Original Article

# Navigation-assisted extraforaminal lumbar disc microdiscectomy: Technical note


## ABSTRACT

**Background:** Extraforaminal lumbar disc herniation (ELDH) amounts of 7%–12% of all lumbar disc herniations. Although they have already been widely described, an optimal treatment is still under discussion in the literature.

**Objective:** We describe a novel application of navigation using 2D/3D imaging system to plan an adequate surgical trajectory and performing a neuronavigated microdiscectomy in ELDH that has not been previously described.

**Methods:** This is a retrospective study in a single institution. Between February 2017 and July 2020, a total of 12 patients (7 males and 5 females), with a mean age of 56 years (range 49–71 years), have been treated because of ELDH through a far lateral microdiscectomy using 2D/3D imaging system-assisted neuronavigation (O-arm).

**Results:** No intraoperative and/or postoperative complications were recorded. Patients presented a mean preoperative Visual Analog Scale (VAS) score of 7.83 ± 0.83 (range 7–9). At the day of discharge, leg pain VAS score effectively improved, decreasing to a mean value of 1.83 ± 0.83 (range 1–3). Further, low back and radicular pain improvement was recorded at 1-, 6-, and 12-month follow-up, respectively.

**Conclusion:** We described a novel use of 2D/3D imaging system navigation in the microsurgical treatment of ELDH that has not previously reported. This technique is safe and effective and provides more intraoperative details compared to fluoroscopy, which can be crucial for the success of the procedure and to reduce complications and particularly indicated in complex cases with altered anatomy.



**Keywords:** Extraforaminal, lumbar disc herniation, microdiscectomy, Navigation, O-arm



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## INTRODUCTION

Lumbar disc herniation can be treated with several techniques that include mainly microdiscectomy, foraminal or interlaminar, endoscopic discectomy. Extraforaminal lumbar disc herniation (ELDH) amounts of 7%–12% of all lumbar disc herniations.[1,2] Although they have already been widely described, an optimal treatment is still under discussion in the literature. Surgical removal can be accomplished through intertransverse or Wiltse approach with open, minimally invasive, or endoscopic techniques.[3] In the modern era, fundamental tools are represented by intraoperative neurophysiological monitoring (IONM), operating microscope, and intraoperative navigation-assisted fluoroscopy. It is


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known that standard fluoroscopy is bidimensional, then the surgeon must recreate in his mind 3D anatomy of the patient and related pathology that sometimes can be difficult and misleading.[4] There are many sophisticated devices that allow to acquire 2D/3D intraoperative images such as intraoperative computed tomography (iCT), O-arm, ZiehmVario 3D C-Arm, and Loop-X. These devices are widely used for pedicle screw placement, deep brain stimulation, brain tumor resection, and spine trauma.[5] We describe a novel application of 2D/3D imaging system navigation to plan an adequate surgical trajectory and performing a microdiscectomy in ELDHs, that has not been previously described.

## METHODS

This is a retrospective study in a single institution. Between February 2017 and July 2020, a total of 12 patients (seven males and five females), with a mean age of 56 years (range 49–71 years), have been treated because of ELDH through a far lateral microdiscectomy using 2D/3D imaging system neuronavigation (O-arm). All patients presented low back pain and radicular pain. The most affected levels were L4–L5 (6 cases), L3–L4 (3 cases), and L2–L3 (3 cases). Patients were assessed pre- and postoperatively using the Visual Analog Scale (VAS) [Table 1]. Preoperative diagnostic examinations included lumbar CT ad magnetic resonance imaging (MRI). Six-month postoperative lumbar MRI was also performed. All patients were evaluated at 1 month, 6 months, and 12 months, respectively, after surgery.

### Surgical technique

All surgical procedures were performed under general anesthesia, IONM, and operating microscope. Patients were positioned prone on the radiolucent imaging surgical table with chest and pelvic bolsters. Using 2D/3D imaging system in antero-posterior and latero-lateral view, the reference frame was inserted through a percutaneous pin to the right (contralateral) posterior superior iliac spine [Figure 1]. We recommend using spinal needles as markers to identify the correct intertransverse space and neuroforamen, comparing it with preoperative lumbar MRI [Figure 2].

Using O-Arm (Medtronic Navigation, Louisville, CO, USA), a 3D scan of the patient was acquired, and the data transferred to the StealthStation S7 surgical navigation system (Medtronic Navigation, Louisville, CO, USA). Using the pointer and a virtual tip offset of variable length, the entry point and surgical trajectory were identified. Navigation accuracy was preoperative and intraoperative checked touching with the tip of the probe the pin surface of the reference frame [Figure 3]. A 2-cm paramedian incision was made through the skin and fascia, and a smooth dissection together with a placement of a minimally invasive spine surgery tubular self-retractor were performed.

At this point, the correct position of the retractor was assessed with the navigation pointer and if needed, adjustments were made. Anatomic landmarks including the medial aspect of the transverse process, lateral aspect of the

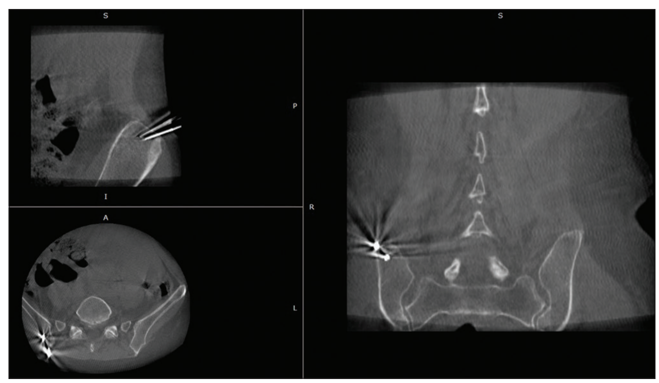

Figure 1: Multiplanar reformation images showing the correct positioning of the pin to the right posterior superior iliac spine to place the reference frame

**Table 1: Demographics of patients affected by extraforaminal lumbar disc herniation**

| Patient | Age (years) | Sex | Level | Side | Symptoms | Duration of symptoms | Preoperative leg pain VAS score | Postoperative leg pain VAS score |
|---|---|---|---|---|---|---|---|---|
| #1 | 61 | Female | L4-L5 | Left | Low back pain+left L4 radicular pain | 6 months | 7 | 2 |
| #2 | 57 | Male | L4-L5 | Right | Low back pain+right L4 radicular pain | 2 months | 7 | 3 |
| #3 | 49 | Male | L2-L3 | Right | Low back pain+right L2 radicular pain | 3 months | 9 | 2 |
| #4 | 52 | Male | L4-L5 | Right | Low back pain+right L4 radicular pain | 2 months | 8 | 3 |
| #5 | 57 | Male | L4-L5 | Left | Low back pain+left L4 radicular pain | 2 months | 9 | 1 |
| #6 | 61 | Male | L4-L5 | Right | Low back pain+right L4 radicular pain | 2 months | 7 | 2 |
| #7 | 58 | Female | L2-L3 | Left | Low back pain+left L2 radicular pain | 2 months | 8 | 1 |
| #8 | 71 | Female | L3-L4 | Left | Low back pain+left L3 radicular pain | 3 months | 9 | 2 |
| #9 | 53 | Male | L4-L5 | Right | Low back pain+right L4 radicular pain | 3 months | 7 | 3 |
| #10 | 48 | Male | L3-L4 | Left | Low back pain+left L3 radicular pain | 2 months | 8 | 1 |
| #11 | 51 | Female | L2-L3 | Left | Low back pain+left L2 radicular pain | 3 months | 7 | 1 |
| #12 | 54 | Female | L3-L4 | Left | Low back pain+left L2 radicular pain | 3 months | 8 | 1 |

VAS: Visual Analog Scale

pars interarticularis, inferior articular facet, superior articular facet, and facet joint line were also recognized [Figure 4]. A paramedian muscle-splitting intertransverse technique was performed, improving disc and nerve root visualization, and reducing soft-tissue damage. The nerve root was identified and retracted using a dissector and cottonoids, preserving radicular vessels. The disc fragment was mobilized with a hook and removed with pituitary pounches [Figure 5]. Removal of the whole disc was not performed.

Finally, the exploration along the nerve route showed no evidence of nerve impingement, with a pulsating and decompressed nerve root. A final intraoperative check in neuronavigation was performed in all patients to verify the disc herniation removal. Hemostasis was performed with irrigation and bipolar cauterization. No drainage was used, and the wound was closed in the standard fashion. All patients were mobilized on the first postoperative day. 6-month postoperative MRI was performed in all cases [Figure 6].

## RESULTS

All 12 patients presented with pure extraforaminal disc herniations and underwent O-Arm neuronavigated far lateral lumbar microdiscectomy. The mean duration of the symptoms was 2.7 months (range 2–6 months). Intraoperatively, no vascular, dural, and/or nerve injury had been encountered. Blood loss was minimal in all cases. Surgical time was measured after draping, from the O-Arm scan to the wound closure, with a mean value of 49.3 min (range 37–53 min). No intraoperative and/or postoperative complications were recorded. Patients presented a mean preoperative VAS score of 7.83 ± 0.83 (range 7–9). At the day of discharge, VAS score effectively improved, decreasing to a mean value of 1.83 ± 0.83 (range 1–3). Further, low back and radicular pain improvement were recorded at 1-, 6-, and 12-month follow-up, respectively.

## DISCUSSION

A key point in lumbar extraforaminal microdiscectomy is represented by fluoroscopic centering, which accuracy

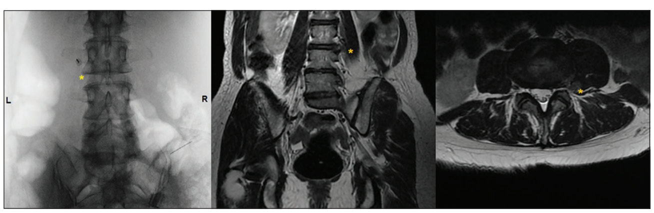

Figure 2: Antero-posterior projection showing the correct positioning spinal needle identify the correct left L3–L4 intertransverse space and neuroforamen (Left, yellow asterisk) Preoperative coronal and axial T2-weighted magnetic resonance imaging images showing pure left L3–L4 extraforaminal lumbar disc herniation (center and right, yellow asterisks)

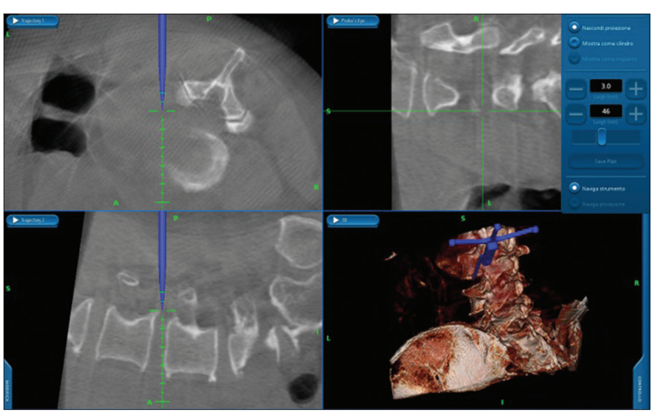

Figure 4: Intraoperative checking using the pointer and a virtual tip offset of variable length to choose the correct surgical trajectory and to identify the anatomic landmarks

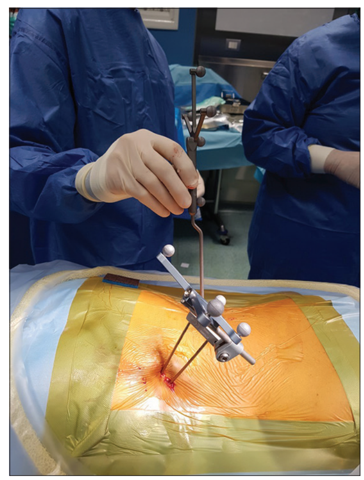

Figure 3: Preoperative checking of navigation accuracy touching with the tip of the probe the pin surface of the reference frame

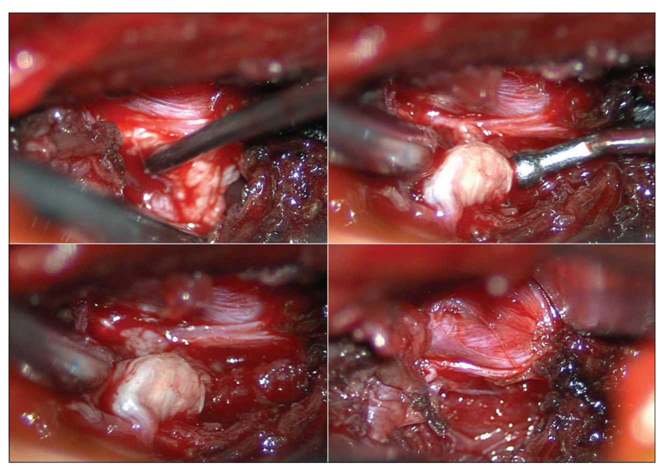

Figure 5: Intraoperative images showing extraforaminal lumbar disc herniectomy. The disc fragment was mobilized with a hook and removed with pituitary pounches. The exploration along the nerve route showed no evidence of nerve impingement, with a pulsating and decompressed nerve root

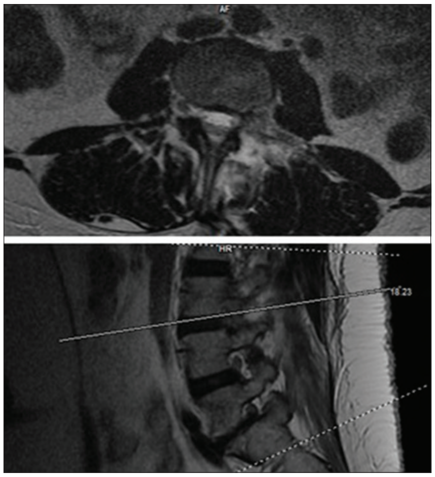

**Figure 6: Postoperative axial (up) and sagittal (down) T1-weighted magnetic resonance imaging images showing left L3–L4 extraforaminal lumbar herniectomy**

allows to reduce surgical exposure, thus performing minimally invasive surgery and related approaches. In the presence of complex anatomy, surgical orientation can be challenging (i.e., obese patients, severe arthrosis, and far lateral approaches). Using intraoperative 2D/3D imaging devices, allow to easily establish the safer and shorter route to the target. Moreover, these devices assist all the procedure allowing to confirm the presence of the disc herniation before start surgery, guide the surgical trajectory, show the entity of disc removal at the end of the procedure and guide the eventual spine fusion if required. In literature use of 2D3D imaging system has been reported in endoscopic lumbar disc surgery, but not in lumbar extraforaminal microdiscectomy.[6] Discogram can be useful to better evaluate the disc herniation consistency and position, of great importance in the presence of migrated fragments. Moreover, the pain can be caused by disc herniation as well as disc granulation tissue[7,8] that can be effectively coagulated with bipolar forceps or radio frequency or laser improving discogenic back pain.[9,10] It is not hard to confirm that low dose multiplanar discography shows a better accuracy to evaluate disc rupture compared to fluoroscopic discography.[11] Spine navigation can assist trajectory adjustments with the aim to coagulate the granulation present nearby the disc fissure and to accomplish a safe and complete disc removal. The use of intraoperative MRI has been also proposed, but it presents several limitations such as elevated costs, longer surgical time, limitation of the surgical positioning, need of MRI compatible surgical instruments, and dedicated surgical room.[12] Nevertheless, the main limitation of the O-arm is represented by the initial cost of machine acquisition[13] low quality in the evaluation of soft tissues. The radiation exposure of the patient is slightly increased compared to standard fluoroscopy, but if we consider the avoidance of postoperative imaging controls, the possibility to evaluate the accuracy of the eventual instrumentation (pedicle screws and intersomatic cages) avoiding misplacement and consequent further surgeries, we can state that intraoperative imaging is safe and cost saving compared to standard fluoroscopy.[14] Our results suggest that O-arm navigation-assisted extraforaminal lumbar disc microdiscectomy reduces intraoperative complication and represent another technique in the neurosurgical armamentarium for the treatment of these difficult pathologies of the spine. ELDH are characterized by severe pain, worse than the common posterolateral disc herniations and are more commonly associated to neurological deficits.[15-17] It is important to reduce facet damage to prevent spinal instability.[18-21] The use of paramedian approaches for ELDH has been reported to be of great importance to reduce facet removal if compared with the common median approach, which allows to reduce postoperative pain and spine instability.[22-24] The use of percutaneous techniques is a well-known option, but it is of limited utility in the presence of migrated fragments.[1,25,26] The use of endoscopy is also effective in the treatment of these pathologies, but requires a dedicated learning curve, cost needed for the equipment acquisition and maintenance. Furthermore, the endoscopic tools occupy part of the distractor space, thus reducing the surgical field. On the contrary, the technique described in this manuscript is a real minimally invasive approach that takes advantages from the familiarity of majority of the neurosurgeons with the use of the intraoperative microscope. In our series, the 2D/3D imaging system navigation-assisted extraforaminal lumbar disc microdiscectomy demonstrated to be a useful tool that helps in minimizing tissue dissection by adopting the best surgical trajectory, easily set by navigation. Even if we report a relatively small patient series, our satisfying results demonstrate that this is a valid and reproducible technique which allows to use the familiar microsurgical technique for the treatment of the ELDH, with the advantage of spinal navigation which allows to identify the best trajectory and to check the entity of the herniectomy.

## CONCLUSION

We described a novel use of 2D/3D imaging system navigation in the microsurgical treatment of ELDH that has not previously reported. Our initial experience suggests that this technique is safe and effective and provides more intraoperative details compared to fluoroscopy, which can be crucial for the success of the procedure and to reduce the complications. Multiplanar reconstruction is particularly indicated in complex cases with altered anatomy.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

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