Minimally invasive cervical microendoscopic laminoforaminotomy

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Spine surgery has seen parallel interest and development in the areas of motion preservation and minimally invasive surgery. Posterior microendoscopic laminoforaminotomy (MELF) allows for neural decompression while maintaining motion via a minimally invasive approach. This technique shares the advantage of maintenance of motion with arthroplasty, but without the need for instrumentation. Therefore, the procedure is motion preserving, minimally invasive and cost-effective. The ideal indications for posterior MELF include unilateral radiculopathy secondary to “hard disc” or spondylosis, as well as soft disc herniations. The authors present a modified surgical technique for posterior MELF as well as a case study illustrating its synergy with anterior arthroplasty. (DOI: 10.3171/FOC/2008/25/8/E2)

KEY WORDS • posterior microendoscopic laminoforaminotomy • minimally invasive surgery • spine

After the initial description of cervical radiculopathy by Murphey et al., the preferred surgical approach for cervical spine pathology was posterior. In the 1930s, Spurling and Scoville as well as Frykholm pioneered the posterior cervical approach for the treatment of cervical radiculopathy.2,17 The posterior approach was limited in dealing with central compressive pathology and the open approach was associated with significant muscle morbidity. Subsequently, in the 1950s, the anterior approach was described and popularized.13,25 Reports by Bailey and Bagley,4 Cloward8 as well as Smith and Robinson25 helped establish ACDF as the gold standard for degenerative cervical disc disease.18 Compared to the open posterior approach, the anterior approach is generally associated with shorter recovery times, but has a greater potential for complications.16 Furthermore, ACDF necessarily results in a loss of mobility at the operated level, and places increased stress with higher shear strains on adjacent levels.12,21,24,28 These stresses are manifested radiographically as increased rates of degenerative disc disease adjacent to fusions.20 These radiographic changes may lead to a higher incidence of symptomatic segmental degeneration, necessitating further fusion surgery.5,29 Rates of symptomatic adjacent level degenerative disc disease range from 10 to 25%.13,19

Recently, spine surgery has seen parallel interest and development in the areas of motion preservation and minimally invasive surgery. Spinal arthroplasty offers the practical advantage of preservation of motion as well as the theoretical benefit of decreased adjacent level surgery.6,10,11,14,15,22,30 Minimally invasive surgery reduces approach-related complications with concomitant shorter recovery times.1,3,27

Cervical arthroplasty maintains the familiar anterior approach to the cervical spine used in ACDF, but also shares similar approach-related complications. The advantages of arthroplasty include maintenance of motion, but requires implantation of a mechanical device. Complications associated with arthroplasty include mechanical implant failure, including displacement and wear, wear debris, and heterotopic ossification with loss of motion.5,11,14,26

Posterior microendoscopic laminoforaminotomy allows for motion preservation via a minimally invasive approach. This approach shares the advantage of maintenance of motion with arthroplasty, but without the need for instrumentation. Furthermore, this technique is accomplished with a muscle splitting, minimally invasive technique that minimizes hospitalization and recovery times.3,27 Complications reported with posterior laminoforaminotomy and MELF include nerve root injury, including splitting of the nerve, dural tearing, spinal cord injury with and without K-wire misplacement, and same-segment and adjacent-segment disease.1,2,7,16

The posterior cervical approach is primarily indicated for foraminal lesions and as such is ideally suited for patients previously treated with an anterior approach who have residual foraminal stenosis. In the case of previous anterior

Abbreviations used in this paper: ACDF = anterior cervical discectomy and fusion; MELF = microendoscopic laminoforaminotomy.
artificial disc placements, these procedures are particularly synergistic because both artificial disc placement and posterior MELF are motion preserving techniques. The following case study illustrates the utility of salvaging anterior artificial disc surgery with posterior MELF.

Case Presentation

This 43-year-old woman presented with neck and right upper extremity pain and weakness. Cervical MR and CT (Fig. 1) imaging revealed a herniated nucleus pulposus at C6–7, paracentral to the right. Her symptoms were progressive despite nonsurgical management, and she was enrolled in the Bryan artificial disc investigational device exemption study and randomized to the Bryan artificial disc group. She then underwent anterior cervical discectomy and artificial disc placement at C6–7 (Fig. 2). Postoperatively, the patient recovered well and had relief of radicular and neck pain for 3 years. However, after this period, the patient noticed a gradual return of right shoulder and arm pain that worsened over 9 months into a right C-7 radiculopathy. Plain radiography revealed good artificial disc placement with maintenance of motion at C6–7 (Fig. 3). Cervical CT scanning showed spondylotic stenosis of the right C6–7 foramen (Fig. 4). The patient’s symptoms remained intractable despite physical therapy. A selective nerve root block at C-7 on the right provided complete, but transient, relief of symptoms. Her pain increased and she developed right triceps weakness. The patient subsequently underwent a right C6–7 MELF as an outpatient (Fig. 5). At her 1-week postoperative visit, the patient reported complete resolution of right upper extremity pain. She remained symptom-free 6 weeks postoperatively, was not taking pain medication, and had full resumption of normal activities. Dynamic radiographs demonstrated maintenance of motion at the operated and adjacent levels without evidence of artificial disc migration or displacement.

Technique

The technique of microendoscopic laminoforaminotomy has evolved over the past 10 years since its original description. There are currently a number of modifications in use around the world. In the present study we describe the technique that we currently utilize after a combined experience of over 1200 cases. The data obtained from that entire series is currently being analyzed for future publication.

After induction of general endotracheal anesthesia, the patient is positioned with Mayfield-Kees headholder in the sitting position. The positioning is done slowly and preceded by a 250–500 ml intravenous fluid bolus to avoid blood pressure fluctuations. Precordial Doppler monitoring is generally used but is not necessary. No central venous pressure monitoring is used.

Intraoperative C-arm fluoroscopy is positioned at the foot of the table to provide a lateral image and draped into the sterile field. We do not routinely use anteroposterior imaging. The neck is positioned in slight flexion under fluoroscopy. Care is taken to avoid overflexion, which may make the neural elements vulnerable to damage from inad-
Posterior microendoscopic foraminotomy

vertant advancement of the K-wire or dilators through the lamina.
A spinal needle is initially placed alongside the neck to identify the correct level prior to skin incision. Once the level is identified, the needle is introduced through the skin 1 to 1.5 finger breadths off of the midline to the affected side, and directed to the back of the cephalad lamina of the target level. The needle is removed and a 16–20-mm obliquely angled incision is cut centered over the puncture site. The incision should be carried deep to the subcutaneous fascia, allowing placement of K-wire and dilators with minimal resistance and minimizing the risk of inadvertent advancement. The cylindrical retractor is placed utilizing real-time fluoroscopy with a muscle splitting approach. Initially, a K-wire may be used to replicate placement of the spinal needle on the cephalad lamina. The first dilator can be difficult to pass through the deep fascial layers, and the docked K-wire can be of assistance in passing it. Medial migration can place the neural elements at risk through the interlaminar space. Once the first dilator is in place, the K-wire is removed and a subperiosteal dissection of the soft tissue off of the lamina and facet is completed. This greatly simplifies the amount of soft tissue work needed after placement of the operative cylinder. The facet “step off” is also identified by feel, and confirmed with fluoroscopy. A scissors or hemostat is then slid along the first dilator and used to release the deep fascia by spreading rather than cutting. This significantly reduces the amount of work necessary to introduce the remaining 3 dilators. Finally, the operative cylinder is placed and the dilators are removed. The cylinder is angled caudally to allow any bleeding to clear the operative field. The cylinder is then anchored to a table-mounted arm and positioned caudally over the facet complex as confirmed with fluoroscopy.

If an adequate subperiosteal dissection is completed, the remaining soft tissue is easily removed from the lamina–facet junction with a pituitary ronguer and Bovie or bipolar electrocautery. The microendoscope is then positioned in the cylinder, anchored, and oriented. Ideally, the cylinder is now centered over the disc space in the cephalad–caudal direction, and the targeted pedicle is centered in the field medial to lateral. This usually corresponds with the lamina–facet junction positioned one-third of the way from the medial border of the cylinder.

The lateral aspect of the spinal canal is identified. The foraminotomy is then initiated with a high-speed electric drill thinning the lateral lamina and medial facet to mimic the expected path of the foraminotomy. Small Kerrison rongeurs are used to complete the foraminotomy, insuring that the nerve root is exposed from its origin at the thecal sac laterally across the cephalad aspect of the pedicle up to the margin of the lateral aspect of the pedicle. At this point, only one-third to one-half of the medial facet has been removed, which should not be enough to alter stability of the joint.

Identifying the medial and cephalad aspects of the pedicle is one of the most important points of the procedure and should be done as quickly as possible once the lateral canal or foramen has been opened. Without this, it may be possible to lose medial–lateral orientation and remove too much of the facet, possibly destabilizing the segment.

In most cases, once the foraminotomy is completed, the floor of the canal and foramen are palpated for soft disc herniations. This is safely completed by passing a nerve hook, pointed caudally along the medial edge of the pedicle to the floor of the canal and then carefully rotated medially and slid cephalad over the disc space as it is rotated out the foramen. Disc extrusions may be mobilized in this fashion and removed with micropituitary rongeurs. Contained herniations may require the use of a micro down-angled curette to open the remaining ligament or annulus fibers before mobilizing the fragments. In the lower levels of the cervical-spine the nerve root may be “split” into 2 rootlets. Finding the floor of the canal under the thecal sac first and then rotating the nerve hook under the nerve root will minimize the risk of injury to one of the rootlets. Once the foraminotomy and any discectomy have been completed, spontaneous pulsations of the nerve root can usually be seen.

The wound is then closed with one layer in the subcutaneous fascia and infiltrated with 0.25% Marcaine (AstraZeneca) before sealing with Dermabond (Ethicon, Inc.).

TABLE 1

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<tr>
<th>Complication avoidance with microendoscopic laminoforaminotomy</th>
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<tbody>
<tr>
<td>avoid overflexion while positioning the patient</td>
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<tr>
<td>incision should be carried deep to subcutaneous fascia</td>
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<tr>
<td>either do not use K-wire or control it under fluoroscopic guidance at all times</td>
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<tr>
<td>K-wire and dilators should be placed w/ minimal exertion</td>
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<tr>
<td>use scissors or hemostat to release deep fascia</td>
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<tr>
<td>identify &amp; drill down the medial &amp; cephalad aspect of the pedicle to use as a localizing landmark</td>
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<tr>
<td>use the micronerve hook to identify the floor of the canal; sweep under thecal sac first &amp; then nerve root for disc fragments</td>
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The patient is then allowed to recover from anesthesia and monitored for 2–3 hours before discharge. The patient is encouraged to return to normal activities as tolerated as early as 1–2 weeks postoperatively. The steps for complication avoidance are summarized in Table 1.

Discussion

The technique of ACDF has evolved over the years. The advent of anterior instrumentation and the increasing sophistication of spinal implants and graft materials have obviated the need for iliac crest autograft harvesting while consistently increasing fusion rates.22 Unfortunately, although fusion rates have approached 100%, the clinical success rates have lagged behind, creating a disconnect between clinical and radiographic success. This basic disconnect between radiographic and clinical success rates illustrates the futility of attempting to perfect a single surgical technique for inherently diverse pathological entities. Theoretical questions of superiority between various techniques such as anterior arthrodesis or arthroplasty and posterior laminoforaminotomy are moot. A more practical path to improving clinical success rates deals with matching respective techniques with their ideal indications. The anterior approach is clearly indicated when dealing with central compressive pathological entities, either soft disc or spondylotic disease, especially in the clinical setting of myelopathy. The anterior approach is also superior when dealing with deformities in the sagittal plane. The posterior approach is ideally suited for unilateral radiculopathy due to lateral/foraminal lesions.

Disadvantages of the anterior approach include the necessity for anterior instrumentation and the complications associated with the anterior visceral structures. The evolution of arthrodesis has minimized the incidence of pseudarthrosis, but the issues of adjacent level stresses and symptomatic adjacent level degeneration remain problematic. Anterior arthroplasty may ultimately address this short-comings in patients with 1- and 2-level, central, and soft disc disease. However, cervical arthroplasty remains largely unproven in multilevel disease and myelopathy and is inappropriate for patients with structural instability, kyphosis, and advanced spondylisis. Although both anterior or procedures—arthroplasty and arthrodesis—are similar, they are not identical. During ACDF, the nerve root may be decompressed directly as well as indirectly via foraminal distraction and loss of motion. With arthroplasty, the interbody device is generally smaller with less foraminal distraction, and motion is preserved. Therefore, relief of radiculopathy is dependent on direct nerve root decompression, making this procedure theoretically more susceptible to residual or recurrent foraminal stenosis.

The posterior approach avoids the complications of the anterior visceral structures, including damage to the trachea and esophagus. The posterior approach also offers familiar anatomy, and the use of endoscopy and muscle-splitting technique minimizes muscle injury.27 These factors make MELF appropriate for the outpatient setting. The procedure is motion preserving without requiring additional instrumentation, making it both minimally invasive and cost-effective. The ideal indications for posterior MELF include unilateral radiculopathy secondary to “hard disc” disease or spondylisis as well as soft disc herniations. In the latter case, large herniations can be safely removed when the apex of the herniated disc is lateral to the lateral aspect of the spinal cord. Contraindications include radiographic evidence of a central compressive pathological entity, significant kyphosis, or a clinical presentation consistent with myelopathy.

Conclusions

Posterior MELF provides relief of radiculopathy through a minimally invasive approach with a concomitant decrease in complications, shorter hospital stays, and a faster return to work. Furthermore, posterior MELF is motion preserving, maintaining the function of the cervical motion segment, and thereby providing synergy with anterior arthroplasty.

References

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