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HOW I DO IT - SPINE DEGENERATIVE

Minimally invasive tubular approach for lumbar extraforaminal disc herniation: how I do it

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Abstract

Background Minimally invasive surgical resection of extraforaminal disc herniation is challenging. The anatomical landmarks are varying from common interlaminar approach. The main risk is to damage the exiting nerve root as it is not yet protected by any bony structure.

Method Here, we present the different steps of the minimally invasive approach to resect a lumbar extraforaminal disc herniation, using tubular retractor under microscopy.

Conclusion Once the key steps of tubular placements are well known, minimally invasive approach for such extraforaminal resection affords appropriate exposure, while reducing blood loss and muscle injury.

Keywords Minimally invasive surgery · Tubular retractor · Microsurgical resection · Extraforaminal · Disc herniation

Relevant surgical anatomy

We performed a right extraforaminal approach, at the L4–L5 level, with minimally invasive technique. Using tubular exposure, the field of view is restricted to less than 2 cm. For this reason, the operator must anticipate the anatomical structures he will face (Fig. 1).

The first step is to identify the selected intervertebral level using a needle and fluoroscopy. After paramedian ipsilateral skin and fascia incision, the tubular dissector is inserted through the deep paravertebral muscles (longissimus thoracis and multifidus). The objective is to dock the tube on the lateral border of the right L4–L5 articular complex (Fig. 2). The L5 transverse process should be visualized at the inferior part of the tube. Then, removing the remaining muscle fibers and fatty tissue in the depth of the tube, just above the projection of the transverse process, the L4–L5 disc is exposed, recognizable by its white color. In some cases, the foraminal venous plexus corresponding to bulging large veins can lie on the disc. It can be sacrificed if obstructing the dissection corridor. Once the disc is well identified, the exiting nerve root, in this case L4, can be dissected at the upper part of the L4–L5 disc. The exiting nerve root is located in the upper third of the neuroforamen, below the L4 pedicle. In its foraminal trajectory, the exiting nerve root is going oblique, caudal, and lateral, surrounded by peri radicular fat, the radicular artery anteriorly and the radicular vein posteriorly. In the reported technique, it is not mandatory to denude the nerve root from the surrounding structures, in order to reduce the nerve and dorsal root ganglion manipulation and bleeding.

Description of the technique

Surgery was performed under general anesthesia with the patient in knee chest position. To reduce the patient lordosis, a ventral pillow or saddle could be used. After draping, we identified the appropriate intervertebral level (L4–L5), using a needle and the fluoroscopy (C-arm). In our experience, we perform only lateral fluoroscopy to reduce x-rays exposure. The needle was inserted almost 4 cm lateral to the midline, at the level of the disc, on the right side (same as the disc

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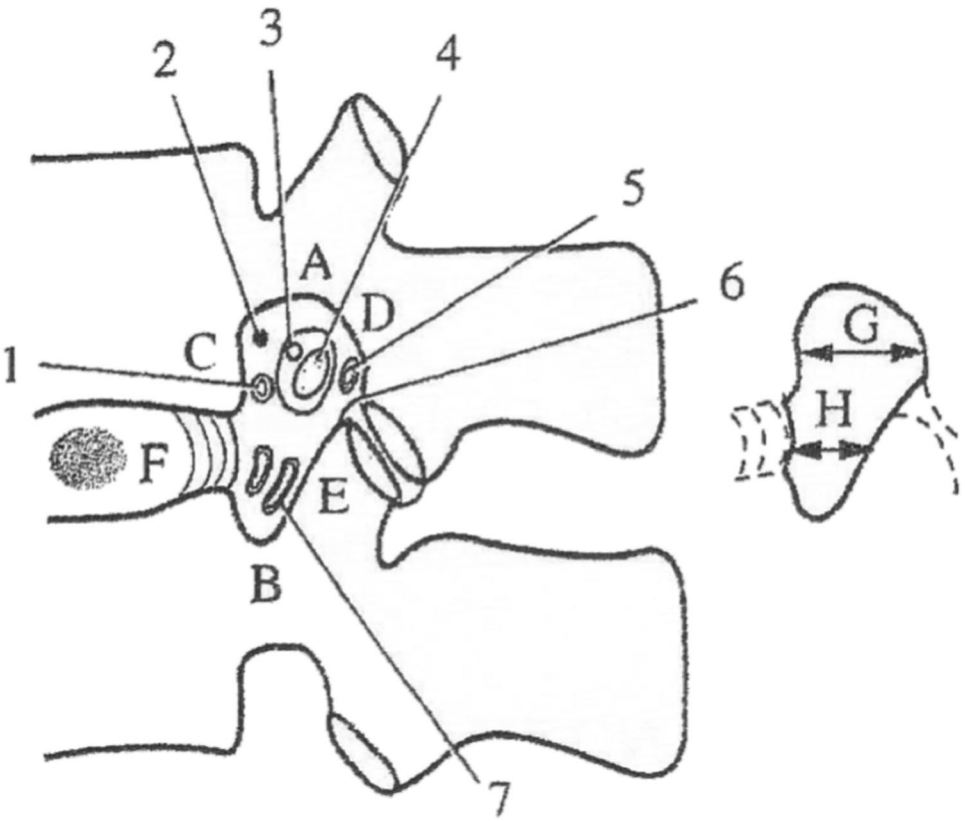

Fig. 1 Neuroforamen in the sagittal plane. A: upper pedicle, B: inferior pedicle, C: vertebral body, D: isthmus, E: superior articular facet of the inferior vertebra, F: intervertebral disc, G: fix portion of the foramen, H: mobile portion of the foramen. 1: radicular artery, 2: sinu vertebral nerve, 3: anterior root, 4: posterior root, 5: radicular vein, 6: joint capsule, 7: foraminal venous plexus

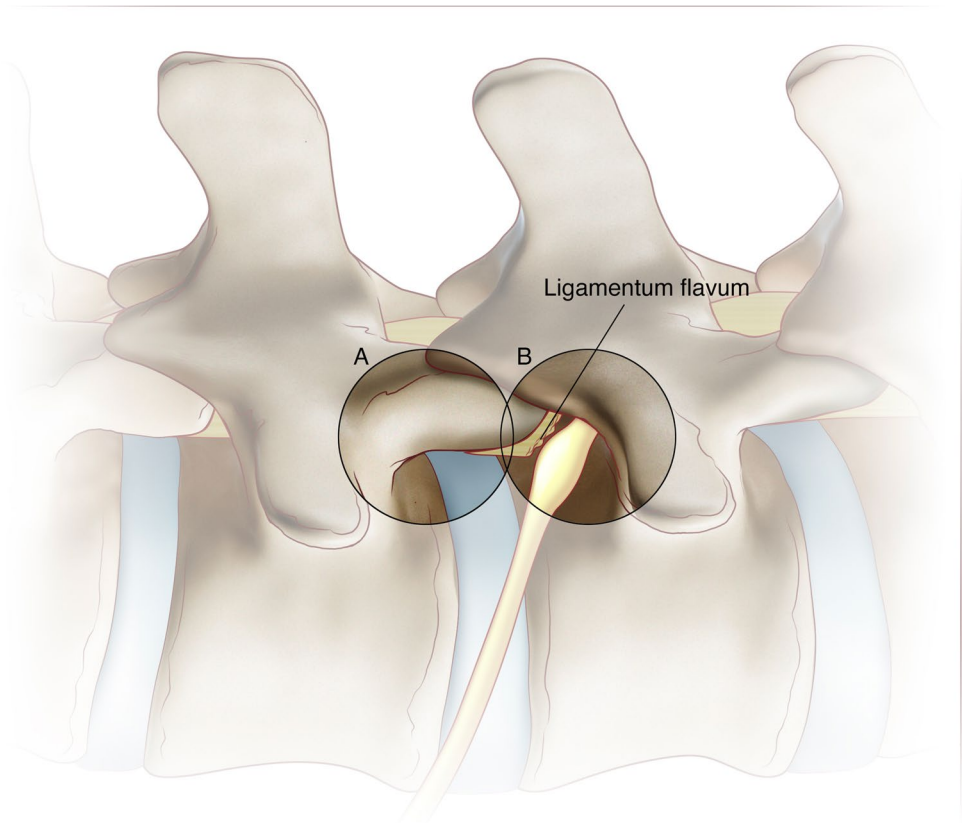

Fig. 2 Lateral and posterior view of the lumbar spine. **A** caudal to cranial (also known as "classic") approach. The dilator is set at the insertion of the transverse process with the superior articular facet of the inferior vertebra. Then, the inferior pedicle can be palpated, the disc is exposed first and the exiting nerve root located at the cranial part of the tube is not necessarily exposed. **B** cranial to caudal (also known as "top down") approach. First the tube should be docked on the pars interarticularis. The ligamentum flavum at the cranial aspect of the foramen is removed. A ball-tip probe is used to palpate the upper pedicle from below, thus allowing to locate the root. Once the root is exposed, the disc located caudally could be approached safely

herniation) and slightly ascendant. Then, we performed a vertical skin incision on the previous needle entry point, from almost 1.5 cm length. The muscle fascia was also penetrated with the blade, in the same proportion, even larger to let the tube going down to the vertebra. The tubular dilators (MetrX®, Medtronic) were subsequently introduced through the incision. We opted for a 18-mm caliber tube (could be 20 mm in patient harboring important bone remodeling due to severe arthritis). The first dilator is used to palpate the anatomy in the coronal and sagittal planes, reaching the lateral border of the L4–L5 facet joint and the superior border of L5 right transverse process. This maneuver also helps expedite soft tissue removal. Bipolar coagulation could be used to retract tissues to the periphery of the tube. A second (and last) fluoroscopy assessed the tube positioning. Navigation guidance could be useful to enhance the accuracy of the tubular retractor, while reducing the x-ray exposure for the surgical team [4, 5].

Afterwards, we went under microscopy (Pentero Zeiss®). Dedicated bayonet surgical instruments were used for this type of minimally invasive procedure. We identified the L4–L5 joint facet on the medial border of the tube and the transverse process at the caudal part of the tube. Additional soft tissues were removed using a Kerrison punch or a pituitary rongeur, taking care not to damage the exiting root which lies at the cranial part of the tube, going laterally. At this stage, intraoperative neuromonitoring could enhance the safety of the procedure. Such monitoring measures the mechanical response of muscle fibers to motor action potential, using direct nerve stimulation. To enhance foramen visualization, the lateral part of the L4–L5 facet joint can be resected with the Kerrison punch. With a Penfield dissector the posterior lateral part of the disc is exposed. Thanks to a ball-tip hook, the superior and inferior pedicles can be palpated. The nerve root is identified at the upper part of the disc, going down laterally. The nerve is surrounded with fat and vascular structures. In our case, we limited the dissection of the nerve. In this patient, the disc herniation has migrated upward and compressed the nerve root and the dorsal root ganglion in its foraminal portion. The compression could be felt with the hook. First, we made some space before performing any traction on the herniation. The annulus was incised followed by soft disc fragments removal with the pituitary rongeur. Once the bulging disc removed, we pulled back with the hook the migrated herniation. A huge fragment corresponding to the visible herniation on preoperative MRI was removed. We then observed a slight venous bleeding, easily controlled by transient pressure with a pad. The operative field was rinsed with saline solution. A gelfoam impregnated with naropene was inserted near the nerve root to get antalgic effect and avoid an epidural hematoma due to an empty space. Under microscopy, the tubular retractor has been withdrawn. Careful hemostasis was performed with the bipolar forceps. We ended the procedure with fascia, subcutaneous, and skin sutures. No drain was used. The whole procedure lasted less than 45 min, without quantifiable blood loss.

Indications

In this case, surgery was performed because of a compressive extraforaminal disc herniation responsible for intractable pain despite morphinic use, associated with motor and sensitive deficit (Fig. 3). Classic approach for such extraforaminal lesion could rely on a Wiltse open surgery. Instead, we performed a minimally invasive approach in order to reduce muscle retraction, avoid facet joint violation, bleeding, and postoperative pain.

Limitations

Performing extraforaminal tubular approach requires previous MIS experience with interlaminar approach. One could assume that the visualization of the exiting nerve root is not as clear as in Wiltse open dissection. If not sufficiently trained, the surgeon could damage the root at the very beginning of the surgery, placing too laterally and deeply the tube. When beginning with MIS technique, do not hesitate to perform additional fluoroscopy controls if you are not sure of your retractor positioning, especially anterior–posterior and lateral X-ray views. The use of 3D intraoperative imaging could be helpful to optimize the tubular retractor insertion, avoiding going too deep and lateral. Moreover, intraoperative neuromonitoring could improve preserving the exiting nerve root.

How to avoid complications

The operator requires sufficient knowledge of vertebral anatomy to ensure appropriate tube placement. One of the safety keys is to dock the first dilator on a bony structure medially to the foramen, in order to avoid to damage the root by going to deep laterally with the dilator tubes. Lateral and frontal fluoroscopy could be performed to assess the right positioning of the tubular retractor. As previously mentioned, intraoperative 3D navigation could enhance the safety of the procedure. Some advocate for root visualization as a first mandatory step before dissecting the disk (top-down approach) (Fig. 2) [2]. According to Virk et al., when performing the top-down approach, first the tube should be docked on the pars interarticularis to prevent unnecessary soft tissue removal from the superior facet joint and transverse process. Second, Virk et al. reported the removal of the ligamentum flavum at the cranial aspect of the foramen,

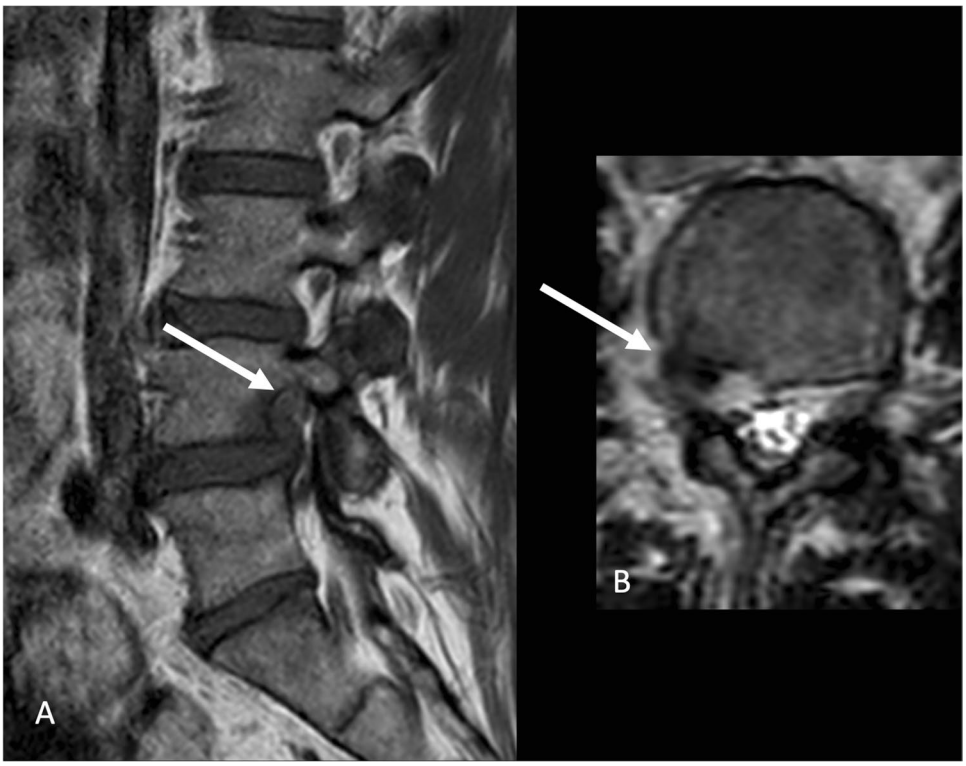

Fig. 3 Preoperative lumbar spine MRI. **A** T1-weighted MRI, sagittal plane, extruded herniation located in the L4–L5 foramen, compressing L4 exiting nerve root and ganglion, with disappearance of the peri radicular fat. **B** T2-weighted MRI, axial plane, extraforaminal disc herniation, moving the root backwards

and third a ball-tip probe was used to palpate the pedicle from below. The root is located in the upper third of the neuroforamen, surrounded by fatty tissue and vessels. We avoid using bipolar cautery in this area, not to hurt the root and its ganglion. We prefer soft dissection with Penfield dissectors. Once the root is exposed, the disc located caudally could be approached safely. Other surgeons approach the vertebral disk directly, avoiding dissecting too cranially and laterally to damage the exiting nerve root. If you perform an extra foraminal approach from the inferior part of the foramen, you have to identify the transverse process and then dissect cranially and medially. Then, you will palpate more deeply the disc which is usually recovered with some fat and vascular structures.

If performing an extraforaminal approach at the L5-S1 level, be aware of a smaller surgical corridor, constrained by the sacral ala and to a lesser extent the lateral facet and L5 transverse process [6]. In the latter case, the use of navigation is all the more justified.

Some authors reported higher reoperation rates and recurrent herniation using MIS [1]. Minimally invasive technique does not mean minimally disc resection. Such MIS exposure affords appropriate condition to perform large disc herniation removal. The tube can be adjusted during the procedure to check the nerve root decompression and ensure patient pain relief. At the end of the procedure, the nerve should be loose.

Specific perioperative considerations

Preoperative workup

To perform MIS in optimal conditions, following devices are needed:

1. Intraoperative fluoroscopy
2. Dedicated tubular retractors and bayonet surgical instruments
3. Surgical microscope

The use of 3D imaging for intraoperative navigation could enhance the accuracy of the tubular retractor placement. As well, intraoperative neuromonitoring with direct nerve stimulation is helpful when dissecting around the exiting nerve root.

Instructions for postoperative care

After such extraforaminal MIS approach, the patient can be lifted up the same day, without any particular restrictions. It can be performed as an outpatient lumbar spine surgery. We do not carry out systematic postoperative imaging, except in case of persistent neurologic deficits or pain.

We usually suture the centimetric scar with absorbable sutures and recommend bandages care every other day for 12 days.

Specific information to give to the patient about surgery and potential risks

In this case of right L4–L5 extraforaminal disc resection, the main risks of the surgical procedure are as follows:

- Lesion of the exiting nerve root (L4), or the root ganglion with potential neuropathic pain.
- Disc herniation recurrence (3.5 to 7% in literature series [3]).

Other general risks, such as infectious complications, postoperative hematoma or scar closure difficulty have to be discussed with the patient. The intraoperative use of X-rays also has to be mentioned.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00701-023-05513-w.

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Declarations

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (name of institute/committee) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The patient gave formal consent to publication of this video.

Conflict of interest The authors declare no competing interests.

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Summary of 10 key points Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

1. MIS for extraforaminal approach is appropriate in the lumbar spine, but requires previous MIS experience with interlaminar approach.
2. A preoperative MRI with axial and sagittal planes is mandatory to assess with precision the position of the root and the potential migration of the disc herniation. In case of chronic evolution of the symptoms, an additional preoperative CT scan is useful to assess disc calcification.
3. Incision should be performed 4 cm from the midline, if too medial the foramen could not be approached conservatively.
4. Inserting the dilator, you aim at the superior part of the foramen, with a convergent and ascendant trajectory.
5. The first dilator could be used to palpate and identify the articular complex, the pars interarticularis and the inferior transverse process.
6. Dock the first dilator on bony structure in order to avoid hurting the exiting nerve root in its extraforaminal trajectory.
7. Use fluoroscopy first in lateral view, and then if necessary, in A-P view to assess tube positioning.
8. The exiting root could be identified under the superior pedicle, using Penfield dissectors.
9. Avoid unnecessary bipolar coagulation in the soft tissue surrounding the nerve root.
10. Then, the surgeon work in the Kambin's triangle to perform the disc herniation removal.