SUBSPECIALTY PROCEDURES

MINIMALLY INVASIVE UNILATERAL LAMINECTOMY FOR BILATERAL DECOMPRESSION

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Introduction

Unilateral laminectomy for bilateral decompression (ULBD) is a recently popularized minimally invasive surgical technique for decompression of the spinal canal. The procedure requires a unilateral exposure and muscle retraction, thereby minimizing iatrogenic injury to the paraspinal muscles¹ and the spinous process/interspinous ligament midline tension band structures. The approach was initially described by McCulloch and Young^{2,3} and has been used for more than 25 years. Conventional laminectomy and decompression can achieve satisfactory neurological recovery, but the ULBD technique preserves the integrity of the contralateral supporting lumbar musculature with its physiological attachment to the spinous process and the midline supporting structures⁴⁻⁶.

ULBD is performed with the patient prone on either a Jackson or an Andrews operating table, equivalent to the position used for standard posterior lumbar spine surgery. The technique requires a posterior midline or paramedian linear incision followed by an incision of the thoracolumbar fascia and retraction of the paravertebral muscles ipsilaterally. An appropriate retractor of the surgeon's choice is inserted to reveal the lamina and spinous process unilaterally at the appropriate level for decompression. The side of the approach is determined by the pathological findings as well as the handedness and preference of the surgeon. The spinal level of intervention is checked with an image intensifier to confirm the level of decompression.

A hemilaminectomy is performed on the approach side to expose the full extent of the ligamentum flavum and its superior and inferior attachments. Angulation of the retractor is performed to undercut the spinous process to achieve access to the midline and contralateral ligamentum flavum. This is followed by a bilateral flavectomy from a unilateral approach, and decompression of the spinal canal, which may involve partial medial facetectomy on the approach side. A contralateral decompression is achieved using a combination of an angled curet and drill. After central and lateral recess decompression, closure is performed in the standard fashion with suture of the thoracolumbar fascia and superficial layers.

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Indications & Contraindications

Indications

- Neurogenic claudication due to lumbar canal stenosis.
- Radiculopathy due to lateral recess stenosis.
- Facet joint cyst with central canal stenosis.

Contraindications

- Prior surgery at the index level may require a bilateral decompression and wide exposure of the neural elements.
- The central canal, the lateral recess, and the entry zone of the foramen can be reached on the ipsilateral side. The decompression on the contralateral side can extend into the entry zone and mid-zone of the foramen (i.e., under the pedicle). Stenosis in the exit zone and far lateral area cannot be reached.
- Congenital stenosis due to short pedicles, where the constriction has the same diameter throughout (a narrow tube as opposed to a constricted-waist appearance at each level), may not be suitable for ULBD.

Step 1: Positioning, Incision, and Instruments Required

With the patient prone on the spinal table of your choice, use an image intensifier to determine the incision position and then position the retractor of your choice to identify the inferior aspect of the superior lamina.

- Following administration of general anesthesia, position the patient prone on the operating table of your choice, such as a Jackson or Andrews spinal table.
- Using an image intensifier, follow standard principles for checking the level of intervention to confirm that it is the correct level of exposure and decompression.
- Position the retractor to identify the inferior aspect of the superior lamina and commence the bone dissection/removal there. For instance, for an L4-L5 decompression, you will start the procedure at the spinous process-lamina junction of L4 on the approach side (Fig. 1).
- Performance of the ULBD requires several key instruments, preferably chosen according to the surgeon's preference and hand comfort. These include:
 - Retractor. The procedure can be performed using a retractor system of your choice, such as a tubular retractor with a dilation technique or a hinged system such as the Versa-Trac (V. Mueller) or McCulloch retractor. The technique does not rely on the specific retractor system used. Unilateral positioning of the retractor avoids dissection of paraspinal muscle bilaterally.

Fig. 1

Fig. 1 ULBD for lumbar canal stenosis. **Fig. 1-A** Central canal stenosis can be managed by a unilateral approach with undercutting of the spinous process to access the contralateral lateral recess. The dotted lines represent the bilateral access achieved using the unilateral approach. **Fig. 1-B** A tubular or hinged-blade retractor system can be used for ULBD.

- High-speed drill. We use a 4-mm round burr on an angled attachment to drill “around corners” (Fig. 2). Side-cutting burrs (matchsticks) are an option, but the surgeon should use the burr geometry with which he or she is most comfortable.
- Curets. Having a variety of angled curets is vital so that the ligament can be dissected off the lamina and for contralateral dissection and ligament removal (Fig. 3).
- Kerrison rongeurs. We prefer 2-mm and 3-mm Kerrison rongeurs. There are “curved” Kerrison rongeurs on the market that can be used for contralateral decompression.

Fig. 2

Fig. 3

Fig. 2 Initial bone exposure and removal as seen on different views (A, B, and C) of the lamina. For an L4-L5 decompression, bone removal starts at the inferior aspect of the superior lamina—i.e., the L4 lamina. The lamina bone is removed using a high-speed drill up to the attachment of the ligamentum flavum, which usually represents the uppermost aspect of the canal stenosis.

Fig. 3 Angled curets and drills are key instruments for the ULBD procedure as they assist with contralateral decompression and removal of ligament and facet hypertrophy. Angled drills can provide access under the spinous process and contralateral lamina, and angled curets can decompress “around corners” to achieve adequate decompression of the neural elements of the contralateral lateral recess.

Step 2: Bone Removal

Begin the laminotomy on the approach side, drilling to identify the ligamentum flavum on the approach side, and remove bone up to the superior attachment of the ligamentum flavum.

- Following identification of the inferior aspect of the superior lamina (for example, the inferior aspect of the L4 lamina for an L4-L5 decompression), begin the bone removal using a high-speed drill of your choice. Introduction of large instruments such as bone nibblers is not possible with a limited exposure.
- Remove the bone of the inferior aspect of the superior lamina to expose the superior limit of the ligamentum flavum attachment (Fig. 2).

Step 3: Undercutting of the Spinous Process

To gain access to the contralateral side of the canal for bilateral decompression, remove enough of the spinous process to gain access to the midline and contralateral ligamentum flavum.

- Angle the retractor so that the base of the spinous process can be visualized and bone removal can be performed.
- You may wish to rotate the patient and bed away from the side that you are standing on so that the approach angle to the contralateral side is more convenient.
- Using a high-speed drill, continue to remove bone so that the ligamentum flavum on the contralateral side is visualized. This is a relatively safe maneuver as the ligamentum flavum helps to prevent “plunging” of the drill in a confined space.
- Undercutting of the spinous process can usually be performed without fracturing the base of the spinous process, although it will occasionally fracture in patients with osteoporotic bone.

Step 4: Identify the Superior Aspect of the Ligamentum Attachment

The superior aspect of the decompression usually corresponds with the superior ligamentum flavum attachment, except in certain cases such as when a facet joint cyst extends beyond the limits of the ligamentum flavum; removal of the upper limit of the ligamentum flavum provides an important landmark to confirm the superior limit of the decompression.

- When using a high-speed drill and microscope (or equivalent illumination/magnification), take care to “slow down” when approaching the upper limit and attachment of the ligamentum flavum to avoid plunging the drill into the dura.
- An angled curet can be used to sweep under the superior lamina (L4 with an L4-L5 decompression) to assist in ligamentum removal.
- Remove the contralateral ligamentum flavum attachment using an angled curet after an appropriate resection of the spinous process and removal of the lamina bone with the drill.
- Following superior removal of the ligamentum flavum attachment, the dura can be identified and the ligament usually retracts inferiorly as it no longer has a superior attachment.
- Be aware that, when the curet is used to release the final attachment of the ligamentum flavum proximally, there is an increased risk of dural tear, particularly when there is tight stenosis.
- Just above the superior attachment of the ligamentum flavum, the dura comes into direct contact with the bone of the undersurface of the residual lamina. In patients with a tight stenosis, the dura may adhere to the bone of the undersurface of the lamina just above the attachment of the ligamentum flavum.
- Take particular care to keep the leading edge of the small curved curet on bone and to carefully and slowly release the dura from the undersurface of the lamina to avoid a durotomy.
- Also make sure to divide any adhesions between the dura and the ligamentum flavum to avoid dural injury and a cerebrospinal fluid leak. We recommend an angled curet to “sweep” between the dura and ligamentum flavum to identify points of adhesion that should be divided.

Step 5: Lateral Recess Decompression on the Ipsilateral Approach Side

Detach the ligamentum flavum from the facet joint on the approach side using a combination of angled curets and Kerrison rongeurs; a partial medial facetectomy, or removal of adequate facet hypertrophy, on the approach side is necessary to expose the traversing nerve root.

- Exposure of the traversing nerve root (the L5 nerve root with an L4-L5 decompression) and removal of the ligamentum flavum on the ipsilateral side are necessary to provide the surgeon “room to move” when addressing the contralateral side. At times, you may wish to decompress the contralateral side first and then return to the ipsilateral side (Video 1).
- The surgeon may need to remove bone from the superior aspect of the inferior lamina (the superior aspect of the L5 lamina in an L4-L5 decompression), so that the inferior aspect of the decompression is complete. Bone removal here is safely performed using a combination of a drill, curet to assess the depth of the lamina, and Kerrison rongeurs to complete bone removal.
- Before addressing decompression of the contralateral canal, complete the decompression of the ipsilateral side, including the ligamentum flavum and a partial medial facetectomy with exposure of the ipsilateral thecal sac and traversing nerve root.
- After release of the superior and inferior attachments of the ligamentum flavum, the generally safest way to enter the canal is by releasing the ligamentum flavum in the midline (usually the furthest point from the dura especially in a tight trefoil stenosis canal). Then gently pull the ligamentum flavum laterally so that a small cup curet can be used to sweep the epidural veins away on the undersurface (avoiding bleeding) and also to release those occasionally encountered but very “pesky” vincula (fibrous attachments between the ligamentum and dura), which can lead to a dural tear if the ligamentum is pulled up with a Kerrison rongeur without releasing underneath.

Video 1 Description of the technique.

Step 6: Decompression of the Contralateral Side of the Canal

Decompression of the thecal sac on the contralateral side of the canal is the potentially dangerous aspect of the procedure, with the highest risk of dural injury and a cerebrospinal fluid leak; thus, create enough room on the ipsilateral side so that instruments can be safely introduced into the canal for the contralateral decompression.

- After completion of the ipsilateral decompression, begin the contralateral decompression (Fig. 4).
- The superior ligamentum flavum attachment should have already been removed in the initial stages of the surgery, as described above.
- Angled curets are the key instruments at this stage of the procedure. They have the dual purpose of (1) creating a plane of dissection between the dura and ligamentum flavum and (2) sweeping the ligamentum flavum toward the surgeon so that it can be removed with a Kerrison punch.
- Do not rush this stage of the procedure. Slowly create more room to perform the procedure as more ligament is removed.
- If you are right-handed, you may prefer a right-sided approach so that you can perform the contralateral decompression using your more dexterous hand directed toward the contralateral recess and traversing nerve root.
- Removal of the inferior aspect of the ligamentum flavum is best achieved with a curet and Kerrison upcut punch under direct vision.

Fig. 4

Fig. 4 Sequence of the procedure. **Fig. 4-A** Initial unilateral exposure for a right-sided approach. **Fig. 4-B** The inferior half of the L4 lamina has been drilled and the base of the spinous process to expose the ligamentum flavum bilaterally to the insertion point deep to the L4 lamina (arrow). LF/L = left ligamentum flavum, and LF/R = right ligamentum flavum. **Fig. 4-C** Decompression of the contralateral (left) side. **Fig. 4-D** Photograph made at the completion of the operation, demonstrating bilateral decompression from a right-sided unilateral approach. The arrows demonstrate the midline of the thecal sac.

Step 7: Hemostasis

Reducing the paraspinal muscle dissection substantially reduces iatrogenic muscle injury and blood loss, and oozing from the bone removal can be easily controlled with bone wax or a variety of hemostatic agents.

- ULBD is usually associated with minimal blood loss, which averages only 10 to 20 mL.
- Blood loss should be controlled throughout the procedure. Make sure to maintain a dry operative corridor to achieve safety during the procedure.
- Use bone wax to control bone bleeding whenever it is encountered. The use of homeostatic gels such as Surgiflo (Ethicon) or Flowseal (Baxter Healthcare) can maintain hemostasis with bleeding from epidural veins, in addition to reducing the volume of bipolar diathermy adjacent to the dura and nerve roots, which may encourage scar tissue formation.

Step 8: Closure

Closure of a unilateral muscle exposure is rapid and the use of wound drainage is very rare, further reducing operative time as well as exposure to complications related to wound drains and subsequent infection risk.

- Closure requires suture of the thoracolumbar fascia and superficial planes using standard techniques. There are 2 layers of thoracolumbar fascia off the midline and, with a paramedian approach, both layers should be incorporated into the closure.
- The use of wound drains is very rare as hemostasis is controlled in a stepwise fashion throughout the procedure. Use of advanced hemostatic agents assists in avoiding the use of wound drains.
- Inject the ipsilateral muscle on the approach side with local anesthetic to reduce postoperative pain. This will also “fill up” the muscle so that it expands to fill the operative corridor and assist with reducing dead space and therefore postoperative hematoma collection.
- Perform fat and skin closure with the method that you prefer.

Results

One of us (R.M.) and colleagues⁵ conducted a prospective randomized trial comparing ULBD with open laminectomy for degenerative lumbar spinal stenosis in 54 patients (27 in each arm of the study) treated from 2007 to 2009. This study, like the one by den Boogert et al.⁴, focused on patient-centered outcomes including the Oswestry Disability Index (ODI), visual analog scale (VAS) score for leg pain, and patient satisfaction scores. Significant improvements in ODI and VAS leg-pain scores were observed after both the open and ULBD interventions; however, the patients treated with ULBD had a significantly greater improvement in the VAS leg-pain scores. Patients who underwent ULBD were also mobilized faster and were more likely to not require opioids to control postoperative pain. Thus, this randomized study demonstrated that microscopic ULBD was as effective as open decompression in terms of improving functional outcomes and had the additional benefits of greater reduction in pain scores, recovery time, time to mobilization, and opioid use. Similar results have been described by others, including Toyoda et al.⁷.

Pitfalls & Challenges

- The 2 most common pitfalls can be avoided by always knowing the location of the principal anatomic landmarks^{2,3}.
 - The principal landmark outside the spinal canal is the lateral border of the pars interarticularis. With the limited microsurgical field of view (especially with a tube), it is easy to continue the medial facetectomy/lateral recess decompression on the ipsilateral side to the point that the pars is thinned or burred through, thus destabilizing the facet or predisposing to a stress fracture.
 - The principal landmark inside the spinal canal is the medial aspect of the pedicle. This is the key to identifying critical anatomic structures (and preventing the surgeon from “becoming lost” in the face of distorted anatomy). The traversing nerve root can reliably be picked up just medial to the pedicle. The disc is just superior to the pedicle.
- There are multiple options with regard to surgical instruments, including the M8 (Midas Rex, Medtronic) side-cutting burr and the round burr. McCulloch and Young preferred the M8 side-cutting burr as this avoids having a cutting surface at the tip of the burr, where there is greater risk of contacting and cutting the dura^{2,3}. However, the round burr remains a viable option for those adequately trained in its use for this procedure.

- Dural tear. If an iatrogenic injury to the dura is encountered, it is best to close it immediately. This may require enlarging the incision so that more instruments can be introduced into the operative field to achieve watertight closure. If a dural tear is encountered on the contralateral side of the operative exposure, the use of fibrin glue may suffice as the dura can tamponade itself against the lamina that remains on the contralateral side.
- There is a learning curve for the performance of this operation down a narrow corridor of exposure.

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