of the spinal cord with fusion of the treated segments (11,36). However, the technical demands and higher failure rates associated with long anterior constructs have driven many surgeons to apply posterior surgery in cases of multisegmental cervical stenosis.

Laminoplasty is a procedure originally developed in Japan to avoid the delayed sequelae of laminectomy without fusion. This procedure initially gained popularity as a treatment for ossification of the posterior longitudinal ligament (OPLL) but is increasingly being used to treat cases of cervical spondylotic myelopathy, (32) and a myriad of modifications to the original technique have subsequently been developed (24,25,34). Laminectomy with instrumented fusion is an alternative to laminoplasty. However, the longer operative time, complications, and costs associated with spinal instrumentation can make this approach less practical, particularly in elderly or debilitated patients.

While several East Asian clinical series of laminoplasty have demonstrated the efficacy of this technique, no large series on North American patients have been reported. This report describes a review...
Nurick Score for Myelopathy

<table>
<thead>
<tr>
<th>NURICK SCORE</th>
<th>CLINICAL FINDINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Root involvement but no evidence of spinal cord disease</td>
</tr>
<tr>
<td>1</td>
<td>Spinal cord disease but no difficulty walking</td>
</tr>
<tr>
<td>2</td>
<td>Slight difficulty walking, but still employable</td>
</tr>
<tr>
<td>3</td>
<td>Difficulty walking preventing full time work or housework but independent ambulation</td>
</tr>
<tr>
<td>4</td>
<td>Able to walk with assistance or walker</td>
</tr>
<tr>
<td>5</td>
<td>Chairbound or bedridden</td>
</tr>
</tbody>
</table>

of clinical outcomes from open door laminoplasty in a large American institution.

METHODS

PATIENT POPULATION

Two hundred and four patients treated with open door laminoplasty at the University of Miami Department of Neurological Surgery by the senior author (B.A.G.) were retrospectively reviewed (1986–2001) by a third party. All patients presented with symptoms and MRI findings consistent with myelopathy secondary to multisegmental cervical stenosis with spondylosis. Compression in all cases extended to at least three disk levels and was multifactorial in nature due to congenitally small canal space, broad disk herniations, and ligamentous hypertrophy. Cases with spinal cord injury due to acute trauma, OPLL, and pediatric patients were excluded.

Improvement in myelopathy was assessed with the Nurick Score (Table 1) (23). Preoperative medical conditions were quantified using the Charlson Comorbidity Score (5). Operating room time, surgical blood loss, hospital length of stay, and disposition were also recorded. Statistical analysis was performed with a Student’s t-test for discrete variables and the chi-squared test for contiguous variables using a $P = 0.05$ level of significance.

SURGICAL PROCEDURE

The open door technique employed is a modification of the original Hirabayashi laminoplasty (14,15). Following subperiosteal dissection to expose the laminae and medial portion of the lateral masses, the tips of the spinous processes were removed with a Horsley rib cutter for later use as autograft. This prevented crowding of the spinous processes with neck extension, but at the base the interspinous ligaments were preserved. Laminotomies were then performed at C2–3 and C7-T1. A thin longitudinal trough was drilled on the open side of the laminoplasty at the junction of the laminae and facets with a matchstick style drill bit to expose the ligamentum flavum from C2 to T1, connecting the laminotomies. Drilling on the contralateral hinge side was identical but left the inner cortex of the laminae intact. Lifting of the five laminae was then performed with curettes, and 10 to 15 mm high rib allograft spacers were placed at C3, C5, and C7 to support the opened posterior arch. The standard decompression thus spanned five laminae and decompressed the entire cervical spine as the patients treated in this manner had extensive cervical disease. In certain cases with compression at C2–3 or C7-T1 a laminectomy was extended rostrally or caudally. In cases with coexistent nerve root compression foraminotomies were performed prior to lifting of the laminae in standard fashion.

RESULTS

DEMOGRAPHICS

Average age was 63 years with a range of 36 to 92 (Figure 1). One hundred and forty-five of the patients were male (Table 2). The average Charlson Comorbidity Score was 1.49. Fourteen patients had decompression performed over four levels, and four patients had six levels decompressed; the remainder had five level decompressions from C3 to C7. One hundred and twenty of the procedures were performed on the right side. Operative time averaged 210 minutes, and blood loss averaged 350cc. Mean follow-up was 16 months. Discharge was to home (72%), inpatient rehabilitation (27%), and skilled nursing facility (1%). There were no perioperative deaths. In 46 patients spinous process autograft was placed in the intersegmental gutter along the lateral masses. In these cases this was done either because of substantial lateral bone removal during a foraminotomy or because of preoperative neck pain. Most of these cases were earlier in the series, a practice which we now rarely employ.

Seventy-five of the patients had evidence of spinal cord damage on preoperative MRI studies. Sixty-three had increased T2 signal in the parenchyma of the spinal cord. Thirty-one had evidence of myelomalacia in the cervical cord; 82% of patients experienced functional neurologic improvement after surgery.

MYELOPATHY

Myelopathy improved as measured by the Nurick score in 62% of patients. Postoperatively Nurick
scores improved by 1 point in 78 patients, 2 points in 37 patients, 3 points in 7 patients, and 4 points in 5 patients; 74 patients experienced no improvement, and 3 patients deteriorated by one point (Figure 2). Twelve patients regained the ability to ambulate after surgery.

Leg weakness was found preoperatively in 100 patients. Postoperatively, symptoms were completely resolved in 41, improved in 32, the same in 25, and worse in two. Lower extremity hyperreflexia was found preoperatively in 137 patients. Postoperatively, this sign was completely resolved in 55, improved in 5, the same in 74, and worse in 3. Bowel and bladder incontinence was found preoperatively in 36 patients. Postoperatively, symptoms were completely resolved in 19, improved in 4, the same in 12, and worse in 1.

Fifty-eight of the patients were age 75 or older. These patients improved an average of 1.18 points on the Nurick score. In comparison, the 146 patients under 75 years of age improved an average of 0.86 points. This difference was not statistically significant ($P = 0.07$).

### RADICULOPATHY

A total of 106 patients had concomitant foraminotomies performed (Table 3). Fifty-seven patients had painful radiculopathy. Of these, 26 experienced complete resolution, 12 improved, 17 remained the same, and two were worse at last follow-up. Sixty-nine patients had motor weakness attributable to

---

**1** Age distribution.

**2** Patient Demographics

<table>
<thead>
<tr>
<th>Charlson Comorbidity Score</th>
<th>Number of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>89</td>
</tr>
<tr>
<td>1</td>
<td>53</td>
</tr>
<tr>
<td>2</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Mean</td>
<td>1.49</td>
</tr>
</tbody>
</table>

---

**Table 3**

Average age 63 years
Age range 27–92 years
Male:female 145:59
Mean operative time 210 minutes
Mean blood loss 350 cc
Mean follow-up period 16 months
Concomitant fusion 46/204
Concomitant foraminotomies 106/204
Charlson Comorbidity Score

nerve root compression in the C5, C6, C7, or C8 distribution. Of these, 26 experienced complete resolution, 27 improved, 13 remained the same, and 3 were worse at last follow-up. Foraminotomies increased operation times from an average of 198 minutes to 222 minutes ($P = 0.004$) and blood loss from an average of 340 cc to 367 cc ($P = 0.084$).

**COMPLICATIONS**

Complications included wound infection in 10 cases, transient C5 root palsy in 4, cardiopulmonary events in 4, dural tear in 1, and postoperative epidural hematoma in 1 (Table 4). Two patients lost sagittal alignment to develop a very mild kyphosis, but in none of these cases was subsequent surgery required.

Eighty-nine patients were free of neck pain before surgery. Six of these patients developed new axial neck pain after surgery that persisted at last follow-up. Of the 115 patients with preoperative neck pain, 58 had complete resolution of symptoms, 22 experienced some improvement, 28 were unchanged, and 7 were worse at last follow-up.

**DISCUSSION**

The management of multilevel cervical stenosis has undergone an evolution over the past century. Early treatments with multilevel laminectomies resulted in initial neurologic improvements but long-term
results in some cases were disappointing. Postlaminectomy kyphosis, while more common in children, has also been seen following posterior decompression in adults (2,4,6,11,12,17,20–22,27,30,34–36). Improvements in the safety of anterior cervical surgery resulted in a proliferation of long-construct anterior decompressions (26). However, because the decompression afforded by corpectomies and discectomies are inherently destabilizing, a formal fusion is required. Long-term evaluation of these constructs has revealed that fusion of three or more levels is subject to arthrodesis failure rates of up to 45% (8,11,36). Additionally, such extensive anterior exposures result in a high rate of dysphagia and recurrent laryngeal nerve paralysis (37). Posterior decompression avoids many of these anterior approach-related morbidities and is able to effect substantial indirect decompression of the spinal cord (1,16,31). Contemporary posterior treatment is largely limited to laminectomy with fusion or laminoplasty (3,9,10). While laminoplasty has been utilized extensively in East Asia, there are few series documenting the clinical outcomes in North American patients.

This study documents the clinical course of 204 North American patients treated with laminoplasty for severe cervical canal stenosis. Overall, impairments were reduced in 82% of the treated patients, and 62% of patients experienced improvements in ambulation as measured by the Nurick score. These results approximate the outcomes in other large series of patients treated surgically for spondylotic myelopathy (18,38). In addition, neurological worsening was uncommon in this cohort, occurring in less than 2% of patients.

In this report a large number of elderly patients with a high comorbidity index were treated, with 42% of patients over the age of 70 years. In addition, medical deblilities relevant to spinal surgery but not measured by the Charlson Comorbidity Score, such as osteoporosis, poor nutrition, alcoholism, and smoking history were highly prevalent. Since a major advantage of laminoplasty is the reduced operative time and blood loss when compared with multilevel anterior decompressions (10), the low complication rates found in this study support the feasibility of laminoplasty as a first-line treatment when the goal is decompression of the cervical spine with minimal associated morbidity.

We also found a less than 2% incidence of C5 root palsy in this series, significantly lower than rates in other studies, which have found this complication to be as high as 12.9% (7). Because C5 root paralysis is putatively the result of posterior traction on the thecal sac (33), this low incidence may be attributable to our tailoring of the spacer size to prevent overlifting of the laminae and meticulous attempts to free dorsal adhesions.

The major drawback of this study is the lack of extended long-term follow-up. Loss of sagittal alignment after laminoplasty has been reported to occur many years after surgery, and the true prevalence of this sequel can be determined only by longitudinal studies spanning five to ten years (19, 28, 29).

Conclusions

Laminoplasty offers a safe alternative to both anterior surgery and laminectomy with fusion for treating cervical spondylotic myelopathy. The advantages of this procedure over other approaches may be especially important when treating elderly, debilitated patients.

REFERENCES


<table>
<thead>
<tr>
<th>Complications</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound infection</td>
<td>10</td>
</tr>
<tr>
<td>New intractable neck pain</td>
<td>6</td>
</tr>
<tr>
<td>C5 root palsy</td>
<td>4</td>
</tr>
<tr>
<td>Cardiopulmonary event</td>
<td>4</td>
</tr>
<tr>
<td>Postoperative kyphosis</td>
<td>2</td>
</tr>
<tr>
<td>Epidural hematoma</td>
<td>1</td>
</tr>
<tr>
<td>Dural tear</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
</tr>
</tbody>
</table>
COMMENTARIES

Wang et al have provided a retrospective review of a large patient population that underwent cervical laminoplasty for cervical spondylotic myelopathy. Their encouraging results illustrate not only the authors’ diagnostic and clinical prowess, but also the utility of laminoplasty. Unfortunately, their study suffers from the deficiencies associated with the majority of published manuscripts regarding the subject of cervical laminoplasty. They do not provide significant information regarding sagittal angle and alignment. Therefore, the true nature of stability and deformity prevention cannot be ascertained from the data presented. Nevertheless, the authors are to be heartily congratulated for their excellent results and their meticulous report.

Edward C. Benzel, M.D.

Cleveland Clinic Spine Institute
Cleveland, Ohio

While supplementing the long lasting belief that posterior decompression remains effective for cer-