Efficacy and results of expansive laminoplasty in patients with severe cervical myelopathy due to cervical canal stenosis

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Aims and objectives: To assess the efficacy and results of expansive laminoplasty in advanced (Nurick’s Grade III or greater) cervical myelopathy. Materials and Methods: We reviewed data in 24 patients who underwent cervical laminoplasty from January 1999 to December 2002. Nurick grading was used for quantifying the neurological deficits and outcome analysis was done using Odom’s criteria. A modified Hirabayashi’s open door laminoplasty was done using Titanium miniplates and screws in 22 patients, autologous bone in one and hydroxyapatite spacer in one patient. Observations: There were 3 females and 21 males with a mean age of 56 years (range 39-72 years). Four patients presented in Nurick’s Grade III, 15 in Grade IV and five in Grade V. MR imaging showed MSCS in 21 cases, OPLL in nine cases and ligamentum flavum hypertrophy in nine cases with cord signal changes being present in 19 cases. Results: All patients with duration of symptoms less than three years, and 50 % with duration ranging from three to six years had improvement by at least one Nurick’s grade following surgery. Eighty-seven per cent Grade IV patients (ambulatory with support) improved to Grade III (ambulatory without support) following laminoplasty. Using Odom’s criteria, 23 patients (95.8%) had a good to fair outcome. Conclusions: Cord decompression with expansive laminoplasty using titanium miniplate fixation may improve the neurological outcome even in patients presenting late, and improvement by even one grade may have major ‘quality of life’ benefits for these patients. Key Words: Cervical canal stenosis, Laminoplasty, Ossification of the posterior longitudinal ligament, Ligamentum flavum hypertrophy.

Introduction

Cervical canal stenosis is caused by the narrowing of the central spinal canal or neural foramina and may be either developmental in origin, or secondary to bony and/or soft tissue changes caused by multisegmental cervical spondylosis (MSCS) or ossification of the posterior longitudinal ligament (OPLL). Cervical laminectomy and laminoplasty have been used to decompress the neural elements posteriorly when there is extensive involvement of the cervical spine. Laminoplasty, which preserves the posterior elements, is considered the preferred posterior procedure. However, there have been no large series with patients having clinically advanced disease. We analyze our experience with this procedure in patients with symptoms of severe cervical myelopathy, done over a four-year period.

Materials and Methods

In this retrospective study, all patients who were admitted and underwent laminoplasty in the department of neurosurgery, from January 1999 through December 2002 (four-year period) were included. The demographic and clinical details, radiological investigations, operation details at admission and at follow-up were analyzed.

Operative technique

Patients were operated under general anesthesia using endoscopic intubation to prevent neck extension, positioned prone with the head in neutral position on a horseshoe. A standard posterior midline approach with exposure of cervical laminae from C2 to C7 and laterally to the medial aspect of the facet joints was performed in all cases. Patients had undergone expansive laminoplasty with various modifications. Twenty-two patients underwent a modified open door laminoplasty originally described by Hirabayashi, modified and popularized using titanium miniplates and screws by O’Brien. Briefly, the technique involves making bony gutters laterally in the lamina at its junction with the facet joint, using a high-speed drill. One gutter (on the side of maximum compression) is deepened across the thickness of the laminae, and the spinous processes and laminae are pushed laterally towards the opposite side like an open door, so that the spinal canal is enlarged. To prevent the laminar door from closing, titanium miniplates, bent in a ‘Z’ shape are screwed to the laminae and/or spinous processes on one side and to the pedicle on the other side using appropriately sized titanium screws. However, on the hinge side, where the adjacent lamina and lateral masses are still connected, the dorsal cortex of these structures are brought into contact as the hinge side trough is closed during elevation and rotation of the pos-
terior elements into the open position. One patient underwent Itoh’s modification of Hirabayashi’s technique, in which bone graft from the rib was inserted to prevent closure of the hinged laminae. One patient underwent a modified Hirabayashi laminoplasty in which hydroxyapatite ‘spacers’ were placed and fixed using nylon sutures. A soft collar was used during the first few days after surgery. No other external orthosis was used after surgery.

**Observations**

**Demographic profile**

There were 21 males and 3 females yielding an M: F ratio of 7:1. Their ages ranged from 39 to 72 years with a mean of 56.73 years. Five patients had associated medical disorders (three had diabetes, one had hypertension and one had both diabetes and hypertension).

**Clinical features**

Stiffness and gait disturbances were the commonest presenting symptoms seen in all the 24 (100%) patients. All patients had evidence of myelopathy in the form of spastic quadriplegia (one patient had Grade 5 power, 14 had Grade 4, three had Grade 3 power and in two patients power could not be assessed due to severe spasticity). Neck pain was seen in 11 (45.8%) of the patients and sensory loss to touch, pain and temperature was present in 12 (50%) patients. Bladder disturbances were present in 11 (45.8%) patients. The duration of symptoms varied from two months to 96 months with a mean of 30.5 months (Table 1). We used Nurick’s grading for the quantification of neurological deficits and for correlation with cord signal changes on MRI (Table 2). Four patients presented with Nurick’s Grade III, 15 in Grade IV and five in Grade V. Cord signal changes were present in 19 patients. One patient in Nurick’s Grade III, 13 patients in Nurick’s Grade IV and five patients in Nurick’s Grade V had cord signal changes (Table 3) (Figure 1c).

**Radiology**

Cervical spine X-rays were available in 14 patients and showed degenerative changes in all (Figure 1a). OPLL was visualized in six cases. Two cases showed evidence of fluorosis. All patients underwent MR imaging (Sonata 1.5T, Siemens, Erlangen, Germany) which showed MSCS in 21 cases, OPLL in nine cases and ligamentum flavum hypertrophy in nine cases. Thirteen patients had five levels, nine patients had four levels and two patients had six levels involvement. Purely anterior compression was present in 15 (62.5%) patients and both anterior and posterior compression was present in 9 (37.5%) patients (Figures 1b and 1c). There was no case with

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**Table 1: Duration of symptoms and cord changes**

<table>
<thead>
<tr>
<th>Duration of symptoms (months)</th>
<th>Number of patients</th>
<th>Cord changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>4-12</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>12-36</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>36-72</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>72-96</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

**Table 2: Nurick’s classification of disability**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 0</td>
<td>Root signs and symptoms</td>
</tr>
<tr>
<td>Grade I</td>
<td>No evidence of cord involvement</td>
</tr>
<tr>
<td>Grade II</td>
<td>Signs of cord involvement</td>
</tr>
<tr>
<td></td>
<td>Normal gait</td>
</tr>
<tr>
<td>Grade III</td>
<td>Mild gait involved</td>
</tr>
<tr>
<td></td>
<td>Able to be employed</td>
</tr>
<tr>
<td>Grade IV</td>
<td>Gait abnormality prevents employment but Ambulant without support</td>
</tr>
<tr>
<td>Grade V</td>
<td>Chair-bound or bedridden</td>
</tr>
</tbody>
</table>

**Table 3: Improvement in Nurick’s grade**

<table>
<thead>
<tr>
<th>Nurick’s grade</th>
<th>Preoperative (no. of pts)</th>
<th>Postoperative (no. of pts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRADE 1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>GRADE 2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>GRADE 3</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>GRADE 4</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>GRADE 5</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>
purely posterior compression. Cord changes were present in 19 cases. In 12 cases MRI films were available for the assessment of the cord changes. Of these 12 cases, 11 patients had cord changes only on T2 weighted images and one patient had cord changes on both T1 and T2 weighted images.

Operating time
The average operating time was 187.67 minutes (range 90-360 min) and the average blood loss was 716.67 ml (range 100-1400 ml).

Complications
One patient on whom laminoplasty was done using hydroxyapatite spacers deteriorated in motor power from grade 4/5 to grade 1/5 in the immediate postoperative period. A repeat MRI showed graft slippage causing cord compression. Re-exploration and removal of grafts resulted in improvement in motor power back to preoperative status.

CSF leak occurred in one patient, which resolved on conservative management. There was no mortality in this series.

Follow-up
The average follow-up in 18 patients was 22 months and ranged from 6 months to 46 months. Six patients were lost to follow-up. All patients had cervical spine X-rays in the immediate postoperative period to see for plate and screw displacement. Two patients had CT cervical spine in the immediate postoperative period—in one case the hydroxyapatite spacers were seen compressing the theca and required re-exploration. In the second case the screws and plates were in position and the open-door position of the laminae was well maintained (Figures 2a and 2b).

Results

Three patients in Nurick’s Grade III improved to either Nurick’s Grade I (n=1) or Nurick’s Grade II (n=2) following the laminoplasty. Thirteen out of the 15 patients (86.6%) who were in Grade IV (ambulatory with support) improved to Nurick’s Grade III (ambulatory without support) postoperatively. Surprisingly, four of the five patients (80%) in Nurick’s Grade V had improved to Grade IV following the laminoplasty, at last follow-up. Outcome assessment was done using Odom’s criteria (Table 4) and using these criteria, 23 patients (95.8%) had a good to fair outcome.

All patients with duration of symptoms less than three years, and 50% of the patients with duration of symptoms ranging from three to six years had improvement by at least one Nurick’s grade following surgery (Figure 3). However, patients with duration of symptoms more than six years did not show any improvement in Nurick’s grade following surgery.

Patients who had cord signal changes on both T1 and T2 weighted images on MRI had a poorer prognosis compared to patients who had cord signal changes only on T2 weighted images. Patients having cord signal changes only on T2 weighted images improved by at least one Nurick’s grade, compared to patients having cord signal changes on both T1 and T2 weighted images, who did not show any improvement in Nurick’s grade following the laminoplasty.

Discussion

Anterior and posterior decompression are established techniques in the management of multilevel cervical canal stenosis resulting in myeloradiculopathy.\textsuperscript{9-12} In the past, laminecto-

Table 4: Odom’s criteria

- **Excellent:** All preoperative symptoms relieved; abnormal findings improved.
- **Good:** Minimal persistence of preoperative symptoms; abnormal findings unchanged or improved.
- **Fair:** Definite relief of some preoperative symptoms; other symptoms unchanged or slightly improved.
- **Poor:** Symptoms and signs unchanged or exacerbated.
Laminoplasty had been the most common method to achieve posterior decompression of the cervical spine in these patients. However, the procedure was complicated by postoperative instability resulting in deformity, particularly kyphosis, as well as postoperative laminectomy membrane formation resulting in restenosis and arachnoiditis. Anterior cervical decompression with spinal fusion is also practiced widely in patients with cervical spondylotic myeloradiculopathy. Laminoplasty was developed to avoid these complications, with the first expansive open door laminoplasty being described by Hirabayashi et al., and since then has been further modified by Hirabayashi and others. The elegance of this procedure lies in its simplicity with results comparable to laminectomy and anterior decompression. Itoh and Tsuji, besides others, have shown increased stability, with less sliding, tilting, and range of motion after laminoplasty compared with laminectomy. This may be protective against postoperative instability.

Various modifications have been advised by various authors to maintain the ‘open’ book position of the posterior elements during laminoplasty. These are often complicated, requiring tedious wiring and bone-grafting techniques that increase the operative time, blood loss, donor site pain and infection, besides increasing the technical difficulty. These considerations could easily outweigh the possible benefits of laminoplasty over laminectomy. Titanium miniplate fixation, originally performed by O’Brien, offers all the advantages of laminoplasty without its drawbacks and offers a simple, durable and efficient technique to maintain the postoperative position of the open door. However, specific indications and contraindications for performing laminoplasty (Tables 5 and 6) have been described and patient selection remains important for the success of the procedure.

Long-term results are also now available on laminoplasty. Iwasaki M, studied 64 patients with OPLL who underwent expansive laminoplasty for more than 10 years (mean follow-up 12.2 years) and found that the neurological recovery was maintained in 60% of the patients. Kyphosis was present in 8% of the patients, although it was not found to be associated with neurological deterioration. The authors recommended expansive and extensive laminoplasty for OPLL. Inoue H, studied long-term outcome (greater than 5 years) in patients with myelopathy due to cervical spondylosis and OPLL who underwent expansive laminoplasty and complete decompression was maintained in 84% of the patients with myelopathy due to cervical spondylosis. The average follow-up in our series was 22 months, which is relatively short to give long-term results. However, as all patients in our study had an advanced disease at presentation, the results are significant. Postoperative improvement was also maintained in all our patients at the last follow-up.

Quantification of deficits for assessing the results of the spinal surgery is also important and Nurick, in 1972, devised a classification for cervical spondylotic myelopathy, largely based on gait disturbances (Table 2). The overwhelming appeal of this classification lies in its simplicity and that it can be applied easily to retrospective data. For this reason Nurick’s classification was chosen for the quantification of deficits in this study. However, as it is based mainly on gait abnormalities, sensory deficits as well as bladder dysfunction are not considered and remain important limitations. Though the JOA scale overcomes these limitations, it is more complex and cannot be applied easily to retrospective data.

For outcome analysis we used the Odom’s scale, as it is the most commonly used scale and is relatively simple (Table 4). Using Odom’s criteria, 23 patients (95.8%) had good to fair outcome (improvement by at least one grade) in the immediate postoperative period and the improvement was continuing or sustained at the last follow-up. More importantly, 13 out of 15 patients (86.6%) who were in Grade IV (ambulatory with support) became ambulatory without support (Grade III). This shows that improvement by even one grade may

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**Table 5: Indications for laminoplasty**

- OPLL over multiple levels (with maintained cervical lordosis)
- Congenital canal stenosis (with maintained cervical lordosis)
- Multilevel cervical spondylosis (with maintained cervical lordosis)
- Posterior compression from ligamentous hypertrophy (with maintained cervical lordosis)
- As part of a staged anterior and posterior canal expanding procedure

**Table 6: Contraindications for laminoplasty**

- Isolated radiculopathy
- Loss of anterior column support resulting from tumor, trauma, or infection
- Focal anterior compression
- Established, absolute kyphosis

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have major ‘quality of life benefits’ for these patients. Another interesting finding of our study was the postoperative improvement by at least one Nurick’s grade in 50 % percent of the patients with duration of symptoms between three and six years. This implies that the disease process may be partially reversible, even in patients presenting late, though early surgery carries the best prognosis.

Our study assumes significance in view of the fact that the majority (80%) of the patients were in Nurick’s Grade IV or V, implying having advanced disease. Laminoplasty was found to be especially beneficial in these patients as almost all showed neurological improvement with minimal morbidity and no mortality.

**Conclusion**

This is one of the largest studies on patients presenting with severe cervical myelopathy and shows that cord decompression using expansive laminoplasty using titanium miniplate fixation may improve the neurological outcome even in patients presenting late, and improvement by even one grade may have major ‘quality of life benefits’ for these patients. Expansive laminoplasty using titanium miniplate fixation offers all the advantages of laminectomy without its drawbacks and offers a simple, durable and efficient technique to maintain the postoperative open-door position, especially in patients with advanced disease.

**References**


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