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ORIGINAL PAPER

Outcomes of percutaneous endoscopic trans-articular discectomy for huge central or paracentral lumbar disc herniation

Yu Wang[1] · Yuqing Yan[1] · Jin Yang[1] · Lifeng Zhang[1] · Chuan Guo[1] · Zhiyu Peng[1] · Hao Wu[1] · Dongfeng Zhang[1] · Qingquan Kong[1]

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Abstract

Purpose This study reports a new technique known as percutaneous endoscopic trans-articular discectomy (PETAD) for huge central/paracentral lumbar disc herniation (LDH).

Methods Sixteen patients with huge central/paracentral LDH who underwent PETAD in our department from July 2015 to July 2016 were retrospectively analyzed. Clinical outcomes were evaluated according to pre-operative and post-operative visual analog scale (VAS) and Oswestry disability index (ODI) scores and the MacNab criteria. Immediate post-operative MRI and CT were conducted to confirm complete removal of LDH along with follow-up flexion-extension X-ray to observe lumbar stability.

Results The huge central/paracentral LDH was completely removed by PETAD in 16 patients, as confirmed by post-operative MRI and CT. Leg pain was eased after removal of the disc herniations. The satisfactory (excellent/good) results were 93.7%. The mean follow-up duration was 15.6 (range, 3–24) months. The mean pre-operative VAS and ODI scores were 5.72 ± 1.18 (range, 4–9) and 60.1 (range, 51–87), respectively, which decreased to 1.26 ± 0.81 (range, 0–3) and 18.1 (range, 10–31), respectively at the third month post-operatively and to 0.78 ± 0.62 (range, 0–1) and 7.2 (range, 0–15), respectively by the last follow-up visit. No recurrence and segmental instability was observed in any of the 16 patients during the follow-up period.

Conclusion PETAD could be a good alternative for treatment of huge central/paracentral LDH.

Keywords Central/paracentral lumbar disc herniation · Percutaneous endoscopic trans-articular discectomy · Tunnelplasty

Introduction

After Kambin first proposed the concept of posterolateral percutaneous lumbar disc decompression in 1973 [1], people had widely improved the technique of percutaneous endoscopic lumbar discectomy (PELD). Nowadays, PELD has become increasingly popular in treating kinds of lumbar disc herniation (LDH) [2–6]. Initially, percutaneous endoscopic lumbar foraminoplasty (PELF) was an important step following the PELD, which is used to enlarge the foramen using trephine and/or high-speed drill to insert the endoscopic system into the spinal canal [7–9]. Thereafter, foraminoplasty was used as a decompressive method when treating lumbar spinal stenosis [10, 11]. The procedure of foraminoplasty was facilitated by changing the specific location of the needle tip and trajectory of trephine to decompress different compressive pathology.

Various foraminoplasty methods are available [12]. The classical TESSYS technique popularized by Hoogland et al. first introduced the foraminoplasty which resected the upper-ventral part of the superior articular process (SAP) [4]. To decompress the lateral recess, variation of the TESSYS technique was needed for removal of lower-ventral part of SAP [7, 10]. In other cases, such as far-migrated disc herniation, a portion of the pedicle should be removed along with SAP in foraminoplasty [13]. We also reported an accurate two-step decompression via foraminoplasty: cutting the medial-ventral part of the SAP and lateral-ventral part of the inferior articular process (IAP), in treating lumbar stenosis containing both retrodiscal space and lateral recess [14]. Very recently, the new concept of percutaneous endoscopic ventral facetectomy has been proposed [15]. Besides, others used similar technique to create working canal via the translaminar

Yu Wang and Yuqing Yan are co-first authors.

✉ Qingquan Kong
kqqspine@126.com

[1] Department of Orthopedics Surgery, West China Hospital, Sichuan University, No. 37, Guoxue Lane, Wainan Street, Wuhou District, Chengdu 610041, Sichuan, China

approach to treat down-migrated LDH [16]. In summary, most current existing PELF focused on removing different parts of SAP.

However, PELF is challenging especially for central/paracentral LDH patients because firstly the dural sac becomes flat and laterally expands resulting from the compression of huge central disc segments; the dural sac and nerve root may easily become injured during foraminoplasty. Second, to reach the central site, more SAP should be resected, which leads to post-operative low back pain (LBP) and potential lumbar instability.

In this study, to solve the aforementioned challenges, we first introduced a new technique to effectively and safely remove the central/paracentral LDH by percutaneous endoscopic trans-articular discectomy (PETAD) using our designed depth-limited trephine and analyzed its short-term clinical outcomes.

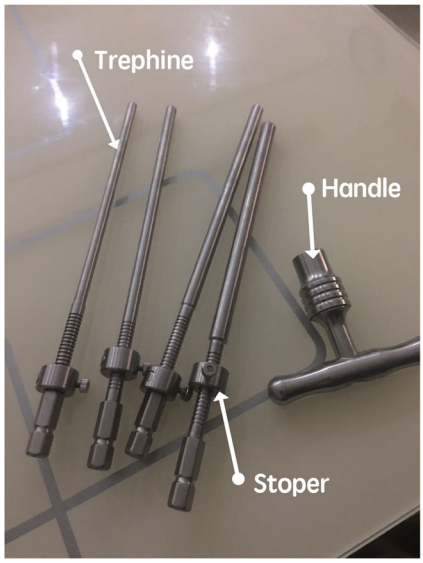

Fig. 1 Specially designed depth-limited trephine

Materials and methods

Sixteen patients with huge central/paracentral LDH who underwent PETAD in our department from July 2015 to July 2016 were retrospectively involved in this study. All procedures were performed by a single endoscopic spine surgeon. Data on sex, age, duration of symptoms, and history of surgery of every patient were collected. Visual analog score (VAS), Oswestry Disability index (ODI), and the MacNab criteria were used by an independent surgeon to assess the clinical outcomes. Patients usually undergo immediate post-operative MRI and CT and are permitted to be discharged. In the last follow-up, patients should undergo MRI to confirm that LDH has not recurred and flexion-extension X-ray to observe lumbar stability.

Surgical tools

Our specially designed instrument for tunnelplasty (ZL 201621149959.2) consists of a trephine, handle, and stopper (Fig. 1). The saw tooth of the trephine is similar to that of the traditional trephine. The trephine has different diameters: 6.5 mm, 7.5 mm, and 8.5 mm. However, the total length of the trephine is the same (243 mm). In the proximal end of the trephine, there are 17 circular grooves; the first groove is 165 mm away from the distal end of the trephine with an interval of 2 mm in the adjacent grooves. The depth of tunnelplasty was accurately controlled and limited by the stopper located in the trailing end of the trephine. The stopper is locked in one of the grooves; the trephine cannot advance because of the obstruction of the stopper from the protective cannula. The desired tunnelplasty depth can be adjusted by the location of the stopper. The handle can be easily assembled and unassembled from the trephine.

Surgical technique

In all patients, PETAD was performed in the prone position on a radiolucent table. The procedure was assisted using C-arm fluoroscopy. Local anesthesia was used to facilitate communication between the surgeon and the patient. First, we inserted an 18-gauge needle by posterolateral approach after infiltrating the intended needle entry tract with 8–10 ml of 0.5% lidocaine. In the lateral view, the needle tip should lie at the tip of the SAP, while the tip of the needle in the anteroposterior (AP) view should be at the lateral surface of the tip of the SAP (Fig. 2d, e).

Then, the needle is replaced with a 1-mm-diameter guide wire after infiltrating 15–20 ml of 0.5% lidocaine in the intervertebral foramen. A blunt, tapered cannulated obturator is inserted over the guide wire under fluoroscopic control. Sequential protective cannulas were inserted over the obturator. Finally, the protective cannula was inserted and was placed in appropriate position.

The depth-limited trephine was used to perform tunnelplasty. The inclination of the depth-limited trephine trajectory should be from the tip of the SAP to the posterior rim of the upper endplate in lateral view and from the tip of the SAP to the midpoint of the upper endplate in AP view (Fig. 2a, b). In the tunnelplasty process, the surgeon should consciously under draft the trephine, keeping the horizontal angle at 5–15°.The accurate depth of tunnelplasty was determined by axial CT scans pre-operatively or based on clinical experience (commonly 15 mm) and was adjusted via the location of the stopper immediately after the trephine reached the facet joint. We should carefully advance the depth-limited trephine with rotation under fluoroscopic guidance. To ensure the inner-ventral part of the SAP, outer-ventral part of the IAP, and a part of the articular facet were removed, the final

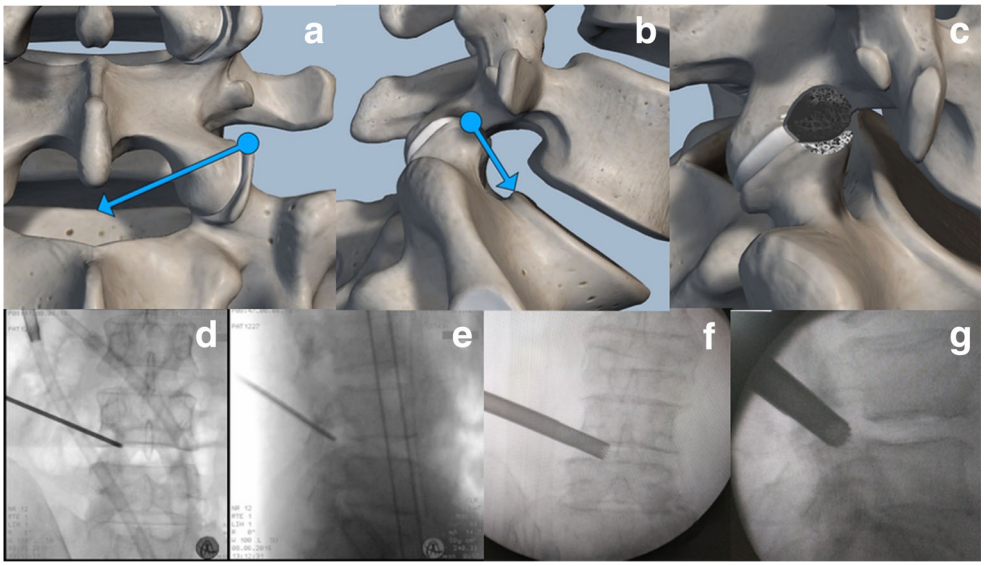

Fig. 2 **a**, **b** Schematic diagram of the inclination of the trephine trajectory in AP and lateral view (shown by blue arrow). **c** Mimic diagram of the post-operative facet joint: inner-ventral part of the SAP, outer-ventral part of the IAP, and a part of an articular facet were removed. **d**, **e** Initial location of the needle tip in AP and lateral view. **f**, **g** Final location of the distal end of the trephine

location of the distal end of the trephine should be confirmed; the distal end of the trephine should reach the midpoint of the spinous process and the medial surface of the pedicle in the AP view, while that just arrived in the ventral boundary of the SAP in the lateral view (Fig. 2f, g). The above-mentioned structure could be removed along with the trephine once they were cut off. The ideal diameter of the bony tunnel was slightly larger than 8 mm to allow the working cannula to pass through.

Subsequently, an 8-mm working cannula replaced the protective cannula. In some cases, additional tunnelplasty was performed when the initial process was insufficient. Then, the herniated nucleus was endoscopically removed by endoscopic forceps through the lateral aspect of the dura. Further, adjusting the working cannula to completely resect any other sequestered discs and hypertrophied posterior longitudinal ligament is necessary. The surgeon can see and mobilize both the traversing, exiting nerve root and the dural sac under endoscopic visualization. Free movement of nerve root and dural sac indicates complete decompression. The radiofrequency probe was used to control epidural bleeding under saline irrigation.

Results

The mean age of the 16 patients was 51.9 (range, 24–76) years, of which nine were male and seven were female. All patients were diagnosed with single-level central/paracentral LDH with the complaint of leg pain with or without LBP. Pre-operative blocking of nerve root could be applied for diagnosis in some intractable cases. The mean duration of symptoms was 8.6 months (range, 4–36). Pre-operative MRI and CT images were obtained in all patients. The patients with lumbar spinal stenosis were excluded. The mean follow-up period was 15.6 months (range, 3–24). The level was L4/5 in ten patients and L5/S1 in six patients.

Clinical outcomes

PETAD was successfully performed in all 16 patients without formation of haematomas, dural tears, or any nerve root injuries. Leg pain was immediately eased after removal of the disc herniation. According to the modified MacNab criteria, satisfactory (excellent/good) results were 93.7% (excellent; 8, good; 7, and fair; 1). The mean pre-operative VAS and ODI scores were 5.72 ± 1.18 (range, 4–9) and 60.1 (range, 51–87), respectively, which decreased to 1.26 ± 0.81 (range, 0–3) and 18.1 (range, 10–31), respectively at the third month post-operatively and to 0.78 ± 0.62 (range, 0–1) and 7.2 (range, 0–15), respectively by the last follow-up visit. In addition, we found post-operative LBP in one patient, which was relieved after conservative treatment. No recurrence and segmental instability were observed in any patient in the last follow-up.

Case presentation

A 51-year-old male patient who could not walk for 1 month was treated in our department. He complained of severe left radicular pain with severe left buttock and leg pain for two months. A huge paracentral LDH in L4/5 was confirmed. After careful analysis, PETAD was performed. We confirmed total decompression by postoperative MRI. The leg pain was relieved immediately after the operation. In the last two year follow-up, no LDH recurrence and lumbar instability were indicated (Fig. 3).

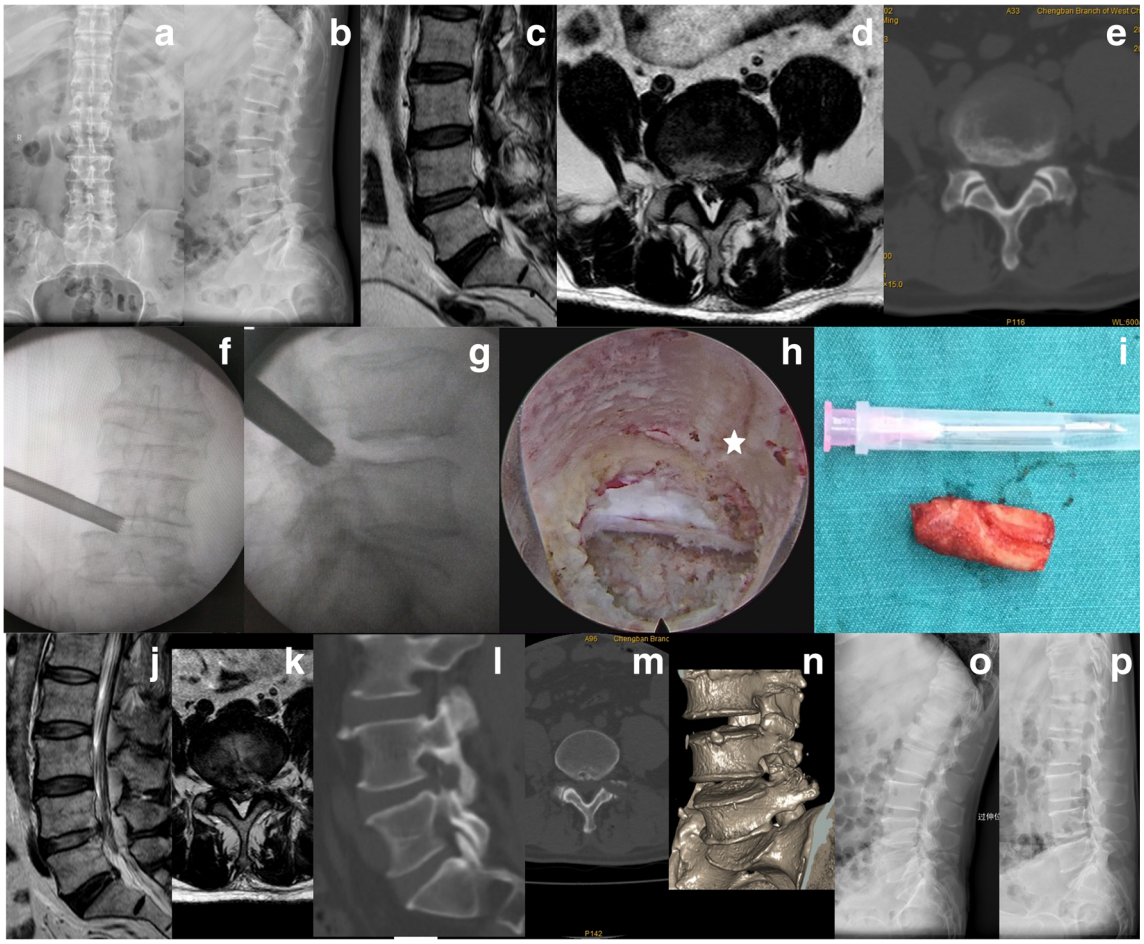

Fig. 3 **a**, **b** Pre-operative X-ray in AP and lateral views. **c**, **d** Pre-operative MRI indicated the left huge paracentral LDH in L4/5. **e** Pre-operative bony window axial CT scan in L4/5. **f**, **g** Fluoroscopy during operation shows the final location of the distal end of the trephine. **h** Intra-operative endoscopic view. The white star shows the articular facet. **i** The removed facet joint including inner-ventral part of SAP, outer-ventral part of IAP, and a part of articular facet. **j**, **k** Post-operative T2-weighted magnetic resonance images shows that the paracentral LDH was completely removed. **l**, **m**, **n** Post-operative CT scan clearly indicates the bony tunnel. **o**, **p** Post-operative flexion-extension X-ray in the last follow-up indicated no lumbar instability

Discussion

Central/paracentral LDH is commonly seen clinically; its symptoms are varied. Pain symptoms typically occur on one or both sides of the lower extremities. Additionally, large central/paracentral LDH is the most common cause for cauda equine syndrome (CES). Fortunately, we did not experience CES in the present series. Large central/paracentral LDH is a challenge for spinal surgeons. In the conventional lumbar posterior approach, the range of laminectomy is larger than that for simple lateral LDH, and the traction of the dural sac tends to be greater with this approach as well. In the past, several types of laminectomy and partial facetectomy were used in posterior approaches for the surgical treatment of large central/paracentral LDH [17, 18]. However, the procedures may cause potentially post-operative instability and occasionally require fixation and fusion. Other surgeons advocate the transdural approach [19, 20]; however, this method has the potential disadvantage of postoperative CSF leakage. With the development of full-endoscopic technique, PELD was used for the treatment of central/paracentral LDH; however, its significance was still controversial. Choi analyzed 10,228 cases treated with PELD and reported that the frequency of incomplete decompression was high in the case of central LDH [21]. Lee and Kang reported good operative outcomes for central LDH patient using percutaneous endoscopic herniotomy [22, 23]. Li also reported good outcomes in 16 consecutive patients with CES who underwent PELD [17]. At present, percutaneous endoscopic interlaminar discectomy (PEID) can also treat central/paracentral LDH well with the advantage of adequate operative space and not damaging facet joint [24]. However, PEID must be performed under general anaesthesia which increases the operative time and risk especially in older patients. There is still no universally accepted surgical technique in treating central/paracentral LDH.

Even though percutaneous endoscopic transforaminal discectomy with foraminoplasty could also [25] treat central/paracentral LDH, there are many drawbacks. To widen the "foraminal gate," various current foraminoplasties aimed at the partial removal of SAP. However, to reach the target site and provide adequate endoscopic exposure, the resection of SAP for large central/paracentral LDH will be more than that in lateral LDH, which was bound to affect the integrity of the facet joint (Fig. 4). Additionally, in older LDH patients, hypertrophy of the facet joint often appeared simultaneously, which made the foraminoplasty difficulty. We believe that reducing unnecessary SAP damage may prevent potential post-operative LBP and lumbar instability. Conversely, the "Kambin's triangle" is not completely safe in the case of large central/paracentral LDH, because the dural sac becomes flat and laterally expands because of LDH compression. Thus, in the process of SAP-resected foraminoplasty, the dural sac and inferior nerve root may easily get injured; these pose as disadvantages and technical challenges even for the experienced endoscopic spine surgeons. In this study, we creatively use PETAD in treating central/paracentral LDH patients. The entire procedure is similar to typical TESSYS technique. Our improved tunnelplasty method has several advantages. First, our approach may allow the working cannula to directly target the central/paracentral LDH (Fig. 4). The key step of PELD is to position the working channel near the herniated mass. In our technique, the working cannula was passed through the created bony tunnel to reach the herniation. The shorter distance between the working cannula and the target site potentially avoids injury to the dural sac and nerve root during the process of puncture and construction of the working cannula. Second, to avoid extensive resection of SAP, the PETAD only removes a part of the facet joint, including the part of the medial-ventral SAP, lateral-ventral IAP, and articular surface. Most of the SAP can be reserved, which is crucial for preventing post-operative lumbar zygapophyseal joint pain [26]. In our study, only one patient presented post-operative LBP with a rate lower than traditional full-endoscopic lumbar discectomy: 12% reported by Rutten [27]. The diameter of our trephines varies between 6.5 and 8.5 mm: a little thicker than conventional procedures. Third, using our depth-limited trephine, the dural sac and nerve root can be well protected and the risk of damage is extremely low. As noted above, the dural sac and nerve root directly lied below the medial-ventral facet joint, which means that the procedure of depth limitation was indispensable. With the protection of the stopper, the excision size can be accurately controlled. Driven by hand, the trephine could only cut off the bony structure; hence, the flavum ligament remained during the procedure, avoiding any damage to the nerve root or dural sac. In addition, surgeons could get instant feedback from patients because they were kept awake under local anaesthesia.

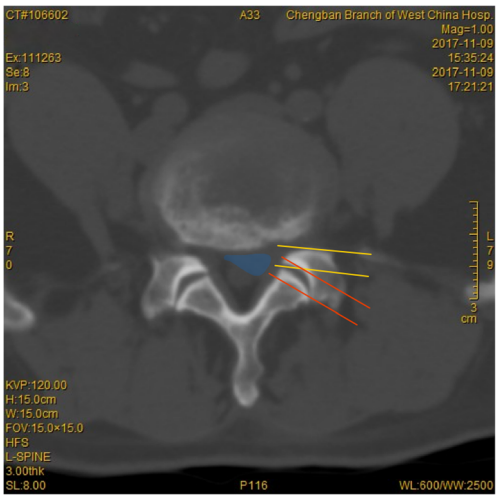

Fig. 4 The blue region shows the location of the huge paracentral LDH. The two yellow lines indicate that portion should be removed in traditional foraminoplasty. The two red lines indicate the portion needs to be removed in our trans-articular tunnelplasty

We are also concerned about the effect on post-operative lumbar segmental stability after the removal of a part of the facet joint. Although facetectomy may decrease spinal stiffness and increases the mobility of the spinal motion segment in all modes of loading [28–30], there is still no evidence that injured or damaged facet joints consequently induce the mechanical instability of the spine [31]. Moreover, our trans-articular tunnelplasty only resect a small part of the facet joint, about less than 10–20% of the whole facet joint. Osman [32] removed the anteriomedial third of the SAP, anterior part of IAP, and portion of the joint between them via posterior and transforaminal decompression in a cadaver biomechanical study and indicated that no flexibility change and instability occurred. The range was a little more than ours. Thus, we think that there was no violation of the anatomic integrity of the spine in our technique, and the risk of surgically induced instability was minimized. We designed lumbar dynamic position X-ray in each patient in the last follow-up. No post-operative iatrogenic segmental instability was found.

In our study, all central/paracentral LDH were successfully removed by PETAD without dural tears or nerve root injuries. With TESSYS technique, 83.9–95.3% excellent or good results according to MacNab's score were achieved in patients with a single-level herniation [21, 33, 34]. Kang successfully treated central LDH by PELD with foraminoplasty without complication in 37 patients and achieved excellent and good rates for 83.5% [23]. Of our patients, 93.7% reported satisfactory clinical outcomes, and none had recurrent herniation. These results are better than in previous endoscopic studies. One of the reasons might be that the specially designed approach not only adequately created endoscopic cannel, realizing directly target to the herniated disc, but also effectively avoided unnecessary resection of SAP. Importantly, our depth-

limited trephine effectively guaranteed the safety of the procedure.

Our study has certain limitations, particularly the small sample size (16 cases) and the short follow-up period in this retrospective study. However, the aim of the study was to introduce an alternative approach for treating central/paracentral LDH rather than to compare it with other methods. In addition, PETAD has a relatively narrow indication: the approach only suited to simple single-level central/paracentral LDH. Especially for large central/paracentral LDH, the co-occurrence of central canal stenosis or lateral recess stenosis is one of the reasons for incomplete removal. Migrated LDH is another contraindication of the technique.

Conclusion

PETAD is a minimally invasive, effective, and safe surgical method that can effectively treat central/paracentral LDH patients with the advantages of directly reaching the target site, lower complication rate, and good short-term clinical outcome. The use of depth-limited trephine was indispensable in preventing nerve root injury for this technique.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Informed consent Informed consent was obtained from all individual participants included in the study.

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