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

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ABSTRACT

AIM: To compare percutaneous endoscopic lumbar discectomy (PELD) and the microscopic tubular technique, and evaluate the outcomes of surgery.

MATERIAL and METHODS: We collected information through retrospective analysis of 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 thirty patients underwent 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 the visual analog scale (VAS) score and Oswestry disability index (ODI).

RESULTS: Fifty-six 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 154.98 ± 64.26 mGy, 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 42.12 ± 17.28 mGy, and duration of hospitalization was 4.12 days. There were two patients with postoperative transient dysesthesia and one underwent reoperation seven months after surgery in the PELD group. One patient had postoperative transient dysesthesia in the MD group. Except low back pain at three 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 ($p<0.05$).

CONCLUSION: Both techniques are minimally invasive, effective, and safe for treating FLLDH 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.

KEYWORDS: Percutaneous, Lumbar disc herniation, Endoscopy, Minimally invasive

ABBREVIATIONS: CT: Computed tomography, **FLLDH:** Far-lateral lumbar disc herniation, **MD:** Microscopic-assisted discectomy, **MRI:** Magnetic resonance imaging, **ODI:** Oswestry disability index, **PELD:** Percutaneous endoscopic lumbar discectomy, **VAS:** Visual analog scale

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INTRODUCTION

Far-lateral Lumbar Disc Herniation (FLLDH), first described by Abdullah in 1974, is a relatively rare spinal disease, accounting for 2%-12% of all lumbar disc herniations (1). With increased awareness of the disease, experts have started paying increased attention to the diagnosis and treatment of FLLDH (12,17). The nerve root symptoms produced by FLLDH are characterized by severe pain, usually accompanied by motor or sensory disturbances (17). The application of computed tomography (CT) and magnetic resonance imaging (MRI) increases the diagnostic probability of FLLDH (19). Although awareness of its existence has improved, the best treatment remains controversial (13). Surgical treatment is challenging for surgeons because FLLDH is difficult to access anatomically due to the adjacent bone structures, such as articular processes (11). 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, endoscopic surgery is the main treatment for lumbar disc herniation in East Asia. Advances in various technologies, including the “inside-out technique,” (24) have made endoscopy an easy to perform surgery on the lumbar and cervical spine using the extraforaminal-targeted fragmentectomy techniques (4). However, the high number of intraoperative punctures increases the exposure of patients and surgeons to radiation (21). The introduction of paraspinal muscle splitting has shown good therapeutic effects on FLLDH (20). Endoscopic and microscopic tubular techniques can avoid extensive facet joint resections to maintain biomechanical stability and reduce postoperative LBP complications by minimizing lower back muscle damage (10). Nevertheless, a comparison of these two minimally invasive surgical approaches has not been reported. The purpose of our research is to compare these two popular, minimally invasive procedures for safety and effectivity for treatment of FLLDH.

MATERIAL and METHODS

We retrospectively analyzed 56 patients who were treated from July 2015 to October 2018 (Medical ethics institution review committee approval number: 20211123175200001 0470). All 56 patients were followed up for 12-24 months. The patients were operated on by same surgical team. PELD involved the cost of using bipolar radiofrequency consumables and intraoperative local anesthesia assisted intravenous anesthesia. Some patients who considered the cost of surgery or were afraid of surgery chose microscopic-assisted discectomy (MD) under general anesthesia because it had no extra cost of consumables. We communicated with the patient before the operation and informed about the advantages and disadvantages of these two surgical methods. The patient decided which operation method to choose. The operation time, duration of intraoperative radiation exposure, and average hospitalization periods were recorded. The postoperative leg and back VAS and ODI scores were recorded and followed up at 3, 12, and 24 months postoperatively.

Inclusion and Exclusion Criteria

The criteria for inclusion of patients 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, no chronic LBP, and the presence of more symptoms of unilateral lower radicular symptoms and inefficacy of conservative treatment (lying on bed traction, physiotherapy) for a minimum of 6 weeks. The PELD group exclusion criteria were as follows: high iliac crest, degenerative lumbar instability spondylolisthesis >grade I or scoliosis >20° and spinal instability and scoliosis causing loss of foraminal height, and the patients were unwilling to undergo local anesthesia. The MD group exclusion criteria were as follows: higher risk of general anesthesia, and the space between the costal process and the transverse process was closed at L5-S1 level. In short, the patients did not require to undergo fusion surgery (10).

Surgical Technique

PELD group

The patient was made to lie prone on the lumbar bridge, and the operation was started under local anesthesia and intravenous sedation. We marked the midline and iliac crest height 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, before inserting an 18-G needle into the skin entrance; we used lidocaine for local anesthesia. 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 (Figure 1A) can reduce the compression of the exiting nerve root located cranially. We chose the skin entry point to be located in the iliac crest to avoid the iliac crest barrier at the L5/S1 segment, which coincides with the intervertebral disc space; the puncture needle angle (10°-30°) at this segment was lower than other levels (30°-50°). Furthermore, we made an incision of approximately 7 mm, and dilators were used to expand the soft tissue gradually along the guide-wire. The working cannula was then placed on the surface space of the intervertebral disc. 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 (Figure 2A). The operation was ended after exploring along the entire exit nerve root.

MD group

The patient was made to lie prone on the lumbar bridge and the operation was started under tracheal anesthesia. We located the lesion segment and made an approximately 2 cm incision at 2-3 cm next to the midline (Figure 1C). After cutting the fascia of the lower back, we used blunt finger dissection to separate the paraspinal muscles from the Wiltse gap, added soft tissue expanders in sequence, and inserted a 14-mm working channel (Figure 1D), confirmed its position by intraoperative X-ray, and fixed it on the operating

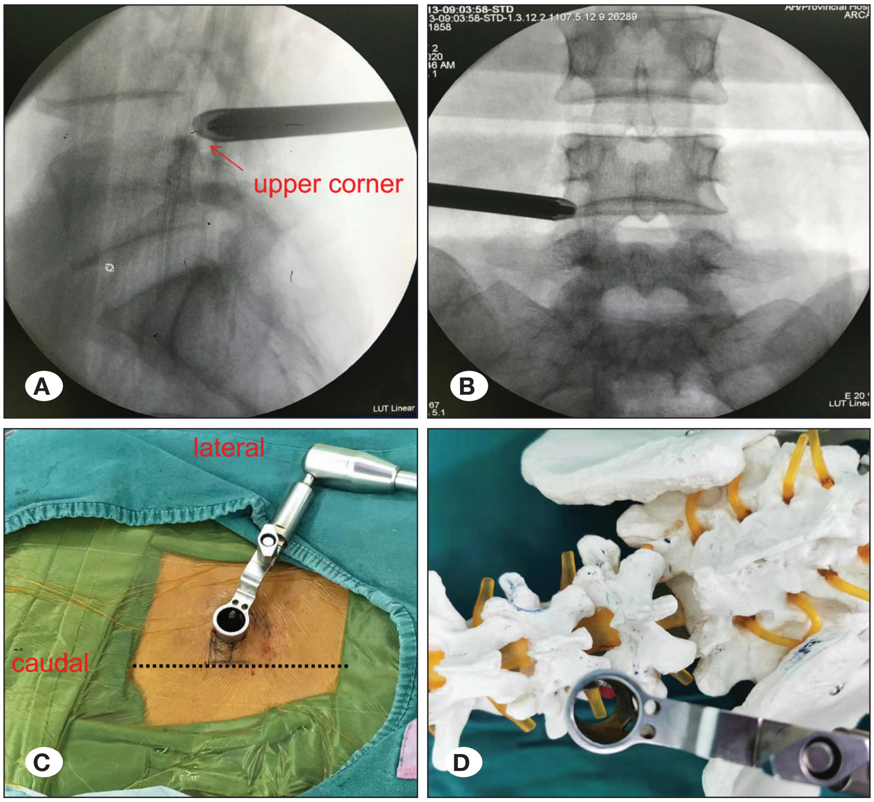

Figure 1: A, B) PELD technique. **C, D)** MD technique.

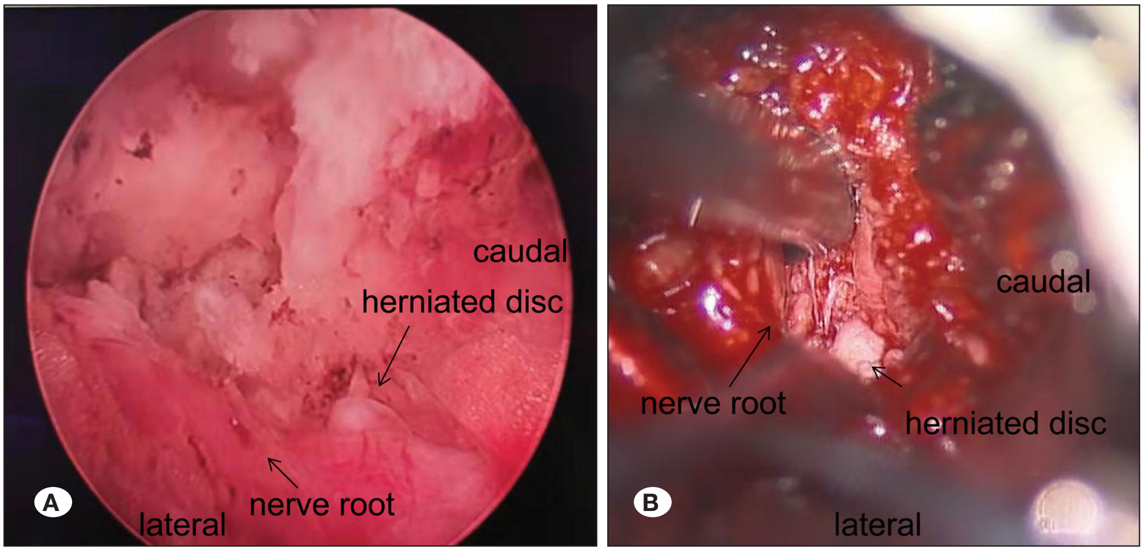

Figure 2:
A) Anatomy under the endoscope in the PELD group.
B) Anatomy under the microscope in the MD group.

table. A surgical microscope was used to complete the subsequent steps. We needed to find the angle between the lower edge of the transverse process and the outside of the isthmus area, which was an important anatomical landmark. The next step was to remove the intertransverse process ligament, carefully exposing and protecting the nerve roots and ganglia. We minimized ganglion surgery to prevent postoperative abnormalities. During the operation, even in the L5/S1 segment, the height of the iliac bone did not affect the operation, because the procedure was performed through the paramedian approach. After removing the herniated disc (Figure 2B), when the nerve roots were 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 only followed up to 12 months. We started recording data and follow-up from the subsequent day; 3-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

SPSS 17.0 (IBM Corporation, Armonk, NY, USA) was used for data analysis. One-way analysis of variance was used to analyze the statistical difference between the PELD group and the MD group, and it was statistically significant when P<0.05.

RESULTS

Fifty-six patients underwent surgery, among whom 26 underwent paraspinal muscle-splitting MD. There were five women and twenty-one men with ages ranging from 20–82 years (mean: 38.4 ± 13.98 years). Eleven patients received treatment at the L4/5 segment, and six received treatment at the L3/4 segment, nine received treatment at the L5/S1 segment. 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). Fifteen patients received treatment at the L4/5 segment, three patients received treatment at the L3/4 segment, and 12 patients received treatment at the L5/S1 segment (Table I). The mean operating time was 65.83 ± 16.64 min in the PELD group (Figure 3A), which was longer than that in 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 154.98 ± 64.26 mGy because intraoperative puncture was required to ensure safety and correct position, which was longer than that of the MD group (42.12 ± 17.28 mGy) (p<0.05). There were two patients with postoperative transient dysesthesia, and one underwent reoperation seven months after surgery in the PELD group. 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. None of the patients had serious complications such as hematoma, severe nerve root injury, or intervertebral space infection. Figure 3B, C show the VAS pain scores, and Figure 3D shows the ODI scores, the results showed that the scores has improved significantly (p<0.05). Patients still had LBP at the follow-up at three months (p>0.05) after surgery. Both groups had significant relief at the follow-up after 12 months (p<0.05). Overall, clinical results were significantly better than they were preoperatively.

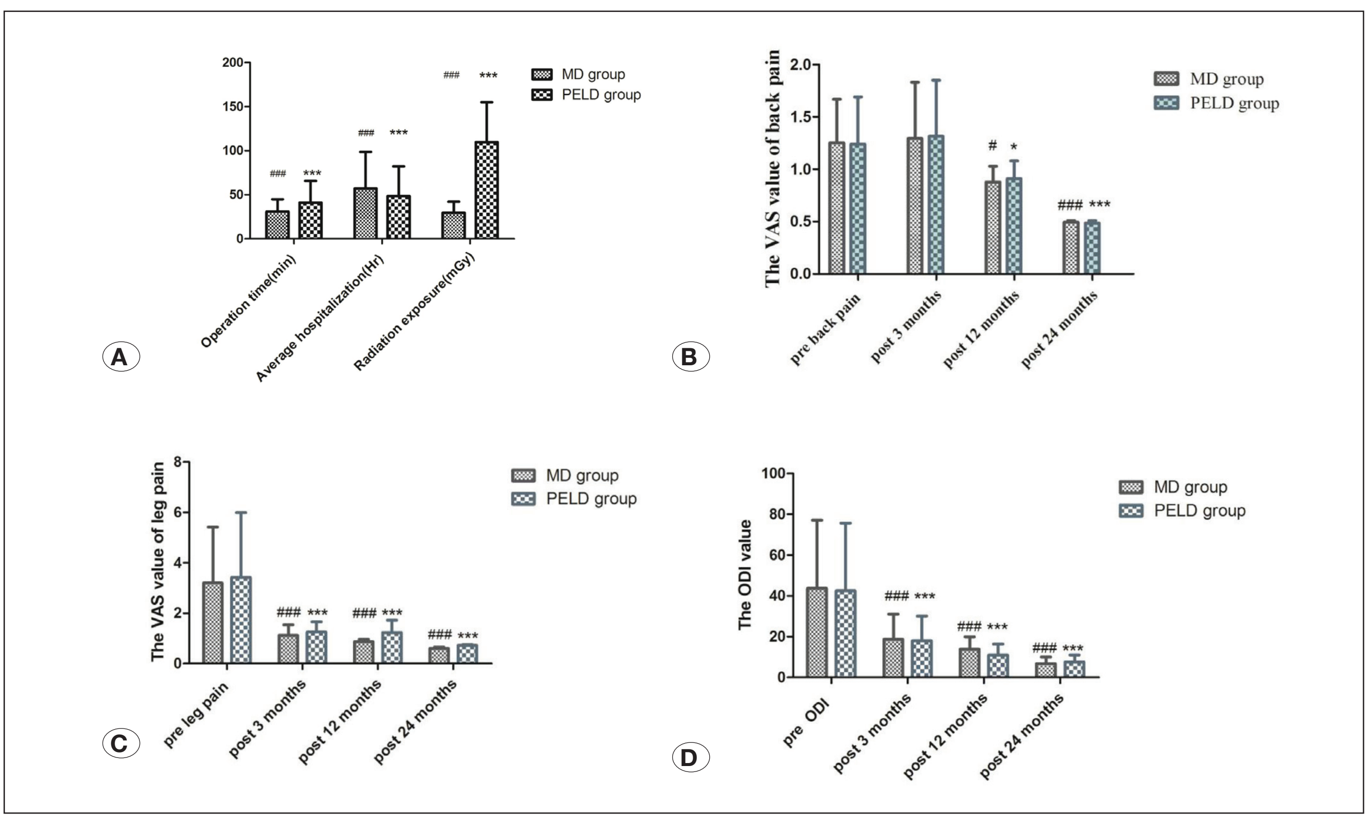

Figure 3: A) The average operation time, radiation exposure, and hospital stay in both groups (### and *** meaning p<0.001). **B, C)** VAS scores for low back and leg pain pre- and postoperatively. The results showed that compared to preoperatively, the leg pain was significantly improved (p<0.001). The patient still had low back pain during the 3-month follow-up after surgery (p>0.05). Both groups had a significant relief at the follow-up after 12 months compared to preoperatively (# and * meaning p<0.05). **D)** The preoperative and postoperative ODI scores, where the results demonstrated significant improvement in ODI scores compare to preoperatively (p<0.001).

Table I: Demographic Parameters of the Patients

Baseline characteristic	Percutaneous Endoscopic Lumbar Discectomy	Microscopic-Assisted Discectomy
Number of patients	30	26
Gender		
Male	20	21
Female	10	5
Age (years; median IQR)	47.4 ± 9.38	38.4 ± 13.98
Postoperative severe complication	0	0
Temporary dysesthesia, n(%)	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 surgery, n(%)	1(3.3)	0
Disease Localization, n(%)		
L4/5	15 (50.0)	11 (42.3)
L5/S1	12 (24.0)	9 (34.6)
L3/4	3 (6.0)	6 (23.1)

***L:** Lumbar.*

DISCUSSION

The first anatomical description of extreme lateral protrusions dates back to 1974, and with the development of spinal surgery, their clinical application has received increasing attention (12). Because the dorsal root ganglia are accompanied by motor and sensory components, LBP can be accompanied by severe nerve root pain. Most FLLDH appear in the L3/4 or L4/5 segment, and patients have substantial thigh symptoms (3). Straight leg elevation test results are negative, and symptoms of scoliosis are exacerbated; this helps distinguish FLLDHs from other common disc herniations. In recent years, various surgical methods have emerged to treat FLLDH (18). However, these surgical methods have changed over the years, including traditional fenestration surgery, microscope-assisted surgery, tubular channel-assisted microsurgery, and percutaneous endoscopic surgery. Benefiting from the advancement of minimally invasive spine technology and the rising expectations of patients, percutaneous endoscopic surgery and microsurgery through a tubular channel have been reported more frequently. The best treatment for FLLDH, however, remains controversial (5). Nellensteijn et al. reported 214 cases of FLLDH treated with transforaminal endoscopy; the median recurrence rate was 2.6%, the median and mean complication rates were 5.1% and 8.0%, respectively (14). Porchet et al. reported the long-term prognosis of 202 FLLDH patients; they used an incision 5-7 cm from the midline and an intermuscular approach (16). The authors reported that the probability of postoperative complications was 5%, and there were only three patients (1.5%) with complications directly related to surgery. 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 decreased from 8.5 to 2.2 (2). 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 (23), our follow-up data were similar.

For FLLDH, the protrusion disc was often located in front of the exiting nerve root, occupying part of the space of the intervertebral foramen and causing "soft stenosis" in the intervertebral foramen. Their technique was similar to the technique used by Yeung and Tsou (22); 8-12 cm from the midline was chosen as the skin entry point. Many surgeons advocated removing the central disc first, and the final step was the removal of the FLLDH, which contradicts the currently accepted principle of targeted discectomy. When the working sleeve was set through the narrow intervertebral foramen into the intervertebral disc, it squeezed the soft intervertebral disc nucleus tissue, leading to exiting nerve root irritation. Due to the presence of dorsal root ganglion (DRG), severe pain often occurs. Furthermore, this technique extends the operation time, and the removal of the central disc increases the possibility of the loss of long-term intervertebral disc height. We made appropriate adjustments and improvements to the puncture approach. The intervertebral disc nucleus pulposus protruding outside the intervertebral foramen tended to shift to the cranial and lateral side, and the exiting nerve root was squeezed towards the "outer side." However, the "inside and below" space was relatively abundant, and this was the ideal position to place the puncture needle and the working sleeve slightly below the protrusion, which was 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 endplate of the lower vertebra, wherein the lateral view during the operation placed the needle at the posterior upper corner of the lower vertebral body, and the anteroposterior view was the puncture needle at the midpoint of the upper and lower pedicles (Figure 1A, B). Disc level had an angulation due to sacral tilt in L5/S1, and the surgical corridor may have been restricted or obstructed by iliac crest and also transverse process of L5. To avoid the obstruction of the iliac crest and transverse process, we chose the paraspine approach (5-8 cm) and the inside of the iliac crest as the skin entry point at the L5/S1 segment, which coincided with the intervertebral disc space. The needle angle at this segment was lower than at other levels, and this was similar to the "targeted fragmentectomy" technique reported by Choi et al. (4), which differed from TESSTYS technology. To better expose the exit nerve roots and find the nucleus pulposus during the operation, partial resection of the L5 upper articular process and methylene blue staining can be performed, if necessary. It is believed that the surgeon and patients need to limit their radiation exposure. Many studies have emphasized the need to educate and protect everyone in the room during fluoroscopy (3,8). The mean duration of radiation exposure was 154.98 ± 64.26 mGy in our PELD group.

There are minimally invasive surgical treatments for FLLDH, including microendoscopic decompression, to avoid damage to the facet joints, muscles, and soft tissues of the paraspine as much as possible (15). Less muscle trauma and fewer osteotomies reduce lumbar back pain and adjacent disc degeneration, reducing lumbar instability and fusion (9). Furthermore, trans-tubular microsurgery helps reduce hospital stay and promotes rapid recovery. In our study, the average duration of hospitalization was 98.64 ± 15.65 hours, which was longer than the PELD group due to intratracheal anesthesia. Compared with conventional paramedian muscle-splitting approaches, trans-tubular microsurgery had the advantage of using a sequential dilator and finally a tubular retractor, which allowed faster and simpler procedures in obese patients compared to thin patients (6). In our department, the surgeons separated the paraspinal muscles using fingers. They were familiar with using microscopes and reducing the operation time. Choi et al. used the percutaneous endoscopic "targeted fragmentectomy" technique to treat 41 cases of FLLDH: two patients developed symptoms of relapse after the early symptoms improved (4.8%) (4), three (7.3%) developed dysesthesia on the legs, and one (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. The height of the iliac bone was not important in this procedure for the L5/S1 level because the procedure was performed through a paramedian approach. Nevertheless, in some patients, when the space between the costal process and the transverse process was closed, we removed part of the sacrum and costal process in the form of a triangle to expose the L5 nerve roots. This may have been the cause of paresthesias or lower back pain in some patients during the 3-month follow-up.

Our study had several limitations. First, this was a single-center study and therefore may have been subjected to selection bias. Hence, we instituted strict inclusion and exclusion criteria. Second, our sample size was small, and we performed a short-term follow-up. Multicenter studies and prospective studies with large samples and long-term follow-ups are required to validate our findings.

CONCLUSION

Paraspinal muscle-splitting MD and PELD techniques are minimally invasive, effective, and safe for treating FLLDH in selected patients. Compared with the PELD technique, MD had a wider field of vision during operation, shorter operation time, and less exposure to radiation. However, due to the choice of different anesthesia methods, the average hospitalization for MD group surgery was longer than that for the PELD group.

AUTHORSHIP CONTRIBUTION

Study conception and design: LK

Data collection: LK

Analysis and interpretation of results: LK, YH

Draft manuscript preparation: LK

Critical revision of the article: TY, HGX

Other (study supervision, fundings, materials, etc...): YH, HGX

All authors (LK,YH,TY, HGX) reviewed the results and approved the final version of the manuscript.

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