Microendoscopic posterior cervical laminoforaminotomy for unilateral radiculopathy: results of a new technique in 100 cases

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Object. In this report the author presents surgery-related outcomes after application of a new technique. A posterior microendoscopic laminoforaminotomy was used for the surgical treatment of unilateral cervical radiculopathy secondary to intervertebral disc herniations and/or spondylotic foraminal stenosis. The results of this procedure are compared with those achieved using traditional laminoforaminotomy and anterior cervical discectomy with or without fusion.

Methods. One hundred consecutive patients who experienced unilateral cervical radicular syndromes, which were refractory to conservative therapy, and in whom imaging studies had confirmed lateral canal or foraminal compression, underwent surgical treatment. An endoscopy-assisted posterior laminoforaminotomy was performed using a microendoscopic visualization system for removal of herniated disc and foraminal decompression while the patient was in the sitting position.

Excellent or good results were obtained in 97 patients, who returned to their preoperative employment and baseline level of physical activity. One patient returned to work but was unable to perform at baseline level; two patients returned to prior sedentary work but continued to have some activity-related pain and paresthesias. Two patients reported experiencing intermittent paresthesias or numbness, but this did not limit their activities. There were two cases of dural punctures, one case of superficial wound infection, and no deaths.

Conclusions. The microendoscopic posterior laminoforaminotomy is an effective alternative for the treatment of unilateral cervical radiculopathy secondary to lateral or foraminal disc herniations or spondylosis. In this group of patients, it is preferable because it does not require the sacrifice of a cervical motion segment, has a low incidence of complications, and is associated with a much quicker return to unrestricted full activity than that obtained with other techniques.

KEY WORDS • cervical spine • cervical radiculopathy • endoscopy • laminoforaminotomy • intervertebral disc • stenosis
and posterior techniques as complementary, focusing on
the advantages of each specific approach and their relative
indications.\textsuperscript{8,39,46,47} One comparative study in which
the authors performed the anterior and posterior approaches
for similar disease was hampered by small patient popula-
tion and statistical insignificance.\textsuperscript{20}

In 1997, an MED system was developed by Smith and
Foley\textsuperscript{41} for the treatment of lumbar disc disease; early eval-
uation confirmed results similar to those achieved after
open lumbar microdiscectomy procedures. The replace-
ment of subperiosteal muscle stripping with the small
muscle–splitting approach necessary for placement of the
16-mm operative cylinder, however, resulted in a marked
reduction in postoperative pain and muscle spasms. The
possibility of achieving similarly improved outcomes in the
cervical spine was raised; after surgeons, who possessed a
several-year experience with posterior cervical laminofor-
aminotomy, also gained experience performing MED in
the lumbar spine. Traditionally, the patient’s primary post-
operative complaint and limitation to return to full activity
has been incision-related muscle pain and spasm. Modifi-
cation to the MED system, including a longer retractor sup-
port and the addition of microinstruments, was necessary.
Cadaveric dissection was completed before first attempting
application of the system in patients. For additional experi-
ence, initial exposure in two patients was performed using
the MED system before the procedure was converted to an
open microdiscectomy. Initially, in our series of 24 patients
with soft-disc herniations, the outcomes were found to be
good and the procedure-related risks acceptable.\textsuperscript{1} In
this study we report the results obtained in the first 100 consec-
utive patients, including the initial 24, who were treated
with this technique.

Clinical Material and Methods

Patient Population

Between September 1997 and August 1999, a total of
100 patients were selected for surgical intervention in
which the microendoscopic laminoforaminotomy tech-
nique was used. There were 63 men and 37 women who
ranged in age from 20 to 74 years (mean 46.6 years). Each
patient presented with a painful single-level radicular syn-
drome. Seventy-six patients presented with reproducible
weakness, and all experienced some degree of sensory
change, either diminished sensation or hypesthesias. Appr
opriate reflex changes were noted in all patients with
weakness but not predictably in those with only sensory
changes. Patients with neck pain alone were not considered
for treatment. Selection criteria for a posterior approach
operation were based on concordant preoperative imaging
studies. Each patient underwent thin-slice computerized
tomography or MR imaging evaluation of the cervical
spine. If the foraminal anatomy was not clearly visualized,
as can occur when using MR imaging, a computerized
tomography myelogram was obtained. The nerve root had
to be compressed in a lateral or foraminal location for the
patient to be considered for this treatment. In the initial 24
patients in this series only soft-disc herniation was present.
As experience with the procedure was gained, we includ-
ed patients with lateral spondylotic disease and foraminal
stenosis. No patient with bilateral or multilevel syndromes
was included, and patients with significant central canal
stenosis, alignment abnormalities, or myelopathy were rec-
ommended for ACD and fusion.

Prior to being considered for surgical intervention, each
patient underwent a trial of conservative therapy, typically-
ly including narcotic agents, decreased activity, and oral
steroid medication. Patients with progressive weakness
were treated on an urgent basis.

Operative Technique

General endotracheal anesthesia was induced, and the
patient was secured in the Mayfield head holder and placed
carefully in the sitting position. The neck was secured in a
neutral, slightly flexed position with no rotation. The fluo-
roscopy unit was positioned at the foot of the bed to allow
for intermittent lateral imaging without having to reposition
the machine. Precordial Doppler ultrasonography and end-
tidal CO\textsubscript{2} monitoring were continued throughout the course
of the procedure. No patient underwent central line place-
ment unless indicated because of cardiac or pulmonary dis-
ease. A single dose of antibiotic medication was adminis-
tered prior to the procedure.

Localization of the operative field was first confirmed
with a spinal needle positioned lateral to the neck. This nee-
dle was then introduced through the skin, in a paramedian
location approximately 2 cm off the midline, and under flu-
oroscopic guidance it was passed to the ipsilateral facet
complex. The best trajectory was slightly inclined from
horizontal and neutral from a medial to lateral orientation.
The needle was then removed, and a 16-mm oblique skin
incision was made through the subcutaneous tissue.

The first step involved in using the dilator system was
to place a K-wire through the incision to the facet com-
plex, originally identified with the spinal needle. The first
tue dilator was then passed along the K-wire into the
facet complex. Typically, because significant resistance
was encountered passing through the fascia of the splenius
and the semispinalis musculature, careful simultaneous
rotation and compression of the dilator were required.
Once the bone of the facet was palpated, the K-wire was
removed. With experience, the first dilator became a use-
ful instrument and was used to palpate the step-off of the
facet. The next three dilators were sequentially placed
over each other. It was very important to maintain some
constant pressure on the initial dilator to ensure that the
system did not migrate when each dilator was inserted;
failure to do so could result in the dilators slipping lateral
off the facet or, worse, medially through the interlaminar
space into the spinal canal. Finally, the operative cylinder
was placed, anchored to the retractor arm, and secured
before removing the dilators (Fig. 1).

The microendoscope was then anchored to the cylinder
and orientation was established (Fig. 2). The remaining soft
tissue overlying the facet was mobilized with curettes and
removed with pituitary rongeurs. The remaining cuff of
soft tissue was cauterized with angled bipolar forceps until
it contracted from the field of view. With the cylinder posi-
tioned over the medial facet and with the lateral laminar–
facet junction clearly visualized, the exact position of the
foramen could be confirmed fluoroscopically. A long han-
dled microdrill was used to initiate the foraminotomy, dril-
ing away a small amount of inferior articular process and
more of the superior articular process until a small defect was created over the foramen. Once this landmark was identified, the location of the pedicle was confirmed using a microhook. The pedicle not only defined the caudad aspect of the foramen but also the lateral margin of the spinal canal (Fig. 3). Bone removal was continued using 1– and 2–mm thin foot Kerrison rongeurs until the upper and lower borders of the nerve root were clearly seen. The extent of medial and lateral decompression depended on the specific disease. In patients with foraminal disc herniation and spondylotic stenosis more attention to lateral decompression was required; however, attempts were always made to preserve at least 50% of the facet. The medial aspect of the decompression required clear definition of the lateral thecal sac and origin of the nerve root. This typically required a small laminotomy and resection of a few millimeters of ligamentum flavum. The posterior internal venous plexus and its supporting connective tissue were then mobilized off of the dura, cauterized using bipolar forceps, and sharply divided. With the origin and path of the nerve root clearly visualized, the floor of the spinal canal could be safely approached by passing a microhook inferorly along the medial edge of the pedicle and rotating it medially under the thecal sac and superiorly up under the root. This maneuver reduced the risk of injury that may occur when motor and sensory nerve roots are separated (this occurs more frequently in the lower cervical levels). With the nerve root mobilized in this fashion, the disc herniation was visualized and removed. Rarely, a disc herniation was found to be superior to the nerve root, requiring removal on the cephalad side.

After determining that the nerve root was adequately decompressed, a pledget of methylprednisolone acetate–impregnated Gelfoam was placed over the nerve root and the operative cylinder was removed. The wound was then closed in two layers with a single inverted interrupted No. 2-0 vicryl in the subcutaneous fascia and the skin edge re-approximated using two inverted interrupted No. 3-0 vicryl sutures.

After emerging from the state of anesthesia, the patient underwent routine postoperative management. Typically, the patient was discharged 3 hours after surgery and provided with a 7-day supply of prescription medication for hydrocodone and cyclobenzaprine. The patient was advised to minimize activity for 4 to 5 days until the soreness resolved. Normal activities could be resumed provided pain did not return. Follow up consisted of 1-week, 6-week, and if necessary, monthly evaluations. At 6 months, a phone interview was conducted or follow-up letter was sent to each patient.

**Results**

The C6–7 and C5–6 were the most commonly affected levels and C4–5 and C7–T1 the least (Table 1). Left-sided radiculopathies (57 cases) were more common than right (43 cases).

Ninety patients were discharged on the day of surgery. Ten patients remained in the hospital overnight; no patient required longer hospitalization. Of those who required hospitalization many lived more than 60 miles from the hospital or suffered postanesthesia-related nausea and vomiting.

Eighty-four patients required no additional prescription medications beyond their initial 7-day doses. Sixteen patients required at least one prescription refill.

Patients were able to return to work or full baseline activity between 1 day and 4 weeks postoperatively (mean 1.9 weeks) (Fig. 4). Sixty patients were able to return to work/activity in 1 week or less, including four practicing physi-
cians, two of whom were surgical specialists. Twenty-four patients returned to work/activity between 6 and 8 weeks. Of these, two were professional football players. Three patients required 6 and 8 weeks of recovery time, and three patients required more than 8 weeks. Several of the patients were housewives or retired individuals and for them a return to work/activity was considered to have been when they were comfortable performing their usual routine, including recreational sports.

A minimum follow-up period of 6 months was obtained in all patients (range 6–31 months; mean 14.8 months). Ninety-one patients had excellent outcomes and reported no ongoing problems or restriction in activities. Six patients had good outcomes and reported some intermittent numbness, paresthesias, or pain that did not interfere in their routine. Two patients had a fair outcome: one returned to a prior sedentary job but continues to have activity-related neck pain; the other who has insulin-dependent diabetes developed a refractory arm pain syndrome despite a full recovery in strength and no significant imaging-documented problems postoperatively. One patient, who had sustained a traumatic disc herniation secondary to a partial scalp injury when her hair got caught in a textile machine, experienced a poor outcome and was unable to return to her prior level of employment. Although her strength was fully recovered and electromyographic findings normalized, she continued to suffer neck pain and headaches.

Three patients with chronic radiculopathies presented with adhesive capsulitis of the shoulder. Two responded to aggressive physical therapy and one required a procedure for surgical release.

Three patients underwent additional neurosurgical procedures. One patient developed a contralateral radiculopathy at a different level, and after a second microendoscopic procedure, made a full recovery. One patient with previously asymptomatic spondylosis at an adjacent level developed symptoms and required an ACD and fusion. One patient in whom a long-standing, late ulnar nerve palsy existed underwent a procedure in which surgical release was performed.

In one case a reoperation was required at the same vertebral level. After returning to full activity at 1 week postoperatively, the patient was asymptomatic for 18 months. Following a motor vehicle accident, the patient developed bilateral symptoms and was found to have a central disc herniation at the vertebral level of a previous surgery. After the patient underwent an ACD and fusion, a full recovery was observed.

There were no deaths. Three patients experienced surgery-related morbidity: one case of superficial wound infection and two cases of asymptomatic dural tears requiring no intervention other than Gelfoam. No incidents of increased motor deficit were noted.

**Discussion**

First described over 50 years ago, the posterior approach has been an excellent surgical option for the treatment of cervical radiculopathy. Scoville and Dohrmann reported excellent or good results in 95% of their patients, and these outcomes are similar to those obtained in recent series. Even the addition of a microsurgical technique to the procedure did not significantly alter the outcome. Our findings in the present series again confirm similar outcomes.

As established by Odom, et al., the patient’s ability to return to their previous level of employment and/or physical activity is very important when considering the effectiveness of therapeutic interventions. In the early years of
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using this treatment, over 90% of the patients consistently returned to their premorbid level of activity.2,12,19,28,36 This finding was again true when the microendoscopic technique was used.

Direct comparison of these results with those obtained using ACD approaches is difficult, except in limited series. The large series of Robinson and Walker,35 and others6,8,9,13 consist of very heterogeneous groups of pathological entities, ranging from unilateral radiculopathies to complex myeloradicular syndromes and alterations of spinal stability. One series reported by Lunsford, et al.,27 however, was limited to patients with lateral disc herniations; good and excellent outcomes were achieved in 67% of patients, with 69% returning to their previous level of employment.

In a study limited to radicular symptoms, Bertalanffy and Egger17 were able to demonstrate slightly better results: good or excellent outcomes were achieved in 82% of their patients. One study in which the authors attempted to compare the posterior and anterior approaches was flawed by small sample sizes, an absence of statistical difference, and posterior approach–related outcomes far worse than those reported in the majority of large published series.60 The differences in approach-related outcomes in these large series may be explained by the findings reported by Raynor42 who confirmed that much better visualization of the nerve root, over a longer distance, was provided when exposed posteriorly.

The attendant risks of mortality and morbidity remain quite low for each approach. Fatal complications are fortunately very rare; in many large series in which both approaches are used there have been none.2,6,9,12,14,28,36,50 The overall spectrum of posterior approach–related complications is much more limited than the anterior approach. Primary concern should be directed at limiting nerve root manipulation and avoiding any spinal cord manipulation.12,19,38,39,46,47,50 There is no risk of inducing segmental instability if 50% of the facet remains intact.31,49 The patients in our series underwent surgery while in the sitting position. No significant air embolic events occurred in this series, which is consistent with other reports.10,24 In some series the authors have reported up to a 7% incidence of detectable air emboli and the incidence of clinically significant embolic events remains extremely small.26

Because of the dissection and retraction required when performing the anterior approach, additional complications must be considered. The risk of graft–site complications has been reported to be as high as 18%.9 This is significant enough to prompt many surgeons to perform discectomies without fusion or to use allografts.23,32,45 In a large series, Flynn14 was able to place the risk of spinal cord injury at approximately one per 1000 procedures. A 2% risk of permanent superior laryngeal and recurrent laryngeal nerve injury is also well established.14 Newhouse, et al.,29 found a 0.25% risk of esophageal perforation. Patients in whom the more limited anterior foraminal decompressive procedures are performed face additional risks from vertebral artery injury and Horner syndrome.17,23,44

In this series, one patient with an asymptomatic postoperative course was subsequently involved in a motor vehicle accident and sustained a traumatic central disc herniation that produced bilateral symptoms. This required reoperation at the same level; an ACD and fusion were performed. No other patients required reoperation at the same vertebral level. This is consistent with results reported by Scoville and Dohrmann,46 Fager,12 and Krupp, et al.,24 who observed no recurrences. Numerous authors have reported a 7 to 15% rate of same-level reoperation after conducting the anterior approach.4–6,27 These included problems with graft displacement and collapse as well as symptomatic pseudarthrosis.

The consequences of cervical fusion and subsequent loss of a motion segment have been a source of concern for many years. In 1972, DePalma, et al.,7 reported on a series of 229 patients who underwent anterior cervical interbody fusion and found an 81% incidence of progressive adjacent-level disease. The radiographic and MR imaging features of adjacent-level changes have been well described.4,48

In 1999, Pospiech, et al.,31 demonstrated an increase in intradiscal pressure at levels adjacent to fusion sites. They postulated that this resulted in metabolic deficiencies that promote the progression of degenerative disc disease. Hillbrand, et al.,31 have postulated that up to 25% of patients who undergo cervical fusion could require treatment of adjacent-level disease within 10 years. This risk is great enough that preservation of motion segments and avoidance of fusion should be considered whenever possible.

Posterior laminoforaminotomy has traditionally provided quick and durable relief of radiculopathy syndromes as noted previously. The primary postoperative limitation experienced by patients was perincisinal pain related to

**TABLE 1**

<table>
<thead>
<tr>
<th>Affected Side</th>
<th>C4–5</th>
<th>C5–6</th>
<th>C6–7</th>
<th>C7–T1</th>
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<tr>
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<tr>
<td>total</td>
<td>5</td>
<td>30</td>
<td>57</td>
<td>8</td>
</tr>
</tbody>
</table>

**FIG. 3.** Artist’s depiction of the surgical exposure for laminoforaminotomy. Note the relation of foraminotomy to the superior or pedicle. Soft-disc herniation can be observed in the axilla of the nerve root.
the subperiosteal detachment of muscular insertions on the spinous process and lamina. In some patients, this pain was associated with severe spasms, which may limit activity for weeks. Aldrich maintained that by performing a more limited exposure for microdiscectomy he was able to reduce hospital stays to 2 days.

The initial experience with microendoscopic laminoforaminotomy has demonstrated similar success for relief of radicular syndromes as well as minimal complications and limited recurrence rates. The use of the microendoscope allows very limited exposures, with tissue destruction occurring only at the site of the laminoforaminotomy. It avoids the disruption of the ligamentum nuchae and the muscle-splitting dissection, in which only a part of the multifidus muscle fibers was sacrificed, and has the advantage of leaving the trapezius, splenius, and semispinalis muscles attached to the spinous process and lamina. This has been associated with very limited postoperative pain in most patients, which, in turn, reduced the need for postoperative narcotics and muscle relaxants, and allowed patients to return to full activity more quickly. The extreme example was illustrated by the two of the patients in this series who were professional football players, both of whom were able to return to aerobic exercise and strength training within 1 week postoperatively. One regained full strength quickly and returned to full contact activity at 3 weeks and played in a game at 4 weeks. The other patient, with foraminal stenosis, sustained a game-related C-5 nerve root contusion and required several months of postoperative conditioning before recovering full deltoid strength. He played without pain and returned to full activity more quickly. The extreme example was illustrated by the two of the patients in this series who were professional football players, both of whom were able to return to aerobic exercise and strength training within 1 week postoperatively. One regained full strength quickly and returned to full contact activity at 3 weeks and played in a game at 4 weeks. The other patient, with foraminal stenosis, sustained a game-related C-5 nerve root contusion and required several months of postoperative conditioning before recovering full deltoid strength. He played without pain and returned to full activity more quickly.

As with any new technique, the learning curve is significant. Even those experienced with the open or microscopic posterior laminoforaminotomy will find the limited 16-mm exposure and two-dimensional video display challenging. It cannot be recommended for surgeons with limited experience performing posterior laminoforaminotomy. In addition, training should occur in a nonclinical setting and initial experience gained in the lumbar spine where potential neurological complications are less severe.

### Conclusions

For the patient with a unilateral cervical radiculopathy and an imaging-confirmed lateral or foraminal source of nerve root compression, the microendoscopic laminoforaminotomy can be performed as an alternative to ACD and traditional posterior laminoforaminotomy for the safe relief of pain and neurological dysfunction. Moreover, it seems to have many advantages, such as the preservation of motion segments, limited bone exposure, and limited muscle-splitting dissection, which allow for a much less painful postoperative course and quicker return to full activity and work.

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