The posterior cervical foraminotomy in the treatment of cervical disc/osteophyte disease: a single-surgeon experience with a minimum of 5 years’ clinical and radiographic follow-up

Clinical article

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Object. This study details long-term clinical and radiographic outcomes following single-level posterior cervical foraminotomy for degenerative disc or osteophyte disease.

Methods. The authors conducted a retrospective review of 162 cases involving patients treated by a single surgeon using a posterior cervical foraminotomy. Inclusion criteria were a minimum of 5 years’ clinical and radiographic follow-up and unilateral single-level posterior cervical foraminotomy for degenerative disease between C-3 and C-7. Patients who had undergone previous operations, those who underwent bilateral procedures, and those who underwent foraminotomy as part of a larger laminectomy were excluded. The Neck Disability Index (NDI) was used for clinical follow-up, and radiographic follow-up was performed using static and dynamic lateral radiographs to compare focal and segmental alignment and changes in disc-space height.

Results. The mean presenting NDI score was 18 (range 2–39). The most common presenting symptoms were radiculopathy (110 patients [68%]), neck pain (85 patients [52%]), and subjective weakness (91 patients [56%]). The mean preoperative focal angulation at the surgically treated level was 4.2° (median 4.1°, range 7.3–15.3°), and the mean preoperative segmental curvature between C-2 and C-7 was 18.0° (median 19.3°, range −22.1 to 39.3°). The mean postoperative NDI score was 8 (range 0–39). Improvement in NDI scores was seen in 150 patients (93%). Resolution of radiculopathy was experienced by 104 patients (95% of patients with radiculopathy). The mean preoperative focal angulation was 4.1° (median 3.9°, range −9.9° to 15.1°) and mean postoperative segmental angulation was 17.6° (median 15.4°, range −40.2 to 35.3°). Postoperative instability on dynamic imaging was present in 8 patients (4.9%); 7 of these patients were clinically asymptomatic and were treated conservatively, and 1 required cervical fusion. Postoperative loss of lordosis (defined as segmental Cobb angle < 10°) was seen in 30 patients (20%), 9 of whom had clinical symptoms and 4 of whom required further surgical correction. Factors associated with worsening sagittal alignment (Cox proportional hazards analysis, p < 0.05) included age > 60 at initial surgery, the presence of preoperative cervical lordosis of < 10°, and the need for posterior surgery after the initial foraminotomy.

Conclusions. The posterior cervical foraminotomy is highly effective in treating patients with cervical radiculopathy and results in long-lasting pain relief and improved quality-of-life outcomes in most patients. Long-term radiographic follow-up shows no significant trend toward kyphosis, although select patient subsets (patients older than 60 years, patients who had previous posterior surgery, and patients with < 10° of lordosis preoperatively) appear to be at higher risk and require closer follow-up. (DOI: 10.3171/2008.12.SPINE08576)

Key Words • cervical spine • disc disease • foraminotomy • radiculopathy

The management of cervical radiculopathy is a controversial area in spine surgery. Although most patients are thought to achieve resolution of symptoms without surgical intervention,6,7 recent data, including randomized controlled studies have provided evidence that surgical intervention may improve short-term disability related to pain when compared with conservative management.8,22

When surgical intervention is chosen, the surgical approach can vary significantly. Although posterior approaches have traditionally been favored in the management of radiculopathy,9 in recent years anterior approaches have been favored by some due to the ease of exposure, wider exposure of the disc space, and less patient discomfort.24 Unfortunately, symptomatic adjacent-
segment disease has been found to develop frequently with time after anterior cervical arthrodesis and affects long-term patient outcomes.33

There are clear advantages of performing a posterior cervical foraminotomy, particularly in patients with cervical radiculopathy. Posterior decompression allows better access to eccentrically located disc fragments while obviating the need for retraction on the esophagus and laryngeal nerve, which can result in postoperative dysphagia and hoarseness following anterior approaches. Additionally, pseudarthrosis, graft subsidence, and kyphosis, which are well-reported complications of ACDF, can be eliminated when a posterior foraminotomy is performed.14,24

The purpose of this report is to examine the long-term clinical and radiographic outcomes following single-level posterior foraminotomies in patients with cervical disc/osteophyte disease.

Methods

Patient Selection

Between January 1993 and January 2008, the senior author (J.A.J.) performed 973 noninstrumented posterior cervical decompression procedures. All patients included in this study underwent single-level unilateral posterior cervical foraminotomies for radicular pain or weakness caused by degenerative disease between C-3 and C-7. Patients who underwent multilevel cervical decompressions, those who underwent bilateral foraminotomies, and those who had undergone previous cervical surgery were excluded. Patients who required surgery for traumatic or neoplastic disease were also excluded from this analysis. To assess long-term outcomes, a minimum of 5 years of clinical and radiographic follow-up was required for inclusion in this study.

A total of 212 patients were identified who met the inclusion criteria, but 12 of these patients died during the follow-up period. Twenty-five additional patients declined to participate in the study, and 13 other patients were excluded due to incomplete or inadequate clinical (4 patients) or radiographic (9 patients) follow-up. Ultimately, sufficient radiographic and clinical follow-up data were available in 162 cases, which formed the basis for this study.

Patient data, including demographic information, presenting symptoms, operative results, complications, and quality of life measures, and radiographic follow-up were compiled into a prospective database and reviewed for the purpose of this analysis. Patient functional status was assessed using the NDI scores, which were obtained during patient interviews (Table 1).30

Surgical Technique

The senior author’s surgical technique for performing posterior cervical foraminotomy has been previously described.31 Following the induction of general anesthesia, the patient is placed in 3-point Mayfield fixation in the prone position. In most patients, the appropriate level for the incision is localized initially using anatomical landmarks, by feeling for C-2 superiorly and the spinous processes of C-7 and T-1 inferiorly. Electrophysiological spinal cord and nerve root monitoring were not performed in the cases included in this study.

After the skin incision is made a subperiosteal dissection is performed down to the lamina, with care taken to preserve the interspinous ligament as well as muscular attachments above and below the level of the foraminotomy. Intraoperative radiographs are acquired early on to confirm the correct level. Because the superior spinous process projects caudally from the level horizontal plane of the targeted facet joint of the cervical spine, the fascia and muscle must be opened 1 level higher to adequately expose the desired foramen.

A hemilaminotomy was performed in all cases. To do this, the lateral portions of the lamina and medial facet joints are drilled using the operating microscope and a high-speed 3-mm diamond drill. This decompression continues with the complete removal of the cancellous bone, exposing the deep cortical bone of both the lamina and descending facet. The remainder of the medial descending facet is removed, along with the cartilaginous endplates, to expose the entire medial aspect of the ascending facet joint. The medial half of the ascending facet is then drilled until only the deep cortical bone remains. At the junction between the spinal canal and the facet joint, the cancellous bone of the lower VB’s pedicle is identified. From this point onward, the deep cortical bone of the medial ascending facet joint and lateral third of the lamina are shaved with careful strokes of the drill. Typically, the medial half of the facet joint is removed during the course of the decompression. To minimize any root or cord injury, the drilling occurs parallel to the course of the nerve root from medial to lateral, and over the spinal canal, from rostral to caudal.

Once the nerve root is identified, any remaining cortical bone and ligamentum are removed using a curette and Kerrison punch to reveal the underlying fibroareolar tissue. The epidural venous plexus is coagulated using bipolar cautery, beginning medially and extending along the nerve root sleeve. This plexus is then divided sharply to expose the thecal sac and exiting nerve root. Since soft-disc herniations are usually located in the axilla of the nerve root, if excessive nerve root manipulation is necessary or the foraminal volume limited, a pediculotomy is performed. With the nerve root protected and under direct vision, the superomedial aspect of the inferior pedicle is resected using the drill (Fig. 1). When a discectomy is needed, this is completed by incising the annulus with a No. 15 blade. Compressive disc fragments and

### Table 1: The Neck Disability Index scale*

<table>
<thead>
<tr>
<th>Raw Score</th>
<th>% Score</th>
<th>Disability Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–4</td>
<td>0–10</td>
<td>none</td>
</tr>
<tr>
<td>5–14</td>
<td>10–28</td>
<td>mild</td>
</tr>
<tr>
<td>15–24</td>
<td>30–48</td>
<td>moderate</td>
</tr>
<tr>
<td>26–34</td>
<td>50–68</td>
<td>severe</td>
</tr>
<tr>
<td>&gt;34</td>
<td>&gt;68</td>
<td>complete</td>
</tr>
</tbody>
</table>

*As described by Vernon and Mior.30
Fig. 1. Depiction of the senior author's surgical technique for cervical foraminotomy. A and B: Preoperative views. The technique is effective for posterolateral disc herniations as well as neuroforaminal stenosis. C: Location of laminectomy and foraminotomy. Using the operating microscope and a high-speed 3-mm diamond drill, the lateral portions of the lamina and medial facet joint are drilled. D: Initial intraoperative view. Once the lamina is drilled, nerve root decompression starts with the complete removal of the cancellous bone, exposing the deep cortical bone of both the lamina and the descending facet. Using this technique, the nerve root can be decompressed with minimal manipulation. E: Final operative view. Once the nerve root is identified, any remaining cortical bone and ligamentum are removed using a curette and Kerrison punch to reveal underlying fibroareolar tissue. When a discectomy is necessary or neuroforaminal space is limited, to avoid excessive nerve root manipulation, a pediculotomy is performed. With the nerve root protected and under direct vision, the superomedial aspect of the inferior pedicle is resected using the drill. F: Postoperative sagittal section. Sagittal view depicting the decompressed nerve root. Reprinted with permission of Shepherd Visual Communications.
osteoarthritic changes were then removed using pituitary forceps or curette without excessive retraction of the nerve root. Hemostasis is achieved and the wound is closed.

**Postoperative Follow-Up**

Patients were routinely seen at regular follow-up intervals of 6 weeks and then 3 months and subsequently yearly. Some patients had longer or shorter follow-up intervals, depending on their clinical status, and the judgment of the senior author. At the time of this study, patients were contacted and quality of life measures were again assessed using the NDI, and the results were compared with the preoperative symptoms.

**Imaging Studies**

Preoperative CT-myelograms or MR images along with plain radiographs were obtained in all cases. Radiographic follow-up analyzed for purposes of this study consisted of the most recent neutral and flexion-extension radiographs. A minimum of 60 months' radiographic follow-up was required for inclusion in the study.

Stability was defined as lack of pathological motion (≤ 2 mm) in postoperative dynamic images, while instability was defined as motion > 2 mm at the operative segment or any adjacent segments on dynamic imaging. Focal alignment was defined by the angle that was formed by lines drawn at the superior margin of the superior VB defining the disc space at the operated level and the inferior margin of the inferior VB on a lateral radiograph obtained with the patient standing. The segmental angulation was defined as the Cobb angle of the entire segment from C-2 through C-7 and was determined using a similar technique to the focal angulation. Angles were measured using quantitative measurement analysis software (Eastman Company) that uses extrapolative algorithms to calculate the angle of intersection between 2 lines drawn by the investigator. All angles were measured 3 times and a mean angle was determined, to allow for investigator error in assessing the margins of the VBs. The same investigator produced all computerized measurements.

Disc-space height was measured from the midpoint of the vertebral body below the surgical level to the midpoint of the vertebral body above the surgical level on neutral lateral radiographs pre- and postoperatively. To normalize this value, it was divided by the height of C-3 at the time of analysis, which was assumed to be constant. The disc height ratio (Rf) represented the ratio of pre- and postoperative measurements of the operated disc space.

**Statistical Analysis**

Statistical analysis was performed to determine factors influencing the development of cervical kyphosis. All statistical analyses were performed using SPSS 16.0 for Windows (SPSS, Inc.).

**Results**

**Patient Characteristics and Presenting Symptoms**

Long-term clinical and radiographic follow-up data were available in 162 cases. The mean patient age at surgery was 48.4 years (range 19–78 years). Ninety-four patients (58%) were men and 68 (42%) were women. Eight patients (5%) had surgery at C3–4; 21 patients (13%) had surgery at C4–5; 63 patients (39%) had surgery at C5–6; and 70 patients (43%) had surgery at C6–7. A summary of preoperative symptoms is presented in Table 2. One-hundred and ten patients presented with radiculopathy (68%), which was confirmed by electromyographic studies in 35 patients (32%). In 127 patients there was radiographic evidence of nerve root impingement (herniated discs in 55; neuroforaminal stenosis secondary to osteophyte formation in 72). Eighty-five patients (52%) noted preoperative neck pain. Preoperative weakness was noted by 91 patients (56%), but was only confirmed on physical examination in 21 patients (13%). Ninety-four patients (58%) had 2 or more of the above symptoms and 43 patients (27%) noted radiculopathy, neck pain, and weakness. The mean presenting NDI was 18 (median 18, range 2–39), and the preoperative disability score varied considerably depending on the patients’ presenting complaint and number of symptoms (Table 2).

**Presenting Radiographic Alignment**

Radiographic measurements were assessed on preoperative neutral radiographs. A summary of the preoperative focal angulation at the surgically treated level is depicted in Table 3. For each of the measurements, kyphotic alignment is indicated by a negative value and lordotic alignment is indicated by a positive value. The mean focal angulation was 4.2° (median 4.1°, range 22.1 to 15.3°). As demonstrated in Table 3, there did not appear to be a substantial difference in preoperative focal cervical curvature between the surgically treated levels.

The mean preoperative segmental curvature between C-2 and C-7 was 18.0° (median 19.3°, range 22.1 to 39.3°). Thirty-two patients (20%) had radiographic evidence of reduced cervical lordosis (Cobb angle < 10° preoperatively), with 4 patients (2.5%) having kyphotic alignment (Cobb angle < 0°). As with focal angulation, there did not appear to be a substantial difference in segmental angulation when cases were stratified by surgically treated level.

**TABLE 2: Presenting symptoms in 162 patients**

<table>
<thead>
<tr>
<th>Symptom(s)</th>
<th>No. of Patients (%)</th>
<th>Mean Preop NDI Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>radiculopathy</td>
<td>110 (68)</td>
<td>16</td>
</tr>
<tr>
<td>subjective weakness</td>
<td>91 (56)</td>
<td>26</td>
</tr>
<tr>
<td>weakness on physical exam</td>
<td>21 (13)</td>
<td>17</td>
</tr>
<tr>
<td>neck pain</td>
<td>85 (52)</td>
<td>13</td>
</tr>
<tr>
<td>≥2 Sx*</td>
<td>94 (58)</td>
<td>19</td>
</tr>
<tr>
<td>3 Sx†</td>
<td>43 (27)</td>
<td>22</td>
</tr>
</tbody>
</table>

* At least 2 of the following 3 symptoms: radiculopathy, weakness, neck pain.
† Radiculopathy, weakness, and neck pain.
Mean presenting cervical disc-space height was 6.7 mm (median 6.3 mm, range 2.3–9.2 mm).

**Hospital Course**

Intraoperative complications included CSF leak in 4 patients (2.5%) and nerve root injury in 2 patients (1.2%), resulting in immediate postoperative weakness in both. Both instances of nerve root injury involved the C-5 nerve root following C4–5 foraminotomy. Both patients awoke with 2/5 deltoid strength on manual motor testing on immediate postoperative evaluation. Both patients were treated with a short course of steroids. The weakness improved substantially within 12 months of surgery, but both patients remained weak (4/5 deltoid strength at last clinical follow-up, 72 and 85 months postoperatively).

The mean length of hospital stay was 1.9 days (range 0–12 days). One patient (0.6%) had his hospital course complicated by a postoperative myocardial infarction resulting in a 12-day hospital stay. Two patients (1.2%) required early reoperation, at 2 and 8 days. In the first case the procedure was revision due to wound drainage related to a postoperative hematoma, while in the second case it was irrigation and debridement for a deep wound infection. The infection was managed successfully after the surgical debridement and a 4-week course of parenteral antibiotic therapy.

**Clinical Follow-Up**

The mean duration of clinical follow-up was 78.4 months (median 73, range 60–180 months). The mean postoperative NDI score was 8 (range 0–39). Improvement in NDI scores was seen in 150 patients (93%). Resolution of radiculopathy was experienced by 104 patients (95% of those with radiculopathy). Characteristics of the patients with worsened NDI scores are summarized in Table 4. Of the 12 patients with worse NDI, 4 (33%) experienced intraoperative complications; while the remaining 8 experienced postoperative kyphosis. Improvement in neck pain was experienced by 40 (47%) of 85 patients with preoperative neck pain. Resolution of weakness was noted by 30 (33%) of 91 patients with subjective complaints and 13 (62%) of 21 patients with preoperative objective weakness on manual motor testing. As demonstrated in Table 5, postoperative symptom improvement did not vary appreciably between the different degenerative pathologies treated or based on preoperative symptoms (Student t-test, p > 0.05).

During the follow-up period, 5 patients (3.1%) required a total of 9 additional cervical spine operations. In 2 cases this was due to disc degeneration at the level previously treated by posterior foraminotomy, making an ACDF necessary. In 2 other cases patients developed cervical stenosis (not present at the time of the initial operation), and posterior decompressions were performed on these patients. An additional patient underwent posterior lateral mass fusion for cervical instability (Fig. 2). The mean time to the second operation in these 5 patients was 38.3 months (range 14–87 months after the initial operation).

**Radiographic Follow-Up**

The mean duration of radiographic follow-up was 77.3 months (range 60–177 months). No statistically significant changes in focal or segmental kyphosis or disc-space height were seen among the overall cohort with time. The mean changes in postoperative radiographic alignment are summarized in Table 3. The mean postoperative focal angulation was 4.1° (median 3.9°, range −9.9–15.1°). Mean postoperative segmental angulation was 17.6° (median 15.4°, range −40.2 to 35.3°). As with the preoperative angulation, there did not appear to be a significant change in postoperative focal or segmental angulation by the initial

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. of Patients</th>
<th>Mean Preop NDI Score</th>
<th>Mean Postop NDI Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>nerve root injury</td>
<td>2</td>
<td>36</td>
<td>45</td>
</tr>
<tr>
<td>CSF leak</td>
<td>1</td>
<td>32</td>
<td>35</td>
</tr>
<tr>
<td>kyphosis</td>
<td>9</td>
<td>33</td>
<td>43</td>
</tr>
</tbody>
</table>

**TABLE 5: Percentage of patients with symptom improvement based on initial radiographic findings**

<table>
<thead>
<tr>
<th>Radiographic Finding</th>
<th>Presenting Clinical Symptom</th>
</tr>
</thead>
<tbody>
<tr>
<td>neck pain</td>
<td>radiculopathy</td>
</tr>
<tr>
<td>disc herniation</td>
<td>42%</td>
</tr>
<tr>
<td>stenosis secondary to osteophyte</td>
<td>49%</td>
</tr>
</tbody>
</table>
surgical level. The overall change in segmental angulation was highly concordant over the first 7 years (−0.08 ± 0.24° [SD] per year; $R^2 = 0.96$). However, after this point, there was considerable change in alignment as depicted in Fig. 3 ($R^2 = 0.62$ after Year 7). Overall, there was a trend toward cervical kyphosis, although it was not statistically significant (Cox proportional hazards analysis and Student’s t-test, $p > 0.05$).

Mean change in disc-space height was 6.4 mm (median 5.9 mm, range 1.9–8.4 mm). Mean percentage change in disc-space height was −4.7% (median −5.9%, range −70 to 12%).

**Instability and Postoperative Deformity**

Postoperative instability on dynamic imaging was present in 8 patients (4.9%) at the surgical level. Seven of these patients were clinically asymptomatic and were treated conservatively, while the remaining patient required cervical fusion, as described above (see Clinical Follow-Up). Postoperative loss of cervical lordosis (defined as segmental Cobb angle < 10°) was seen in 30 patients (18.5%), 9 of whom had clinical symptoms (see Clinical Follow-Up). The mean duration of follow-up for these patients was 93.2 months (median 84 months, range 60–145 months), and the mean segmental cervical angulation was −6.4° (median −13.2°, range 8 to −40.2°). The mean postoperative NDI score for patients with postoperative kyphosis was 26 (median 32, range 12–78), which was lower than the NDI score for the entire cohort (Student’s t-test, $p = 0.029$).

Statistical analysis was performed to determine the factors associated with postoperative deformity and instability, and the results are summarized in Table 6. Factors associated with worsening deformity included age > 60 at initial surgery, the presence of preoperative segmental angulation of < 10°, and the need for subsequent laminectomy (Fig. 4). Level of surgery, indication for surgery, and the need for subsequent surgery did not correlate with worsening segmental kyphosis. None of the factors that were examined (Table 6), including patient age, preoperative segmental angulation, and surgical indication, correlated with the development of focal kyphosis following foraminotomy.
Discussion

Clinical Outcomes Following Posterior Cervical Foraminotomy

Ten years before Smith and Robinson described the ACDF procedure, Spurling and Scoville reported successfully treating patients with cervical radiculopathy using a posterolateral approach. The advantages of a posterior approach include direct visualization of the involved nerve root and decompression without the need for fusion. In a study of 182 patients, Tomaras et al. noted that 93% had good or excellent outcomes at a mean follow-up of 19 months. Henderson et al. also reported the resolution of radicular symptoms in 96% of 846 patients, with 91.5% reporting good or excellent outcomes. In keeping with these previous reports, we note that the foraminotomy is highly effective in treating cervical radiculopathy, and improving patient quality-of-life outcomes. The uniqueness of the present study lies in the fact that it demonstrates in a large cohort that the pain relief offered can be long lasting.

Factors influencing the decision to use the posterior approach in this series included patient age, the types of pathological changes visualized on imaging studies, the laterality of the disease, and the number of motion segments affected. The keyhole foraminotomy as described here allows dorsal resection with a lower rate of instability and cervical kyphosis compared with anterior cervical approaches.

The senior author’s general technique for posterior cervical foraminotomy is similar to the technique described in previous reports except that we favor a more radical facetectomy and pediculotomy. This is performed to maximize the disc-space exposure and minimize the rate of nerve root injury, which has been reported to be as high as 10% in some series. The purported drawback of a facetectomy is the potential for cervical kyphosis, although this does not appear to be proven in the current series.

Consistent with our previous report on anterior cervical discectomy, it appears that patients with neck pain alone do not respond quite as well as those with radiculopathy, even with a posterior approach, and when taken as a whole, these 2 studies appear to indicate that these patients may not have as satisfactory outcomes as patients with true neurological findings.

Posterior Versus Anterior Surgery in Cervical Disc-Osteophyte Disease

Few studies have compared the clinical outcomes of anterior versus posterior surgery in patients with cervical disc disease, but a review of the literature suggests that the clinical outcomes are similar. Onimus et al. analyzed 28 cases involving patients with soft posterolateral cervical disc herniations; 14 of the patients underwent an anterior decompression with autologous iliac crest bone graft and 14 underwent a posterior decompression. At mean follow-up times of 30 and 36 months, respectively, per group, the...
2 groups displayed statistically equivalent results, with 8 patients (57%) in the posterior group and 7 patients (50%) reporting excellent results. In addition, 5 patients (36%) in the posterior group and 6 patients (43%) in the anterior group reported good results with neck fatigue at work.

Herkowitz et al.\textsuperscript{12} also compared the anterior and posterior approaches for cervical soft disc herniations; the mean duration of follow-up in their study was 4.2 years. Patients were classified by the type of herniation, with 33 patients presenting with single-level anterolateral herniations and 11 patients presenting with central herniations. In the former group, 17 patients underwent ACDF and 16 underwent posterior laminectomy and foraminotomy. All the patients in the latter group underwent ACDF. In patients undergoing the anterior procedure, 16 (95%) reported either excellent results with complete relief of symptoms or good results with improvement of pain symptoms but still requiring occasional analgesia. Of the patients undergoing the posterior procedure, 12 (75%) reported excellent or good results.

Our general experience, reflected in this paper, is that unilateral radiculopathy can be addressed with a posterior cervical foraminotomy, while bilateral or multifocal radiculopathy and myelopathy may require a more extensive posterior approach (laminectomy or laminoplasty) or anterior surgery depending on the clinical circumstances.

**Postlaminectomy Kyphosis Following Cervical Foraminotomy**

Postoperative kyphosis was the most commonly seen radiographic complication in our patients (observed in 20%), and patients with kyphosis had lower quality-of-life outcomes postoperatively.

Published data have indicated that postlaminectomy kyphotic deformity is influenced by factors such as patient age, postoperative diagnosis, and aggressiveness of posterior resection.\textsuperscript{1,2} Many have argued that the extent of facetectomy plays a major role in the development of postoperative kyphosis.\textsuperscript{4} The rationale for this lies in the fact that the normal lordotic alignment of the cervical spine is maintained via the sagittal weight-bearing axis lying posterior to the VBs between C-2 and C-7.

Because of this, most of the load transmission occurs through the facet joints and posterior column.\textsuperscript{1,}\textsuperscript{21} According to this rationale, loss of integrity of this posterior...
Single-level cervical foraminotomy

### TABLE 6: Factors related to postoperative deformity and instability

<table>
<thead>
<tr>
<th>Factor</th>
<th>Postop Deformity (33 patients)</th>
<th>Postop Instability (8 patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hazard Ratio</td>
<td>95% CI</td>
</tr>
<tr>
<td>age &gt;60</td>
<td>1.32</td>
<td>0.62–2.45</td>
</tr>
<tr>
<td>age &lt;60</td>
<td>2.23</td>
<td>0.96–1.08</td>
</tr>
<tr>
<td>surgical level</td>
<td>0.21</td>
<td>0.39–6.43</td>
</tr>
<tr>
<td>postop laminectomy</td>
<td>1.99</td>
<td>0.96–3.01</td>
</tr>
<tr>
<td>postop surgery</td>
<td>1.51</td>
<td>0.94–1.01</td>
</tr>
<tr>
<td>preop segmental cervical</td>
<td>2.12</td>
<td>0.92–1.05</td>
</tr>
<tr>
<td>alignment &gt;10°</td>
<td>1.43</td>
<td>0.69–2.85</td>
</tr>
<tr>
<td>preop segmental cervical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>alignment &lt;10°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>preop focal alignment</td>
<td>1.23</td>
<td>0.98–1.05</td>
</tr>
<tr>
<td>indication for surgery</td>
<td>1.32</td>
<td>0.12–1.12</td>
</tr>
</tbody>
</table>

* Statistically significant difference.

Conclusions

The posterior cervical foraminotomy is highly effective in treating patients with cervical radiculopathy and results in lasting pain relief and improved quality-of-life outcomes in most patients. Long-term radiographic follow-up shows no significant trend toward deformity, but patients who have preexisting loss of cervical lordosis, patients over 60 years of age, and patients who have had previous posterior surgery may be at higher risk for kyphosis and deserve closer follow-up.

Disclaimer

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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