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Percutaneous Transforaminal Endoscopic Discectomy for Lumbar Disc Herniation: A Retrospective Study

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Abstract

Aim: To explore the long-term outcome of patients with lumbar disc herniation (LDH) performed with percutaneous transforaminal endoscopic discectomy technique (PTED).

Materials and methods: In this retrospective study, we collected the medical records from 974 patients with LDH who received PTED operation from May 2010 to July 2015. Follow-up measurements were performed at 1, 3, 6 and 12 months after surgery. Before and after surgery, visual analogue scale (VAS) was used for evaluating pain in leg and low back. Oswestry Disability Index (ODI) was used for evaluating the recovery of function. Japanese Orthopaedic Association (JOA) and modified MacNab criteria were used for clinical efficacy evaluation.

Results: We found that the mean value of VAS and ODI were significantly decreased at each follow-up time points compared with that before operation (each $p<0.01$). The JOA showed significantly improving after the surgery through the follow-up period (each $p<0.05$). Furthermore, according to the modified MacNab criteria, the overall response of clinical efficiency was excellent in 32.7% patients and good in 54.9% patients..

Conclusion: PTED performed with broad, easy, and immediate surgery (BEIS) technique is an effective endoscopic discectomy approach for the treatment of LDH.

Keywords: Lumbar disc herniation; PTED; BEIS technique; Discectomy

Introduction

About 70% of the population at some point in time may be affected by LDH with different degrees of symptoms severity [1]. Reports also reveal that the lifetime incidence of lumbar radicular syndrome ranges from 12% to 43% [2]. Axial torque/twist and repetitive motions of flexion-extension are thought to be the most common causes of LDH, as well as gene mutations have also been proposed as a potential cause [3-5]. Nucleus pulposus, herniated form disrupted annular, causes the simulation and compression of nerve root, eventually leading to radiculopathy, such as sciatica or low back-related leg pain [1,2,6].

Surgeries are generally recommended to patients with refractory symptoms invalid against conservative management, especially suitable for those with obvious herniated lumbar disc, or severe sciatica with serious or progressive neurologic deficits [7-10]. However, open surgery can cause many complications, such as epidural fibrosis, lateral and foraminal stenosis, segment instability, progressive facet joint degeneration and myofascial pain known as “failed back surgery syndrome” [11]. Therefore, transforaminal endoscopic technique, a more minimally invasive surgical approach, has been widely used and developed [12-14]. Among them, PTED has become the most frequently-used technique. PTED offers many advantages over other surgical lumbar discectomy techniques, such as smaller incisions, less disruption of muscles, less blood loss, less postoperative pain and faster recovery, potentially making it an excellent choice for the treatment of LDH [15-18].

Transforaminal Endoscopic spine system (TESSYS), developed by Dr. Thomas Hoogland [19], has steadily become a prevalent method in the procedure of PTED [20-23]. This method made it possible to use foraminoplasty to operate inside the spinal canal and wide the foramen between vertebras. Furthermore, on this basis, Professor Yi-Bing Bai

improved TESSYS and developed a new technique called improved TESSYS or BEIS (broad, easy, and immediate surgery) [24]. Briefly, BEIS improves the simplex intervertebral disc-targeted discectomy for nerve root decompression into multi-targeted removal of all associated-factors responsible for nerve root compression. The purpose of this present study was to investigate the further efficacy and outcome of patients with LDH treated with BEIS system.

Materials and Methods

Study design and patient recruitment

A retrospective design was used in this study. The research was conducted in our hospitals. From May 2010 to July 2015, 974 patients with LDH were underwent PTED.

Inclusion criteria: The inclusion criteria were as follows:

- The diagnosis of LDH was confirmed by clinical characteristics and imaging examinations.
- Symptoms of low back and leg were unresponsive to conservative treatment for 3 months.
- Patients were willing to accept PTED.

Exclusion criteria: The exclusion criteria included:

- LDH with spinal mechanical instability, lumbar spondylolisthesis or congenital deformity.
- Clinical symptoms inconsistent with imaging findings.
- Patients with infection, trauma, hemorrhagic disorders, mental disorder, or severe systemic infectious diseases.
- Patients refusing the participation.

General data collection

Before the PTED procedure, a written informed consent form was obtained and the risks and benefits of the surgical procedure were adequately explained. Basic characteristics including demographic variables (name, gender, age), current disease related information (disease duration, herniated disc segment) and data associated with the surgery (time of surgery, volume of bleeding during surgery and hospitalization time) were collected.

PTED operation with BEIS system

BEIS system was used in this study. The procedure was divided into 7 steps, including:

- Intervertebral foramen expansion.
- Lateral recess decompression.
- Vertebral posterior margin osteophyte resection.
- Yellow ligament formation.
- Fibrous ring formation.
- Posterior longitudinal ligament formation.
- Nucleus removal.

During operation, all factors associated with the compression of nerve root and epidural sac can be processed, and the activity space of nerve root can be expanded along its trend. Compared with TESSYS system, BEIS system has increased the head tilt angle of puncture approach from horizontal or 20 ~ 25° into 60° or even 70°.

Operative position

Patients were arranged in lateral position with the affected side upwards. As reports showed, the use of lateral position can avoid the risk of adverse vascular events and it does not affect the intradiscal pressure [25]. Compared with the prone position, the lateral position may effectively decrease the risk of high abdominal pressure, the damage of venous plexus and extensive bleeding. Furthermore, the straight leg rising test can be carried out during the operation for assessing the situation of nerve root decompression.

Body surface localization

The two-line method was used for body surface localization. The anteroposterior line, located between two projections of vertebral plate and spinous process, was adjusted according to the body type of the patients. This line was used to determine the distance of the puncture point from median line. Another line was diagonal line, which was used as the surgical puncture pathway, going through the apex of superior articular process directly to the posterosuperior edge of the next centrum **(Figure 1)**.

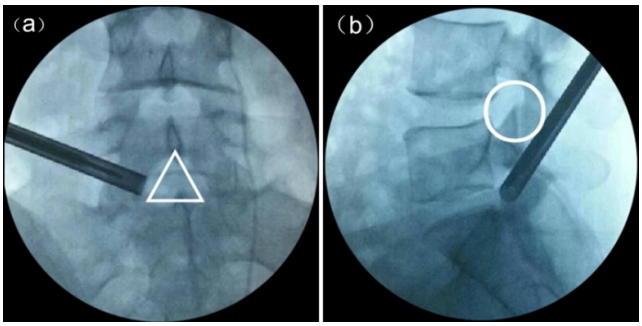

Figure 1 Two-line localization method. (a): Anteroposterior line and (b): Diagonal line.

Surgical procedures

C-arm X-ray device was used for verifying the interval of the herniated disc. In order to achieve accurate location, anteroposterior and lateral X-ray images were obtained **(Figure 2)**. Then local infiltration anaesthesia was performed by using lidocaine (0.5%). A spinal needle was pierced into the intervertebral disc. Before removing the spinal needle, a guide wire was inserted through the needle, and then a 7 mm skin and fascia incision was made around the guide wire. Three expansion tubes were then introduced step by step along the wire, and the outermost tube was docked for providing channel for the working cannula **(Figure 3)**. Then the surgery was carried out with the guidance of endoscope. The blue-stained nucleus pulposus was removed with suitable grasping

forceps. Under endoscope, intervertebral foraminal enlargement, ligamentum flavum plasty, lateral recess decompression, posterior longitudinal ligament plasty, vertebral osteophyte resection and the fibrous ring plasty were then performed for the neurolysis of nerve root. After the compression of the nerve root was removed, the pulsation of the nerve root was checked **(Figure 4)**. The endoscope and working cannula were retracted and the skin incision was stitched.

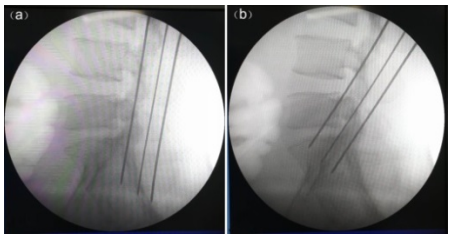

Figure 2 The establishment of accurate location. (a): The anteroposterior X-ray image was obtained for confirming the spinous process was located in the midline and both ends of targeted spinal levels were on the same line. Then a regular triangle can be seen as shown. (b): The lateral X-ray image was obtained for confirming the bilateral superior articular processes were overlapped, just as shown.

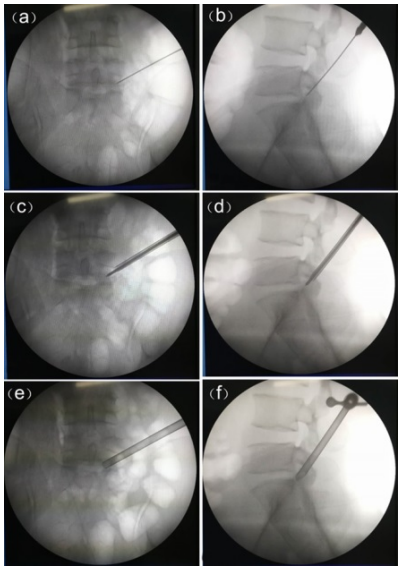

Figure 3 The expansion step by step. (a) and (b): The anteroposterior and lateral X-ray images of puncture needle. (c) and (d): The anteroposterior and lateral X-ray images of expansion tubes. (e) and (f): The anteroposterior and lateral X-ray images of working cannula.

Postoperative management

All patients did not require to be treated with antibiotics after operation. Treatment of dehydration, anti-inflammatory and analgesia were not performed in patients without untoward reactions after operation. Moreover, as the operative incision was very small, patients could get off the bed within 2 hours after operation. In addition, patients can be discharged at the third day after operation if there was no sign of infection after the re-examination of inflammatory indicators. Progressive rehabilitation training was needed 6 months after discharge.

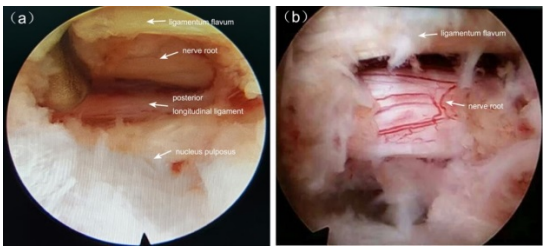

Figure 4 Images of nerve root before and after surgery. (a): Image of nerve root before surgery. (b): Image of nerve root after surgery.

Follow up and assessment

Postoperative follow-up of all patients was performed by surgeons in the clinic at 1 month, 3 month, 6 month, and 12 month after surgery. The evaluation of osphyalgia and skelalgia were performed with the VAS (score range: 0-10). VAS pain score was evaluated by using a 10 cm horizontal line. One end of the line is 0 representing no pain, and the other end is 10 representing most pain. The middle part of the line represents different degrees of pain.

The assessment of lumbar function was carried out with ODI (score range: 0-100) and JOA (score range: 0-29) evaluation questionnaire. The questionnaire of ODI is designed for evaluating the impact of daily activities on the low back pain (or leg pain). It includes 10 items involving pain, standing, sitting, walking, lifting, daily activities, sleeping, social activities and travelling. A higher score indicates more serious the impact. JOA questionnaire was used for evaluating the upper and lower extremity motor function, sensory disturbances and bladder function. A lower score indicates the more obvious of dysfunction.

Additionally, the overall response was assessed with modified MacNab criteria. According to the modified Macnab criteria, the clinical efficiency was gradated into 4 levels including excellent, good, fair and poor. The four levels were determined based on the following standards: symptoms completely disappear, restore the original work and life; mild symptoms, activities mild limited, no impact on public life and work; symptoms mild relief, activity is limited, affecting the work and life; no differences before and after treatment or even worse.

Statistical analysis

Statistical analysis was carried out by using SPSS 19.0. Continuous data are expressed as mean ± standard deviation (SD) or median (interquartile range). Categorical variables are

presented as number of patients (percentage). Data were analysed with the use of t test or rank test. Two-tailed p value less than 0.05 was regarded statistically significant.

Results

General data

The 974 patients including 564 males and 410 females who were followed up for an average of 12 months. The mean age was 51 ± 30 in all patients. Furthermore, the mean disease duration was 35 ± 28 months. The spinal level of disc herniation was occurred at L1/2 in 2 (0.2%) patients, L2/3 in 38 (3.9%) patients, L/4 in 85 (8.7%) patients, L4/5 in 536 (55.0%) patients, and L5/S1 in 313 (32.1%) patients. The mean operating time was 90 ± 21 min. The mean volume of blood loss was 13 ± 8 ml. The mean post-operative hospital stay was 5 ± 2 days **(Table 1)**.

Table 1 General data of patients (n=974).

Variables	Data
Male/Female	564 (57.9%)/410 (42.1%)
Age (years)	51 ± 30
Duration of disease (months)	35 ± 28
Duration of operation (minutes)	90 ± 21
Hospital stay (days)	5 ± 2
Blood loss (ml)	13 ± 8
Level of disc herniation	
L1/2	2 (0.2%)
L2/3	38 (3.9%)
L3/4	85 (8.7%)
L4/5	536 (55.0%)
L5/S1	313 (32.1%)

General data of patients involved in the present study were showed in **Table 1**. Data were presented as mean ± SD, or number of patients (percentage).

Table 2 VAS pain scores.

Variable	Score at different time				
	Before	1 month	3 months	6 months	12 months
VAS	7 (5-10)	4 (1-6)[a]	3 (0-4)[a]	1 (0-3)[a]	1 (0-2)[a]

Pain evaluation with VAS

The average VAS pain scores of all cases decreased significantly from 7 (5-10) before operation to 4 (1-6) at 1 month after surgery, 3 (0-4) at 3 months after operation, 1 (0-3) at 6 months after operation and 1 (0-2) at 12 months after operation (each p<0.001) **(Table 2)**.

The VAS scores at different follow-up time points were showed in **Table 2**. After the PTED, VAS score was significantly reduced at each time point (p<0.01); Data are presented as median (range); (a: p<0.01 compared with pre-operation).

Improvement of lumbar function

Lumbar function was evaluated with ODI and JOA. The mean ODI scores were significantly decreased to 28.2 ± 3.6, 22.0 ± 2.5, 17.6 ± 3.1, and 12.1 ± 1.8 (each p<0.001) at 1, 3, 6 and 12 months respectively compared with 56.1 ± 12.8 measured before the operation **(Table 3)**.

Table 3 Evaluation of lumbar function.

Variable	Score at different time				
	Before	1 month	3 months	6 months	12 months
ODI	56.1 ± 12.8	28.2 ± 3.6[a]	22.0 ± 2.5[a]	17.6 ± 3.1[a]	12.1 ± 1.8[a]
JOA	14.3 ± 7.7	20.8 ± 6.3[b]	25.5 ± 6.9[a]	26.4 ± 7.3[a]	27.1 ± 4.2[a]

Compared with 14.3 ± 7.7 measured before the operation, the mean JOA scores were significantly improved to 20.8 ± 6.3 (p=0.012), 25.5 ± 6.9 (p<0.001) 26.4 ± 7.3 (p<0.001), and 27.1 ± 4.2 (p<0.001) at 1, 3, 6 and 12 month follow-up period respectively.

The lumbar function at different follow-up time point was evaluated by using ODI and JOA. Compared with before operation, ODI score at different time point was significantly decreased since 1 month after operation to the last follow-up time point (each p<0.001). The mean JOA score was significantly improved after operation comparing with the JOA score measured before operation (p=0.012 at 1 month, p<0.01 at 3, 6 and 12 months). Data are presented as mean ± SD. (a: p<0.01 compared with pre-operation; b: p<0.05 compared with pre-operation).

Assessment of clinical efficacy

For evaluating the overall response of clinical efficacy at 12 months after operation, modified MacNab criteria was used. 32.7% patients (318/974) had excellent clinical efficacy, 54.9% (535/974) presented good clinical efficacy, and 9.4% (92/974) had fair and 3.0% (29/974) had poor clinical efficacy **(Table 4)**.

Table 4 Clinical efficacy.

Variable	Number of patients			
	Excellent	Good	Fair	Poor
number	318 (32.7%)	535 (54.9%)	92 (9.4%)	29 (3.0%)

The overall efficacy was evaluated with modified MacNab. 33.7% patients were presented with excellent efficacy, 56.9%

patients were presented with good efficacy and 9.4% patients were presented with fair efficacy. No one was with poor clinical efficacy. Data are presented as number of patients (percentage).

Discussion

The major goal of surgical treatment for LDH is sufficient decompression with minimal operation-induced trauma and intra or post-operative complications [23,26]. The open surgery certainly requires dissection of sacrospinalis, removal of flaval ligament and parts of lamina or facet joint, and retraction of spinal dura and nerve root, all of which would increase the risk of iatrogenic morbidity [23]. Therefore, microendoscopic discectomy has been accepted and carried out worldwide since 1997, when it was initially developed [27,28]. Transforaminal endoscopic spine system (TESSYS), developed by Dr. Thomas Hoogland, has steadily become a prevalent method of PTED for the treatment of LDH. In addition, some studies has reported the beneficial clinical outcomes of TESSYS for the treatment of LDH [20,29]. On this basis, Professor Ying-Bing Bai made some improvements and developed a new method called BEIS, which improves the simplex intervertebral disc-targeted discectomy for nerve root decompression into multi-targeted removal of all associated-factors responsible for nerve root compression. In our study, total of 974 patients with LDH underwent PTED with BEIS system. Our research data suggested that the approach of BEIS is effective for the treatment of LDH.

BEIS-Multi-targeted technique

The BEIS technique is an improvement of the TESSYS method. The remarkable characteristics are surgery on the dural sac and nerve root foramen, multi-directional discectomy and removal of calcification [24]. Besides the herniated disc, there are many other problems need to be solved, including the nerve roots compression, ligament hypertrophy and/or calcification, annulus fibrosus calcification, vertebral osteophyte, and articular process hypertrophy [30]. BEIS technique transforms the simplex intervertebral disc-targeted discectomy into multi-targeted removal of all associated-factors responsible for nerve root compression. Many operations can be performed during the surgery procedure with the use of BEIS technique, such as intervertebral foraminal enlargement, ligamentum flavum plasty, lateral recess decompression, discectomy, posterior longitudinal ligament plasty, vertebral osteophyte resection and the fibrous ring plasty. Consequently, the compression of nerve roots is not merely relieved, but simultaneously the blood supply of the nerve roots was improved and the nerve root mobility was recovered.

Deal with nucleus pulposus during PTED

Postoperative recurrence of LDH is one of the most common complications. Reports have suggested that the pressure applied on the nucleus pulposus and the mechanical overload are high risk factors of recurrence postoperatively [31,32]. The current study recommends that, during the surgery, the nucleus pulposus should be remained in normal position as much as possible. By doing this, the physiological function of the disc is retained, the spinal stability is maintained, the iatrogenic damages of the spinal functions are reduced, lumbar regression is postponed and eventually the life quality of patients is improved. In our study, the recurrence rate is 2.7%, which is much lower than 3.6% reported by Schubert M and colleagues [33]. As recommended in our study, there are three main indicators for the removal of nucleus pulposus:

- Significant shrinkage of the fibrous rings.
- Significant fracture of the fibrous rings.
- Significant decrease of the surrounding fibrous rings tension.

In addition, after the removal of compression associated factors, the fibrous rings should be handled with electrocoagulation, so as to increase the stability of fibrous rings and intervertebral disc and reduce the post-operative recurrence rate of disc herniation.

Protection of the nerve root

During the operation process, nerve roots and dural sac are easily damaged, especially the S1 nerve root which is separated from the dural sac and exports at the L5-S1 disc space. As reported, during PTED, the invasion into the epidural space is inevitable in order to catch the tail of a dorsally migrated disc fragment [34]. However, the direct access to the shoulder of the S1 nerve root is very likely to damage the nerve root because of its special anatomical position [34]. In the present study, in order to protect the microenvironment of the nerve root and reduce the post-operative incidence rate of the nerve root adhesion, the operations were performed, as much as possible, on the side away from the nerve root. For example, when handling the posterior longitudinal ligament hypertrophy, we did our utmost to operate at the ventral side of the posterior longitudinal ligament, in order to maintain the integrity of ligament at the nerve root side. In the cases with opposite disc protrusions simultaneously, we firstly separated the posterior longitudinal ligament from the ventral side, and then placed the endoscope and instruments at the opposite side. As a result, the interference of the instruments to the intraspinal structures and surrounding tissues of the nerve root were reduced.

Postoperative relapse phase

In the present study, 108 cases developed post-operative nerve root symptoms at three days post-operatively. Their clinical manifestations included low back and buttock pain, numbness and distended feeling at the affected side. According to the MRI imaging, hematoma formation, incomplete nucleus pulposus removal, or recurrent herniation of remaining tissues of disc were showed. Considering the clinical symptoms and imaging examination, endplate inflammation was diagnosed. Under these circumstances, timely handling with effective treatments was needed. The

repeated duration can be short or long, ranging from days to 3 months, and most patients can gradually recover because of self-healing capability. The shock wave or silver needle therapy can be performed post-operatively for patients with intraspinal diseases and simultaneously with extraspinal soft tissue lesions, in order to relieve the local soft tissue pain.

Limitations

Due to the retrospective nature of the study design, the main limitation of the current study is the significant bias that can impact the recall of the former exposure to risk variables. In addition, the lack of a control group and the appropriate randomization are significant drawbacks of the study design. Furthermore, limitations such as the short period of follow up and the impact of confounding factors during the course of treatment can be further explored in future studies.

Conclusion

In conclusion, the current study has examined retrospectively the efficacy of PTED for LDH by using the BEIS technique in a sample size of 974. The results indicated that the mean values of the VAS score were significantly decreased during the follow-up period. Moreover, the lumbar function was significantly improved at each follow-up time points after operation. Meanwhile, the overall response of clinical efficacy was succeeded in over 90% patients. In addition, a comprehensive report is presented in terms of the surgical procedures, with particular note on the prevention of potential nerve damage and management of nucleus pulposus. The study adds valuable insight in the existing knowledge of the treatment of LDH.

Ethical Approval

The study was approved by the Ethics Committee of the hospital. Written informed consent was obtained from all participants enrolled. The study was conducted according to Good Clinical Practice (GCP) guidelines and the Declaration of Helsinki.

Conflict of Interest

The authors declare no conflict of interests.

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