

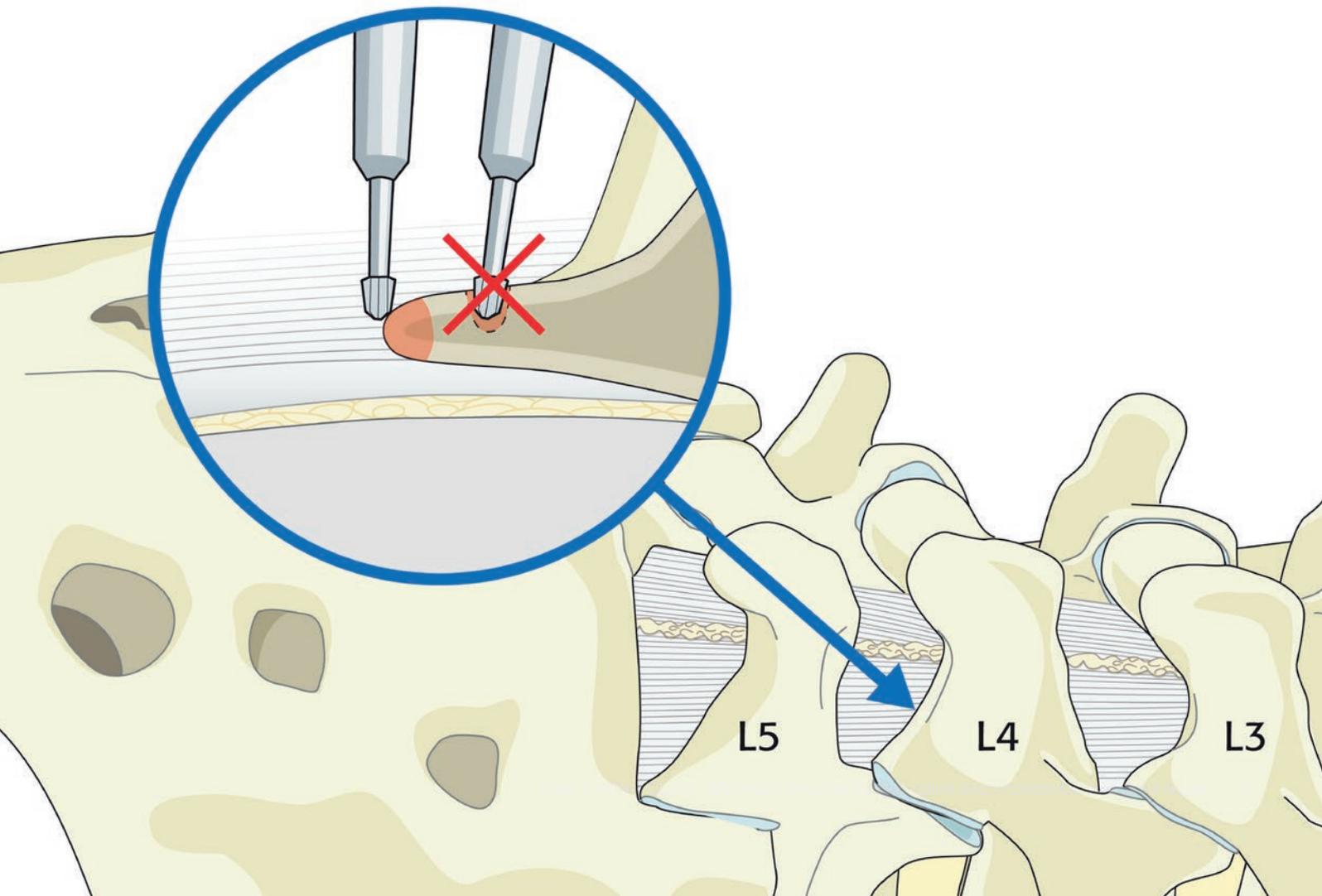
Education

Minimally invasive tubular approaches to lumbar spine decompression and dural repair—surgical techniques

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Step-by-Step Guide: Minimally invasive tubular approaches to lumbar spine decompression and dural repair—surgical techniques

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This surgery is performed with the patient under general anesthesia. Usually, no urinary catheterization is needed. Adequate venous access is established. The patient is positioned prone on a radiolucent table. It is important to eliminate compression on the abdomen to reduce venous pressure in order to decrease intraoperative blood loss. The patient's pressure points are appropriately padded and the surgical field is prepared in a sterile fashion. An image intensifier is used for spinal level localization.

A microscope is used for magnification and for illumination. Normally, the foot of the microscope is placed behind the surgeon and the image intensifier is positioned on the contralateral side to avoid space problems when placing both simultaneously in the operating field.

Tubular retractors are used in these minimally invasive surgical approaches. There are multiple commercially available tubular retractor systems, all consisting of sequential dilators in diameter, all marked in length to select the final appropriate retractor size for the case, several tubular retractors in lengths and diameters, a table clamp, and a holding arm.

Typically the table clamp is located contralateral to the surgeon. An assistant also stands on the contralateral side.

The surgical instruments used in the tubular approaches are:

- A tubular retracting system, as previously described
- A surgical power drill with a spinal minimally invasive terminal (in most drills this consists of a curved long attachment, but some systems have a long-angulated one). We recommend the use of a 3 mm fluted matchstick drill bit, and avoid diamond drills and round drills (though some surgeons prefer diamond drills at the final part of the procedure)
- 2, 3, and 4 mm bayoneted Kerrison rongeurs, 45° and 90°
- 12 and 9 French size suckers. Some surgeons use also a "retractor-sucker" to retract the thecal sac or the root simultaneously with aspiration
- Bayoneted pituitary rongeurs (straight and angulated upward and downward, different sizes)
- Bayoneted ball tip nerve hook, one oriented to the right and one to the left
- Bayoneted dissector
- Bayoneted hook (without sharp tip)
- Bayoneted scalpel
- 90° down-angled long curette
- Bayoneted long bipolar forceps
- Long tip bovie
- Bayoneted micro-scissors can be useful in some surgeries
- Endoscopic dural repair set

Surgical drilling with a fluted matchstick drill is side-drilling, so the surgeon must use the instrument this way, starting at the inferior edge of the superior lamina of the surgical level, at the insertion of the yellow ligament, and continuing drilling medially, laterally, and cranially according to the surgical target, until the yellow ligament is completely visualized.

After completing the decompression, the surgical field is washed with saline solution (some surgeons use antibiotic dilution) to rule out any bleeding points. Hemostasis can be achieved with bipolar coagulation, protecting the neural elements with a pattie, thrombine-embedded patties and hemostatic agents, such as fibrin glue or others. It is important to complete hemostasis before closing, as hematoma can cause compression of the neural elements, muscular pain, fibrosis, and infection. Usually no drain is placed in lumbar tubular decompressive surgeries; however, in cases where it is used, it is removed the next day.

Microsurgical tubular discectomy (MTD) technique

The patient is positioned prone as previously described under general anesthesia. The surgeon stands on the side of the herniated disc and the level is marked with the image intensifier lateral. Some surgeons also use an AP view to confirm the placement of the skin incision, which is usually 1 to 1.5 cm lateral to the midline. The fascia must be opened.

Sequential dilators are placed through the multifidus muscle, with the tip at the inferior edge of the superior lamina (the correct position is confirmed with the image intensifier lateral after the placement of the last dilator). Then the tubular retractor is placed and secured to the arm. The orientation of the dilators is perpendicular to the lamina and the final position of the retractor is slightly medial. For microdiscectomy, 15 or 16 mm diameter tubes are used.

A small amount of soft tissue (muscle and fat) at the tip of the retractor is eliminated with the bovie, and laminectomy is performed using a drill and Kerrison rongeur. If necessary, the medial facet can be removed, although extensive facets removal must be avoided to prevent instability. The yellow ligament is opened with the help of the bayoneted hooks and resected with the Kerrison rongeurs, and microdiscectomy is completed as in open surgery.

For extraforaminal discs, dilators and tube must be docked at the pars caudal to the upper transverse process by drilling the lateral part of the facet and pars, until the pedicle wall and the exiting nerve root and the extruded disc are identified. Skin incision in these cases must be lateral.

In the case of recurrent discs with fibrosis, as in open surgery, the interface between scar and normal bone must be identified—this interface indicates where the laminectomy should start.

Microsurgical tubular laminectomy (MTL) technique: “over the top decompression”

Surgical minimally invasive tubular approach for lumbar spinal stenosis is similar to MTD and MTF (microsurgical tubular foraminotomy). In this case an 18–19 mm diameter tube is used and a more extensive bone and yellow ligament resection is done to achieve adequate decompression of the dural sac. In some cases more resection of the ipsilateral facet joint is necessary.

The specific anatomical level determines the exact position of the tubular retractor. For example, at L1-L2, L2-L3, L3-L4 the lamina is narrow, facet joints are sagittally oriented and pars is thinner. For those reasons, the tubular retractor must be placed closer to the midline (approximately 1 cm from midline) and more vertically angulated than at L4-L5 and L5-S1, where the skin incision is usually 2–3 cm from the midline and tubes are placed in a more medial angulation.

For bilateral decompression, if the surgeon is right-handed usually the best side for the approach is the right side because laminectomy is performed following the natural direction of the surgeon's hand and the direction of the roots, minimizing the risk of dural tears.

After placing the retractor, the soft tissue is eliminated and laminectomy is started with the high-speed drill, removing the medial portion of the lamina, then continues with the Kerrison 45°, starting from the smaller and proceeding to the others according to surgeons' preference and safety of the procedure. Ipsilateral ligamentum flavum is exposed. Some surgeons prefer to keep all ligamentum flavum in place till all the bone has been taken out (and this may be safer in order to avoid dural tears); others prefer to remove it before performing the contralateral part of the laminectomy, and this may give the surgeon a better anatomical orientation.

To perform the contralateral decompression, the tube is aimed medially and the table is tilted away from the surgeon. Contralateral laminectomy is initially done with the drill, protecting the dura with the suction tube (we recommend changing the suction to a smaller size, like 9), and then with the Kerrison. A 90° Kerrison may help to avoid dural tears when performing contralateral laminectomy and downward laminectomy.

In some cases with extensive stenosis, and in some cases with spondylolisthesis, hypertrophy of the ligament can extend below the disc level, and it may be necessary to tilt the tube caudally.

Each time the tube is tilted, we again introduce the last dilator (the greatest) used when initially placing the tube. This helps to prevent the soft tissue from getting into the tube and also facilitates tilting the tube.

After removing the bone and before taking out the yellow ligament, this can be dissected from the dural attachments using the ball tip hooks.

Usually one incision is enough for up to two levels. In these cases, fascial incisions and introduction of the dilators is done in both levels before carrying out the first level decompression to minimize dural injuries from the dilators (in case we introduce them through a previously decompressed level).

For more levels a Slalom technique can be used to decrease the risk of instability from extensive unilateral facet destruction. When utilizing the Slalom technique, two surgeons can simultaneously perform the surgery, one on each side. This is a way to reduce operative time.

MTL steps

1. Placement of the tubular retractor: inferior edge of the medial ipsilateral lamina.
2. Removal of soft tissue. Identification of inferior border of the lamina and base of spinous process.
3. Laminectomy: bone removal of the ipsilateral lamina using drill and 45 degree Kerrisons.
4. Identification of the cranial insertion of the yellow ligament
5. Removal of ipsilateral yellow ligament (previous dissection from dural attachments with the hooks).
6. Tilting the tube medially and the table positioned contralateral from the surgeon. Drilling of the base of the spinous process.
7. Undercutting of the spinous process and of the contralateral lamina with Drill and Kerrison.
8. Resection of contralateral ligamentum flavum with Kerrison (90° angle may be preferred).
9. Contralateral foraminotomy if needed. In this case identification and decompression of exiting nerve root.
10. Ipsilateral yellow ligament complete removal, tilting back the table and retractor, hemostasis, retractor removal and closure. Infiltration with local anesthetics.

Microsurgical tubular repair of dural tears

Dural tear is one of the most common complications of spine surgery. Avoiding such a tear demands a meticulous surgical technique. Most durotomies occur during removal of the yellow ligament attached to the dura in the caudal and contralateral parts of the surgical field in the tubular approaches.

To prevent dural tears some technical points are useful:

- Careful separation of ligament from the dura using the ball tip hooks before using the Kerrison
- Use of 90° Kerrison when working caudally and medially
- Move the Kerrison slightly to both sides before biting to rule out simultaneous movements of the dura, which means the dura is also caught by the rongeur
- Adequate selection and use of the drill bit

In the presence of a dural tear, management depends on the size of the tear. If it is a small tear without protrusion of the nerve roots, in most cases a simple covering of the defect with fibrin glue or some type of biologic sealant may be enough. If the dural tear is big and the nerve roots are protruding, a repair is recommended. In these cases, a first step is draining the cerebrospinal fluid to lower the pressure inside the thecal sac to permit the roots returning into the sac, and then the durotomy can be repaired using a 5-0 suture and, for example, an endoscopic dural repair set. After suture, a watertight closure is confirmed by Valsalva maneuver and a sealant is applied.

Patients are mobilized 3 to 4 hours following surgery. However, those with dural tears are kept in bed for 24 hours.

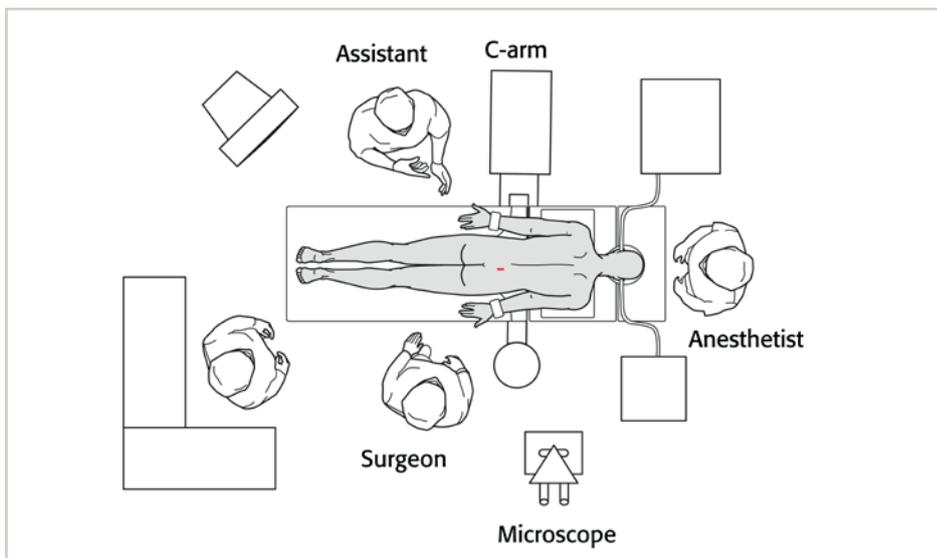
Oral analgesia is administered to manage pain postoperatively. Some surgeons prefer to maintain patients on intravenous analgesia for the first 24 hours. Muscle relaxants must be sustained for at least a week after tubular surgeries to prevent pain from muscle spasm. Patients can usually be discharged within 24 to 48 hours after a tubular microsurgical lumbar procedure with written instructions. Follow-up visits are scheduled 1 to 2 weeks postoperatively to check surgical scar and general function.

Step-by-Step Guide: Key Steps in a Microsurgical Tubular Laminotomy

Prepared by:
Dr Roger Härtl for the Bioskills Course—Microsurgical Decompression and Fusion Procedures in Lumbar Spine Course

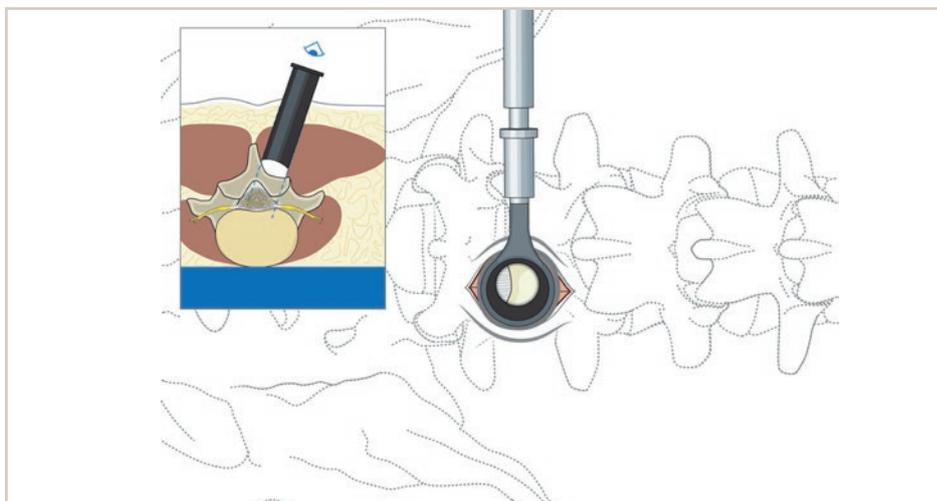
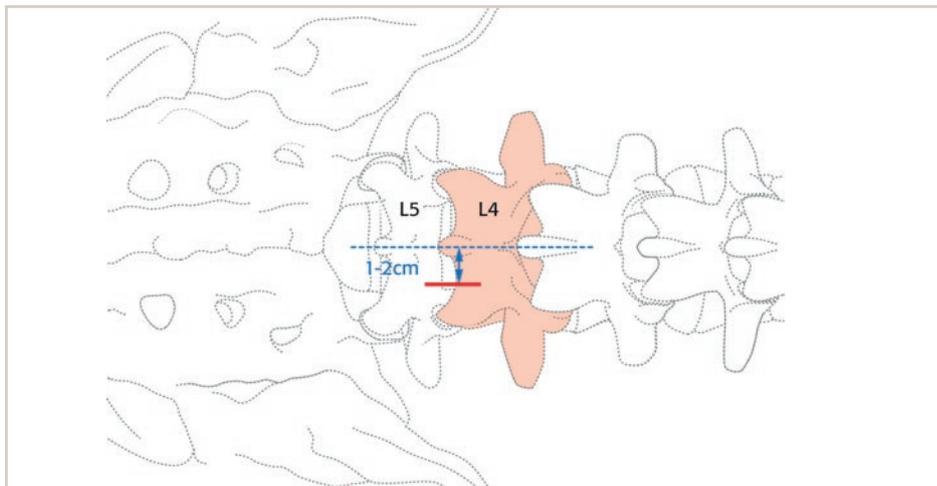
1. Optimal operating room set-up for MIS surgery

In cases with equal bilateral stenosis and symptoms, a right handed surgeon should stand on the right side of the patient (who is placed in the prone position) along with the scrub nurse. The assistant stands on the opposite side. The operating microscope and the C-arm are positioned on opposite sides; this allows for no interference between these structures during surgery. After draping the patient, the table mounted retractor unit is fixed at the opposite side of the skin incision.

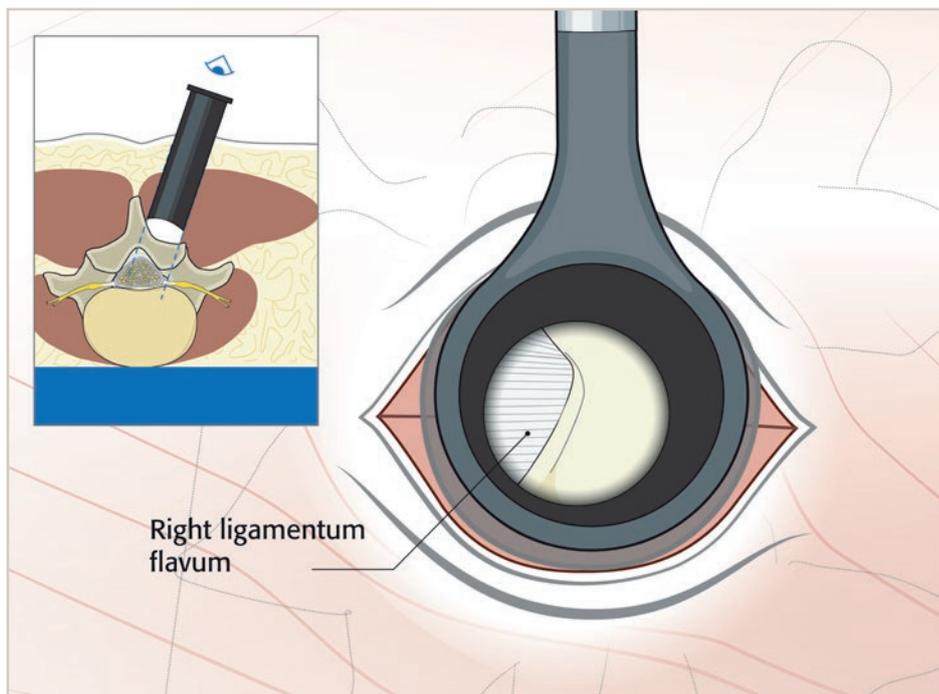


2. Tube placement

Tube placement over the inferior edge of the medial ipsilateral lamina.

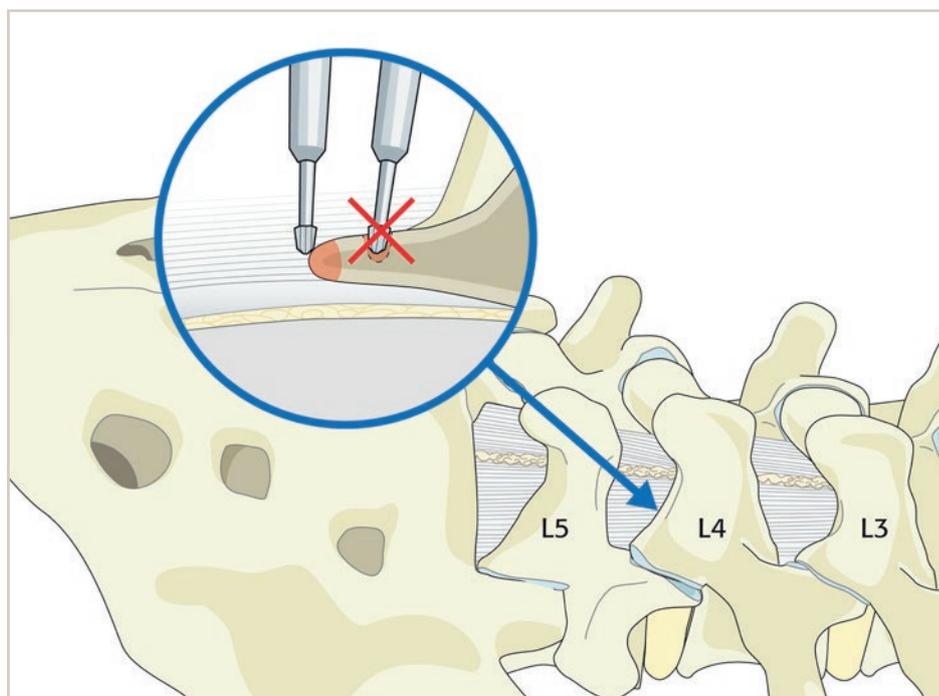


3. Removal of soft tissues and identification of inferior edge of the lamina and ipsilateral base of spinous process



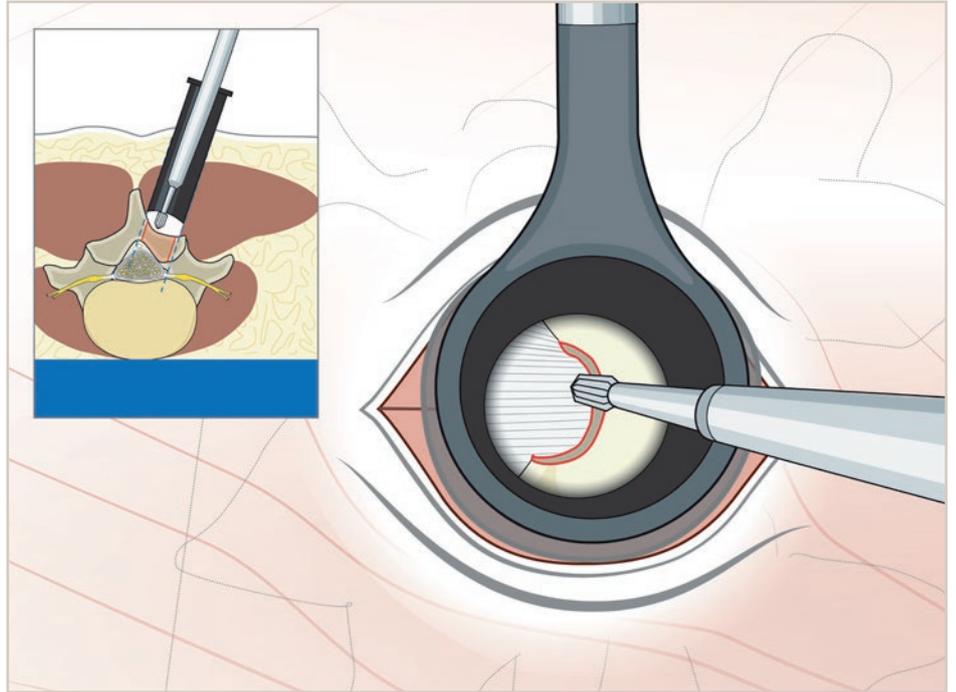
4. Drilling technique with curved drill shaft with a 3 mm fluted matchstick drill bit

The side cutting burr is placed at the inferior edge of the lamina with the side of the drill bit depending on the type of exposure needed, with the blunt tip always sitting on the ligamentum flavum. Vertical drilling is not recommended (crossed out).



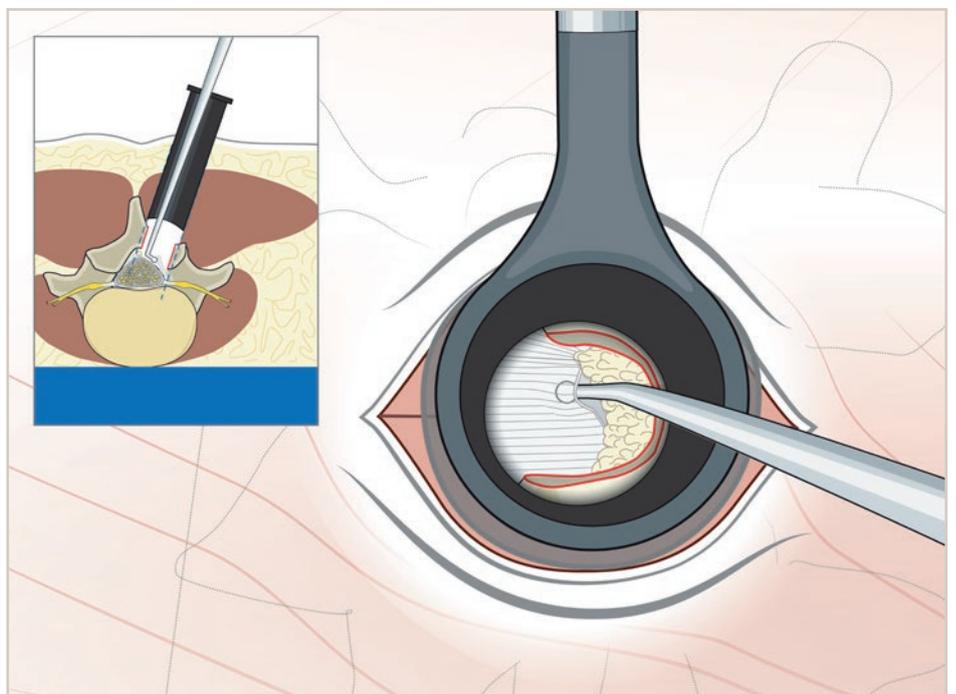
5. Laminotomy

Drilling of the medial portion of the lamina in a cranial direction. Bone removal using bayoneted 2 and 3 mm 45° Kerrison rongeurs.



6. Exposure of the cranial insertion of the ligamentum flavum

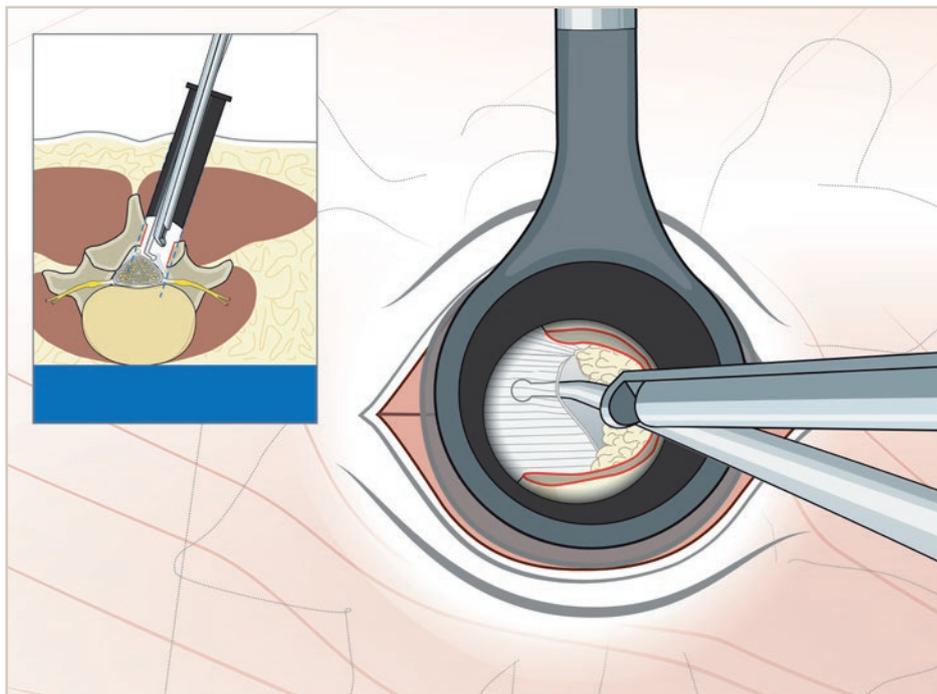
Exposure of the cranial insertion of the ligamentum flavum (LF), an area that may be identified by the presence of epidural fat. Epidural fat can also be identified between the two leaves of the LF along the midline.



7. Removal of the medial portion of the ipsilateral LF

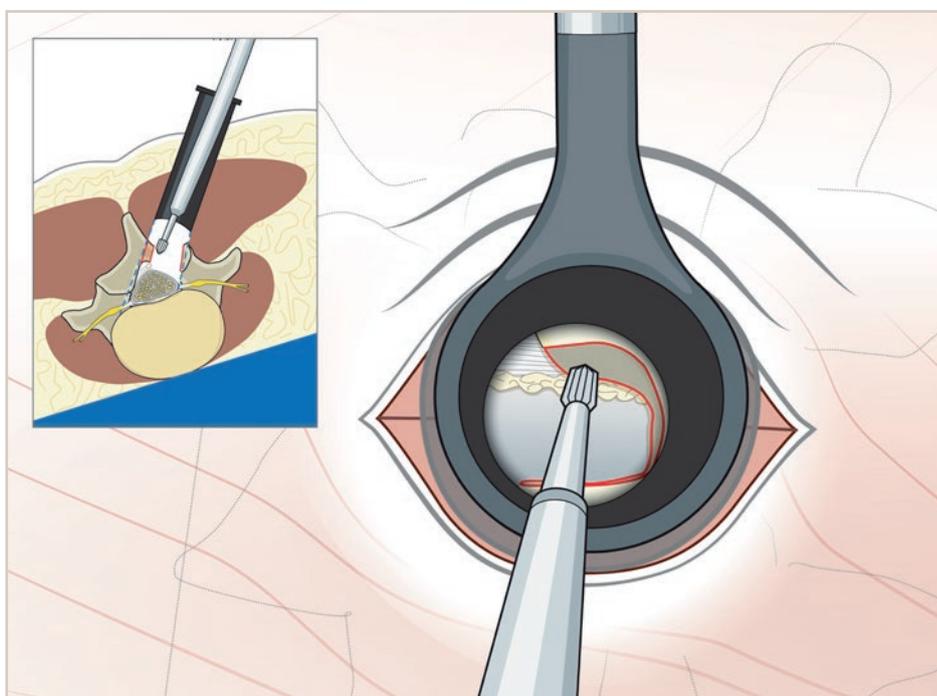
Removal of the medial portion of the ipsilateral LF either from cranially above the insertion of the LF or from the midline gap in between the leaves of the LF.

Note: This is for better visualization of the ipsilateral dura and underlying structures, however keeping the LF in place until after all bony decompression is another option that some may find safer.



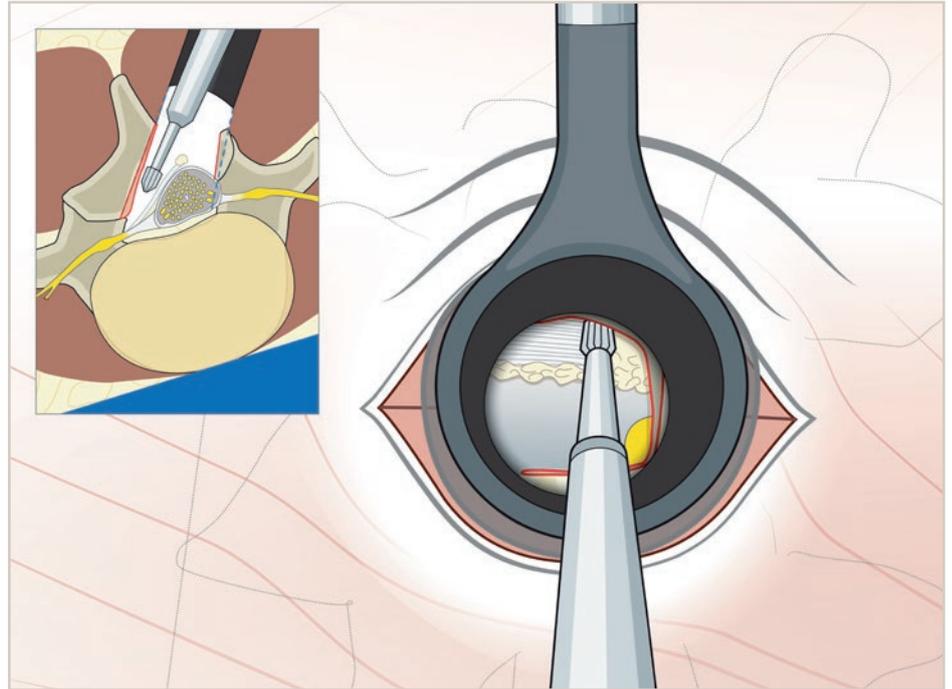
8. Aiming the tube

Aiming of the tube medially towards the midline and tilting of the operating table away from the surgeon, and if necessary, more medial bone drilling.



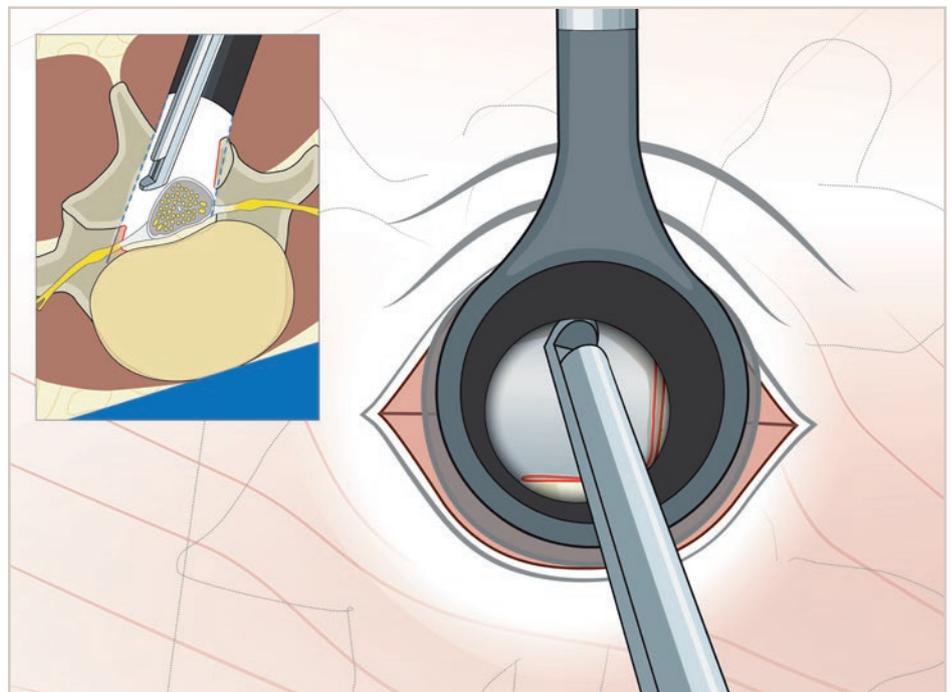
9. Contralateral drilling

Undercut drilling of the bone "behind" the contralateral LF while protecting the dura with the suction. The suction is downsized to a number 9 and only 2 mm rongeurs are used in order to minimize compression of the thecal sac and nerve roots. For medial and inferior bony work, 90° Kerrison rongeurs can also be used to minimize risk of potential durotomy.



10. Removal of the contralateral LF

The use of 90° Kerrison rongeurs may allow more complete resection of the LF.



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