Lower-limb nerve root pain caused by lumbar disc herniation is the most frequent indication for spinal surgery. Sixty-thousand such operations are performed in France each year. While the procedure is not usually technically difficult, fundamental principles must be respected to avoid potentially severe complications.

Satisfactory clinical results require not only precise surgical technique but precise evaluation of indications: i.e., good correlation between clinical and radiological findings, specifying nerve root compression by the herniation as the source of the pain.

The present paper describes the surgical techniques to relieve the impingement induced by lumbar discal hernia.

**Prerequisites**

**Pre-operative assessment**

Clinical and radiological assessment founds the surgical indication, approach and technique.
Surgical indications

Surgery may be indicated in the following cases:

- emergency:
  - cauda equina syndrome (absolute emergency),
  - morphine-resistant hyperalgesia sciatica,
  - paralyzing sciatica, grade less than 3 (other than toe muscles, where isolated palsy is not an indication for surgery);
- residual disabling pain despite 6–8 weeks' full medical treatment; predominance of radicular over lumbar pain is an essential criterion.

When these criteria are met, surgery is recommended, informing the patient as to:

- the natural evolution of lumbar discal hernia and the risk of recurrence;
- absence of alternative medical strategies, with surgery as the last remaining resort;
- the risk/benefit ratio for surgery, with benefit especially in terms of nerve root pain, and risk of paralysis, nosocomial infection and large vessel wounds;
- surgical technique and approach.

History of surgical techniques

History

In 1934, Mixter and Barr [1] described the first surgical lumbar discal hernia ablation technique, on a wide posterior transdural approach.

In 1939, Love [2] described an approach inclining the dural sac and releasing the nerve root by ablating the hernia, with associated disk resection. These basic procedures are still employed today, although the technique has been refined, with a smaller standard unilateral 5-cm approach, inclining the multifidus muscle and creating a limited interlaminar space, instead of the original L3-sacrum approach. This is standard discectomy (SD).

In 1988, Wiltse and Spencer [3] described a paraspinal approach between multifidus and longissimus, for extraforaminal discal herniation.

Over the last 30 years, many variant techniques have been described, to reduce blemish and muscle trauma and improve vision, but conserving the same basic principle. Changes concern a reduced muscular approach thanks to magnification and illumination systems. This is intended to reduce postoperative pain and hospital stay and costs, with earlier return to work and improved clinical results by reducing lumbar pain and periarticular fibrosis (scar).

In 1977, Caspar [4] and Williams [5] described a surgical microdiscectomy technique (MD). The muscular approach was reduced to 3 cm, using a speculum or distractor to distract the muscles and a microscope for illumination.

In 1988, Kambin and Sampson [6] described a purely endoscopic technique (full endoscopy: full endoscopy [FE]) on an extraforaminal approach, for non-sequestrated intracanal discal hernia.
Surgical disectomy for lumbar disc herniation: Surgical techniques

Ten years later, with a view to managing all kinds of herniation, Foley and Smith [7] and Destandau [8] described a video-assisted technique using a tubular work canal (microendoscopic disectomy: MED) or speculum with a 2-cm incision on a transmuscular approach without multifidus release.

In 2002, Yeung and Tsou [9] described an FE technique able to ablate all forms of discal herniation on a transforaminal approach.

Most surgeons use a reduced approach with a light source adapted to visualizing neural structures, but debate continues between the advocates of microscopes and of endoscopes.

Comparison between standard disectomy and microdisectomy

Kahanovitz et al. [10] found no difference in results between the two techniques, except for shorter hospital stay with MD (2 vs. 7 days). Gibson et al.’s meta-analysis [11] found no benefit of MD over SD, although the number of references retrieved was small. Katayama et al.’s prospective study [12] found no difference except in hospital stay and bleeding, which were lower in MD. Vereschiagina et al.’s prospective study [13] reported no significant difference between the techniques.

Comparison between standard disectomy and microendoscopic disectomy

We compared 98 MED and 56 SD procedures [14]. Hospital stay and immediate postoperative analgesia were lower in MED, but pain at 3 months showed no difference; nor did recurrence. Wu et al. [15] compared 873 MED and 358 SD procedures. Mean hospital stay, bleeding and time to return to work were lower in MED, but long-term pain results were equivalent. Rhighesso et al. [16] came to the same conclusions in a prospective randomized study. Franke et al. [17], comparing the two techniques in two centers, one with good experience of MED and the other less so, found no long-term difference between the clinical results of the two centers. A learning curve of 25 to 100 MEDs was required, in agreement with Wu et al. [15]. Finally, Arts et al. [18], in a randomized double-blind study, found no difference in terms of postoperative pain, occupational impact and recurrence.

Comparison between microdisectomy and full endoscopy

Ruetten et al. [19] reported no difference in terms of lumbar or radicular pain, or Oswestry or North American Spine Society (NASS) pain or neurology scores at 2 years’ follow-up.

Comparisons on recent meta-analyses

Gotfryd and Avanzi [20] and Nellensteijn et al. [21] performed systematic literature reviews. The former compared SD, MD and endoscopy (MED and FE). Endoscopy and MED were preferable to SD in terms of hospital stay and bleeding but not of clinical result. The latter assessed efficacy in FE and MED, stressing the methodological weakness of the studies reviewed, only one of which was randomized; even so, they concluded that there was no difference between the techniques in terms of pain, complications or recurrence.

The literature as a whole fails to show any one technique to be clearly preferable to another. While it is certain that hospital stay is shorter with FE and MED, SD remains reliable and not outdated. Such a lack of difference is not really surprising, as the key element (eliminating impingement) is the same in all, only the approach to the nervous structure varying.

Surgical technique

We shall first describe SD techniques according to herniation position, and then the particularities of MD, MED and FE.

Standard disectomy

Disectomy on unilateral posterior approach for posterolateral discal hernia

Step 1: Preliminary assessment. In France, the 2009 “Patient safety in theater” checklist drawn up by the Health Authority (Haute Autorité de santé: www.has-sante.fr) should be implemented. The pre-incision step is essential, to check:

- that all theater equipment is sterile;
- that antibiotic prophylaxis has been performed; the French Society of Anesthesiology and Intensive Care (www.sfar.org) recommends 2 g iv cefazolin 30 minutes ahead of incision;
- any anesthesiologic or surgical particularities liable to arise peroperatively.

Installation (Fig. 2) is an essential step, performed jointly by the surgeon and anesthesiologist. The patient is positioned genuepectorally, with abdomen free and a comfortable chest support. The head is in the axis of the trunk, or slightly turned, with eyes free, on a gelatin headrest; depending on the
model, a mirror may be incorporated, allowing the anesthesiologist to see the patient's eyes throughout surgery. Cranial tongs are the surest way of avoiding eye compression, but make the surgical protocol more complicated. The shoulders are in 90° abduction and the elbows in 90° flexion. The brachial plexus and ulnar nerve are checked. This posture places the lumbar spine in kyphosis, opening the interlaminar space to facilitate access. Ventral decubitus is another possibility, inducing lordosis and closing the interlaminar space. The freedom of the abdomen and absence of compression of the lateral cutaneous nerve of the thigh are checked.

Usual scialytic lighting may be sufficient, but a frontal light source is strongly advised to enhance depth of visualization.

The assistant faces the surgeon, who stands at the herniated side.

Hypotension controlled at 9–10 systolic pressure with a mean pressure maintained at more than 6 facilitates surgery and reduces bleeding; it should be discussed with the anesthesiologist, depending on comorbidity.

Pitfalls: faulty positioning, inducing eye or nerve compression.

**Step 2: Incision and interlaminar space exposure.** Spinous process palpation locates the interspinous space for incision (Fig. 3). L4-L5 lies caudally and L3-L4 cranially to the horizontal between the two posterosuperior iliac crests. Image intensification is recommended as of this step.

A 4-5 cm incision is made from one spinous process to the other. The skin is pulled back using a Beckman retractor. The aponeurosis is incised using a cautery, and the multifidus is released from the spinous process on one side, using a Cobb bone curette, until the joint bone is visible. The muscle is retracted using a Taylor retractor on the lateral side of the joint, or a Williams retractor. The ligamentum flavum is exposed. Fluoroscopic control is performed. In large medial hernia compressing both nerves, the approach is bilateral.

Pitfall: confusion of level.

**Step 3: opening the ligamentum flavum and exposing the discal hernia.** The ligamentum flavum is opened by a surgical knife or fine spatula (Fig. 4), and drawn back using a Kerrison punch. The dura mater is exposed and delicately pushed back with a blunt spatula toward the midline, to expose where the compressed nerve emerges. The arching of the discal hernia or excluded sequestra may become visible first, but it remains essential to locate and dissect the nerve root before proceeding to disk resection (Fig. 5).

The epidural fat is left in place. Partial laminectomy of the inferior edge of the upper lamina will be necessary if the disk is not centered on the interlaminar space, as in levels higher than L4-L5. In L1-L2, the dural sac should not be inclined, especially if the medullary cone is present: total

**Figure 3**  Posterior approach in standard discectomy.

**Figure 4**  Incision of ligamentum flavum.

**Figure 5**  Exposure of dura mater and nerve root.
arthrectomy and reconstruction are then required to gain lateral access to the disk. In non-contained or voluminous hernia, widening the space provides visualization of sequestra. Partial arthroctomy is performed in case of associated stenosis.

Pitfall: dura mater rupture when opening the ligamentum flavum, and temptation to remove the hernia before locating the nerve root.

Step 4: nerve root release and hernia resection. The root is released by spatula, starting from the shoulder, and is passed over the hernia (Fig. 6) without traction; the bone window should be widened if the traction is too great. Epidural vessels hampering the operation are preventively coagulated by bipolar forceps. A dura retractor is used to draw the nerve root gently toward the midline. The common vertebral ligament is incised using a lancet (Fig. 7). Excluded or intradiscal sequestra are removed by disk forceps (Fig. 8) of variable size (2–5 mm) and orientation (straight or upward or downward oblique).

The forceps, still open after passing the ligament, must never be introduced more than 3 cm into the disk. Disk excision (not always performed by some teams if only sequestrated fragments remain) can now begin. The disk is not to be withdrawn in its entirety, as this is impossible and would not be useful: there is a risk of crossing the anterior common vertebral ligament and damaging vessels anterior to the spine. Excision removes a variable amount of substance, and stops when nothing is removed after two or three attempts with the forceps. Curettage of the plates should not be attempted, to prevent onset of discopathy.

If the hernia is sequestrated downward, the sequestra are removed via the shoulder of the root. If this is impossible, the laminectomy should be extended so as to slide the fragment downward and remove it without traction to the nerve axilla, which could induce paralysis.

If the hernia is sequestrated upward, hemi-laminectomy of the overlying vertebra is performed. The overlying nerve should be checked before removing sequestra.

At the end of this step, the freedom of the nerve and dural sac are checked by passing a hook in all directions (Fig. 9).

Pitfall: excessive traction on nerve in ablating the hernia, epidural bleeding, large vessel wounds.

Step 5: closure and postoperative course. After checking hemostasis and cerebrospinal fluid leakage, lavage with physiological saline is performed. It is wise but not mandatory to fit a Redon drain, which will be removed when drainage falls below 50 mL. The aponeurosis, subcutaneous fascia and skin are closed by resorbable suture. The patient can get up after a few hours and be discharged at 24 to 72 hours. Anticoagulants are prescribed according to
comorbidity. Analgesia may be local (im Naropeine®) or general. Step III analgesics are not indispensable. Early pain recurrence requires contrast-enhanced MRI investigation to rule out iterative hernia or hematoma. A seated posture is usually authorized. Rehabilitation focusing on the extensors is initiated 1 month later. Corsets are not useful.

**Particular situations**

**Dural tear**
Dural tear may occur at any point during surgery. If it is located, aspiration is reduced, and a Patti neurosurgical sponge is placed on the site. The laminectomy edges are extended if necessary, to expose the tear for repair with thin (5/0) non-resorbable suture. Tears are easy to suture on the dorsal side of the sac, but this is rarely possible at the emergence of the nerve root. Biologic glue (Bériplast®, Tissu Col®) is used at end of surgery. A subcutaneous non-aspirative Redon drain may be fitted, but requires careful postoperative surveillance.

**Epidural bleeding**
Treatment is primarily preventive, with careful dissection and vessel coagulation; but there are sometimes real venous “lakes” that cannot be coagulated. In case of severe hemorrhage, the hernia and sequestra should be removed while using hemostatic compresses (Surgicel®) with or without Patti sponges, sometimes for several minutes. If there is no tear, oxygenated water is useful. As the compresses cannot be left in place, a local hemostatic (Surgiflow®, Floseal®) may be useful.

"I can’t find the hernia”
When exploration fails to match imaging:
- the dates of the images (which should be less than 2 months old) should be checked, although excluded sequestrum may resorb more quickly than this;
- the level should be checked again under image intensification, making sure there is no transitional abnormality; the numbering on the images may be false and fail to take hinge abnormalities into account;
- enlargement provides a better view;
- hooks should be used to explore forward of the dural sac and to test nerve root mobility; a sequestrum can easily be left behind.

**Abnormal nerve root emergence**
Abnormal nerve root emergence can usually be suspected from pre-operative imaging, but may also come as a per-operative surprise. The risk is accidental wounding during dissection. It is necessary to enlarge, sometimes to the point of total arthrectomy to find part of an annulus if the dural sac. Small disc forceps are introduced and the sequestra removed with the help of hooks. Gradually, the nerve bundle is mobilized, but disk excision may be difficult; undue traction on the nerves is to be avoided.

**Large vessel wounds**
This is the worst complication associated with this procedure, and is life-threatening. It results from excessive disk excision.

Different situations may arise in emergency:
- the surgeon sees that the forceps have gone too far, and the anesthesiologist very soon finds a drop in blood pressure. The operation must be stopped immediately, with rapid closure; the patient should be laid on his or her back, and help called for. Depending on severity, immediate laparotomy may be performed; if the situation is less catastrophic, an ultrasound scan may be taken in the recovery room to confirm hemorrhage, and the patient is transferred to interventional radiology for embolization;
- the operation as such may have been event-free, but the situation worsens in the recovery room. The wound does not usually involve the aorta or vena cava; ultrasound scan in the recovery room followed by embolization may resolve the problem. Abstention and surveillance may also, depending on hemodynamic status, be the solution, especially for venous wounds.

**Recurrence of discal herniation**
The difficulty of surgery lies in adherence of the various tissues, the main risk being dural tear or nerve root lesion. Technically, the situation is not different from the standard procedure. Care must be taken as the fibrosis resembles a nerve, which can be wounded. The approach is unilateral, or bilateral in case of associated stenosis. Pre-operative MRI should check for dural sac sequestration through the interlaminar space. A Creed spatula is used to release the edges of the previous laminectomy, and a Kerrison punch to enlarge the interlaminar space. Hook palpation of the pedicle of the root in question locates it easily, and the dura mater is released from the bone; releasing the anterior side of the dural sac from the annulus is more difficult, with a risk of tearing, which often cannot be sutured. Disk excision is not
Standard discectomy on a posterolateral approach, for extraforaminal herniation

Described by Wiltse and Spencer [3], this procedure gives access to the impingement without joint destabilization. It may be especially tricky at L5-S1 if the L5 vertebra is impacted, but incurs no special problems at higher levels. **Step 1: preliminary assessment.** Preliminary assessment is as in SD.

**Step 2: incision and exposure of the intertransverse space.** In L4-L5 discal hernia, the skin is incised between the L4 and L5 spinous processes. After passing through the subcutaneous layer, the incision shifts 2 cm from the midline to the muscular aponeurosis, which is incised to locate the passage between the multifidus and longissimus (Fig. 10), which is easier the higher the position, using a Cobb bone curette or a finger, to palpate the transverse process of the L4 vertebra. A Beckman, Williams or Taylor retractor is positioned, which is not always easy or stable. A cautery is used to release the L4 isthmus, L4-L5 joint bone and L5 transverse. It is often necessary to coagulate the perforating branch of the dorsal branch of the lumbar artery by bipolar forceps. The intertransverse fascia is exposed (Fig. 11).

**Step 3: opening the intertransverse fascia and exposure of the hernia.** The L4 isthmus is partially rasped or thinned by an oblique Kerrison punch. A blunt spatula is used to palpate the inferior edge of the L4 pedicle. The intertransverse fascia is removed. The root is located under the L4 pedicle, and followed up to the hernia (Fig. 12). It may be completely flattened, and mistaken for the hernia, which is why it should be located as of its emergence from the foramen: it is essential not to attempt to remove the hernia before having properly visualized the nerve root.

**Step 4: root release and hernia excision.** Excising the discal hernia may be difficult due to the degree of compression.

Ablation preferably proceeds from the shoulder of the nerve root. The disk need not necessarily be removed, especially in case of excluded sequestra. When excision is performed, lateral false passage is to be guarded against. If necessary, release via the foramen toward the canal is possible, taking care not to damage the dural sac. At end of surgery, it is mandatory to check toward the canal and along the root, using an oblique hook.

**Step 5: closure and postoperative course.** The procedure is as in SD.
Standard discectomy for foraminal hernia

Both previously described approaches are possible for removing foraminal hernia. Depending whether the hernia extends toward the foramen or the canal, the Wiltse approach or the standard posterior approach with some adaptation will be used.

**Posterior approach**

Incision is longer, extending toward the superior vertebra. The two nerve roots are located by hemi-laminectomy. The superior root is followed from its emergence up to the fora- men. The isthmus is thinned, taking care not to weaken it (leaving at least 5 mm), to avoid joint fracture. The her- nia is located by spatula. The disk is incised at the foramen and sequestra are removed by disc forceps. Root freedom is checked by a hook.

**Wiltse posterolateral approach**

The foramen can be opened using a rasp and Kerrison punch on a paravertebral approach. Care should be taken not to weaken the isthmus or damage the dura mater. It is not easy to check root freedom in the canal, and this approach should not be used if sequestrated intracanal fragments are suspected.

**Mixed posterior and posterolateral approach**

Certain large discal hernias may compress the nerve along the entire intra- and extra-canal route, requiring release at both levels. Combining both approaches, conserving multifidus continuity, enables root freedom to be checked without breaking the isthmus; but this is not always feasible, espe- cially at L5-S1, where stenosis is often associated. Total arthrodesis of the inferior L5 joint is then necessary, requir- ing arthrodesis reconstruction.

**Microdiscectomy**

Described by Caspar [4], MD requires a microscope to illu- minate and magnify the surgical field. Step 2 differs from SD; the other steps are similar, except for being performed under the microscope.

A 3-cm skin incision is made. After crossing the subcuta- neous fascia, the muscular aponeurosis is incised 1 cm from the midline. The multifidus is released from the spinous pro- cesses up to the joint bone, and the speculum is introduced and opened. The microscope, with zoom, is placed facing the surgeon and positioned over the incision. Magnifying goggles can be used instead of a microscope.

**Microendoscopic discectomy with operative canal**

MED requires dilators of increasing sizes and a dedicated endoscope (MET™, Medtronic). An alternative system, Destandau’s Endospine™ [8] (Storz), allows the same pro- cedure. A classic endoscope and instrumentation can be introduced via a speculum with several canals.
Posterolateral approach

The incision is made 4 cm from the midline. The K-wire or small dilator is introduced obliquely down toward the isthmus and transverse in the axis of the disk under AP and lateral fluoroscopic control. Once bone contact is achieved, the dilators are brought down and the procedure continues as above.

Full endoscopy

The approach is basically lateral and transfemoral, and requires dedicated instrumentation. It may be performed under local anesthesia. The entry point is 12 to 14 cm off the midline, at an angle of 20° to 30°. Intradisk staining reveals sequestra. The 8-mm endoscope includes a canal for introducing forceps, and is coupled to an irrigation system to keep the field free of blood; it is positioned in front of the foramen. Intracanal hernias that are centered with respect to the disk and non-extruding are removed intradiscally by forceps. This approach is not recommended for sequestrated intracanal fragments.

Conclusion

Lumbar discal hernia removal techniques have greatly evolved in terms of instrumentation over the last 30 years, but without any spectacular improvement in clinical results. Correct surgical indication remains the key factor. The technique used must be fully mastered; otherwise, the choice is open and up to the individual surgeon after informing the patient.

Disclosure of interest

The author declares that he has no conflicts of interest concerning this article.

References


