Retrospective Analysis of Paraspinal Muscle-Splitting Microscopic-Assisted Discectomy Versus Percutaneous Endoscopic Lumbar Discectomy on Patients in the Treatment of Far-Lateral Lumbar Disc Herniation

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Abstract

Background: Minimally invasive surgery includes percutaneous endoscopic lumbar discectomy and the microscopic tubular technique. This study aimed to compare the two techniques and evaluate the outcomes of the procedures.

Methods: We retrospectively analyzed patients with far-lateral lumbar disc herniation (FLLDH) from June 2015 to October 2018. Twenty-six patients underwent paraspinal muscle-splitting microscopic-assisted discectomy (MD) and 30 patients underwent percutaneous endoscopic lumbar discectomy (PELD) surgery by the same surgical team. Data included the duration of the operation, duration of intraoperative radiation exposure, and average duration of hospitalization. Pre- and postoperative pain scores and neurological functions were recorded using a visual analog scale (VAS) score and Oswestry disability index (ODI).

Results: 56 patients remained in the study over the 12–24 months period. The mean operating time was 65.83 ± 16.64 min in the PELD group, mean duration of radiation exposure was 2.87 ± 1.19 min, and average of hospitalization was 3.43 days. The mean operating time was 44.96 ± 16.87 min in the MD group, duration of radiation exposure was 0.78 ± 0.32 min, and duration of hospitalization was 4.12 days. There were two patients with postoperative transient dysesthesia and one underwent reoperation 7 months after surgery in the PELD group. One patient had postoperative transient dysesthesia in the MD group. Except low back pain at 3 months ($p > 0.05$), all patients in both groups showed significant improvement in VAS and ODI scores compared with pre-operation and until final follow-up ($p < 0.05$). Although the learning curve of MD is shorter compared with the PELD, beginners should practice on cadavers and receive teaching demonstrations from senior surgeons.

Conclusion: Both techniques are minimally invasive, effective, and safe for treating far-lateral lumbar disc herniation in selected patients. Compared with the PELD technique, the MD procedure offers a wider field of vision during operation, shorter operation time, fewer postoperative complications, and shorter learning curve.

Background

Far-lateral lumbar disc herniation (FLLDH) is a rare disease that accounts for 2–12% of all lumbar disc herniation syndromes, and it was first described by Abdullah in 1974^[1]. With increased awareness of the disease, experts have paid increasing attention to the diagnosis and treatment of FLLDH^[2, 3]. The resulting nerve root syndrome is characterized by intense pain, often accompanied by motor or sensory disturbances^[3]. The diagnostic probability of FLLDH increases with the use of computed tomography (CT) and magnetic resonance imaging (MRI)^[4]. Although awareness of its existence has improved, the best treatment remains controversial^[5]. Surgical treatment can be challenging for spine surgeons as the FLLDH is difficult to access anatomically due to the adjacent bone structures, such as articular processes^[6]. Traditional treatments for FLLDH include midline incisions, extensive subperiosteal

exposures, and partial excision of the articular processes and laminae^[7]. However, these inevitably affect the stability of the lumbar spinal segment and eventually lead to refractory low back pain (LBP). Unlike in Europe, the gold standard in East Asia for the treatment of lumbar disc herniation is endoscopic surgery. Advances in various technologies (including the “inside-out technique”^[8]) have made endoscopy easy to perform surgery on the lumbar and cervical spine using the extraforaminal-targeted fragmentectomy techniques^[5]. However, the high number of intraoperative punctures has increased exposure of patients and surgeons to radiation^[9]. The introduction of paraspinal muscle splitting has shown good therapeutic effects on FLLDH^[10]. Percutaneous endoscopic and transmuscular techniques through tubular retractors can avoid extensive facet joint resections to maintain biomechanical stability and reduce postoperative LBP complications by minimizing access-related soft tissue trauma^[11]. Nevertheless, a comparison of these two minimally invasive surgical approaches has not been reported. The purpose of our research is to compare the two most popular minimally invasive procedures at present, which are the safest and most effective methods for treating the FLLDH.

Materials And Methods

We retrospectively analyzed 56 patients who were treated from July 2015 to October 2018. Fifty-six patients underwent surgery, of which 26 underwent paraspinal muscle-splitting microscopic-assisted discectomy (MD). There were 5 women and 21 men with ages ranging from 20–82 years (mean: 38.4 ± 13.98 years). Nine patients underwent surgery at the L5-S1 level, 11 underwent surgery at the L4-5 level, and 6 underwent surgery at the L3-4 level. Thirty patients underwent percutaneous endoscopic lumbar discectomy (PELD) surgery; 10 women and 20 men, with ages ranging 27–77 years (mean: 47.4 ± 9.38 years). A total of 12 patients underwent surgery at the L5-S1 level, 15 patients underwent surgery at the L4-5 level, and 3 patients underwent surgery at the L3-4 level (**Table 1**). They were treated using the PELD technique by the same surgical team. The operation time, duration of intraoperative radiation exposure, and average hospitalization periods were recorded. The postoperative leg and back visual analog scale (VAS) and Oswestry disability index (ODI) scores were recorded and followed up at 3, 12, and 24 months postoperatively.

Inclusion and exclusion criteria

The inclusion criteria were as follows: X-ray imaging without lumbar instability; MRI or CT indicating far-lateral lumbar disc herniation; patients not receiving other minimally invasive treatments; the presence of more symptoms of unilateral lower radicular symptoms, such as pain, numbness, or abnormal sensation; and inefficacy of conservative treatment (lying on bed traction, physiotherapy) for a minimum of 6 weeks. Exclusion criteria were as follows: chronic LBP; substantial intervertebral foramen stenosis; degenerative lumbar instability spondylolisthesis >grade I or scoliosis >20°; and spinal instability and scoliosis causing loss of foraminal height. In short, patients who did not require to undergo fusion surgery^[12].

Surgical technique

PELD group

The patient was placed in the prone position and the surgery was performed under local anesthesia and intravenous sedation. We marked the midline and the height of the iliac crest from the preoperative assessment of axial MRI scan calculating the skin entry point; making appropriate adjustments according to the patient's body shape and weight, approximately 5–8 cm, lidocaine was injected for local anesthesia. We inserted an 18-G needle into the skin entrance. The angle between the needle and the sagittal plane depended on the segment and position of the disc herniation. In our experience, placing the needle tip in the upper corner of the caudal vertebral body (Fig. 2b) can reduce the compression of the exiting nerve root located cranially. An approximately 7-mm incision was made and dilators were used to expand the soft tissue gradually along the guidewire. Working cannulas were then placed on the surface of the disc space. Some soft tissues covering the disc were first observed under endoscopy. Using a flexible bipolar radiofrequency probe, we cleared the soft tissues to expose the exit nerve root. We used endoscopic grasping forceps to search for and grasp the tail of the nucleus pulposus and gently pull it. This was usually sufficient to remove the protruding nucleus (Fig. 3a). Finally, exploration was performed along the entire exit nerve root.

MD group

The procedure was performed under tracheal anesthesia and the patient was placed in a prone position. We located the lesion segment and made an approximately 2cm incision at 2-3 cm next to the midline (Fig. 2d). After cutting the fascia of the lower back, we used blunt finger dissection to separate the paraspinal muscles from the Wiltse gap. We then added soft tissue expanders in sequence, inserted a 14-mm working channel (Fig. 2c), confirmed its position by intraoperative X-ray and fixed it on the operating table. A surgical microscope was used to complete the subsequent steps. The angle between the lower border of the transverse process and the outside of the isthmus area was an important anatomical landmark. The intertransverse process ligament was removed and the nerve roots and ganglia were carefully exposed and protected. We minimized ganglion surgery to prevent postoperative abnormalities. After the herniated disc was removed (Fig. 3b), the nerve root was completely decompressed, the fascia was closed, and the skin was sutured.

Follow-up

The follow-up examinations were conducted on the day after the operation (54 patients) and at 3, 12, and 24 months. Two patients in the MD group were followed up at 12 months. We started recording data and follow-up from the subsequent day; 6-month, 12-month, and 24-month data were collected in the outpatient clinic. The ODI and VAS scores were recorded for back and leg pain.

Statistical analysis

Data analysis was performed using SPSS 16.0 (IBM Corporation, Armonk, NY, USA). One-way ANOVA was used to analyze the statistical difference between the PELD group and the MD group. The value of P

<0.05 was considered to be statistically significant in all cases.

Table 1
Demographic parameters of the patients

Baseline characteristic	(PELD) (MD)
Number of patients	30 26
Gender	M (20)/ F (10) M (21)/ F (5)
Age (years; median IQR)	47.4 ± 9.38 38.4 ± 13.98
Postoperative severe complication, n (%)	0 0
Temporary dysesthesia	2 (6.7%) 1(3.8%)
Severe back pain	0 0
Average hospitalization(day)	3.43 4.12
Operation time (min)	65.83 ± 16.64 44.96 ± 16.87
radiation exposure(min)	2.87 ± 1.19 0.78 ± 0.32
Revision L4/5	1(3.3%) 0
	15 (50.0%) 11 (42.3%)
L5/S1	12 (24.0%) 9 (34.6%)
L3/4	3 (6.0%) 6(23.1%)

Results

A total of 56 patients were followed up over 12–24 months. In the PELD group, the mean operating time was 65.83 ± 16.64 min (Fig. 1a), which was longer than that of the MD group (44.96 ± 16.87 min) ($p < 0.05$). Because our patients were hospitalized before surgery and underwent different anesthesia protocols, the average duration of hospitalization in the PELD group was 82.32 ± 14.88 hours ($p < 0.05$), lesser than that of the MD group (98.64 ± 15.65 hours). The mean duration of radiation exposure was 2.87 ± 1.19 min because intraoperative puncture was required to ensure safety and correct position, which was longer than that of the MD group (0.78 ± 0.32 min) ($p < 0.05$). In the PELD group, there were two patients with postoperative transient dysesthesia and one underwent reoperation 7 months after surgery. Only one patient had postoperative transient dysesthesia in the MD group. All patients received rehabilitation and nerve stimulation treatment. Symptoms resolved in less than 12 weeks. Due to continuous irrigation and the absence of postoperative drainage in PELD surgery, we could not accurately compare the amount of bleeding. There were no severe complications, such as epidural hematoma, nerve root injury, or intervertebral disc infection. Figures 1c and 1d show the VAS pain scores, and Fig. 1b shows the ODI scores. There results demonstrated significant improvement in the pain and ODI scores ($p < 0.05$). Patients still had LBP at the follow-up at 3 months ($p > 0.05$) after surgery. Both two groups had

significant relief at the follow-up after 12 months ($p < 0.05$). Overall, clinical results were significantly better than they were preoperative.

Discussion

The first anatomical description of extreme lateral protrusions dates back to 1944, and with the development of spinal surgery, their clinical application has received increasing attention^[1, 13]. Because the dorsal root ganglia are accompanied by motor and sensory components, LBP can be accompanied by severe nerve root pain. Most FLLDH occur at the L3-4 or L4-5 level; therefore, most patients have substantial thigh symptoms^[14, 15]. Straight leg elevation tests are negative, and symptoms of scoliosis are exacerbated; therefore, this helps distinguish FLLDHs from other common disc herniations. In recent years, various surgical methods have emerged to treat FLLDH^[7, 11, 16]. However, these surgical methods have changed over the years, including traditional open surgery, surgery using an operating microscope, microsurgery through a tubular channel, and percutaneous endoscopic surgery. With the advancement of minimally invasive spine technology and patients' expectations, percutaneous endoscopic surgery and microsurgery through a tubular channel have been reported more frequently, the best treatment for FLLDH, however, remains controversial^[17]. Nellensteijnin reported 214 cases of FLLDH treated with transforaminal endoscopy; the median recurrence rate was 2.6%, the median complication rate was 5.1%, and the median was 8.0%^[18]. Porchet reported long-term prognosis in 202 patients with FLLDH; they used a 5–7-cm midline incision and transmuscular approach^[19]. The authors reported that the probability of postoperative complications was 5%. However, only 3 patients (1.5%) had complications that were directly related to the surgical procedure. According to Macnab's criteria, the results of surgical treatment were excellent or good, and the average VAS of radical leg pain before surgery to final follow-up was 8.5 to 2.2^[20]. The incidence of reoperation was significantly lower than that of the percutaneous endoscope. A study by Yoon found that, compared with lumbar discectomy, postoperative VAS and ODI scores following tubular microsurgery were significantly better than those of percutaneous endoscopic surgery^[21]. Our follow-up data were the similar.

Using endoscopic technology, the working sleeve is first inserted into the intervertebral foramen to identify the nerve root, and then the working sleeve is retracted along the nerve root to locate the protruding intervertebral disc. A group of 47 patients reported their experience with transforaminal endoscope technology for the treatment of distant lateral and foraminal protrusions^[22]. Their technique was similar to the Yeung technique^[23], with the selected entry point of 8–12 cm from the midline. They advocated removing the central disc first and the final step was the removal of the extraforaminal disc. PELD procedure has some advantages compared with MD procedures. First, PELD can be performed under local anesthesia, and the second PELD is less invasive in incision length. In China, many surgeons use various methods to treat FLLDH using the in-outside method, which contradicts the currently accepted principle of removing only protruding discs and loose fragments located in the posterior annulus. Furthermore, this technique extends the operation time, and removal of the central disc increases the possibility of loss of long-term intervertebral disc height. For FLLDH, the protrusion disc is often located

in the anterior medial aspect of the exiting nerve root, occupying part of the space of the intervertebral foramen, and causing “soft stenosis” in the intervertebral foramen. When the working sleeve is set through the narrow intervertebral foramen into the intervertebral disc, it squeezes the soft intervertebral disc nucleus tissue, leading to more severe compression of the exiting nerve root. Due to the presence of dorsal root ganglion (DRG), severe pain often occurs. We made appropriate adjustments and improvements to the puncture approach. The intervertebral disc nucleus pulposus protruding outside the intervertebral foramen tends to shift to the cranial and lateral side, and the exiting nerve root is squeezed towards the “outer side.” However, the “inside and below” space is relatively abundant, and this is the ideal position to place the puncture needle and the working sleeve slightly below the protrusion, which is beneficial in removing the protruding nucleus pulposus tissue (properly rotating the working cannula) and reducing nerve root injuries and irritation of the DRG. The puncture target was placed at the intersection of the slight inner side of the protruding position and the upper endplate of the caudal vertebra, wherein the lateral position of the puncture needle was located at the posterior horn of the caudal vertebral body and the anteroposterior position was located at the outer edge of the midpoint of the pedicle (Figs. 2a and 2b). Many studies have emphasized the need to educate and protect everyone in the room during fluoroscopy^[24, 25]. The mean duration of radiation exposure was 2.87 ± 1.19 min in our PELD group. It is believed that the surgeon and patients need to limit their radiation exposure.

There are minimally invasive surgical treatments for FLLDH, including microendoscopic decompression of the endoscopic to minimize the damage to facet joints, muscles, and ligaments^[26]. Less muscle trauma and fewer osteotomies reduce lumbar back pain and adjacent disc degeneration, reducing lumbar instability and fusion^[27]. Furthermore, trans-tubular microsurgery helps reduce hospital stay and promotes rapid recovery. In this study, the average duration of hospitalization was 98.64 ± 15.65 hours, which is longer than the PELD group due to intratracheal anesthesia. Compared with conventional paramedian muscle-splitting approaches, trans-tubular microsurgery has the advantage of using a sequential dilator and finally a tubular retractor, which allows procedures in obese patients fast and simple compared to thin patients^[28]. In our department, the surgeons separate the paraspinal muscles using fingers. They are familiar with using microscopes, reducing the operation time. Choi et al. used the percutaneous endoscopic “targeted fragmentectomy” technique to treat 41 cases of FLLDH; 2 patients developed symptoms of relapse after the early symptoms improved (4.8%)^[5], 3 (7.3%) developed dysesthesia on the legs, 1 (2%) experienced persistent lower extremity pain after surgery and underwent microdiscectomy revision via paraspinal approach. In the MD group, intratracheal anesthesia helped the patient cooperate, the intraoperative vision was clear, and there was less nerve stimulation, which reduced the risk of lower limb numbness and recurrence after surgery. Nevertheless, regardless of the surgical method, to achieve adequate decompression, a certain number of bone resections and treatment of nerve roots and dorsal root ganglia are sometimes required. This may cause paresthesia, reflex sympathetic dystrophy, or chronic back pain in some patients at a 3-month follow-up.

There are several limitations to this study. First, it was a single-center study, and therefore may be subjected to selection bias. Hence, we instituted strict inclusion and exclusion criteria. Second, our

sample size was small and it was a short-term follow-up. Multicenter studies and large samples prospective study, long-term clinical follow-ups are needed to validate our findings.

Conclusions

Paraspinal muscle-splitting microscopic-assisted discectomy and PELD techniques are minimally invasive, effective, and safe for treating FLLDH in selected patients. Compared with the PELD technique, MD has a wider field of vision during operation, shorter operation time, and less exposure to radiation. However, the average duration of hospitalization was longer in the MD procedure compared to the PELD group due to different anesthetic techniques.

Abbreviations

PELD: percutaneous endoscopic lumbar discectomy

VAS: Visual Analog Scale

ODI: Oswestry Disability Index

MD: Microscopic-assisted discectomy

FLLDH: far-lateral lumbar disc herniation

CT :Computed tomography

MRI :Magnetic resonance imaging

Declarations

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Competing interests

The authors declare that they have no competing interests.

Conflicts of interest

The authors confirm that they have no conflicts of interest.

Availability of data and materials

Corresponding author Hong -guang Xu can be contacted to request the raw data.

Consent for publication

Not applicable

Ethics approval and consent to participate

All procedures were in accordance with the ethical standards of the committees responsible for human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed consent was obtained from all patients before being included in the study.

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Authors' contributions

L Kong designs and writes all of the manuscript. HG Xu , *WZ Zhang* modified the paper and put forward some positive ideas, such as the overall framework and the limitation of the study, and made the final edition. All authors participated in every revision and improvement of the manuscript. Absolutely, we declare all authors have read and approved the manuscript.

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Figures

Figure 1

a The average operation time, radiation exposure, and hospital stay in both groups (### and *** meaning $P < 0.001$). c and d The preoperative and postoperative leg and back pain VAS scores. The results demonstrated significant improvement in leg pain compared with preoperative ($p < 0.001$). The patients still had low back pain at the follow-up at 3 months ($p > 0.05$) after surgery. Both groups had a significant relief at the follow-up after 12 months compared with preoperative (# and * meaning $p < 0.05$). b The preoperative and postoperative ODI scores, where the results demonstrated significant improvement in ODI scores compare with preoperative ($p < 0.001$).

Figure 2

a and b PELD technique. c and d MD technique.

Figure 3

a Anatomy under the endoscope in the PELD group. b Anatomy under the microscope in MD group

Supplementary Files

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