Original Article

Outcome of Laminoforaminotomy for Unilateral Cervical Radiculopathy

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ARTICLE INFO

ABSTRACT

Background: Cervical foraminotomy provide excellent results in appropriately selected patients with foraminal stenosis in either soft disc prolapse or osteophyte. Objective: The aim of this paper is to report the outcome of laminoforaminotomy of cervical radiculopathy. Material and Methods: We studied prospectively 40 consecutive patients with unilateral cervical radiculopathy without myelopathy operated by minimal invasive cervical laminoforaminotomy and followed up for 2 years postoperatively. Results: There were 25 male and 15 female with mean age 44.9±7.1 year (29-65 ys). The mean duration of complaint was 4±1.7 months (1-7 months). There were 10 patients had C5, 12 patients had C6, 9 patients had C7 and 4 patients had C8 symptomatology while double level occurred in 3 patients. One occurred at C5/6 while two occurred at C6/7. The mean operation duration was 74.5±25.9 minutes (45-120 minutes). Outcome was categorized into satisfactory and unsatisfactory. Satisfactory outcome was found in 37 (92.5%) and unsatisfactory in 3 (7.5%) patients. Complications occurred in 5 patients in the form of superficial wound infection in 1 patient, temporarily parasthesia in 2 patients, permanent parasthesia in 1 patient, and permanent muscle weakness in 1 patient. Conclusion: Cervical foraminotomy for cervical radiculopathy is an effective option in well selected patients with postero-lateral foraminal stenosis in either soft disc prolapse or osteophyte for nerve root decompression.

INTRODUCTION

Although presently anterior cervical discectomy and fusion is the procedure of choice for many surgeons, posterior cervical foraminotomy can provide excellent results in appropriately selected patients17. Posterior cervical foraminotomy was described a long time ago and widely accepted as a safe and efficacious method for the surgical treatment of cervical radiculopathy14,19. The advantage of cervical laminoforaminotomy over anterior approach in selected cases for decompression of the nerve root in postero-lateral disc and foraminal stenosis has been well documented by many authors due to preservation of cervical motion, no need for internal or external bracing, moreover, it avoid many hazards of the anterior exposure as recurrent laryngeal nerve, trachea, oesophagus, carotid sheath, thoracic duct injury, and avoid the adjacent segment syndrome due to the unnecessary fusion as in anterior cervical discectomy and fusion (ACDF)21,25,16,22,28,29. One of the drawbacks of conventionally performed posterior cervical foraminotomy is the nerve root injury, significant muscle stripping and retraction that performed to expose the spine which may result in a significant postoperative pain, and impaired muscle function15. The limited popularity of this technique may be due to the limited surgical view, difficulty in osteophyte and disc resection and instability caused by extensive facet resection21,23,26,29,32.

In this manuscript we report the outcome, complications, and patients satisfaction of cervical laminoforaminotomy for 2 years postoperatively.

PATIENTS AND METHODS

We studied 40 consecutive patients with unilateral cervical radiculopathy without myelopathy admitted in the neurosurgery department at the period from January 2009 to January 2011 they were operated by minimal invasive posterior cervical laminoforaminotomy and followed up for 2 years postoperatively.

The indication for surgery was made after detailed examination with mean symptoms duration of our patients was 4±1.2 months (1-7 m).

The inclusion criteria included; radiculopathy of single or double level caused by lateral foraminal disc herniation or foraminal stenosis by osteophyte.

Exclusion criteria included; radiculomyelopathy, severe degenerative spine disease, previous cervical
surgery, instability, trauma, infection, tumour, and associated major co-morbidity.

All patients data regarding to age, sex, diagnosis, duration of complaints, and clinical examination for neck pain, brachialgia, muscle power grading (shoulder abduction, adduction, elbow flexion, extension, wrist flexion, extension, finger abduction, adduction), reflexes (Biceps, Brachioradialis, Triceps), and sensory deficit were collected. The lower limb examination showed no detected anomalies.

All patients underwent detailed radiological investigation (including X-Ray (Fig. 1), CT (Fig. 2), MRI (Fig. 3 & 4), EMG and nerve conduction study when needed) demonstrating lateral foraminal disc herniation or foraminal stenosis by osteophyte. The radiological investigations were corresponding to the patients’ complaint and clinical examination. Cervical spondylotic foraminal stenosis was found in 24 patients while soft disc herniation was found in the other 16 patients. The outcome and patient satisfaction were followed up for 2 years postoperatively.

Fig. 1: Cervical X-ray side view showing C3/4, C4/5, C6/7 cervical spondylosis

Fig. 2: CT axial plane showing left foraminal stenosis

Fig. 3: T2 MRI sagittal plane showing C6/7 cervical disc in patient with left brachialgia

Fig. 4: Axial MRI C3/4 Left central and foraminal disc herniation

Fig. 5: Schematic drawing of laminoforaminotomy
Surgical Technique

Under general anaesthesia; all patients were positioned on prone position. The neck was mildly flexed and the head was mildly turned to the contralateral side of lesion and fixed with a three-point Mayfield.

After confirmation of the level by a fluoroscopic imaging by lateral view; 4-5 cm skin incision was done about 1 cm from the midline of the ipsilateral pathology. After haemostasis, the fascia was incised and the neck muscle was retracted by periosteal elevator. A confirmatory lateral x-ray was always taken prior to definitive bony exposure. The overlying lamina and interlaminar space was identified and exposed using a combination of monopolar and bipolar cautery.

Once the appropriate level has been identified, the ligamentum flavum which is thin or absent at the lateral edge of the interlaminar space is separated from the most lateral attachment to the upper lamina using straight microcurett taking care of a higher risk of injury to the dura or the cervical spinal cord. Removal of ligamentum flavum after thinning down the adjacent upper and inferior lamina, including >50% of the lateral mass-facet complex (more than 50% facet removal may cause iatrogenic instability of the cervical motion segment), using an appropriate rongeur under the lateral shelf of the lateral part of the lamina with small bite until the foraminal entry which was confirmed by microhook palpation.

This allowed lateral exposure of the spinal cord at the origin of the affected nerve root and a formal rhizolysis was completed. Microcurette of varying angles and cup toward the bone and back toward the nerve root were used through the posterior aspect of the foramain entry with progressive careful separation of the nerve root to avoid dural tear.

Once stenotic pressure has been removed, it is suitable to begin the foraminotomy by 1 or 2 mm 45° Kerrison rongeur. A drill with a long bit can be used to thin the medial facet and lateral mass in marked facet arthropathy and enlargement. The decompression is carefully continued inferiorly and laterally along the course of the neural foramen.

Bleeding from epidural veins and from the edge of the ligamentum flavum was controlled via a long tipped and/or angled bipolar cautery. Periosteal and bone bleeding can be controlled with bone wax and cautery. Brisk dark bleeding that occurred from the rich venous plexus surrounding the vertebral artery wound us against further dissection and thus helped to prevent arterial injury. The surgeon should be aware of the location of the vertebral artery during foraminotomy so as not to damage this vessel. In some cases, a small piece of gel-foam soaked with Solumedrol was placed gently over the laminoforaminotomy defect.

The laminoforaminotomy was completed after the nerve root was exposed along its proximal foraminal course (Fig. 5). The adequacy of the decompression could be assessed by palpating the root along its course with a small nerve hook. In cases of herniated disc, the nerve root mobilized superiorly to expose the disc space and fragment with a nerve hook or small #4 Penfield. Drilling the supero-medial portion of the pedicle below the exiting nerve root could obtain additional exposure and would create space for the root to be mobilized (Fig. 6).

The disc fragment was removed with curettes and long pituitary rongeurs underneath the retracted root. Any encountered osteophytes were drilled or curetted. It would be better to confirm the free passage along the root with a nerve hook after the completion of the discectomy and decompression under lateral fluoroscopic image. Additionally, we should ensure that the anterior surface, axilla and shoulder of the nerve root are free of residual disk material. But, further caution was needed for the decompression of the paracentral disc herniations or osteophytes.

After sufficient decompression, the fascia and surgical wound were cosmetically closed. A neck collar was used for 2 weeks after surgery to avoid painful movement of the neck. The postoperative hospital stay was 1-2 day.

Outcomes Measures

Outcome was measured according to Odom’s outcome classification early postoperative, at 6 months, 1 year, and 2 years postoperatively.

The final outcome was categorized into; Excellent; No cervical symptoms, daily activities not impaired, Good; Intermittent discomfort, no significant interference with work, fair; subjective improvement but significant limitation of physical activities and mild improvement of radicular pain, and Poor with no improvement or worse. The outcome was then categorized into Satisfactory; with Excellent and good results while unsatisfactory with fair and poor outcome.

Statistical Analysis is made by IBM SPSS statistical program, version 21.
RESULTS

Table 1: Demographic data

<table>
<thead>
<tr>
<th>Data</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>44.9±7.1 (min 29, max 65 ys)</td>
</tr>
<tr>
<td>Sex</td>
<td>25 M, 15 F</td>
</tr>
<tr>
<td>Duration of symptoms</td>
<td>4±1.7 m (1-7 m)</td>
</tr>
<tr>
<td>Op duration</td>
<td>74.5±25.9 (45-120 min)</td>
</tr>
</tbody>
</table>

Our patients were 25 male and 15 female with age ranged from 29 to 65 years old. The mean age was 44.9±7.1 years. The duration of complaint ranged from 1 to 7 months and the mean duration was 4±1.7 months. The duration of surgery ranged from 45 to 120 minutes with a mean duration of 74.5±25.9 minutes (Table 1).

Table 2: Clinical picture and diagnosis

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>C5</th>
<th>C6</th>
<th>C7</th>
<th>C8</th>
<th>C5,C6</th>
<th>C6,C7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spondylosis</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Soft disc</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>12</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

The clinical diagnosis was C5 in 10 patients, C6 in 12 patients, C7 in 9 patients, and C8 in 4 patients while double level was found in 5 cases (in 3 cases double compression was at C5/6 root and in 2 cases it was at C6/7 root). Soft disc was found in 15 patients while spondylosis in 25 patients (Table 2).

Table 3: Severity of pain by VAS scale

<table>
<thead>
<tr>
<th>Pain</th>
<th>Mild</th>
<th>Mod</th>
<th>Severe</th>
<th>Worst</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck pain</td>
<td>4</td>
<td>6</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>Brachialgia</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

By clinical examination, neck pain was mild in 4 patients, moderate in 6 patients, and severe in 30 patients while brachialgia was severe in 20 patients and worst in the other 20 patients with no sign of myelopathy which was assessed by visual analogue scale (Table 3).

Table 4: Muscle Power

<table>
<thead>
<tr>
<th>Grade</th>
<th>3</th>
<th>4-</th>
<th>4+</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder abduction</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Elbow flexion</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Elbow extension</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Wrist flexion</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Wrist extension</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Finger abduction</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Thumb extension</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Neurological Muscle power examination and grading of the upper limb was done and showed Shoulder abduction indicating C5 compression was grade 3 in 4 patients, grade 4 in 5 patients, and grade 4+ in 4 patients. Elbow flexion and wrist extension indicating C6 affection were grade 3 in 3 patients, grade 4 in 6 patients, and grade 4+ in 5 patients. Elbow extension and wrist flexion indicating C7 compression were grade 3 in 4 patients, grade 4 in 4 patients, and grade 4+ in 1 patient. Finger abduction and thumb extension indicating C8 were grade 4 in 2 patients, grade 4+ in 2 patients, and grade 5 in 1 patient (Table 4).
Table 5: Muscle Reflex

<table>
<thead>
<tr>
<th>Reflex</th>
<th>Normal</th>
<th>Hyporeflexia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biceps</td>
<td>27</td>
<td>13</td>
</tr>
<tr>
<td>Brachioradialis</td>
<td>27</td>
<td>13</td>
</tr>
<tr>
<td>Triceps</td>
<td>26</td>
<td>14</td>
</tr>
</tbody>
</table>

Reflexes were examined in all patients and showed hyporeflexia in 13 patients with biceps reflex indicating affection in C5& C6, while 13 patients with Brachioradialis reflex indicating affection in C5& C6, and 14 patients with Triceps reflex indicating C7&8. Motor skill, sensation, and reflexes of the lower limb, trunk, and bladder had no disability in all patients (Table 5).

Table 6: Investigation

<table>
<thead>
<tr>
<th>Investigation</th>
<th>C4/5</th>
<th>C5/6</th>
<th>C6/7</th>
<th>C7/T1</th>
<th>C4/5&amp;C5/6</th>
<th>C5/6&amp;C6/7</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI</td>
<td>10</td>
<td>12</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>CT</td>
<td>10</td>
<td>12</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Nerve conduction study</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Radiological investigation was done to all patients including cervical X-Ray, MRI, CT, and sometimes EMG and nerve conduction study were done when needed to confirm the diagnosis. MRI and CT showed foraminal stenosis in 10 patients at C4/5, in 12 patients at C5/6, in 9 patients at C6/7, in 4 patients at C7/T1, in 3 patients at C4/5& C5/6, and in 2 patients at C5/6& C6/7. Twenty one patients were on the right side and 19 on the left side. Cervical spondylosis was found in 25 patients while soft disc was found in 15 patients. Electromyography was done to confirm the diagnosis when there was controversy of diagnosis in 4 patients and found C4/5 in 2 patients, C4/5& C5/6 in 1 patient, and C5/6& C6/7 in 1 patient.

Table 7: Outcome prognosis over time

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Early</th>
<th>6 Months</th>
<th>1 Year</th>
<th>2 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>21</td>
<td>16</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>Good</td>
<td>16</td>
<td>13</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>Fair</td>
<td>2</td>
<td>10</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Poor</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Outcome of our patients was done at early postoperative period, 6 months, 1 year, and 2 years.

The final outcome at 2 years was excellent in 21 (52.5%) patients, good in 16 (40%) patients, fair in 2 patients (5%), and poor in 1 patient (2.5%) which was collectively satisfactory in 92.5% and unsatisfactory in 7.5% by Odom’s outcome. (Table 7)

Postoperative complications were found in 5 patients in the form of Superficial wound infection in 1 patient, temporary motor weakness in 2 patients which improved during 6 months postoperatively, permanent paraesthesia in 1 patient, and permanent motor weakness in 1 patient.

DISCUSSION

Although the anterior approach for the treatment of cervical disc prolapse and spondylotic cervical canal stenosis is more commonly performed and studied by many authors, posterior laminoforaminotomy is used for decompression of the nerve root in cases of foraminal stenosis or removal of posterolateral soft disc fragments. It maintains the motion in the affected segment and does not cause major instability. Due to the nature of the approach it also has a lower complication rate when compared to anterior procedures. There is significant evidence which suggests that it is an effective procedure for cervical monoradiculopathy.

The distribution of pathology encountered in our work closely parallels that reported by other authors. We found that 77.5% (31 patients) were commonly distributed at C4/5, C5/6, and C6/7 foraminal stenosis and poster-lateral cervical disc prolapsed. Henderson et al reported that 85% of their 846 cases of lateral disc herniation occurred at either C5/6 or C6/7. Krupp et al similarly reported that 89% of their patients, and Fessler...
and Khoo\textsuperscript{11} found 79% of operated levels had abnormalities at these levels.

Foraminotomy is indicated only when there was a clear-cut radicular symptomatology; it is not indicated for non-segmental pain of the shoulder and neck or myelopathy\textsuperscript{10,28,32,33}. With a few exceptions, acute radicular pain, associated with neurological deficits in the shoulder/arm area, is caused by compression of one nerve root. For this reason, the exposure of only one nerve root is indicated in a high percentage of these cases\textsuperscript{10,23}. Henderson et al.\textsuperscript{17} reported that 99.4% of their patients presented with radicular pain, 70% with neck pain, 68% with muscle weakness, and 85% with decreased sensation. Fessler and Khoo\textsuperscript{11} found 96% with radicular pain, 64% with neck pain, 36% with muscle pain, and 80% with decreased sensation. We found parallel results of neck, radicular pain, motor, and reflex deficit in all cases.

We operated all our patients in prone position by microsurgical approach using C-arm fluoroscopy to determine the level and found that this position is comfortable and safe. The mean operation time in our series was 74.9±25.9 min with range from 45-120 min, which was near the results reported by Takahashi et al.\textsuperscript{14}, who found 78.2±26.1 min. (range: 46-144 min.) and Williams at 1983\textsuperscript{35} who reported one hour for a single level foraminotomy and blood loss rarely exceeded 100cc.

Odom’s Outcome was used in the present study to detect the prognosis of our selected patients. We found significant improvement in 92.5% of our patients after 2 years follow up. These results are comparable to the many previous series that demonstrate a success rate of 90-96% \textsuperscript{2,6,17,23,31,36,37}. Adamson \textsuperscript{1} reported in a series of 100 patients significant improvement in 97% of patients and the complication rate was only 3%. Fessler and Khoo\textsuperscript{11} reported in a series of 25 patients reported successful results in 92% of patients. Holly et al.\textsuperscript{19} reported in a series of 21 patients that 90% of patients had successful outcomes as their pain completely resolved after our procedure. Kumar et al. reviewed 89 patients treated with laminoforaminotomy for cervical spondylotic radiculopathy caused by osteophytes\textsuperscript{24}. Patients with disc herniation were excluded. Good or excellent results were obtained in 95.5% of patients, a mean follow up of 8.6 months using Odom’s criteria. Davis reviewed 170 patients who underwent laminoforaminotomy for cervical radiculopathy\textsuperscript{28}. Follow up, at a mean of 15 years, revealed good or excellent outcomes in 86% of patients, based on Prolo score. There was a 6% recurrence rate with most occurring within the first 3 years of the surgery.

Our results compared quite favourably to those previously reported results and indicated that this procedure could be successfully performed in a minimally invasive fashion for distinct patients. Furthermore, the hospital stays were significantly shorter and postoperative narcotic use was significantly low. Shorter duration of the preoperative complaint is significantly correlated with better outcome.

Postoperative complications were found in 5 (12.5%) patients. Superficial wound infection occurred in 1 patient. Temporary motor weakness occurred in 2 patients. Permanent parasthesia and permanent motor weakness each occurred in 1 patient.

**CONCLUSION**

Cervical foraminotomy for cervical radiculopathy is an effective option in well selected patients with posterolateral foraminal stenosis in either soft disc prolapse or osteophyte for nerve root decompression.

**REFERENCES**

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