20 Cervical Microforaminotomy and Decompressive Laminectomy

JARED D. AMENT, HEUM DAI KWON, and KEE D. KIM

Overview

Disorders of the cervical spine can cause radiculopathy, myelopathy, or both. Compression of the neural elements occurs most commonly as a result of disk herniation and/or osteophyte formation but can also be caused by congenital deformities, facet joint hypertrophy, infection, and neoplasm. Conservative, nonoperative management is initially recommended for most patients with radiculopathty.

In patients refractory to nonoperative treatment, surgical intervention can often lead to significant long-term improvement in quality of life.[1,2] Depending on the etiology, posterior cervical microforaminotomy (PCMF) or decompressive laminectomy can offer several important benefits over an anterior cervical approach and fusion: better preserved neck motion, no complications associated with instrumentation, no risk of pseudarthrosis, and decreased costs associated with shorter operative times and lack of implants.[3,4] Posteriorly approached tandem foraminotomies have similar outcomes while maintaining superior neck motion when compared with anterior decompressions and fusions.[1] Multilevel disease, even with ventral spinal cord compression, may be adequately decompressed with cervical laminectomy. Reports have suggested that adjacent-segment disease and C5 nerve root palsy are also mitigated by the posterior approach.[5,6]

In patients with sagittal or coronal deformity or any signs concerning for instability, a concomitant fusion may be appropriate and unavoidable. Furthermore, if the majority of the disk or facet joints are removed, the posterior decompression itself can lead to instability.

Diagnosis

As is normally the case, patient anamnesis is critical for making the correct diagnosis and for surgical planning. Typically, patients come to medical attention with complaints of neck and radiating arm pain. This is often associated with numbness or tingling in the arms and fingers. In addition, they may indicate difficulties with specific tasks, such as opening a jar, playing a guitar, or turning a car key. It is similarly important to inquire about clumsiness and gait and balance issues, as these can be early signs of myelopathy.

Radiographic images—such as magnetic resonance imaging (MRI) scan or computed tomographic (CT) myelogram, the latter being useful in patients with previously instrumented fusion—should supplement, not replace, the patient history and exam (Fig. 20-1). Plain radiographic images including anteroposterior (AP), lateral, and flexion and extension views, should always be obtained to evaluate spinal curvature, alignment, and motion. Oblique views may be helpful in assessing foraminal stenosis. When the source of the pain is difficult to localize, selective nerve root blocks or electromyography with nerve conduction velocity testing may be considered.

The goal of surgery may dictate the approach taken and the number of cervical levels addressed. Surgery may be limited to address symptoms or may extend more broadly to address subtle signs and radiographic abnormalities. The patient must be included in the decision-making process and must be informed of all advantages and disadvantages associated with any given intervention.

Indications and Contraindications

POSTERIOR CERVICAL MICROFORAMINOTOMY

Indication

- Cervical radiculopathy at one or more levels caused by disk herniation and/or osteophyte formation

Relative Contraindications

- Cervical myelopathy
- Midline disk herniation
- Cervical instability at the pathologic level
- Preoperative cervical kyphosis
- Vertebral body pathology
- Disk herniation with bilateral radiculopathy at the same level

LAMINECTOMY

Indications

- Multilevel cervical spondylotic myelopathy
- Cervical stenosis involving three or more levels
- Ossified posterior longitudinal ligament (OPLL) at multiple levels

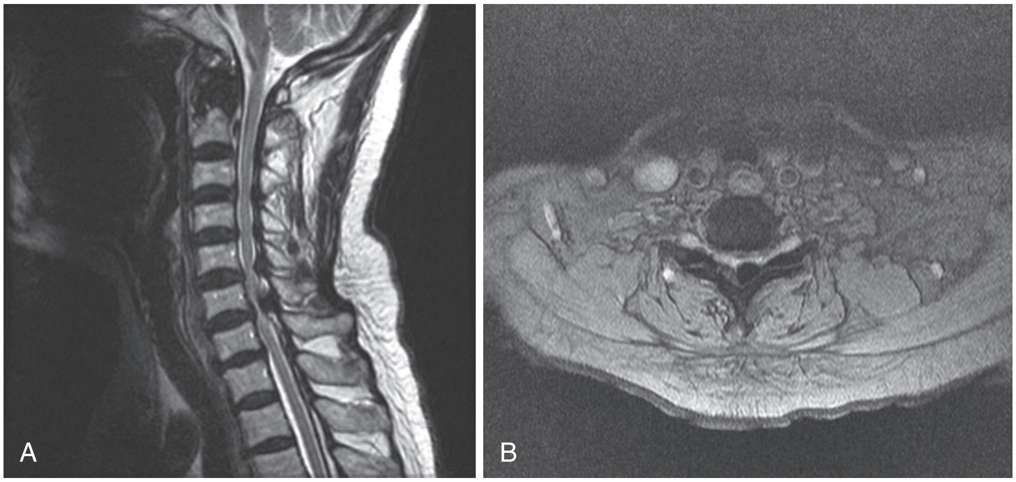

Figure 20-1 T2-weighted (**A**) sagittal and (**B**) C5–C6 axial magnetic resonance images illustrate the extent of the spinal cord compression. In addition to congenital spinal stenosis, this patient also had an ossified ligamentum flavum.

- To access an intradural pathology (e.g., extramedullary and intramedullary neoplasm)
- Structural difficulties with an anterior approach (previous anterior surgery, short neck, barrel chest, obesity)
- Failure of previous anterior decompressive surgery

Contraindications

- Kyphotic deformity
- Instability of the pathologic level
- Younger patients (high risk of developing kyphotic deformity)

Operative Technique

EQUIPMENT

The Mayfield head clamp is recommended over a horseshoe headrest to avoid pressure on the central retinal artery. Excessive and extended pressure on the orbits and central retinal artery can lead to blindness.

PATIENT POSITIONING

PCMF or decompressive laminectomy is best approached with the patient in a prone position. The sitting position may reduce blood loss secondary to collapse of the epidural vessels but requires greater preoperative preparation and intraoperative vigilance for detection of air emboli. The embolic risk in prone position is relatively small and can be further reduced by proper positioning. The patient's knees should be positioned higher than the heart, and bilateral compression stockings should be the standard of care. The authors prefer and recommend the prone position with the patient's chin flexed approximately 45 degrees to reduce cervical venous pressure and to increase the interlaminar space. With the patient secured, the reverse Trendelenburg position is often used so that the cervical spine is roughly parallel to the floor (Fig. 20-2).

Figure 20-2 The patient is positioned in slight flexion to facilitate surgical exposure. The neck is maintained parallel to the floor to decrease epidural bleeding and risk of air embolism. The patient's eyes should be free from direct pressure, especially when using the horseshoe headrest.

MINIMALLY INVASIVE APPROACH

With the minimally invasive approach to PCMF, a spinal needle is inserted approximately 1 to 2 cm off midline at the pertinent level. The target, the junction of the medial facet joint and two laminae, should then be confirmed with intraoperative fluoroscopy. A 12- to 14-mm stablike incision is made over the needle puncture site and is followed by removal of the spinal needle and insertion of a guidewire or a small dilator. The dilator is preferred over the guidewire to avoid penetration of the ligamentum flavum and creation of an inadvertent durotomy.

The dilator should be advanced and docked on the corresponding lateral mass. This can be confirmed by intraoperative fluoroscopy. Gentle soft-tissue dissection is carried out with subsequent dilators until the appropriate sized tubular retractor can be inserted. The location should again be confirmed by intraoperative fluoroscopy (Fig. 20-3). The

Figure 20-3 Anteroposterior fluoroscopic view shows tubular retractor setup for left C6–C7 posterior cervical microforaminotomy, lateral mass instrumented fusion for pseudarthrosis, and residual foraminal stenosis after previous anterior C5–C6 and C6–C7 surgery.

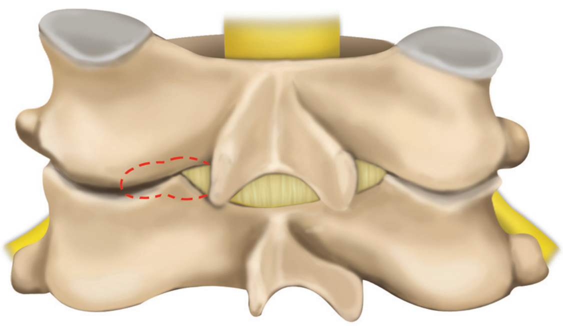

Figure 20-4 The operative boundary for posterior cervical microforaminotomy. The "keyhole" (*red dotted line*) is made up of the lateral portion of the superior and inferior laminae and the medial one third of the facet joint. (All schematic drawings by Phillip Lee.)

operative microscope is then brought over the surgical field to allow for direct visualization of the corresponding laminae and facet joint. The subsequent steps, whether done via a minimally invasive approach or by open PCMF, are identical and are described below.

CERVICAL MICROFORAMINOTOMY

Once the initial soft-tissue exposure is complete, the Bovie is used for subperiosteal dissection. Adequate hemostasis and unobstructed visualization are required before using the high-speed drill. The drill should be fitted with a 3 mm burr, which is then used to thin the laminae and expose the thecal sac. Continue the exposure laterally, thinning both the superior and inferior laminae up to the medial third of the facet joint (Fig. 20-4). While drilling, the hard outer cortical layer, the softer middle cancellous layer, and the inner cortical layer should be appreciated. We recommend using both hands on the drill for better control. Intermittent saline irrigation by an assistant is important in preventing thermal injury.

The bone is drilled until only a thin inner osseous layer remains. This layer is carefully removed with a curette from an anterior-posterior direction to reduce the risk of injury to the underlying spinal cord and nerve root. The ligamentum flavum is identified medially and incised with a scalpel or a microcurette. The goal is to create an anatomic plane between the ligamentum flavum and the dura to facilitate resection of the ligamentum flavum and exposure of the thecal sac and exiting nerve root. An epidural venous plexus commonly overlies the nerve root, and if necessary, it may be coagulated with bipolar cautery. Surgifoam (absorbable gelatin powder) mixed with thrombin administered via a syringe tip also works well to achieve hemostasis.

For lateral decompression to be sufficient, 5 mm of nerve root exposure is generally required (Fig. 20-5). A thin dental probe can be passed laterally along the foramen, tracing the path of the nerve root to assess the decompression. Pedicle-to-pedicle and more lateral facet joint resection may be performed for maximal bony decompression.

DISKECTOMY

For most soft-disk herniations, PCMF results in adequate nerve root decompression. However, in patients with noticeably diminished nerve root mobility following PCMF, the vascular cuff enveloping the nerve root should be removed to allow further exploration of both the nerve root and disk. The nerve root should always be manipulated in a controlled fashion to avoid injury (Fig. 20-6). When the herniated disk is below the nerve root, gentle rostral retraction should be applied. Similarly, gentle caudal retraction should be applied for a herniated disk above the nerve root.

Free disk fragments are carefully removed with a small pituitary ronguer. Depending on the location of the disk herniation, the annulus may be approached over the nerve root shoulder or from beneath the axilla. First, make an incision into the annulus; this initial incision can often yield substantial disk material; however, in the case of degenerative disk disease, more aggressive resection, often with a small pituitary rongeur, is normally required. To avoid manipulating the dura, use a small nerve hook to retrieve any loose disk fragments.

OSTEOPHYTECTOMY

The surgeon is sometimes presented with hard disk pathology or degenerative spurs. In these patients, the adequacy of the decompression needs to be further assessed. Pass a small Penfield probe around the shoulder, axilla, and foramen of the nerve root in question. If any resistance is felt, the foraminotomy should be extended. The pedicle below the exiting nerve may be palpated with a small dissector for anatomic orientation. Anterior osteophytes may be drilled away from the nerve root with a 2-mm diamond-tipped burr. This should only be attempted when there is observable deformation or compression of the nerve after unroofing the foramen.

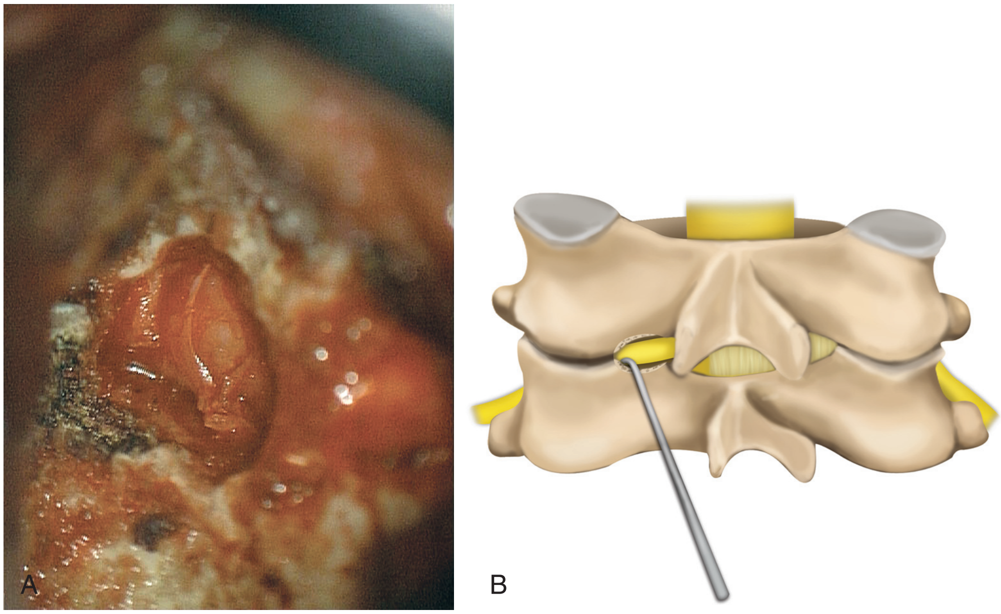

Figure 20-5 Intraoperative photograph (**A**) and schematic drawing (**B**) of a left C5–C6 posterior cervical microforaminotomy demonstrates a decompressed nerve root.

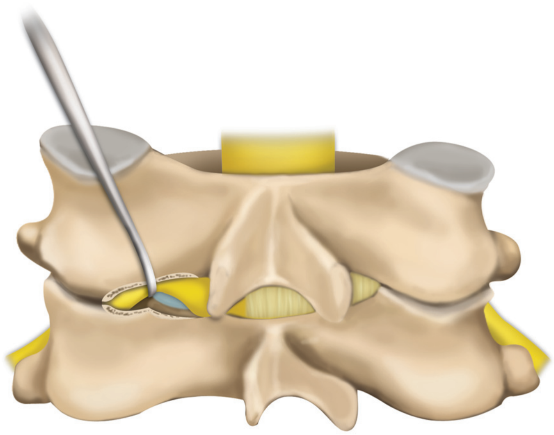

Figure 20-6 The nerve root is gently mobilized and retracted upward to expose the herniated portion of the disk.

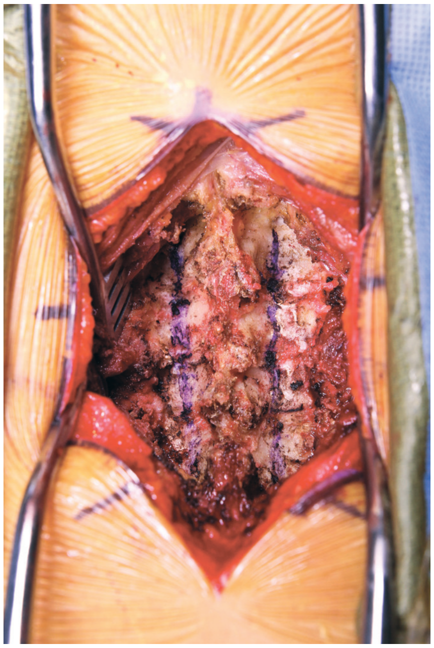

Figure 20-7 Operative view after subperiosteal exposure for a cervical laminectomy. A blue surgical marker demarcates bilateral troughs to be created just medial to the laminofacet junction.

DECOMPRESSIVE LAMINECTOMY

After prepping and draping in the normal sterile fashion, make a midline skin incision that is appropriate in length for the procedure and required exposure. Dissect down to the fascia, and identify midline structures to avoid transecting through the paraspinous muscle. Expose the spinous processes of the involved levels using a scalpel and/or Bovie cautery. Subperiosteal dissection is important to limit the amount of blood loss during the exposure. If at any point in the procedure the targeted anatomic level is unclear, an intraoperative radiograph should be obtained.

Cerebellar retractors adequately maintain the exposure; however, tension should be intermittently released to avoid ischemic injury to the paraspinal muscles and skin. Continue the subperiosteal dissection over to the lateral masses bilaterally while being cognizant of, and not disrupting, the facet joint capsule (Fig. 20-7). If the C1 posterior arch needs to be removed, electrocautery should not be used more than 1.5 cm from the midline to avoid injury to the vertebral arteries.

After completing the subperiosteal dissection, the authors recommend an en bloc resection of the involved laminae. Bilateral troughs are created with a 3-mm cutting burr just medial to the facet joint (Fig. 20-8). With intermittent irrigation, the troughs are created down to the ligamentum flavum. Drilling should proceed in a controlled and careful manner to avoid contact with the dura or underlying nerve root. Another, arguably safer option is to drill down to the

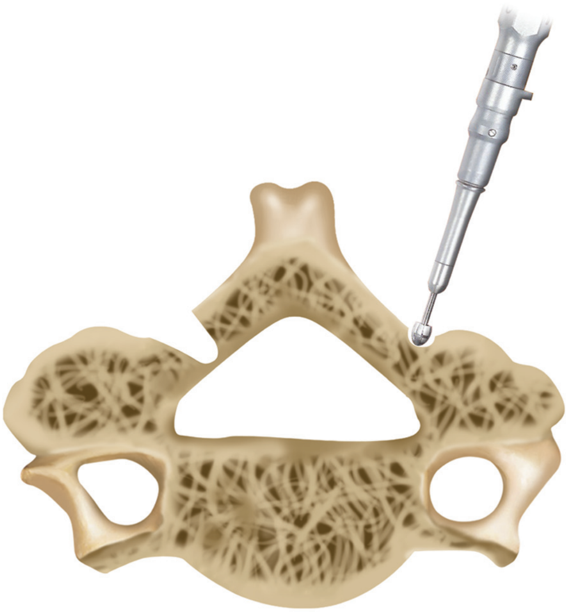

Figure 20-8 The trough is created using a 3-mm burr just medial to the laminofacet junction. A high-speed drill may be used to create the trough down to the ligamentum flavum, or partially down to the inner cortex, followed by use of a Kerrison rongeur.

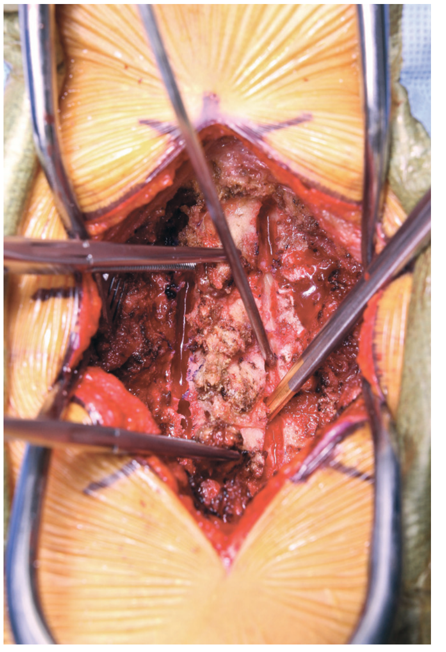

Figure 20-9 A small Kerrison rongeur is used to reduce the ligamentum flavum to complete the en bloc laminectomy. Kocher forceps are used to grasp the cranial and caudal spinous processes to distract the lamina to allow safe completion of laminectomy.

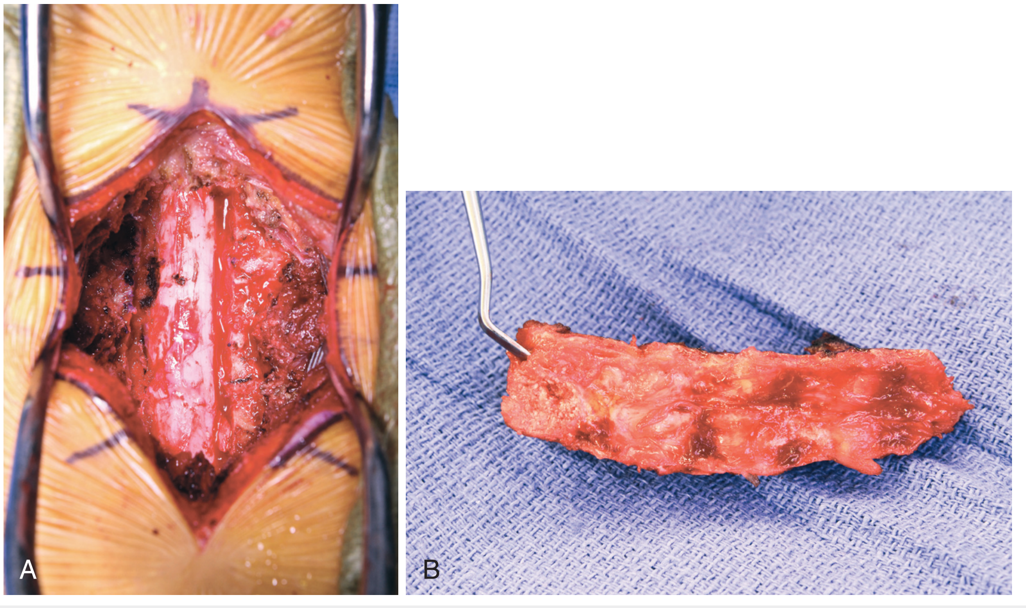

Figure 20-10 En bloc C3–C6 laminectomy with undercutting of C2 and C7 laminae. The lateral margins of the dura are visualized with the facet joints intact (**A**). Intraoperative photograph shows the undersurface of C3 to C6 en bloc laminae of the patient (**B**). Note the yellowish hue of the ossified ligamentum flavum.

inner cortex and complete the trough using a 1 or 2 mm Kerrison rongeur.

Upon completing the bilateral troughs, Kocher clamps are used to grasp the most cephalad and caudad spinous processes to gently distract the en bloc laminae away from the spinal canal (Fig. 20-9). Gently pull the Kocher clamps to one side, and expose the ligamentum flavum from below the contralateral trough. Without disrupting any epidural veins, use a small Kerrison rongeur to ensure separation of the ligamentum flavum from the dura. Repeat these steps along the contralateral trough. To prevent injury to the spinal cord, it is critical that the laminae and ligamentum flavum be removed outward and in a controlled manner, especially because areas of the dura may still be adherent to the laminae.

When the en bloc laminectomy is properly carried out, the lateral margins of the dura with intact facet joints are visible (Fig. 20-10). Use a Kerrison rongeur or a curette to remove any bony spicules and, if desired, to perform a foraminotomy. The foramen should first be palpated with a small nerve hook or a dental probe to ensure adequate decompression.

Postoperative Care

Postoperatively, a cervical collar does not need to be routinely provided. Patients often request a collar for comfort; however, it is preferable that its use be limited. Laminectomy patients benefit from exercises and muscle strengthening after adequate time is given for recovery. Collars can directly inhibit this, resulting in weak paraspinal muscles and increased susceptibility for developing a delayed cervical kyphotic deformity.

Complications

Among the possible complications of PCMF and cervical laminectomy, C5 nerve palsy, postsurgical instability, and kyphotic deformity deserve special attention.

C5 nerve palsy affects approximately 5% to 7% of patients, making it the most common motor palsy following cervical spine surgery.[6] Despite this, its pathogenesis remains unclear. A number of etiologies have been proposed, including direct nerve root injury, cord tethering, reperfusion injury, progressive malalignment, and iatrogenic foraminal stenosis. Interestingly, the C5 root is shorter than other nerve roots, and the angle it exits from the cord is more obtuse than at any other level. It also seems to occur irrespective of the procedure type, surgical technique, or initial pathology.[7] Radiographic differences among postoperative patients with and without C5 palsies have also been demonstrated. In affected patients, computed tomography and magnetic resonance imaging scans demonstrate narrowing of the intervertebral foramen, larger superior articular processes, and significantly greater posterior shift of the spinal cord.[7]

Efforts have been made to better understand and prevent C5 palsies. Some authors have suggested raising the mean arterial pressure during surgery or limiting reperfusion injury with free radical scavengers. Others have been proponents of multimodal intraoperative monitoring. Although the results appear to be highly sensitive and specific, the level of evidence that an intraoperative response to a neuromonitoring alert reduces the rate of perioperative deterioration remains low.[8] However, the most compelling evidence suggests that a prophylactic foraminotomy in patients undergoing laminectomies or laminoplasties significantly reduces the incidence of C5 palsy.[9]

Unlike C5 nerve root palsy, postsurgical instability is much better described. Zdeblick and colleagues[10] applied physiologic loads to human cadaveric cervical spines following resection of 25%, 50%, 75%, and 100% of the facet joint and capsule, unilaterally. They reported a statistically significant increase in the displacement observed during flexion after 75% or 100% capsular resection. Hence, when decompression involves greater than 50% of the facet joint, a concomitant fusion may be necessary. Novel surgical techniques have subsequently been described in an effort to preserve the facet joint. For example, Chang and colleagues[11] described a posterior cervical inclinatory foraminotomy with substantial facet preservation and reported excellent biomechanical and clinical results.

Cervical spine deformity and axial neck pain have also been reported following cervical laminectomy. This has been attributed to muscle disruption, primarily at the C2 and C7 spinous processes.[12,13] We strongly advise against resection of the C2 and C7 soft-tissue attachments to avoid this complication and to better maintain cervical lordosis. We prefer a C3–C6 decompressive laminectomy combined with undercutting of the C2 and C7 laminae. If a C7 laminectomy is necessary, cervicothoracic instrumentation is recommended.

Postlaminectomy kyphosis is a disabling problem that may be avoided by careful preoperative evaluation. Although this deformity can occur at any age, it occurs most frequently in children.[14] In adults with cervical spondylotic myelopathy, Kaptain and colleagues[10] reported a 21% incidence of postlaminectomy kyphosis.[15] Kyphosis has also been shown to be directly correlated with facet disruption and preoperative deformity and malalignment.

Conclusions

For the appropriate indications, posterior laminectomy and PCMF are safe and effective decompressive surgical modalities. There is also some evidence to suggest that the incidence of C5 motor root palsy is decreased in patients who undergo PCMF in addition to decompressive laminectomy. Cervical laminectomy, however, is associated with a higher incidence of delayed cervical deformity. Risk factors such as age, the cervical levels requiring decompression, and preoperative cervical alignment and motion must be carefully considered to avoid this complication.

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