SUBSPECIALTY PROCEDURES

MINIMALLY INVASIVE DECOMPRESSION IN
LUMBAR SPINAL STENOSIS

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Investigation performed at the Innlandet Hospital Trust, Lillehammer; the Hospital of Ålesund, Ålesund; the University Hospital of North Norway, Tromsø; Oslo University Hospital, Oslo; and St. Olavs Hospital, Trondheim, Norway

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Introduction

Unlike traditional open laminectomy, minimally invasive decompression (MID) spares the important midline structures of the spine (i.e., the spinous process and the supraspinous and interspinous ligaments). The benefits are faster recovery, fewer instability problems, and fewer complications^{1,2}. The procedure can be used in most patients with lumbar spinal stenosis, including those with recess stenosis and those who have had reoperations. However, the procedure may have a steeper learning curve, and for some patients, especially those who have complex scoliosis or who are obese, laminectomy offers the open view that is needed. Minimally invasive spine surgery has become increasingly popular, and the method of minimally invasive decompression in lumbar spinal stenosis has been described in several papers³⁻⁶.

We describe a step-by-step approach to this procedure. Our aim was to provide the steps of this common procedure for surgeons who are at an early stage of adopting this approach. As with any procedure, experience leads to personal preferences; however, the basic steps that we describe should remain the same. Establishing a routine of steps to identify key anatomic landmarks will lead to the avoidance of common pitfalls.

Indications & Contraindications

Indications

- The main indication for surgery is neurogenic intermittent claudication, which causes pain and paresthesias in the back, buttocks, and lower limbs.
- Symptoms are usually provoked by walking or extending the spine and are relieved by flexion.
- Magnetic resonance imaging (MRI) of the lumbar spine shows stenosis in at least 1 level.
- The indication for an operation for lumbar spinal stenosis is related to patient education and involves a shared decision-making process between the physician and the patient, leading to the decision for surgery.

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Contraindications

- The procedure is considered to be too risky with respect to the use of anesthesia.
- Problems of instability that should be addressed by arthrodesis.

Step 1: Preoperative Planning

Determine the levels and laterality for the decompression on the basis of the symptoms and findings on the MRI scan.

- Review the MRI scan and compare it with radiographs for the purposes of localization, especially in patients with transitional anatomy.
- Preoperatively, discuss the procedure with the patient to ensure that he or she understands the expected risks, benefits, and alternatives to the procedure.
- Mark the skin using a water-resistant pen so that the marks will be visible the day after the procedure.

Step 2: Operating Room Setup

Ensure the correct positioning of the patient and the proper setup of the equipment.

- General anesthesia is often used, but the procedure can also be performed with the patient under epidural or spinal anesthesia.
- Prophylactic antibiotics are given as 1 dose within 30 minutes before the start of surgery, to reduce the risk of infection.
- Place the patient in the prone or knee-elbow position to open the spinal interspace and to avoid pressure on the abdomen (Fig. 1).
- Use a radiolucent spinal frame or table to allow fluoroscopy to be used.
- Stabilize the hips to prevent them from moving and to allow the table to be tilted in any direction.
- Check the fluoroscopic imaging setup before beginning.
- Use a microscope, or surgical loupes with a headlight, according to surgeon preference.

Fig. 1

Fig. 1 A patient in the prone position with the hips and knees in flexion and the abdomen free to avoid pressure on the abdominal blood vessels and thus to reduce bleeding.

Step 3: Marking the Level(s)

Use fluoroscopy to localize the level(s) of the stenosis.

- Introduce a long needle at the planned location of the surgical decompression. For level L3-L4 and more cephalad levels, 2 long needles are necessary to keep track of the marked levels as it is not possible to see the sacrum, which is the anatomic landmark. Another option is to use a narrow metal instrument that is held laterally to the patient, such as an initial dilator.
- True anteroposterior and lateral fluoroscopy is used to determine the placement of the skin incision (Figs. 2 and 3).
- Mark the skin at the planned level between the cephalad and caudad pedicles (Fig. 4).

Fig. 2

Fig. 3

Fig. 4

Fig. 2 Lateral fluoroscopic view.

Fig. 3 Anteroposterior (AP) fluoroscopic view.

Fig. 4 Mark the skin at the planned level according to the findings on fluoroscopy.

Step 4: Skin Incision and Tube Positioning*Ensure the correct placement of the tube.*

- Administer local anesthesia before making the skin incision to minimize the pain.
- The skin incision should be made approximately half the diameter of the intended tubular retractor (e.g., 9 mm for an 18-mm tube) from the midline (spinous processes) (Fig. 5).
- For 2 levels, it may be feasible to extend the incision.
- Determine the length of the tube after placing the first dilator at the inferior aspect of the lamina that is intended to be exposed (Fig. 6). After sequential dilation, connect the final retractor to the tabletop to secure its position (Figs. 7 and 8).
- Again, check the position with lateral fluoroscopy along with the trajectory of the tube (Fig. 9).
- The microscope or the magnifying loupes with a headlight should be used at the start of the decompression to identify the key anatomic landmarks of the pars interarticularis, the base of the spinous process, and the facet joint.
- For ≥ 3 levels, a contralateral incision can be used for the different levels. We prefer a midline incision and the use of a bladed retractor (Fig. 10).

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Fig. 10

Fig. 5 Planning the incision for the tube. The dashed line indicates the midline (spinous processes).

Fig. 6 Positioning of the tube.

Fig. 7 Through the skin incision, a serial dilation makes way for the tube.

Fig. 8 The length of the tube retractor is read on the dilation tube.

Fig. 9 Check the position of the tube with fluoroscopy.

Fig. 10 For ≥ 3 levels, we prefer a midline incision and the use of bladed retractors.

Step 5: Resection of the Lower Part of the Lamina

Use a high-speed drill and Kerrison rongeur to enter the spinal canal.

- Use a pituitary rongeur and electrocautery to remove soft tissue covering the lamina and key landmarks (Fig. 11).
- Use bipolar forceps to stop the bleeding, if necessary.
- Use a high-speed drill to thin the lamina so that a Kerrison rongeur can be used (Fig. 12, Video 1).
- Release the ligamentum flavum from the undersurface of the lamina with a micro-curet (Fig. 13).
- Complete the hemilaminotomy to the caudal aspect of the cephalad lamina (Figs. 14, 15, and 16). Ensure that the laminotomy extends to the base of the spinous process, which marks the midline, and then extends laterally to the medial aspect of the inferior facet. Resection with a Kerrison rongeur (Video 2) may be combined with high-speed drilling, according to the preference of the surgeon.

Fig. 11

Fig. 12

Fig. 13

Fig. 14

Fig. 15

Fig. 16

Fig. 11 A microscope provides a clear view into the lamina and soft tissue.

Fig. 12 With a high-speed drill, the upper part of the lamina is resected.

Video 1 The use of the high-speed drill.

Fig. 13 With a slightly curved micro-curet, the ligamentum flavum is undermined from the caudal edge of the lamina.

Fig. 14 With a Kerrison rongeur, the caudal edge of the lamina is resected, starting in the upper medial corner at the foot of the spinal process.

Fig. 15 An illustration showing the Kerrison rongeur being used to resect the caudal edge of the lamina, starting in the upper medial corner at the base of the spinal process.

Fig. 16 Proceed from the upper part of the lamina down to the lower part.

Video 2 The use of the Kerrison rongeur.

- Proceed caudally to make a smaller resection in the cephalad lip of the lamina of the caudal vertebra (Fig. 17).
- The resection follows along the passage of the nerve root as it passes the pedicle and continues until it has passed the stenotic site.
- Keep the ligamentum flavum intact as long as the drill is used and as long as possible using the Kerrison rongeur. Continue undermining with the curet as progress is made to define the space between the lamina and the ligamentum flavum (Fig. 18).

Fig. 17

Fig. 18

Fig. 17 Move slowly toward the lateral aspect and down to the medial aspect of the facet joint.

Fig. 18 Loosen the ligamentum flavum from underneath the lamina.

Step 6: Resection of the Medial Part of the Facet Joint

Proceed cautiously at the point where the spinal canal is usually narrowest.

- Use a high-speed drill on the medial part of the facet joint, since it is usually too thick for a Kerrison rongeur.
- Resect the medial half of the inferior articular process of the cephalad vertebra.
- When the joint surface of the lower or caudal part is exposed, which happens at times, it indicates that the narrowest part of the spinal canal has been reached and the dura is most likely to be adherent to its surroundings. Proceed slowly and cautiously.
- Release the lateral aspect of the ligamentum flavum completely and remove the medial lip of the superior facet with a curette. Use a smaller Kerrison rongeur, preferably with a thinner footplate, if necessary.
- For the upper lumbar facet joints (L1 to L3), the risk of inadvertent facet disruption is higher because of the narrower lamina and more sagittal facet joints. Hence, it is important to be cautious and have a more central approach.

Step 7: Resection of the Ligamentum Flavum

Resect the ligamentum flavum piecemeal with a Kerrison rongeur.

- The ligamentum flavum should be exposed at this point (Fig. 19).
- If a crossover resection is used, keep the flavum intact and proceed to Step 8.
- Place a ball-tipped probe under the lamina pointing upward. Rotate the tip 180° medially and caudally to bring it under the upper edge of the ligamentum flavum and into the spinal canal. Then, drag and lift the ligament caudally.
- Lift the ligament from the dura; use a curved micro-curet to separate the dura from the ligament carefully (Fig. 20).
- Resect the ligamentum flavum piecemeal with a Kerrison rongeur along with hypertrophied facet capsular tissue to appreciate the lateral edge of the dural sac and traversing root.
- Proceed to step 9.

Fig. 19

Fig. 20

Fig. 19 The ligamentum flavum is exposed and kept intact as long as possible.

Fig. 20 Localize the upper border of the ligamentum flavum and lift it caudally to expose the dura.

Step 8: Crossover Technique (Optional)

Use the crossover technique to reach across the midline and decompress the contralateral lateral recess (Video 3).

- Pull back the tubular retractor to completely expose the lower half of the spinous process (many retractors are beveled to help with this step).
- If necessary, angle the retractor or tilt the table to the contralateral side.
- Drill the lower portion of the spinous process to access the contralateral lamina. A high-speed drill can remove the deep half of the contralateral lamina at the level just above the contralateral ligamentum flavum.
- Use a Kerrison rongeur to gently push the most dorsal midline aspect of the dural sac and resect the lower part of the contralateral joint and lateral recess (Fig. 21).
- Resect the ligamentum flavum as described in Step 7.

Fig. 21

Video 3 The crossover technique for decompression of the contralateral side.

Fig. 21 With the crossover technique, it is possible to reach across the midline to decompress the contralateral lateral recess.

Step 9: Closing the Wound

Perform a check to be certain that all steps have been completed before closing the skin.

- To ensure that the decompression has been done sufficiently in both the cephalad and caudal directions, use a ball-tipped nerve hook or a foraminal probe (Figs. 22 and 23) and lateral fluoroscopy to identify the upper and lower edges of the decompression. Compare the findings with those on the initial MRI scan. Be careful if the dura is adherent.
- Make certain that there is no excessive bleeding. If there is, use the bipolar forceps to stop it. When the tube is withdrawn, no blood should fill the cavity (Fig. 24).
- Be sure to check for a cerebrospinal fluid leak and any previously unidentified dural tears by initiating a Valsalva maneuver.
- Close the fascia with absorbable sutures (Fig. 25).
- Close subcutaneously with absorbable sutures if there is a thick subcutaneous layer.
- Close the skin.

Fig. 22

Fig. 23

Fig. 24

Fig. 25

Fig. 22 With a ball-tipped nerve hook, follow the nerve under the ligamentum flavum to ensure that there is no adherence between the two.

Fig. 23 When the ligamentum flavum is removed, the nerve roots are visualized and followed to ensure that they are not squeezed. With the hook, be sure that nothing is hidden between the dural sac and the disc.

Fig. 24 Two levels of unilateral decompression are completed, leaving a scar approximately 3 cm long. After the removal of the tube, observe whether there is any bleeding.

Fig. 25 The fascia is closed with absorbable sutures.

Results

In the study by Lønne et al., the 41 patients managed with MID had significant improvement at 6 weeks and throughout the 2-year observation period⁷. The overall results from MID show that it significantly reduces clinical symptoms and disability, a result that is maintained for at least 5 years^{8,9}. In a Norwegian pragmatic effectiveness study from the spine registry that compared MID and laminectomy, the mean reduction in the Oswestry Disability Index score at the 1-year follow-up evaluation was 19 points in the MID group and 16 points in the laminectomy group¹⁰. The 3-point difference between groups was significant ($p = 0.023$) and favored the MID; however, it was smaller than the 8 points that the study was designed to detect. Nevertheless, MID has the benefit of using smaller incisions, which saves soft tissue and osseous structures and leads to a faster recovery, fewer instability problems and complications, and a shorter hospital stay^{5,9,11-13}.

Pitfalls & Challenges

- There are several challenges in diagnosing and treating lumbar spinal stenosis. MRI scans may show stenotic levels in asymptomatic individuals. Symptoms for other reasons, such as atherosclerosis, neuropathy, and trochanteric tendinitis, may coexist with an MRI scan showing lumbar spinal stenosis, without lumbar spinal stenosis being the reason for the symptoms. The key is to listen carefully to the patient's symptoms and perform a proper clinical investigation.
- An obvious goal is to avoid perioperative complications. Typically, intraoperative complications are a dural tear, excessive bleeding, and injury of the nerve roots. Slowing down at crucial points in the operation that require meticulous technique will save time and reduce complications.
- Dural tears, which are the most common complication, must be handled with care intraoperatively and postoperatively. If cerebrospinal fluid leakage is detected, ensure a proper and complete view of the tear, widening the laminectomy as needed. The tears are usually managed through the tube, with equipment made for this purpose. Be careful not to damage any nerve rootlets, which sometimes can loop out of the tear. If this happens, relocating the nerve roots is the first step. Larger tears may be sutured with 5-0 or 6-0 monofilament suture with a small curved needle, following a fibrin sealant. Small tears may be closed with a collagen membrane or a fibrin sealant made for this purpose. Most patients recover from dural tears without any symptoms^{10,14}, but insufficient decompression may be the result.
- The control of intraoperative bleeding is critically important in spinal surgery. If in doubt, a hemostatic agent can be used¹⁵.
- Wrong-level surgery continues to be a common reason for malpractice lawsuits in spine surgery¹⁶. A good routine and multiple checks when in doubt can help to prevent unnecessary error.
- As an MRI scan may not reveal instability, radiographs should include not only anteroposterior and lateral views for localization purposes but also flexion-extension views.

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