Retrospective Review

Transforaminal Endoscopic Discectomy for Treatment of Central Disc Herniation: Surgical Techniques and Clinical Outcome

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Background: Though transforaminal endoscopic discectomy has achieved a satisfactory clinical outcome in the treatment of paracentral disc herniation, it has a high failure rate for treating central disc herniation.

Objective: To explore the surgical techniques of transforaminal endoscopic discectomy in treating central disc herniation and the clinical outcome based on 2-year follow-up.

Study Design: A retrospective study.

Setting: The Department of Spinal Surgery at the Third Hospital of Hebei Medical University in China.

Methods: Sixty-nine consecutive patients (male:female = 14:9, mean age 38.8 ± 10.5 years) were enrolled in the study, all of whom underwent transforaminal endoscopic discectomy due to central disc herniation. The rod adjustment technique, apex technique, and posterior longitudinal ligament detection technique were adopted for intraoperative individualization. All of the patients were followed up for 24 months to assess the visual analog scale (VAS), Japanese Orthopaedic Association (JOA), and Oswestry Disability Index (ODI) scores. The postoperative segmental instability and recurrence were observed during the follow-up period as well. MacNab criteria scores were recorded both intraoperatively and at the final follow-up; postoperative complications and the surgical outcome and safety were also evaluated.

Results: The herniated disc tissues were successfully removed for all patients, without revision by open surgery. Twenty-one cases (30.43%) were rated excellent, 44 (63.77%) good, 4 (5.80%) fair, and 0 (0.00%) poor upon the final follow-up, with an overall excellent-to-good rate of 86.96%. The VAS scores of low back and leg pain were all significantly lower at 3, 6, 12, and 24 months postoperatively compared to preoperatively (all $P < 0.05$). The JOA scores at the 3-month and 24-month postoperative follow-ups were significantly higher than the preoperative values (all $P < 0.05$). The ODI evaluation was significantly lower at 3 and 24 months postoperatively than preoperatively (all $P < 0.05$).

Limitations: The retrospective nature of this study is a limitation, as well as the small sample size and short observation time.

Conclusion: The application of novel surgical techniques can help improve the safety and efficacy of transforaminal endoscopic discectomy in treating central disc herniations. Intraoperative individualized application of rod adjustment technique, apex technique, or posterior longitudinal ligament detection technique is the key to satisfactory clinical outcome.

Key words: Central disc herniation, rod adjustment technique, transforaminal endoscopy, minimal invasion, complication

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With the rapid development of minimally invasive spine surgery in recent years, spinal endoscopic technology has made revolutionary progress, and percutaneous endoscopic technology is also continuously improving, which has attracted widespread attention owing to its advantages of being less invasive, more accurate, and leading to faster recovery (1). Nevertheless, transforaminal endoscopic discectomy has some shortcomings such as the steep learning curve (2), which often results in a poor outcome for patients with central disc herniation (3,4). Choi et al (3) followed-up 10,228 patients with lumbar disc herniation (LDH) who underwent transforaminal endoscopic discectomy and found that the failure rate was 4.3% (436/10,228) and that 91 of 283 patients with incomplete nucleus pulposus removal were central disc herniation patients (32.2%). Lee et al (4) analyzed 328 patients with central lower canal compromise and found a surgical failure rate of 2.4%, and the rate was higher (15%) for patients with upper canal compromise. The authors analyzed the reasons: on one hand, the placement of the working channel was undesirable, which made it difficult to completely remove the herniated nucleus pulposus and on the other hand, lower extremity radiating pain would be induced during cannula placement because the position of the exiting nerve root precluded cannula placement. To address this problem, we applied the rod adjustment technique, apex technique, and posterior longitudinal ligament detection technique clinically to treat such diseases and achieved a satisfactory clinical outcome.

The purpose of this study is to explore the surgical techniques of transforaminal endoscopic discectomy in treating central disc herniation and to analyze the clinical outcome based on 2-year follow-up, in order to provide the reference for clinical practice.

Methods

General Information

The clinical data of 72 patients with central disc herniation treated by transforaminal endoscopic discectomy from February 2010 to April 2014 at the Third Hospital of Hebei Medical University were retrospectively analyzed. Finally, 69 patients were included in the present study.

Inclusion criteria were as follows:

1. Monosegmental central disc herniation with varying degrees of unilateral or bilateral lower extremity radicular pain, whose imaging findings were consistent with clinical signs and symptoms
2. Patients who had received conservative treatment for at least 6 months preoperatively, but had an unsatisfactory outcome or aggravating symptoms
3. No lumbar instability or spondylolisthesis according to the preoperative lumbar flexion-extension x-ray examination
4. Confirmed central disc herniation by the preoperative lumbar disc computed tomography CT and lumbar magnetic resonance imaging (MRI)
5. Patients who were scheduled for percutaneous endoscopic lumbar discetomy (PELD).

Exclusion criteria were as follows:

1. Patients with overt preoperative degenerative deformity, instability of lumbar vertebrae, intervertebral disc calcification, or sequestration, extrusion of nucleus pulposus
2. Previous history of lumbar surgery
3. Protruding sections scheduled for surgery was not influenced by iliac crest and parapophysis of L5
4. Patients with pathological conditions (infection/tumor) or metal allergy and those unsuitable for PELD
5. Obese patients with BMI ≥ 28 kg/m^2
6. Simple low back pain
7. Cauda equina syndrome
8. Upper disc herniation
9. Incomplete information or lost during the follow-up period.

Definition and classification of central disc herniation

Central disc herniation was defined by consulting Bärlocher et al's (5) method and classified into 2 types: central mass prolapse (CMP) and contained central disc herniation (CCDH). CMP referred to the herniated nucleus pulposus tissues exceeding 50% of the spinal canal, whereas CCDH referred to the herniated nucleus pulposus tissues not exceeding 50% of the spinal canal and were closely adhered to the posterior longitudinal ligament.

The present research program, including instructions, flow charts, data collection, and related ethical issues, has been approved by the ethics committee of our hospital. All of the patients and their families signed the informed consent.

All data were collected by 2 physicians who did not participate in the study design, analysis, interpre-

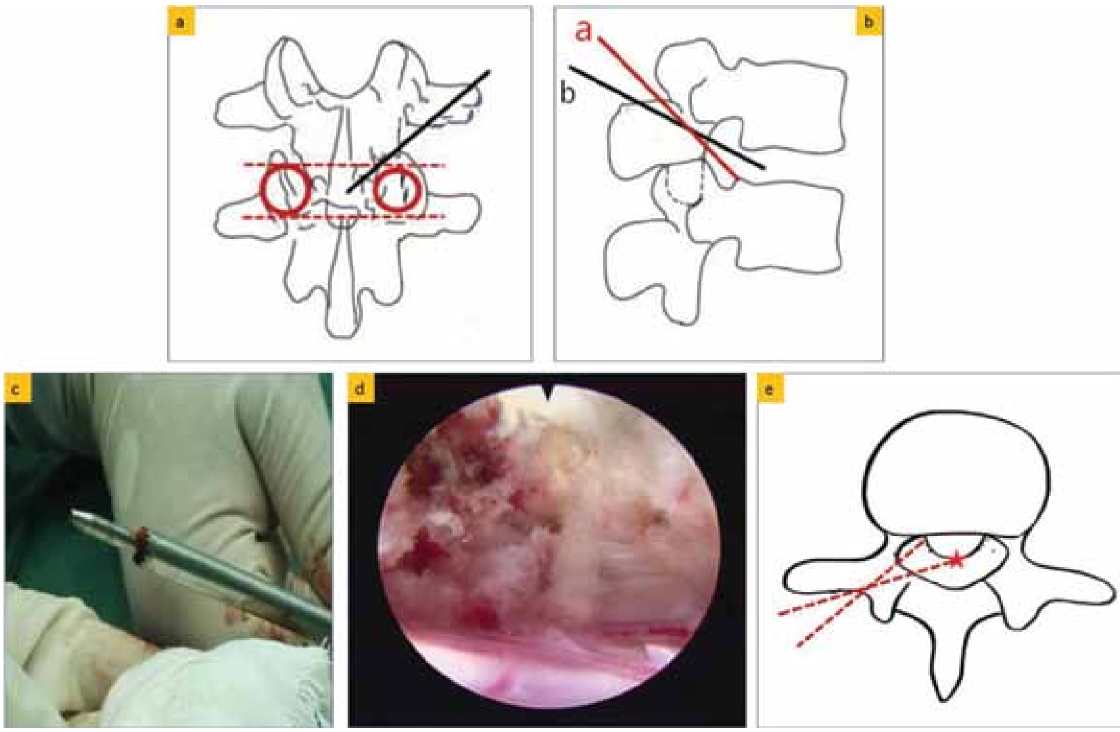

Fig. 1. *Schematic diagram of surgery. a. On anteroposterior view, the tip of the puncture needle should reach the center of an intervertebral disc. b. Different from the traditional TESSYS technology which requires the puncture needle-tip to stop posterior to the intervertebral disc under the lateral x-ray fluoroscopy (a), in the rod adjustment technique, the needle-tip should slightly enter the disc on the lateral view (b). c. Expansive facet formation with eccentric trepan. d. The herniated disc and its fragments were visible endoscopically. e. For patients with higher canal compromise rate, the location of the guide rod was adjusted from the base of the herniated nucleus pulposus to the apex (★) of the herniated nucleus pulposus, which was precisely the apex technique.*

tation, or paper publication. A physician unaware of the present data undertook data analysis and result interpretation.

Surgical Methods

Position and Anesthesia

All surgeries were performed by the same experienced surgeon. Patients were placed in the lateral position, with the affected side up and contralateral waist padded. Preoperative anteroposterior x-ray fluoroscopy angle was parallel to the affected segmental endplate. The affected intervertebral disc plane and spinous process posterior midline were marked. The needle-point and distance depended on the body type of each patient, and the distance was usually 12–14 cm. Under lateral x-ray fluoroscopy, the line connecting the superior facet margin was marked as the safety line. The puncture needle should not be lower than this safety line, so as not to enter the abdominal cavity to injure vital organs and blood vessels. In terms of surgical approach, a posterolateral approach was adopted. After disinfection and draping, the skin and deep fascia were anesthetized with 1% lidocaine.

Rod Adjustment Technique

An 18 G needle was inserted through the puncture site and punctured under the guidance of a C-arm x-ray machine. The needle-tip should reach the center of the intervertebral disc on the anteroposterior view (Fig. 1a). Different from the traditional transforaminal endoscopic surgical system (TESSYS) technology which requires the puncture needle-tip to stop posterior to the intervertebral disc under the lateral x-ray fluoroscopy, in the rod adjustment technique, the puncture needle-tip should slightly enter the intervertebral disc on the

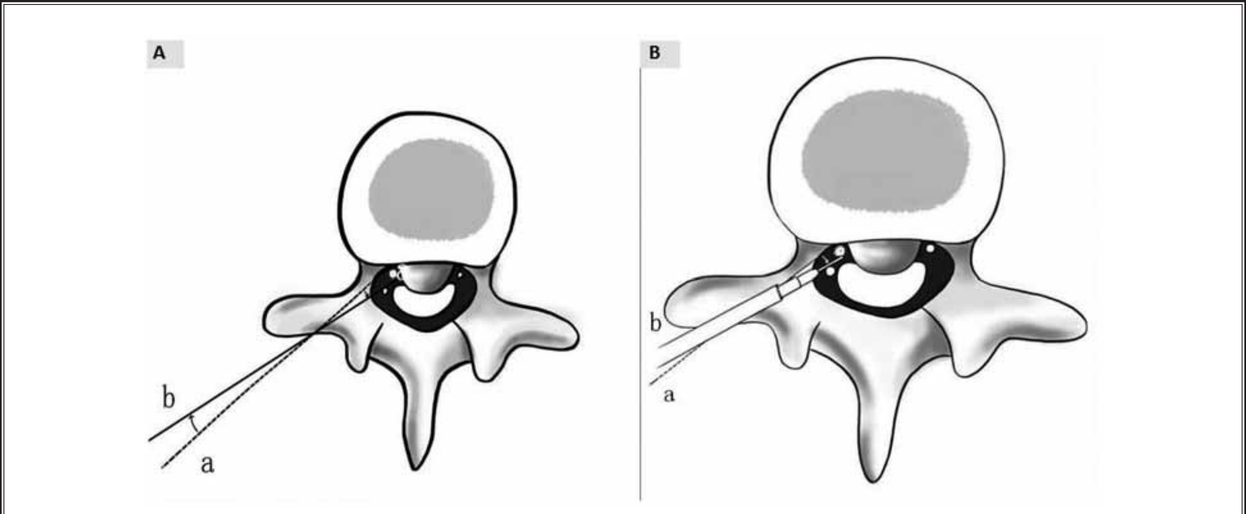

Fig. 2. *Rod migration technique for central disc herination. A. (a) Position of the needle. (b) Adjusted position of the first rod. B. (a) Position of the needle. (b) Reaming on the adjusted rod.*

lateral view (Fig. 1b), in order to ensure that the 18 G needle was on the ventral root (Fig. 2a). Afterwards, a 21 G needle was removed from the 18 G needle, then the guide wire was inserted and the puncture needle was removed after fluoroscopic confirmation of proper positioning. An 8 mm incision was made in the center of the puncture-point on the skin. In accordance with the method shown in Fig. 2, the guide rod and working cannula were used progressively to elevate the nerve root from the dorsal side to the ventral side (a -> b). During this process, the nerve root was pushed progressively to the ventral side, in order to ensure the safe placement of endoscope.

Facet Formation

The guide rod and dilating catheter were inserted along the guide wire to enlarge surgical access. Next, the dilatation catheter was removed progressively, and a trepan was inserted along the guide rod. Under fluoroscopy with a C-arm x-ray machine, the hypertrophic yellow ligament and facet were removed with an eccentric trepan towards the dorsal root as far as possible to expand the intervertebral foramen (Fig. 1c). Next, the trepan was removed, and a working cannula was placed along the guide rod. After fluoroscopic confirmation of proper positioning, the endoscope was placed.

Endoscopic Decompression of Nerve Root

The herniated disc and its fragments were visible endoscopically (Fig. 1d). The degenerated nucleus pulposus tissues were removed through the transforaminal endoscopic pathway with a special clamp. The dural sac was clearly visible under the endoscopy and beat with the heartbeat, which was an important indicator of thorough decompression and surgical termination. The straight leg-raising test was negative, which further suggested thorough, effective decompression.

Apex Technique

For patients with higher canal compromise rate, the location of the guide rod was adjusted from the disc center and the base of the herniated nucleus pulposus to the apex of the herniated nucleus pulposus (Fig. 1e). Moreover, the herniated nucleus pulposus tissues were removed completely.

Posterior Longitudinal Ligament Detection Technique

The posterior longitudinal ligament was isolated for detection. If intact, the ligament was retained without resection, and if fractured, it was necessary to cut off the ligament and remove the nucleus pulposus tissues that were migrated to the dorsal part of the ligament from the perspective of a ventral dural sac. At last, the annulus tears were shrunk and repaired with the bipolar radiofrequency electrode, while electrocoagulation was performed on the intraoperative bleeding points. The working cannula was rotated to check for the presence or absence of bleeding, residual fragments, etc. After confirming no abnormalities, the endoscopy and working cannula were removed, and the incision was sutured with one stitch.

Postoperative Management

After resting in bed for 1–2 days postoperatively, the patients could have off-bed activity as appropriate with a protective belt and begin lumbodorsal muscle exercise and straight leg-raising exercise. One week later, the patients resumed light physical labor. Dehydration (mannitol 50 g, intravenous, once/day), hemostasis (etamsylate 0.2 g, intravenous, once/day), and neurotrophic agent (methylcobalamin 0.5 mg, oral, 3 times/day) were given depending on the patient's specific conditions.

Clinical Assessments

Functional Assessment

The severities of low back and leg pain at one day preoperatively, immediately postoperatively, and at 3 and 12 months postoperatively were assessed on the visual analog scale (VAS). Neurological function of the patients at one day preoperatively and 12 months postoperatively was evaluated according to the Japanese Orthopaedic Association (JOA) scoring system. The patients' daily living ability was assessed using the Oswestry Disability Index (ODI). The final follow-up MacNab criteria scores were recorded for evaluating the early clinical efficacy: "excellent" indicated no pain in waist or leg and no activity limitation, "good" indicated occasional pain in waist or leg that did not affect work and life, "fair" indicated slightly improved function but presence of intermittent pain that changed work and life, and "poor" indicated no improvement in pain and function.

Imaging Assessment

Preoperatively, the patients underwent routine lumbar spine anteroposterior, lateral, and flexion-extension x-ray, lumbar disc computed tomography (CT), and lumbar magnetic resonance imaging (MRI). Routine lumbar spine flexion-extension x-ray was performed immediately after surgery and 24 months postoperatively to observe the presence or absence of intervertebral instability. Lumbar MRI was performed at 3 months postoperatively to observe whether the nerve root compression was relieved. At 24 months postoperatively, the patients were observed for recurrence of LDH.

Adverse Events

Adverse events included postoperative revision, complications (residual nucleus pulposus, dural tear, nerve injury, postoperative intervertebral infection, retroperitoneal hematoma (6), postoperative sensory abnormalities (7), abdominal organ injury (8), epilepsy (9), postoperative pseudocyst (10), etc.), and death at 2 weeks postoperatively.

Other Assessments

Other perioperative data included a surgical segment, lesion type, estimated blood loss (mL), operative time (minutes), intraoperative fluoroscopy use (times), and medical resource utilization (postoperative hospital stay and direct medical expenses incurred by surgery, hospitalization, and other surgical procedures).

Statistical Analysis

Statistical analysis was performed using SPSS Version 19.0 (IBM Corporation, Armonk, NY). Preoperative VAS scores did not follow the normal distribution, which was expressed as M (P25, P75). The Wilcoxon rank-sum test was used to compare the VAS scores before and after surgery (Table 1). The paired t test was performed on the preoperative and postoperative JOA scores of patients at a significance level of $\alpha = 0.05$.

Results

Demographic Data and Surgical Conditions

All patients were successfully operated. A total of 69 patients with complete data were enrolled in this study. Table 2 lists their demographic baseline data.

Table 1. *The VAS scores for low back and leg pain in 69 patients before and after surgery. M (P25, P75).*

	Pre-Surgery	3 mos Post-Surgery	6 mos Post-Surgery	12 mos Post-Surgery	24 mos Post-Surgery	*P*-Value*
Low back pain VAS score	7 (6,7)	2 (1,2)	1 (1,2)	1 (1,2)	1 (1,2)	< 0.01
Leg pain VAS score	7 (6,8)	2 (1,2)	1 (1,2)	1 (1,2)	1 (1,2)	< 0.01

* Various postoperative follow-up periods compared with before surgery.

Table. 2. *Demographic data and surgical data of the patients*

Item	Transforaminal Endoscopic Discectomy (n = 32)
Age ($\bar{x} \pm s$, yrs)	34 ± 12
Gender (%)	
Male	36 (56.17)
Female	33 (47.83)
Surgical Segment (%)	
L3/4	5 (7.25)
L4/5	37 (53.62)
L5/S1	27 (39.13)
Symptom Types	
Unilateral limb symptom	54
Bilateral limb symptom	15
With low back pain	9
Disease Types	
CCDH	38
CMP	31
Disease Duration ($\bar{x} \pm s$, mos)	6.9 ± 2.0
Comorbidities (case)*	9
Intraoperative Blood Loss ($\bar{x} \pm s$, mL)	80.5 ± 15.0
Operative Time ($\bar{x} \pm s$, min)	124.5 ± 23.5
Intraoperative Fluoroscopy Use ($\bar{x} \pm s$, times)	22.0 ± 6.0
Hospital Stay ($\bar{x} \pm s$, days)	3.2 ± 1.0
Surgical Costs ($\bar{x} \pm s$, 10,000 yuan RMB)	2.5±0.4
Postoperative Follow-Up Time ($\bar{x} \pm s$, mos)	24.0 ± 0.0
Postoperative Revision (cases)	0
Postoperative (case)#	1

* Complications include: hypertension, diabetes, bronchitis, coronary heart disease, peroneal nerve paralysis, and degenerative scoliosis. # One patient had a dural tear during surgery. CCDH = contained central disc herniation; CMP = central mass prolapse

Clinical Outcomes

Preoperative and Postoperative Follow-Up VAS Scores for Low Back Pain and Lower Extremity Radicular Pain

Preoperative and Postoperative Follow-Up JOA Scores

Comparison (Fig. 3A) found significant differences between the preoperative and postoperative JOA scores for the 69 followed-up patients (all $P < 0.05$).

Preoperative and Postoperative Follow-Up ODI

Comparison (Fig. 3B) also found significant differences between the preoperative and postoperative ODI evaluations for the 69 followed-up patients (all $P < 0.05$).

Clinical Efficacy

According to the MacNab scoring system, 21 patients (30.43%) were rated excellent, 44 (63.77%) good, 4 (5.80%) fair, and 0 (0.00%) poor upon the final follow-up, with an overall excellent-to-good rate of 86.96%.

Imaging Results

All patients underwent routine flexion-extension x-ray reexamination of the lumbar spine during various postoperative follow-up periods, which revealed no intervertebral instability. Evident retraction or disappearance of the herniated disc was observed upon the routine lumbar MRI reexamination 12 months postoperatively compared to before surgery; moreover, no recurrence was detected at the operated segments.

Complications

One patient had a dural injury during surgery and was given symptomatic treatment such as postoperative fluid infusion (0.9% sodium chloride injection 500 mL + 5% glucose injection 500 mL) and antibiotic infection prevention (ceftriaxone 1.0 g, intravenous infusion, twice/day). The patient recovered 2 weeks after surgery, without showing symptoms like intracranial hypotension headache. The incision was healed by the first intention.

Typical Cases

A 28-year-old male with left lower extremity pain for 2 years; VAS score for low back pain was 6 points before surgery and 3 points, 2 points, and 1 point at 3 and 12 months after surgery, respectively. VAS score for leg pain was 7 points before surgery and 3 points, 1 point, 1 point, 1 point, and 1 point immediately after surgery, as well as 3, 12, and 24 months after surgery, respectively. (Fig. 4)

Discussion

LDH is a common and frequently occurring disease, with paracentral herniation as the prevailing type clinically. Nevertheless, central disc herniation is not rare, and its reported incidence is about 3.6% (10). Central disc herniation manifests itself in diverse forms, including low back pain, unilateral, bilateral, or alternating lower limb pain, spinal stenosis symptoms such as intermittent claudication, or even cauda equina syndrome symptoms such as perineal paresthesia and sphincter disturbance.

Since the invention of Yeung Endoscopic Spine System (YESS) technology by Anthony Yeung in 1999, percutaneous transforaminal endoscopic disectomy has been widely used in the treatment of LDH and has achieved good results (11,12). Yeung et al (13) reported 307 cases of LDH treated with the YESS technique followed-up for more than one year, and the

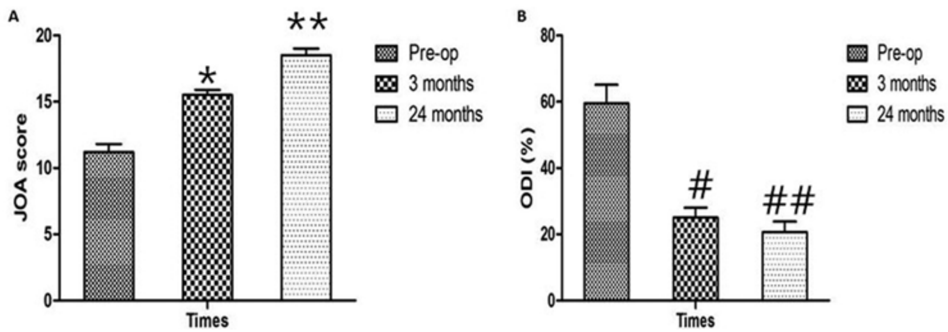

Fig. 3. *Changes in the JOA scores (A) and ODI scores (B) before surgery and after various postoperative follow-up periods. Note: Pre-op = preoperative; 3, 6, and 24 months = 3, 6, and 24 months after operation. JOA = Japanese Orthopaedic Association; ODI: Oswestry Disability Index . * Compared with preoperative score P < 0.05, ** Compared with preoperative score P < 0.05. # Compared with preoperative index P < 0.05, ## Compared with preoperative index P < 0.05*

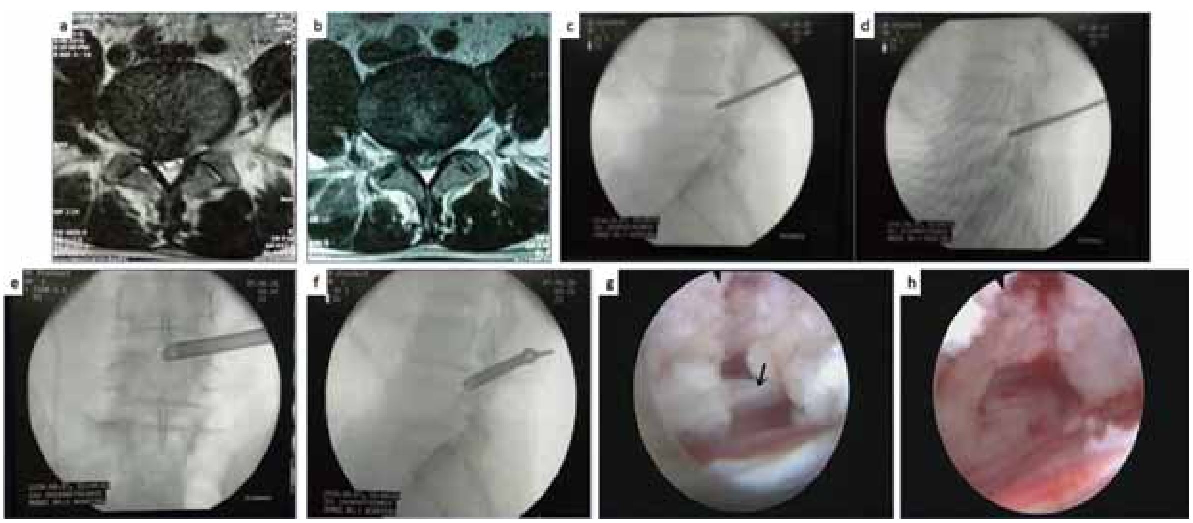

Fig. 4. A 32-year-old male with a central disc herniation. a. Preoperative MRI showed central disc herniation of L4/5 and nerve root compression. b. Reexamination at 12 months after transforaminal endoscopic discectomy showed complete removal of herniated nucleus pulposus and decompression of nerve root. c. The front end of the guide rod was located at the disc center initially, which ensured the guide rod to be located at the ventral root. d. The front end of the guide rod was located in the spinal canal, so that the nerve root was elevated gradually towards the dorsal side to the apex of the herniated nucleus pulposus. e. On anteroposterior fluoroscopy, the working channel was located at the disc center. f. On lateral fluoroscopy, the working channel was in the spinal canal at the apex of the herniated nucleus pulposus. g. The posterior longitudinal ligament (arrow) was cut off to detect the nucleus pulposus tissues migrated to the dorsal posterior longitudinal ligament in front of the dural sac. h. Under endoscope, sufficient decompression of the nerve root was observed, as well as complete removal of the herniated nucleus pulposus at the ventral root.

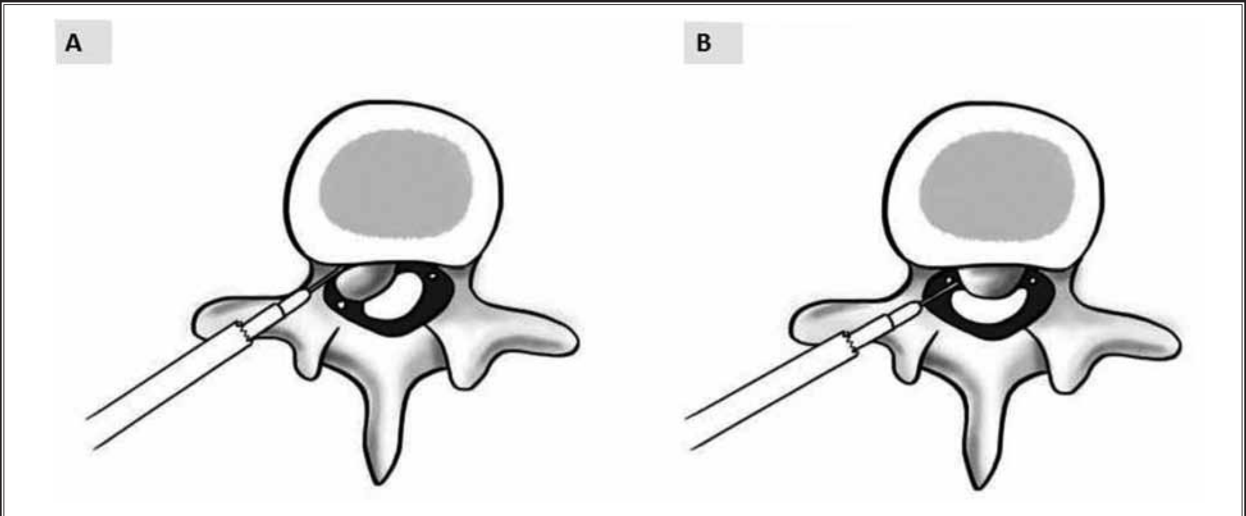

Fig. 5. *Possible transverse nerve injury mechanism for endoscopic discectomy for central disc herniation. A. Endoscopic discectomy for lateral disc herniation. B. Endoscopic discectomy for central disc herniation.*

excellent-to-good rate was 89.3%. Hoogland et al (14) reported the use of TESSYS technology for the surgical treatment of LDH, which achieved over a 90% success rate based on 2-year follow-up. Moreover, the surgical success rate was about 85% for recurrent patients, and the early recurrence rate was below 3%. In theory, transforaminal endoscopic discectomy can manage all types of LDH, but according to previous reports, its application for central disc herniation was often accompanied by high failure rates (3,4). Therefore, central disc herniation was considered a contraindication for transforaminal endoscopic discectomy in the past. Choi et al (3) followed-up 10,228 patients with LDH who underwent transforaminal endoscopic discectomy. They found that the failure rate was 4.3% (436/10,228), and 91 of 283 patients with incomplete nucleus pulposus removal were central disc herniation patients (32.2%). Lee et al (4) analyzed 328 patients with central lower canal compromise and found a surgical failure rate of 2.4%, and the rate was higher (15%) for patients with upper canal compromise. This was because for patients with central disc herniation, the ruptured annulus and nucleus pulposus tissues protruded towards the canal center to compress the dural sac backwards, thereby involving the nerve roots while moving them outwards (Fig. 5A). As for patients with paracentral disc herniation, the nucleus pulposus tissues protruded sideward to elevate the involved nerve roots (Fig. 5B); therefore there was a greater safety in the establishment of the working channel compared to the central herniation. If a surgeon fails to make a clear classification of LDH preoperatively, compression, injury, or even severing of the nerve root will be highly likely if the clinician establishes the working channel in accordance with the procedure for paracentral disc herniation during the surgery. Thus, surgical treatment of central disc herniation differs significantly from the paracentral disc herniation in the establishment of the working channel, and this step is also where the difficulty and essence of the surgery lies. During the transforaminal endoscopic discectomy for central disc herniation, the rod adjustment technique can be used to gradually lift the nerve root, which is the key and highlight to the success of the surgery.

The premise of treating central disc herniation with transforaminal endoscopic discectomy is the sufficient expansion and formation of intervertebral foramen. Decompression of nerve root dorsal structure (yellow ligaments, part facets) is required for sufficient expansion of intervertebral foramen. This allows, on one hand, adequate mobility of the guide rod during the adjusting process, so that it will not be entrapped by the narrow foramen. On the other hand, this allows proper placement of the working channel. Clinical symptoms of central disc herniation are diverse and variable since the protrusions are located in the center of spinal canal, with lower limb pain that can be unilateral, bilateral, or alternating. Choi et al (4) analyzed 10,228 patients receiving PELD, of which 283 experienced surgical failure due to residual nucleus pulposus. For 91 of these 283 patients, the failure was attributed to improper placement of the working channel during the treatment of central disc herniation. Therefore, correct placement of the working channel is particularly important in the transforaminal endoscopic discectomy for central disc herniation. We innovatively proposed that the intervertebral foraminal expansion based on eccentric trepan technology can not only ensure sufficient mobility of the channel, but also allows ideal placement of the working channel, thereby achieving extensive resection of annulus and nucleus pulposus tissues along the protruding interface. Where necessary, it can cross the midline to decompress the contralateral nerve root.

During the surgery, routine resection is recommended for the ruptured posterior longitudinal ligament. On one hand, degenerated posterior longitudinal ligament is often accompanied by evident hyperplasia and hypertrophy or even chondrification and ossification. Studies have shown that fibrin loss in the posterior longitudinal ligament occurs primarily in the dorsal posterior longitudinal ligament, and the no longer elastic posterior longitudinal ligament will fold into the spinal canal with the loss of disc height, thereby compressing the nerve root. On the other hand, resection of the posterior longitudinal ligament allows complete removal of nucleus pulposus tissues migrated to the dorsal side of the ligament and the ventral side of dural sac, thereby preventing residue of nucleus pulposus tissues to achieve adequate decompression. In the present study, the posterior longitudinal ligament was resected intraoperatively in 35 patients, after which free nucleus pulposus tissues were found in 33 (94.3%) of them. Therefore, it might be difficult to achieve effective decompression if the posterior longitudinal ligament is not resected. However, possible adverse factors after the resection of the ligament include:

The posterior longitudinal ligament bears the lumbar tension load and plays an important role in maintaining spinal stability. Whether resection of posterior longitudinal ligament will lead to lumbar segmental instability is worthy of our concern. In the present study, 35 patients received intraoperative resection of posterior longitudinal ligament, none of whom showed lumbar instability upon 2-year follow-up observation. Nevertheless, further follow-up is needed to figure out the long-term outcome

Retention of posterior longitudinal ligament can prevent the reherniation of nucleus pulposus.

Nucleus pulposus is the largest non-vascular tissue in the body. After the ruptured herniation breaks through the posterior longitudinal ligament, vascular invasion into the herniation or vascular invasion is initiated due to contact with blood supply, thereby causing a series of inflammatory, immune responses to result in adhesion between the nucleus pulposus and dural sac, which is likely to lead to dural injury during surgery. In the present study, one patient had dural tear, which resulted in cerebrospinal fluid leakage. Because of the limited endoscopic operative field, broken dura could not be sutured. Therefore, we sutured incisions tightly in surgery, added appropriate electrolytes after surgery, and used antibiotics to prevent infection.

Based on the above considerations, for central lumbar disc herniation patients with an intact posterior longitudinal ligament, blind resection of the posterior longitudinal ligament is not desirable. Therefore, accurate determination of whether the posterior longitudinal ligament is ruptured seems particularly important.

There is not much research on the rupture of the posterior longitudinal ligament presently. Grenier et al (13) compared the signal differences between T1-weighted and PD-weighted images by MRI studies of cadavers and clinical patients. They claimed that the most reliable signal for determining the rupture of the posterior longitudinal ligament was the defect, interruption, or disappearance of the low signal line on the periphery of the disc. If the peripheral low signal line was normal and continuous, the possibility of ligament rupture could be ruled out. They concluded that the T1-weighted images were more accurate than the PD-weighted images (2 false positives) because of no false positive findings on them. Silverman et al (14) distinguished between the subligamentous type and transligamentous type according to whether the low signal line posterior to the herniated nucleus pulposus was intact on the T1-weighted image, as well as the size of the herniated nucleus pulposus. They found the accuracy of MRI diagnosis was only 42%. Therefore, we recommend the incorporation of transforaminal endoscopy for intraoperative presence or absence detection of slits in the posterior longitudinal ligament, in order to improve the diagnostic rate.

There are 2 main approaches to spinal endoscopic surgery: transforaminal approach and interlaminar approach. The reasons we preferred the transforaminal approach for central disc herniation are as follows:

- In central disc herniation, the herniated nucleus pulposus is often large, and the nervous tension high. Intraoperatively, when the channel passes through the nerve root level, it compresses the nerve root to produce severe pain, and even the cauda equine syndrome
- Interlaminar approach is often only applicable to the L5/S1 space, which is very dangerous to the L4/5 space
- Central disc herniation often manifests bilateral symptoms, and the transforaminal approach can achieve bilateral decompression via a unilateral approach
- Central disc herniation is often accompanied by calcification, and even severe adhesion to the dural sac and nerve roots, which are hardly separable through the interlaminar approach, with great surgical risk.

Among 69 patients enrolled in the present study, 21 (30.43%) were rated excellent, 44 (63.77%) good, 4 (5.80%) fair, and 0 (0.00%) poor upon the final follow-up, showing an overall excellent-to-good rate of 86.96%. Bärlocher et al (5) performed microscopic laminectomy for 34 patients with central disc herniation, which yielded a success rate 68% upon a follow-up period of 3.3 years. Yeung and Tsou (15) summarized that the postoperative success rate of transforaminal endoscopic lumbar discectomy via the posterolateral approach was 89.3% in 307 cases. Schubert et al (16) used the TESSYS technique to treat 611 patients with LDH and found a success rate of 95.3% based on over a 2-year follow-up on 588 of the patients (follow-up rate 91.2%). Comparatively, transforaminal endoscopic discectomy yielded a better clinical outcome for patients with central LDH.

Despite the good early clinical efficacy of transforaminal endoscopic discectomy for central LDH patients, there is not yet a comparative study of bilateral decompression via unilateral approach versus bilateral approach for those with simultaneous or alternating bilateral symptoms when the working channel can hardly reach the canal center. Next, compared to unilateral/ bilateral fenestration and micro endoscopic discectomy, the transforaminal endoscopic discectomy causes less muscle and bone damage in theory, which can better maintain the spinal stability. Comparison of its efficacy needs to be further investigated. In addition, as the present study has a small sample size and short observation time, a mid- to long-term large sample study and follow-up observation are needed.

Conclusion

The application of novel surgical techniques is conducive to improving the safety and efficacy of transforaminal endoscopic discectomy for treating central disc herniation. Intraoperative individualized application of rod adjustment technique, apex technique, or posterior longitudinal ligament detection technique is the key to satisfactory clinical outcome.

Disclosure

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