

Open Door Laminoplasty Technique

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Introduction

Laminoplasty is a posterior method of spinal cord decompression that was originally designed as an alternative to multilevel laminectomy for treating multilevel cervical myelopathy. Advantages over laminectomy alone include: 1) a much lower rate of postsurgical kyphosis, and thus potentially less neck pain, deformity, or recurrent myelopathy; 2) avoidance of postlaminectomy membranes which can cause recurrent cord compression; and 3) preservation of bone stock and covering over the dural sac, which could make a revision posterior operation easier to perform than in the presence of multilevel laminectomy. Advantages over anterior surgery include avoidance of fusion and all fusion related complications (e.g., nonunion, graft kickout, implant failure, potential for accelerated adjacent segment degeneration), as well as avoidance of issues related to the anterior cervical approach (e.g., dysphagia, dysphonia, airway obstruction, vertebral artery injury). Laminoplasty can achieve spinal cord decompression directly, via an enlargement of spinal canal dimensions and removal of ligamentum flavum. More commonly in the cervical spine, myelopathy arises from anterior structures such as disc herniations, spondylotic bars, and ossification of the posterior longitudinal ligament (OPLL) in the setting of a congenitally narrowed canal. In such cases, laminoplasty achieves an indirect cord decompression as well by allowing the spinal cord to drift away from compressive anterior structures.

Indications

The ideal indications for cervical laminoplasty are in the patient with multilevel (≥ 3 motion segment) myelopathy, with preserved lordosis, and little to no spondylotic axial neck pain. Preoperative upright neutral lateral xray is mandatory for assessing alignment and suitability for laminoplasty. In properly selected patients, laminoplasty provides an excellent means of cord decompression with neurologic outcomes similar to those achieved with anterior operations while preserving motion and avoiding fusion.

Procedure

Positioning

Proper patient positioning is critical to the success of surgery and avoidance of complications. Proper positioning helps to avoid iatrogenic neurologic injury, decreases surgical site bleeding, and generally makes the operation easier to perform. Cervical tongs are utilized in order to immobilize the cervical spine and suspend the eyes and face to avoid pressure. We prefer to use a Mayfield head holder because it provides very secure fixation of the head. The patient is placed onto longitudinal bolsters in order to diminish abdominal pressure. The bed is placed into a reverse trendelenburg position in order to decrease venous pressure at the surgical site. The knees are bent with the lower legs appropriately padded in order to prevent the patient from sliding caudally. The shoulders are then taped longitudinally in order

to allow them to be pulled caudally out of the way for lateral xray localization. Doing so also pulls the shoulder girdles away from the posterior neck and diminishes redundant skin folds to facilitate a posterior cervical exposure. However, the shoulders should not be taped with excessive force, as this may cause stretch on the brachial plexus.

The neck is placed into a neutral to slightly flexed alignment as the Mayfield tongs are attached to the bed frame. Extension during positioning for laminoplasty is not desired for two reasons. First, extension of the stenotic cervical spine generally leads to narrowing of the canal diameter and increase in spinal cord compression. Thus, it is important to check the amount of extension tolerated by the patient preoperatively without developing neurologic exacerbation (e.g., increasing numbness, Lhermitte's), and then never exceed that amount during intubation or positioning intraoperatively in order to avoid potential spinal cord injury in the severely myelopathic patient. Second, extension leads to an increase in the amount of "shingling" or overlap between adjacent laminae, making the operative procedure more difficult to perform. If a fusion is performed in conjunction with laminoplasty, it is important to reposition the neck into appropriate lordosis prior to securing the instrumentation. However, for non fusion applications, the alignment does not need to be altered once it is properly set.

Anesthesia

Preoperative discussion with the anesthesiologist is important whenever operating on myelopathic patients. In those who poorly tolerate cervical extension, have difficult appearing airways, or develop exacerbation of neurologic symptoms with extension, consideration should be given to performing a fiberoptic intubation. Alternatively, glide-scope intubation is generally the method of choice at our institution. The important point is to avoid extension in severely stenotic myelopathic patients. It is also important to maintain spinal cord perfusion intraoperatively by keeping the blood pressure adequately elevated. There is no consensus on the optimal intraoperative blood pressure, but we generally ask that the patient be maintained relatively normotensive. Arterial lines may be necessary in those with labile blood pressures or if the cuff readings are not reliable. As the patient not uncommonly becomes hypotensive during reverse trendelenburg positioning prior to start of surgery, the anesthesiology service should be alerted to remain vigilant with respect to blood pressure throughout the operation even before the incision is made.

Neurologic monitoring

Neurologic monitoring is generally used during laminoplasty, but there are no absolute guidelines. In our opinion, monitoring is most helpful when performing deformity correction. Although deformity correction is typically not performed during laminoplasty, monitoring still provides some potentially useful information. Monitoring may help detect cord hypoperfusion due to drops in blood pressure, oxygenation, or hematocrit. It can potentially identify positioning-related nerve compression in the extremities or excessive traction on the brachial plexus from taping of the shoulders. Monitoring signals may also be affected by excessive cervical traction or extension causing stretching or increased compression of the spinal cord, respectively.

Baseline data should be obtained after positioning in order to allow for comparisons should any change occur. Pre-positioning baseline data in the supine position may also be considered in those with severe myelopathy to determine whether the cervical spine has been properly positioned after the patient is turned prone.

Whereas motor evoked potentials (MEPs) have generally become the standard of care with deformity surgery because of increased sensitivity in detecting spinal cord injury during correction maneuvers, the utility of MEPs during laminoplasty remains unclear. Although MEPs are more sensitive than somatosensory evoked potentials (SSEPs), they are less specific and more prone to false positive results (e.g., loss of MEPs due to causes other than true neurologic injury) as they tend to be more affected by anesthetic and other factors. Opponents of MEP use during laminoplasty argue that false positive results require a search for corrective action which can cause increases in operating time and “unnecessary” maneuvers that may actually be counterproductive (e.g., aborting surgery, removing fixation devices that may not be problematic, converting to laminectomy to be certain that there is no cord compression under the lamina, etc.). As a result, we generally use SSEPs but not MEPs during laminoplasty.

Exposure

A midline longitudinal subperiosteal approach is taken to the spine, staying strictly in the midline raphe in order to minimize muscle damage and bleeding. Exposure is carried laterally to just beyond the lateral mass- lamina junction. If plate fixation is used, the central portion of the lateral mass needs to be exposed in order to accommodate the plate. However, the remainder of the facet complex should not be disrupted to the extent possible. Whenever possible, the muscle attachments to C2 are left intact in order to help preserve the mechanical function of the cervical extensor mechanism. Often, patients with multilevel myelopathy do not have stenosis involving the C2-3 segment. In such cases, a full laminoplasty of C3 -- which will require detaching some of the C2 muscle insertions in order to get sufficient exposure -- does not need to be performed in order to achieve cord decompression at the C3-4 disc level and below. Instead, a dome laminectomy of the inferior surface of C3 can be performed to decompress the C3-4 disc level while dissecting the muscles only on the inferior portion of C3 and leaving all of the attachments to C2 intact. However, in patients with stenosis above the level of the C3-4 disc (e.g., OPLL behind the body of C3, stenosis at C2-3, etc.), a full laminoplasty of C3 may be required along with detachment of at least some of the muscles insertions on C2. If so, the insertions should be reattached to the remnant of C2 at the end of the case, and the amount of detachment limited only to that absolutely necessary to perform the C2 dome laminectomy.

After exposure has been obtained and the correct levels verified, the interspinous ligaments at the top and bottom of the construct are removed.

Creating the open side

The open side is created first. In those with purely spinal cord compression, we favor opening the side that has greater compression or symptoms. In those who have concomitant root compression, foraminotomies are easier to perform on the open side, although they can be performed on the hinge side as well. The opening is created at the lateral mass-lamina junction. A burr is used to drill down both the dorsal and ventral cortices until there is only a thin shell of ventral bone. A curette or micro-kerrison

rongeur is used to remove the remaining flake of anterior cortex. It is important to thin the bone sufficiently such that there is minimal intrusion into the spinal canal during placement of tools to remove bone. The cephalad portion of the lamina tends to be both thicker and potentially covered by the overhang, or “shingling,” of the caudal aspect of the proximal lamina. Thus, it is often necessary to focus the burring in this area. Paradoxically, extra caution should be observed when burring in this area, because whereas the dura ventral to the inferior portion of the lamina is protected by ligamentum flavum, that underneath the cephalad portion of the lamina is not. It is possible to observe a change in color of the lamina as it is thinned. On the caudal aspect, one can appreciate the yellowish hue of the ligamentum flavum, whereas on the cephalad aspect, one can appreciate the bluish hue of the underlying dura or the crimson of the longitudinal epidural veins.

Creating the hinge side

The hinge side is then created at the opposite lateral mass-laminar junction. This time, however, only the dorsal cortex is removed. For the same reasons as is the case on the open side, deeper burring is needed at the cephalad portion of the lamina. The hinge is progressively thinned as it is tested for pliability by exerting a dorsal pressure on the lamina. It is important to try to maintain a “springy” hinge and not thin it down excessively. Great care must be taken to ensure that the lamina does not recoil and slam into the dural sac during opening.

Opening the laminoplasty

The laminoplasty is then sequentially opened by exerting dorsal pressure on the lamina, lifting it away from the canal. As this is done, the ligamentum flavum will come under stretch on the open side at each segment and is resected with a Kerrison. Similarly, the flavum extending across the floor of the spinal canal at the top and bottom of the construct should be resected. As this is done, epidural bleeding may be encountered and need to be controlled with bipolar or thrombin-gelfoam. Often, epidural bleeding decreases once the entire length of the construct has been opened up due to a release of the tourniquet effect as the pressure is released off the veins.

At this point, fixation is applied. There are a number of different techniques of fixation, including sutures passed around the base of the spinous process and into the hinge side facet (Hirabayashi technique), bone struts (either spinous process autograft or rib allograft) wedged across the open side from the cut edge of the lamina into the lateral mass, or plates. We prefer plate fixation because it provides for more secure fixation than that achieved with the alternative methods, and it is generally very easy to apply. Premature laminoplasty closure has been reported in up to 34% of segments with suture fixation (Matsumoto JNS Sp 2008), and bone struts can dislodge into the spinal canal causing neurologic compression. In contrast, in a study of 217 laminoplasty levels with plate fixation only and no supplemental bone graft, no premature closures, plate dislodgements, or plate failures were seen (Rhee, *Spine* 2011). In addition, CT scans demonstrated that 93% of hinges had healed by stringent criteria at 12 months postoperative. In the remaining 7%, the canals remained patent with recreation of an expanded laminar arch despite radiographic hinge nonunion as those segments developed a stable fibrous union. Generally, two screws are placed into the lateral mass, and either one or two screws into the cut edge of the lamina as needed to achieve stable fixation. We generally prefer to instrument every segment in order to optimize fixation.

Foraminotomies can be done as necessary. It has not been established whether prophylactic C5 foraminotomy may decrease the incidence of postoperative C5 root palsy. We generally perform foraminotomies for symptomatic foraminal stenosis on the open side after the laminoplasty has been opened and plate fixation applied, as it is much easier to do at that stage. If foraminotomy is needed on the hinge side, it should be performed prior to opening the laminoplasty, as hinge side access is limited after the laminoplasty has been opened.

Occasionally, lateral mass fusion is performed in conjunction with laminoplasty. The benefit of laminoplasty and fusion versus laminectomy and fusion is a larger surface area for bone healing. However, a downside is a decrease in the amount of local laminar autograft. In addition, the sequence of instrumentation needs to be orchestrated appropriately, as lateral mass screws need to be inserted prior to opening of the laminoplasty. In general, we prefer laminectomy and fusion to laminoplasty and fusion for those reasons.

References

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