TECHNIQUE FOR LUMBAR DECOMPRESSION OF SPINAL STENOSIS

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This article presents a technique for lumbar laminectomy and decompression in patients suffering from acquired lumbar spinal stenosis. The technique is discussed in detail and illustrated accordingly. The discussion reviewed a "typical" L3 to S1 (i.e., L3-4, L4-5, and L5-S1) lumbar laminectomy without fusion.

KEY WORDS: lumbar laminectomy, surgical technique, spinal stenosis, complications

Indications for decompressive surgery for lumbar spinal stenosis primarily involves the activity-related leg symptoms or neurogenic claudication. Severe spinal stenosis involves epidural canal compromises of less than 100 mm² of area and walking and standing tolerances of less than 5 minutes.¹ Neurological deficits are variable, but disturbances of the cauda equina and lower lumbar nerve roots are common.²

When the patient's natural history fails to show improvement with conservative measures, including a series of epidural steroid injections, then decompression surgery is considered the primary remaining option. Because most patients suffering from lumbar spinal stenosis are older, optimization of the patient's health status and medical clearance is recommended, but few contraindications exist for this type of surgery.

The surgical procedure applied for lumbar cauda equina and nerve root decompression is a lumbar laminectomy with or without foraminotomy (partial or complete), or discectomy (partial). The purpose of this article is to describe a technique for lumbar decompression, specifically, lumbar laminectomy and its variants.³⁴ The cornerstone of management of spinal stenosis is cauda equina and nerve root decompression. As Tyle reminds us, we must "deal with the compressive pathology where it exists" to accomplish adequate relief of an extremity-related pain and dysfunction.⁵⁶ The surgical technique described requires (1) no concurrent deformities such as a degenerative spondylolisthesis or degenerative scoliosis, and (2) leg symptoms to exceed axial-based lower back pain, the latter being due to facet arthropathy.

Adequate illumination, magnification, and exposure are irrefutable elements of the surgical technique in all cases. The steps of a lumbar laminectomy are covered as follows: (1) positioning of the patient; (2) posterior element exposure; (3) spinous process resection; (4) laminae thinning; (5) midline bilateral laminectomy; (6) lateral decompression or foraminotomy; (7) assessment of adequacy of decompression; (8) autogenous fat grafting; (9) wound closure; and (10) perioperative care. Finally, it should be emphasized that this article presents a technique, not the technique, for lumbar laminectomy.

PATIENT POSITIONING

The patient is commonly positioned prone for the operation. A number of commercially available frames can be used for this (Fig 1A, B). The purpose of this prone position is to (1) distribute the anterior pressure broadly over the chest and lower extremities; (2) allow the abdomen to hang free; (3) allow some flexion at the hip to relax the iliopsoas muscle; (4) position the lumbar spine in slight extension (tends to maximize the stenosis); and (5) avoid pressure on vulnerable areas such as the orbits, elbows, or upper extremities.

Two types of frames are used by the author: (1) a kneeling prone-type frame (OSI Andrews by Orthopaedic System, Inc., CA) (Fig 1) or (2) a four-poster frame (CHOP Frame by U.S.A. Medical, PA) (Fig 2); both meet the above criteria. The four-poster is used for older patients in whom osteoarthritis of the hip and knee is a preexisting clinical problem. The kneeling prone position is preferred by the author especially in younger or heavier patients. Experience has shown no significant complications with either frame, with the exception of the transient lateral femoral cutaneous nerve palsies with the four-poster frame (pressure over or near the anterior superior iliac spine). However, position-related complications are reported, and there is no substitute for attention to details (Fig 1A, B).

OPERATIVE TECHNIQUE

The operative technique is discussed in a logical sequence of steps. These steps can be expanded or compressed, but each must be completed with care and attention to detail.

POSTERIOR LUMBAR SPINAL EXPOSURE

Exposure of the posterior lumbar bony spine is the next step (Fig 2). The goal is to accomplish this with minimal blood loss and minimal muscle dissection/release. For
Fig 1. Patient positioning for lumbar laminectomy and decompression. (A) Kneeling prone position for lumbar laminectomy. The patient’s arms should be positioned so as to protect the ulnar nerve and not hyperextend the shoulders. Care should be taken to either position the neck in slight flexion or to turn it to one side. Great care must be exercised in avoiding all periorbital pressure (B). The patient’s chest should be placed on the torso pad so as to evenly distribute the pressure. In women, the breast should be directed laterally to avoid any direct pressure on the nipples (C). The abdomen should hang free so as to decompress the epigastrial space (D). The buttock should be positioned behind the knees so as to provide a more stable position. The buttock should rest firmly against the buttock pad (E). The hips should be flexed to approximately 100 to 110 degrees, and pressure should be evenly distributed across the tibia. The pressure should not be directly on the knees, and additional padding of the knees and tibia tubercles with a gel pad is recommended (G). Finally, the patient should have antithrombotic stockings placed or compression boots to improve peripheral circulation during the surgery (F). (B) Extended prone posturing for lumbar laminectomy. This particular posture is often helpful in older patients, in whom a kneeling posture may be poorly tolerated because of intrinsic knee or hip disease. This position also generally affects more lumbar extension, especially if the hips are placed in an extended position. In this position, the patient also should have antithrombotic stockings or compression boots to improve peripheral circulation during the procedure (A). The hips should be positioned at approximately 20 to 30 degrees of flexion. Excessive extension is not necessary because maintenance of lordosis is absolutely critical. It is helpful to decompress these patients in slight extension to maximize their spinal stenosis (B). The anterior superior iliac crest should be carefully padded and positioned on the inferior pad. Care should be taken to pad this well to avoid lateral femoral cutaneous nerve palsies (C). The superior pad should be placed on the chest wall. In this position, care should be taken not to have excessive pressure on the hip area. For women, the breast tissue should be pushed medially so as to avoid any direct breast pressure (D). The elbows should be carefully padded to avoid any ulnar nerve pressure (E). The shoulders should be slightly flexed and not hyperextended to avoid brachial plexus stretch injuries (F). The neck should be slightly flexed, and extension should be avoided at all times. Care should be taken in elderly patients to check their range of motion before positioning. At no time should their preoperative range of motion be exceeded (G). Finally, the patient’s face should be placed in a well-padded foam with cutouts, and periorbital or ocular pressure should be zealously avoided (H).

discussion purposes, this technique describes an L3-S1 two-level laminectomy. Thus, the skin is excised from the L3 spinous process to the S1 spinous process. Remember that the spinous processes are at the level of the interlamellar space, so the incision will extend from the top of L3 to the bottom of the S1 spinous processes.1 The skin incision is made just to the subdermal level; then the dissection of the subcutaneous tissue is performed with the unipolar electrocautery, thereby minimizing blood loss. Bleeding is controlled layer by layer. Meticulous hemostasis is an essential principle for this technique, thereby ensuring adequate visualization (Fig 3A). Self-retaining retractors are used at each level but are never overdistraeted to minimize soft tissue or muscle necrosis.

The dorsolumbar fascia is now identified, and predictably segmental perforating vessels are encountered approximately 0.5 to 1.0 cm lateral to the level of the spinous process and are coagulated. Release of the fascia from the spinous processes begins in the avascular midline, then extends along the bulbous spinous process tips (Fig 3B). The dissection is continued to the base of the spinous process, where it joins the lamina. Care is exercised to avoid straying into the paraspinal muscle layer where hemorrhage is more likely. The self-retaining retractors are positioned deeper at the fascia level at this point. Release and excision of the interspinous ligaments can now be accomplished.

The exposure now turns to the release of the short rotators from the laminae and facets. A peristeal elevator with the aid of the unipolar electrocautery is used to accomplish this portion of the exposure, taking great care to preserve the facet capsules at each level. Remember that the facet is more dorsal or upward projecting than the lamina, so the elevator should be directed slightly upward off the lamina.1 Also recall that the laminae project approximately 40 to 45 degrees cephalad from the base of the spinous process so the elevator should be directed in a parallel direction (Fig 3C). These short rotators attach most firmly along the inferior (caudal) border of the lamina.

At the completion of this step, the facet joints should be visualized and their capsules preserved. The paraspinous muscles should be retracted side to side over the levels of L3 to the sacrum. The bony lamina and spinous processes should be cleansed of their soft tissue attachments and any bleeding controlled even if the bone wax is required. The operative field should be dry or the next step is not started until this has been obtained.
THINNING OF THE LAMINA

The laminae of L3, L4, and L5 in spinal stenotic patients are often thick and hypertrophic. Manual removal with double-action rongeurs or angled Kerrison punches is difficult. Furthermore, this difficulty and lack of finesse and control risks inadvertent dural tear or injury. For these reasons, the author likes to thin the laminae within the resection area so that the complete bilateral laminectomy can be done with a more controlled technique (Fig 5A, 5B, 5C). The Kerrison punch is positioned under the lamina in a fashion so as to dissect the under or anterior surface of the lamina. Once the Kerrison punch is closed, a gentle side-to-side twist of the instrument completes the bite. This technique is favored in reducing the likelihood of dural tearing compared with a maneuver in which the instrument is pulled posteriorly or upward.

The laminae to be removed are thinned to the cortical bone adjacent to the epidural space without actually entering the epidural space (Fig 5B). Any type of high-speed burr tip (e.g., a number 8 tip for the Midas Rex system) can serve to thin the hypertrophic laminar bone. The caudal half of the lamina can be more aggressively removed because the dura is covered and protected by the ligamentum flavum (Fig 5C). Recall that the yellow ligament originates from the cephalad edge of the lamina below and inserts under the caudal lamina above (Fig 5C). As one gains experience with this step, the lamina can be thinned to 1 to 2 mm, making the subsequent step much more safe and controlled.

SPINOUS PROCESS RESECTION

The fourth lumbar (L4) and fifth lumbar (L5) spinous processes and any residual interspinous ligaments are resected using a bone cutting angled rongeur (Fig 4A). Approximately one half of the third lumbar (L3) and first sacral (S1) spinous processes are beveled and removed so that the L3-4, L4-5, and L5-S1 interlaminar spaces are identified (Figure 4B). If necessary, the base of the resected spinous process and the exposed cancellous surface is covered with bone wax or Gelfoam (Upjohn; absorbable gelatin sponge). This defines the resection area for the laminectomy. The resected spinous process bone is cleaned of its soft tissue and saved, in the event that instability occurs at the time of the decompression. If not used, the bone can be submitted to the pathology laboratory, saved in a bone bank, or discarded, depending on the clinical situation.

At this time, the pars interarticularis is exposed at each level (Fig 3A). This is important because one wishes to preserve the integrity of the pars at all times. Also, the facet segmental arteries should be identified and coagulated as they surround the cephalad and lateral aspect of the facet. Exposure of the pars interarticularis frequently encounters these predictable arteries where the pars extends from the inferior (medial) articular facet.

![Electrocautery](image1)

![Exposure of spinous processes and laminae](image2)

**Fig 2. Landmarks for incision.** The skin incision should allow for adequate exposure but detach no more paraspinal musculature than is absolutely necessary to follow the three principles of spinal surgery, ie, magnification, illumination, and hemostasis. The skin incision for an L4–S1 lumbar laminectomy needs to extend from the top of the L3 lamina to the bottom of the S1 spinous process. The skin incision is shown by the dark hatched line (A). The intercostal line, which is usually a useful landmark to identify the L4–L5 level, is shown by the light hatched line (B).

**Fig 3. Exposure of spinous process.** Once the skin and subcutaneous layer have been exposed, the deep dissection is begun by releasing the midline fascia over the spinous processes (A). Note that the tips of the lumbar spinous processes are bulbous. Care should be exercised in keeping the electrocautery on bone, not straying into the vascular paraspinous muscle (B). The initial dissection should release the paraspinals from the spinous processes and laminae without disrupting the facet capsules. The exposure should be from the facet to the opposite facet (C). The paraspinals are retracted side to side with self-retaining retractors.
and L5 laminae; (3) the L4–5 ligamentum flavum; (4) the L3–4 ligamentum flavum; and (5) the L5–S1 ligamentum flavum (if involvement of L5–S1 or the S1 nerve roots is clinically noted) (Fig 6).

Incidental dural tears are an expected and common intraoperative problem in this type of surgery. The likelihood of dural tear increases the more narrow the stenosis and the longer it has been present. At the area of maximum narrowing (usually at the interlaminar space with medial facet hypertrophy, superior facet overgrowth, and ligamentum flavum infolding/hypertrophy) is where the dura is most adherent and thin. Most of these incidental tears can and should be repaired primarily. The technique for repair and the type of suture is less important than a watertight repair. The author uses both 4-0 Vicryl on a noncutting tapered needle or 5-0 silk on a similar tapered needle.

**LATERAL DECOMPRESSION OR FORAMINOTOMY**

The lateral extent of the decompression will vary from case to case, but the surgeon must deal with the compressive

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**Fig 4. Resection of spinous process.** Now that the posterior elements have been exposed and cleaned of their residual soft tissue attachments, the spinous process are resected (A). (B) Extent of the initial spinous process resection. The cancellous bone along the base of the residual spinous processes often bleeds, requiring bone wax or other gelatin material to control this ooze.

The bur should only thin the portion of the posterior elements that are to be removed. The medial facet should not be violated at this time. The lateral extent of the laminar thinning should stop at the pars interarticularis and at the junction of the lamina and the medial facet. The latter is made by a flare upward or posterior from the surface of the lamina (Fig 5C).

**MIDLINE BILATERAL LAMINECTOMY**

Once the extent of bone removal has been defined and the laminae thinned, the laminectomy is performed, starting caudal at L5–S1. The lamina are more posterior at their caudal edge, sloping toward the epidural space at the cephalad end. The laminectomy begins with the release of the ligamentum flavum using an angled curette (2-0 or 3-0 size works well). Angled Kerrison punches are then used to remove the laminar bone piecemeal. Before employing these punches, the dura mater is checked for adhesions. Any such dural adhesion should be carefully dissected free, commonly with a Penfield #4, or Freer’s elevator; or, on occasion, a small cottonoid is placed between the dura and laminar bone as an additional protective layer. The midline bilateral laminectomy should remove the (1) inferior/cephalad portion of the L3 hemilaminare; (2) the L4

**Fig 5. Thinning lamina.** The extent of the bone removal for the midline decompression requiring bilateral laminectomy is shown in (A). Commonly, the laminae are hypertrophic and thick. Thinning of the laminae before removal with an angled Kerrison punch is helpful and improves the safety of the decompression (as it relates to incidental dural tears). (B) Thinning procedure beginning at L5. The outer cortical and inner cancellous bone is removed, matching the planned decompression area shown in (A). The laminae may safely be thinned along the caudal one half of the laminae because the ligamentum flavum passes under the laminae, as shown in (C).
Fig 6. Midline decompression L3−S1. The midline decompression removes the midline ligamentous flavum at L3−4, L4−5, and L5−S1 (optional). The laminae of L4 and L5 are completely removed, and a small portion of the caudal L3 laminae and the cephalad portion of the S1 laminae. Note the L4−5 ligamentum flavum in this example is hypertrophic and folded.

Lesions as they are encountered. In most cases, the lumbar nerve roots can be released (1) without more than a 10% to 20% foraminotomy; (2) without sacrificing more than 25% of the medial facet; or (3) without dividing any of the thick cortical bone of the pars interarticularis (Fig 7A, B). Additionally, the intervertebral disk should be carefully palpated or visualized to exclude a concomitant disk herniation. A herniated disk can be expected in approximately 20% to 25% of cases, but these are usually contained protrusion or extrusion types. Concomitant disk pathology is more likely in cases in which (1) acute unilateral radiculopathy/radiculitis is noted; (2) the patient has a unilateral tension sign; (3) unilateral weakness is noted in a single dermatome; or (4) leg pain persists despite rest or sitting down (Fig 8—lateral-based pathology).

If the lateral decompression is extensive and the medial facet(s) and pars interarticularis are sacrificed, a fusion should be considered at the time of the incident surgery. It should be emphasized that this occurrence should be infrequent. The initial preparation and draping should allow access to the posterior ilium for additional autogenous bone graft if fusion becomes necessary (Fig 9A). Further discussion of the technique of lumbosacral bilateral lateral fusion is beyond the scope of this article and is discussed elsewhere in this issue.

The midline bilateral laminectomy decompresses the cauda equina or deals primarily with a central type of stenosis. However, each nerve root within the surgical area must also be decompressed, with lateral decompression with or without foraminotomy. Meeting this goal is critical to the success of the operation. Principles employed in nerve root decompression include (1) always work parallel to the nerve or along the nerve tract; (2) work on the left side of the spine by standing in the right side (and vice versa); and (3) start cephalad and work caudally (Fig 7A). This part of the decompression procedure is the most difficult and requires a three-dimensional appreciation of the route of each lumbosacral nerve root (Fig 7B). Because the L4−5 level is the most common level of stenosis, typical decompression of this level is discussed.4

Fig 7. Lateral recess decompression. Once the midline decompression is completed, decompression of the lateral recesses and lumbar nerve roots is addressed (A). (B) Hypertrophic medial facet and infolded ligamentum flavum compromising the lumbar nerve root. Removal of this lateral compressive pathology is essential to adequately relieve the lumbar nerve root compression.

Fig 8. Lateral-based compressive pathology. Additional potential anatomic areas of lateral-based lumbar nerve root compression include hypertrophy and spurring of the superior articular facet medially (A), lateral or foraminal disk herniations (B), and foraminal narrowing (C). Foraminal narrowing can be caused by chondroosseous spurs around the intervertebral disk (1), hypertrophy and spurring of the medial facet (2); or hypertrophy and spurring of the superior articular facet (3).
over the nerve root. Bleeding in the epidural space is controlled with bipolar electrocautery. Control of blood flow from the anterior and posterior internal vertebral veins that surround the nerve root is crucial to (1) maximize visualization; and (2) reduce overall intraoperative blood loss. At this time, the dura mater is checked by Valsalva maneuver to exclude previously unrecognized cerebrospinal fluid (CSF) leakage.10

**AUTOGENOUS FAT GRAFT**

The laminectomy defect is now covered with a 1-cm-thick autogenous fat graft harvested from the subcutaneous layer. Care is taken not to leave a large dead space in the subcutaneous layer. The goal of this free tissue (avascular) transfer is to reduce but not eliminate excessive epidural scarring.11 In cases in which the patient is too thin to allow cutaneous fat harvest, the graft is either excluded or the dura mater is covered with thrombin-soaked gelatin material.

**WOUND CLOSURE**

The importance of the wound closure should not be deemphasized (Fig 10). The self-retaining retractors are removed and the paraspinal muscle layer inspected. Devitalized muscle tissue is removed and any bleeding controlled or eliminated with unipolar or bipolar electrocautery. The muscle/fascial layer is approximated with 0 Mersilene or Ethibond suture employing a figure 8 or vertical mattress technique. The goal is a watertight closure. Drainage of the subfascial layer is recommended.

**ASSESSMENT OF ADEQUACY OF DECOMPRESSION**

Once the midline and lateral decompression are completed, each nerve root and nerve root tract is checked for adequacy of decompression. Many techniques have been described for this, but the author favors the following criteria (subjective): (1) the nerve root is easily displaced medially and posteriorly; (2) a uterine sound or blunt dental probe passes easily under the nerve root; and (3) the same probe passes easily into the foramen posterior or

![Diagram of Transpedicular screw fixation and posterolateral fusion.](image)

**Fig 9.** Transpedicular screw fixation and posterolateral fusion. In rare cases, a complete foraminotomy is required to decompress the lumbar nerve root. If complete sacrifice of the pars interarticularis is necessary, fusion with and without instrumentation should be performed. Stabilization of one or more motion segments can be rigidly provided with transpedicular screw fixation as shown.

![Diagram of Wound closure.](image)

**Fig 10.** Wound closure. Closure of the wound should be by layer. Paraspinal muscle sutures are placed to decrease dead space followed by a watertight fascial closure with interrupted ethibond or mersilene sutures. The subcutaneous layer is closed with interrupted inverted vycril suture (0 and 2–0). The skin is closed either with staples or with a running subcuticular 3–0 or 4–0 vycril suture as shown. A closed-system drain is used deep to the fascia to prevent epidural blood collection, or hematoma.
using a closed system continuous suction device. Recently, the use of drains has been in question, but the risk for their use is minimal. The subcutaneous level is approximated with inverted 0 or 2-0 Vicryl sutures, attempting to obliterate all dead space. The skin edges are reapproximated with staples or a 3-0 or 4-0 running subcutaneous suture. Butterfly strips are applied as needed, and the wound is dressed with a sealed sterile dressing.

**PERIOPERATIVE CARE**

The patient is assessed in the recovery room for new neurological deficits, and medically stabilized. The Foley catheter and closed-system drainage tube are removed during the first or second postoperative day. The patient learns to log roll, get out of bed, and maintain a correct posture as soon as possible. The author uses an abdominal binder for support and as a reminder to the patient to protect their back for about 3 to 4 weeks after surgery. Walking is encouraged to tolerance, and sitting is limited to eating, bathroom privileges, or other essential activities. The patient is usually hospitalized for 2 to 3 days after the lumbar laminectomy. Transfusion is almost never required because intraoperative and perioperative blood loss rarely exceeds 500 mL. Postoperative plain radiographs confirm the correct level and extent of decompression (Fig 11).
SUMMARY AND CONCLUSIONS

This article has presented a technique for lumbar decompression of acquired spinal stenosis without significant associated deformity (e.g., degenerative spondylolisthesis or degenerative scoliosis). The procedure has been discussed in stages, or steps, for organization and presentation. The steps have been presented in detail and illustrated accordingly. The goals and principles have been stressed to (1) provide adequate decompression in a caudal to cephalad direction as well as side to side; (2) emphasize a safe and appropriate technique; (3) minimize blood loss; (4) minimize the risk of incidental durotomy; (5) address the compressive pathology without sacrificing excessive bone or segmental spinal stability. Above all, this technique is a decompression of the neural elements (cauda equina and adjacent lumbar nerve roots), because this is what will relieve the patient’s complaints of neurogenic claudication. In the vernacular, (1) “think nerve decompression,” but (2) “pressure stability.”

REFERENCES


