Comparison of Conventional Fenestration Discectomy Versus Percutaneous Transforaminal Endoscopic Discectomy for Treating Lumbar Disc Herniation

Quanyi Li
  Shaanxi Provincial People's Hospital

yongchun zhou (✉ yong_chunzhou@163.com)
  Xiangya Hospital Central South University

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Abstract

Purpose: To compare the efficacy of conventional interlaminar fenestration discectomy (IFD) versus percutaneous transforaminal endoscopic discectomy (PTED) for treating lumbar disc herniation (LDH).

Methods: The clinical data of 1,100 patients who had been diagnosed with LDH from January 2012 to December 2017 were retrospectively analysed. IFD was performed on the 605 patients in Group A, while PTED was performed on the 505 patients in Group B. The Oswestry Disability Index (ODI), Visual Analogue Scale (VAS) for pain, and modified Macnab criteria were adopted to evaluate the outcomes. Moreover, the surgery durations, intraoperative blood loss, postoperative off-bed activities, and postoperative lengths of hospital stay for the two groups were observed.

Results: The follow-up period ranged from 24 months to 60 months, with an average duration of 43 months. As the excellent and good outcome rate was 93.5% in Group A and 92.6% in Group B, there were no significant differences in efficacy between the two groups ($P > 0.05$). However, Group B had significantly less intraoperative blood loss and shorter bed rest durations and postoperative lengths of hospital stay than did Group A ($P < 0.05$). There were two cases of postoperative recurrence in Group A and three in Group B.

Conclusions: Although conventional IFD and PTED had similar levels of efficacy in treating LDH, transforaminal endoscopic discectomy exhibited several advantages, such as less trauma, less bleeding, and a shorter length of hospital stay, and it can be considered an ideal surgical option for treating LDH.Save and Continue

Introduction

Lumbar disc herniation (LDH) is a condition in which the spine deteriorates; it is commonly observed in clinical orthopaedic clinics and can cause severe symptoms, including lower back pain and sciatica, which greatly impacts patients' daily lives, and most patients are admitted to the hospital [1].

Conservative treatment is often preferred for LDH, but patients who fail to respond to such therapies are treated with surgery [2]. The aim of surgical treatment is to remove the herniated nucleus pulposus to the largest extent possible to relieve nerve compression while minimizing spinal instability [3]. Interlaminar fenestration discectomy (IFD) is the most commonly performed clinical procedure and is considered the standard procedure for treating LDH [4]. Although surgery can be performed to completely remove the herniated nucleus pulposus and relieve nerve compression, it will affect spinal stability, as the posterior portion of the spine is partially removed [5, 6]. With the development of minimally invasive techniques in recent years, endoscopic lumbar discectomy has gradually become of great interest among scholars. With percutaneous transforaminal endoscopic discectomy (PTED), the degenerated nucleus pulposus can be completed removed, which directly decompresses the nerve root while the anatomy and biomechanical stability of the lumbar spine are preserved [7, 8].

Few studies on the therapeutic effects of IFD and PTED on LDH have been conducted, so this study was designed to compare the clinical efficacy of conventional IFD versus PTED in treating LDH.

Materials And Methods

Patient population

A total of 1,100 patients who had been diagnosed with single-segment LDH by X-ray, CT, and MRI and underwent lumbar discectomy from January 2012 to December 2017 in our hospital were included in this study. All patients underwent formal conservative treatment including bed rest, lumbar traction, physical therapy, and oral doses of nonsteroidal anti-inflammatory drugs (NSAIDs) for three months, and patients with poor outcomes after treatment were then treated with surgery. The exclusion criteria were as follows: (1) obvious lumbar instability evident in an X-ray; (2) central stenosis confirmed by CT or MRI; (3) severe ossification of the posterior longitudinal ligament; (4) large posterior central herniation; (5) unconsciousness and the inability to adhere to the treatment; (6) the refusal to sign the informed consent form; (7) a lumbar deformity, tumour, or stenosis; (8) infection at the surgical site; and (9) severe liver and kidney dysfunction or cardiovascular or cerebrovascular diseases. Patients were divided into two groups; Group A underwent IFD, and Group B underwent PTED.

Operative technique

Each patient in Group A was placed in the prone position under general anaesthesia. A four- to six-cm incision was made in the posterior midline of the spine with the deteriorating segment positioned in the centre. The skin and underlying layers were separated until the lumbar fascia was exposed. The attachment of the spinalis muscle was cut near the spinous process so that the supraspinous and interspinous ligaments were preserved. The soft tissue behind the laminae was stripped to reveal the intervertebral space, upper and lower lamina and small joints. A laminar rongeur was used to remove the ligamentum flavum between the lamina and small portions of the upper and lower lamina adjacent to the deteriorating segment; thus, interlaminar fenestration was performed. A neuroexfoliator was used to separate and gently retract the nerve root, revealing the intervertebral disc of the deteriorating segment. The fibrous ring was cut with a sharp blade, the nucleus pulposus was removed with dedicated forceps, and the incision was closed [4, 9].

Each patient in Group B was placed in the lateral recumbent position. The body surface projection of the deteriorating intervertebral space was determined under C-arm X-ray. An entry point was made 12 to 14 cm from the posterior midline of the spine on the horizontal line of the responsible intervertebral disc. Local infiltration anaesthesia was administered with 1% lidocaine. The puncture needle was slowly inserted from the entry point through the lateral posterior muscles to the fibrous ring in the deteriorating intervertebral space. X-ray imaging showed that the puncture needle was positioned at the outer edge of the superior articular process in the ipsilateral intervertebral space and that the needle was located ¼ behind the intervertebral space in the lateral direction, near the upper edge of the lower vertebrae. One millilitre of methylene blue was injected through the puncture needle into the intervertebral disc for

contrast radiography. A guide wire was inserted. Once it was confirmed by X-ray that the tip of the guide wire had crossed the articular process, the puncture needle was withdrawn along the guide wire. A scalpel was used to cut the skin at the entry point by 8 mm. The cannulas were inserted along the guide wire in order from the thin cannula to the thick cannula, and the superior articular process was partially removed with a ring drill. The working cannula was inserted into the epidural space. A transforaminal endoscope (TESSYS® [transforaminal endoscopic spine system], joimax® GmBH, Germany) was inserted, and the degenerative, blue-stained intervertebral disc was removed. Part of the nucleus pulposus was ablated by a radiofrequency electrode (Ellman, USA). The spinal canal was assessed carefully, and the nerve root was detached. After the wound was rinsed, the fenestrated fibrous ring was repaired by electrocoagulation, the working cannula was removed, and the incision was closed [10].

Postoperative care

Both groups were administered 15 mg/time of sodium aescinate (intravenous drip, once per day) and 500 µg/time of mecobalamin (oral intake, three times per day) after surgery until discharge. Patients in Group A were asked to perform straight leg raises in bed on the same day after surgery and off-bed training with lower back braces two days later. Patients in Group B were asked to perform straight leg raises in bed on the same day after surgery and off-bed training with lower back braces one day later.

Evaluation measures

Before and one month after surgery and during the last follow-up, the patients were asked to use the Visual Analogue Scale (VAS) [11] to rate the severity of the pain in their lower back and legs. A score of 0 points corresponded to no pain, a score of 1 to 3 points corresponded to slight pain, a score of 4 to 6 points corresponded to obvious pain that affected sleep but was still tolerable, and a score of 7 to 10 points corresponded to intense pain that was unbearable. Functional changes were evaluated using the Oswestry Disability Index (ODI)[12], which is composed of 10 questions on the severity of pain, ability to perform self-care, lifting objects, walking, sitting, standing, difficulty sleeping, social life, and travel. There were six response options for each question, and the highest score allowed for each question was 5 points. The lower the score was, the better the postoperative recovery. The MacNab criteria [13] were adopted to evaluate the surgical efficacy, in which the patient outcomes were graded as excellent, good, fair, and poor. A grade of excellent corresponded to no symptoms, good corresponded to mild symptoms and slight limitations in mobility, fair corresponded to improved symptoms and large limitations in mobility, and poor corresponded to unimproved or even worsened symptoms. The excellent and good rate was calculated as follows: (excellent + good)/total cases * 100%.

Statistical analysis

SPSS 19.0 (SPSS, IL, USA) software was used for statistical analyses. Measurement data are expressed as the mean ± standard deviation (x ± s). Comparisons between groups were performed by one-way analysis of variance and t tests. Comparisons of the count data, as well as the excellent and good rates, between the two groups were performed by the x^2 test. $P < 0.05$ indicated a significant difference.

Results

A total of 1,100 patients were included in this study. Among them, 605 patients underwent conventional IFD (Group A), while 505 underwent transforaminal endoscopic discectomy (Group B). In Group A, there were 300 males and 305 females, with a mean age of 42.9 ± 12.4 (ranging from 23 to 64) years old. In Group B, there were 285 males and 220 females, with a mean age of 40.5 ± 13.7 (ranging from 20 to 67) years old. The difference in surgery duration between the two groups was not statistically significant ($P>$ 0.05). However, Group B had significantly less intraoperative blood loss and shorter bed rest durations and postoperative lengths of hospital stay than did Group A ($P< 0.05$). The surgical characteristics of the patients are summarized in Table 1.

Table 1
Surgical characteristics of patients in the two groups

Characteristic	Group A ($n= 605$)	Group B ($n= 505$)
Sex (males)	300 (49.6%)	285 (56.4%)
Age at initial operation (years)	42.9 ± 12.4 (23−64)	40.5 ± 13.7 (20−67)
Posterolateral herniation	224 (37.0%)	196 (38.8%)
Central herniation	78 (12.9%)	50 (9.9%)
Paracentral herniation	218 (36.0%)	206 (40.8%)
Extreme lateral herniation	85 (14.1%)	53 (10.5%)
L3/4 herniation	136 (22.4%)	107 (21.2%)
L4/5 herniation	252 (41.7%)	220 (43.6%)
L5/S1 herniation	217 (35.9%)	178 (35.2%)
Surgery duration (min)*	65.5 ± 6.0 (42−113)	63.6 ± 6.3 (40−108)
Intraoperative blood loss (ml)*	140 ± 10 (110−220)	55.3 ± 11 (30−140)
Length of hospital stay (d)*	7.3 ± 0.9 (6−11)	4.3 ± 0.3 (2−8)
Bed rest duration (d)*	3.23 ± 0.5 (1−6)	1.6 ± 0.4 (1−3)
Data are denoted as n (%) or mean ± standard deviation (range).		
*$P< 0.05$ for Group A *vs.* Group B.		

All patients were followed up after surgery for 26 to 60 months, with a mean follow-up duration of 43.67 ± 7.0 months. Three cases of surgical complications occurred in Group A: there was one case of superficial infection of E. coli in the wound, which healed after antibiotic treatment, and two cases of

cerebrospinal fluid leakage. During the follow-up, one case recurred 11 months after surgery, and another case recurred 18 months after surgery. Both cases were then resolved by decompressive laminectomy via the posterior approach and internal fixation with an intervertebral fusion cage. In Group B, there were four cases of dura mater injury and thus cerebrospinal fluid leakage. During the follow-up period, one case recurred 11 months after surgery, one recurred 16 months after surgery, and one recurred 26 months after surgery. Of these three cases, two were resolved by PTED again, and two were cured by decompressive laminectomy via the posterior approach and internal fixation with an intervertebral fusion cage. Neither group had complications, such as nerve root or cauda equina injury.

There was no statistically significant difference in the VAS-LP scores between the two groups ($P > 0.05$), and the scores progressively decreased. One month after surgery and at the last follow-up, there was no significant difference in the VAS-BP scores between the two groups. One day after surgery, however, the VAS scores were significantly higher in Group A than in Group B ($P < 0.05$) (Table 2). One day after surgery, one month after surgery, and at the last follow-up, there was no significant difference in the ODI values between the two groups ($P > 0.05$), but the values in the two groups were significantly lower than before surgery ($P < 0.05$) (Table 2).

Table 2
Measures of baseline severity and surgical outcomes in the two groups

Measure	Group A	Group B
VAS-LP		
Preoperative	7.1 ± 1.3	7.2 ± 1.2
1-day postoperative	2.0 ± 0.9*	1.9 ± 0.8*
1-month postoperative	1.8 ± 0.4$^\Delta$	1.7 ± 0.5$^\Delta$
Last follow-up	0.6 ± 0.07$^+$	0.6 ± 0.08$^+$
VAS-BP		
Preoperative	7.9 ± 1.0	8.1 ± 1.1
1-day postoperative	4.4 ± 0.8*	2.8 ± 0.9$^{*\#}$
1-month postoperative	2.0 ± 0.5$^\Delta$	1.9 ± 0.6$^\Delta$
Last follow-up	0.7 ± 0.04$^+$	0.7 ± 0.05$^+$
ODI, %		
Preoperative	68.3 ± 14.1	69.2 ± 12.2
1-day postoperative	24.2 ± 3.1*	23.9 ± 3.2*
1-month postoperative	15.6 ± 0.1$^\Delta$	16.1 ± 0.2$^\Delta$
Last follow-up	7.9 ± 0.04$^+$	8.3 ± 0.03$^+$

ODI, Oswestry Disability Index; VAS-LP, Visual Analogue Scale for Leg Pain; VAS-BP, Visual Analogue Scale for Back Pain.

$^*P < 0.05$ *vs*. preoperative.

$^\Delta P < 0.05$ *vs*. 1-day postoperative.

$^+P < 0.05$ *vs*. 1-month postoperative.

$^\#P < 0.05$, Group A *vs*. Group B.

According to the modified MacNab criteria, in Group A, the outcomes were excellent in 483 cases (79.8%), good in 88 cases (14.6%), fair in 28 cases (4.6%), and poor in six cases (1%), and the excellent and good rate was 93.5%. In Group B, the outcomes were excellent in 392 cases (77.6%), good in 86 cases (17.0%),

fair in 22 cases (4.4%), and poor in five cases (1%), and the excellent and good rate was 92.6%. The outcomes of the two groups were tested by x^2, and there was no significant difference (P > 0.05).

Discussion

Patients who fail to respond to conservative treatment are treated with surgery, the aim of which is to remove the herniated nucleus pulposus to the largest extent possible to relieve nerve compression while minimizing spinal instability [1–4]. IFD is the most commonly performed clinical procedure and is considered the standard procedure for treating LDH. Because the operation is easy to perform and allows a clear field of vision, the technique enables surgeons to reveal and cut the ligamentum flavum and the pathological hyperplasia of bones under naked-eye observation in order to expand and decompress the nerve root canals. Thus, compression of the nerve root and dural sac can be relieved while the normal anatomy of the spine is preserved to the greatest extent possible to ensure patients can undergo early postoperative rehabilitation [5, 6]. Nevertheless, in clinical practice, since the nerve root and dural sac need to be pulled during this surgery to expose the herniated nucleus pulposus, the dura can be injured easily, and there is a high risk of adherent and damaged nerve roots. Moreover, the soft tissue needs to be stripped during this surgery, which can easily lead to denervation of the muscles and is not conducive to postoperative recovery of the patients [14, 15]. In this study, there were two cases of dura mater injury complicated with cerebrospinal fluid leakage. One day after surgery, the severity of lower back pain was significantly higher in Group A than in Group B, which might be related to IFD leading to more trauma.

In recent years, many advancements in spinal endoscopy have been made, and lumbar discectomy under endoscopy has been frequently performed for the treatment of LDH. Transforaminal endoscopic discectomy can be performed to remove the herniated nucleus pulposus directly via the subforaminal safe-triangle approach, thereby eliminating the degenerated nucleus pulposus and its metabolites and reducing the central pressure on the intervertebral disc. Moreover, it can minimize damage to normal tissues and maintain spinal stability [6, 7]. Combined with radiofrequency bipolar haemostasis and reconstruction of the fenestrated fibrous ring, this surgical approach greatly reduces the amount of postoperative scarring around the nerve root, as well as the severity of denervation in the ablation of the intervertebral disc, and it alleviates the postoperative symptoms of lower back pain [16, 17]. Radiating pain in the lower limbs is caused by the dual effects of mechanical compression and chemical stimulation at the nerve root. After the nucleus pulposus is removed, the centre of the intervertebral disc is decompressed, allowing the fibrous ring, especially its herniated portion, to retract, which constitutes the first stage of decompression of the nerve root. When the tongue-shaped end of the working cannula is retracted near the lateral recess, the course of the nerve root and the side of the dural sac can be clearly identified by rotating and turning the cannula. The adhesions and un-retracted bulges and herniations can be removed directly and clearly under the endoscope, achieving the second stage of local decompression of the nerve root. Different types of ring drills used in PTED can be used to enlarge the transforaminal working cannula to a moderate extent, allowing the endoscope to reach any position inside the intervertebral disc and the spinal canal on the affected side to remove the herniated tissue. The

shortcomings of incomplete decompression after early transforaminal endoscopic discectomy are thus entirely resolved. After intraoperative injection of methylene blue into the intervertebral disc, the degenerative and damaged tissues are first stained dark blue, while the nerve root, the fibrous ring, and the dural sac are not stained, for the most part, thereby improving the surgeon's ability to identify the target to be removed.

Compared with IFD, PTED involves a smaller incision and a clearer field of vision, while the ligamentum flavum is not removed and the paravertebral muscles are not dissected. These advantages help reduce the amount of postoperative adhesion and denervation of the nerve root inside the spinal canal. Moreover, local anaesthesia is administered during the surgery to enable communication with the patient during the procedure and prevent nerve damage. Moreover, cannulas of various sizes are used to establish the working cannula, thereby minimizing damage to the spine and ensuring lumbar spinal stability [18, 19]. This study shows that PTED leads to less intraoperative blood loss, faster off-bed rehabilitation, and a shorter length of hospital stay, which is consistent with the results of the previous study. This study also shows that there is no statistically significant difference in surgery duration between the two groups over time. A possible reason for this result is that the surgeons' expertise in performing minimally invasive techniques is constantly improving in our spine centre, and their level of proficiency is satisfactory.

Different spine surgical options have their respective advantages. The surgical method should be selected according to the type of the herniated disc so that the optimal surgical outcome is obtained, the incidence of postoperative complications is minimized, and ultimately, the patients experience improvement. This study also has some limitations: it had a single-centre retrospective study design, and the patient population was not very homogenous. In the future, a prospective study will be carried out to analyse the efficacy of IFD and PTED in treating LDH.

Conclusion

Given the appropriate surgical indications, both IFD and PTED can be used to achieve desirable outcomes in the treatment of LDH. However, compared with IFD, PTED leads to less trauma, faster recovery, and fewer complications. It can maintain the anatomy and biomechanical stability of the lumbar spine. It is an ideal surgical method for treating LDH.

Abbreviations

IFD: Interlaminar fenestration discectomy; PTED: percutaneous transforaminal endoscopic discectomy; CT: Computed tomography; MRI: Magnetic resonance imaging; VAS: Visual analog scale; ODI: Oswestry Disability Index; Post-op: post-operation; VAS-LP: Visual Analogue Scale for Leg Pain; VAS-BP: Visual Analogue Scale for Back Pain.

Declarations

Ethics approval and consent to participate

Ethical approval from the Ethics Committee of the Shaanxi Provincial People'sHospital was obtained for this study (No. 2011-009). Each author certifies that all investigations were conducted in conformity with ethical principles. Written informed consent was obtained from all patients included in the study.

Consent for publish

All patients signed informed consent to publish their personal details in this article.

Availability of data and materials

The datasets supporting the conclusions of this article are included within the article. The raw data can be requested from the corresponding author on reasonable request

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

QLand YZ participated in the recruitment, data collection and analysis. All authors contributed to the study design and drafting of the manuscript. All authors read and approved the final manuscript.

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