








# Comparable effectiveness of transforaminal endoscopic spine system technique combined with selective nerve root block between far lateral lumbar disc herniation and central or paracentral herniation

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Lumbar disc herniation (LDH) is a common disease of the spine, of which the population is becoming younger and shows an increasing tendency. Most patients are young and middle-aged, which exposes great economic and medical burdens to individuals, families and society.<sup>[1]</sup> It has been estimated that two-thirds of adults suffer from back pain induced by LDH in their lives<sup>[2]</sup> and approximately 85% of patients have sciatica induced by LDH.<sup>[3]</sup>

Lumbar disc herniation is often broadly classified based on their axial location, including central, paracentral, and far lateral.<sup>[4]</sup> The far lateral LDH (FLDH) is a rare type of LDH, accounting for 0.7 to 11% of all disc herniation.<sup>[5,6]</sup> Due to its atypical imaging and insidious onset, FLDH is

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## ABSTRACT

**Objectives:** This study aims to compare the clinical effectiveness of transforaminal endoscopic spine system (TESSYS) technique combined with selective nerve root block (SNRB) in treating patients with far lateral lumbar disc herniation (FLDH) and patients with central or paracentral herniation (C/PDH).

**Patients and methods:** Between June 2015 and June 2019, a total of 204 patients (80 males, 124 females; mean age: 62.3±5.4 years; range, 51 to 66 years) with a herniated disc were included. Of these, 22 consecutive adult patients with FLDH formed the FLDH group, while 182 patients with C/PDH formed the C/PDH group. Considering that FLDH was a rare type of LDH and occurred outside the spinal canal, the patients with LDH in the spinal canal (C/PDH) were selected as the controls in our study. All cases received ultrasound-guided SNRB to identify the diseased disc and treated by the TESSYS technique. Data including demographics, duration of operation, duration of hospital stay, surgical cost, complications, Visual Analog Scale (VAS) scores for the back and leg, and Oswestry Disability Index (ODI) scores and the modified MacNab criteria were analyzed.

**Results:** The FLDH group presented the similar clinical outcomes and costs with the C/PDH group. No significant differences in the VAS score, ODI score, and Macnab score were observed between the groups ( $p>0.05$  for all). Both groups showed the significantly improved postoperative VAS scores on Day 3, at 1, 3, 6, and 12 months compared to baseline. The postoperative ODI scores at 6 and 12 months were also significantly improved ( $p<0.05$ ). At the final follow-up at 12 months, the FLDH group showed the MacNab criteria rating excellent and good of 81.8% and C/PDH group showed 84.62%.

**Conclusion:** The FLDH patients presented the comparable clinical effectiveness with C/PDH patients. Based on these findings, the TESSYS technique combined with ultrasound-guided SNRB for FLDH is safe and feasible with caution, although the risk of nerve root injury may be worried.

**Keywords:** Far lateral disc herniation, selective nerve root block, transforaminal endoscopic spine system.

often misdiagnosed.<sup>[7,8]</sup> It can be mainly divided into foraminal type, extra-foraminal type and mixed type.<sup>[9]</sup> The prolapsed disc often compresses the exiting root and ganglion, leading to severe radicular pain. With the posterior root ganglion frequently involved, more severe and medically refractory pain syndromes are observed in patients with FLDH than those patients with central or paracentral herniation (C/PDH).

Considering the characteristics of FLDH with a lower incidence and different anatomical positioning and fear of causing nerve damage, surgery for FLDHs in releasing the neural compression is challenging and conservative therapies are usually selected in the treatment of FLDHs. A worse postoperative course and outcome often follow lumbar discectomy compared to C/PDH.<sup>[8,10]</sup> Recently, minimally invasive spine (MIS) surgeries, such as (transforaminal percutaneous endoscopic lumbar discectomy; TPELD), MIS-TLIF combined with contralateral translaminar screw (MIS-TLIF CTS), and MIS-TLIF combined with bilateral pedicle screws (MIS-TLIF BPS), have been developed rapidly and recognized by more and more surgeons and patients.<sup>[11-13]</sup> Transforaminal endoscopic spine system (TESSYS) technique has shown good effectiveness in treating FLDHs in a few studies.<sup>[14,15]</sup> However, there is no consensus approach to surgical management yet. Literature is scarce regarding comparative postoperative outcomes of FLDH versus C/PDH.<sup>[8,16,17]</sup>

In the present study, we aimed to compare clinical effectiveness of TESSYS technique combined with selective nerve root block (SNRB) in treating patients with FLDH versus C/PDH.

## PATIENTS AND METHODS

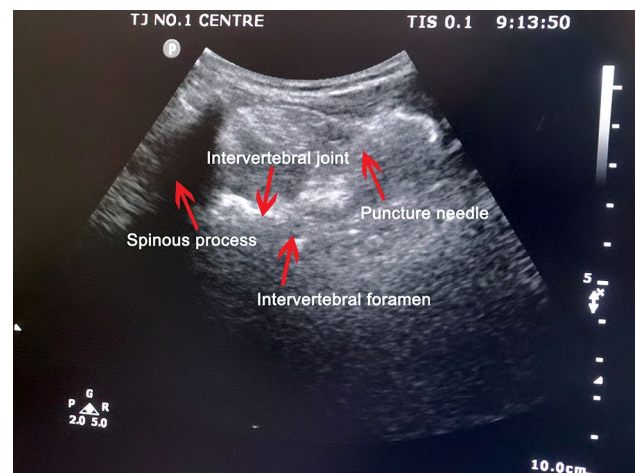
This retrospective study was conducted at Tianjin First Central Hospital, Department of Pain Management between June 2015 and June 2019. A total of 204 patients (80 males, 124 females; mean age:  $62.3 \pm 5.4$  years; range, 51 to 66 years) with a herniated disc were included. Of these, 22 consecutive adult patients with FLDH formed the FLDH group, while 182 patients with C/PDH formed the C/PDH group. Before surgery, the patient's condition was carefully and comprehensively assessed. All cases received ultrasound-guided SNRB to identify the diseased disc and TESSYS technique. The surgery indication was radiculopathy and/or neurogenic claudication in the setting of failed conservative treatments. All surgeries were performed by a single team of experienced pain surgeons.

Inclusion criteria were as follows: (i) history of concordant radicular leg or back pain before surgery; (ii) no relieving or even aggravating after three-month conservative treatment; (iii) FLDH or C/PDH confirmed by magnetic resonance imaging (MRI) and/or computed tomography (CT); and (iv) receiving ultrasound-guided SNRB and TESSYS. Exclusion criteria were as follows: (i) patients with severe heart, brain, liver, kidney, lung and other diseases; (ii) patients with lumbar spondylolisthesis on plain radiographs; (iii) patients requiring TPELD twice or more due to various reasons during the period from the operation to the end of follow-up; (iv) having a history of lumbar spine surgery, infections or tumors; (v) patients who were unable to cooperate with surgery, such as coagulation dysfunction or mental disorders; (vi) follow-up less than six months; and (vii) A Visual Analog Scale (VAS) score  $>3$  after SNRB.

## Surgical interventions

Two days before the operation, the diseased discs were identified by ultrasound-guided SNRB in all cases (Figure 1). After routine disinfection, a local anesthesia (20 mL 2% lidocaine mixed with 30 mL 0.9% sodium chloride) was performed on the affected side at 6 cm site from the midline. The original symptoms of patients could be reproduced 1 h to 2 h after SNRB and a VAS score of the affected limb  $\leq 3$  was regarded as effective and SNRB success.

The patients in both groups were placed in the prone position and given cefuroxime sodium 1.5 g intravenously to prevent infection 30 min before surgery. Next, a 16-gauge needle was introduced



**FIGURE 1.** Diseased discs were identified by ultrasound-guided selective nerve root block in all cases.

from the entrance point to the tip of upper articular process of lower vertebral body under the guidance of G-arm fluoroscopy. The guidewire was inserted and a surgical incision of about 7 mm was made. A dilator (five-stage trephine) was gradually expanded and then inserted the working cannula. The frontal position of sleeve was located at the line of the spinous process and the lateral position was located at the line of the posterior edge of the vertebral body. An intervertebral foraminal mirror was placed. The ligamentum flavum was removed with nucleus forceps and sent for pathological examination. Then, bipolar radiofrequency electrodes were placed to stop bleeding and shape the fibrous annulus. Criteria for the end of the operation: (i) There was a certain space (sufficient decompression) around the nerve root or dural sac; (ii) The nerve root or dural sac pulsated well with changes in pulse or water pressure; (iii) The nerve root or dural sac was well filled with blood vessels. Finally, the skin incision was sutured.

The main operable differences were intraoperative formation of intervertebral foramen and treatment of inner and outer protrusions of intervertebral foramen. Compared to C/PDH patients treated with the conventional "inside-out" decompression mode, FLDH patients adopted an "outside-in" decompression mode under the transforaminal endoscope. The protrusion of FLDH was mainly inside or outside the intervertebral foramen, which reduces the operable

space of the intervertebral foramen. An "outside-in" decompression mode could effectively avoid nerve root damage and improve surgical comfort with caution.

After the operation, all patients were instructed to stay in bed for at least two days strictly before getting out of bed with waist circumference, not to sit for a long time, not to bear weight, not to bend over and hold heavy objects within three months. Back muscle functional exercises were also given, if possible.

#### Demographic and outcome measurements

Demographic variables in two groups including age, sex, body mass index, LDH segment, hypertension, diabetes, coronary heart disease were collected. As patient-reported outcomes, the VAS scores for the back and leg preoperatively and Day 3, at 3, 6, and 12 months postoperatively were collected. The VAS score ranges from 0 to 10, and 0 score indicates no pain and 10 indicate severe pain. The Oswestry Disability Index (ODI) scores preoperatively, at six and 12 months postoperatively were also collected. The ODI score ranges from 0 to 100 and higher scores indicate more disability related to pain. The modified MacNab criteria at 12 months postoperatively were also analyzed. Excellent for no pain and no restriction of activity; good for occasional back or leg pain of sufficient severity to interfere with work or normal activities; fair for improved functional capacity, but

**TABLE I**  
Baseline clinical characteristics and demographic data

	C/PDH group (n=182)			FLDH group (n=22)			p
	n	%	Mean±SD	n	%	Mean±SD	
Mean age (year)			64.34±5.71			61.21±6.35	0.60
Sex							
Male	70	38.46		10	45.45		0.47
BMI (kg/m <sup>2</sup> )			25.17±8.42			24.42±9.16	0.82
ASA classification							0.93
I	56	30.77		8	36.36		
II	126	69.23		14	63.64		
Complications							0.97
Hypertension	84	46.15		8	36.36		
Diabetes	70	38.46		10	45.45		
Coronary heart disease	42	23.08		4	18.18		
Disc herniation level							0.67
L4-5	126	69.23		12	54.54		
L5-S1	56	30.77		10	45.45		

C/PDH: Central or paracentral herniation; FLDH: Far lateral lumbar disc herniation; SD: Standard deviation; BMI: Body mass index; ASA: American Society of Anesthesiologists.

restriction of activity and interference with normal activities and work; poor for no improvement or even aggravation. Meanwhile, duration of operation, duration of hospital stay, surgical cost, and complications were also analyzed.

### Statistical analysis

Statistical analysis was performed using the IBM SPSS version 22.2 software (IBM Corp., Armonk, NY, USA). Continuous variables were expressed in mean  $\pm$  standard deviation (SD), while categorical variables were expressed in number and frequency. Comparison between the two groups was analyzed using the Student t-test, whereas the difference between baseline and each postoperative point in each group were assessed using a paired t-test. Categorical data between the groups were analyzed using the Fisher exact test, and ranked data between the groups

with the Mann-Whitney U test. A two-sided *p* value of  $<0.05$  was considered statistically significant.

## RESULTS

As shown in Table I, we compared baseline clinical characteristics and demographic data between patients with C/PDH (C/PDH group) and patients with FLDH (FLDH group). All patients successfully completed the surgery. All baseline parameters, including age, male sex, BMI, American Society of Anesthesiologists (ASA) classification, complications and disc herniation level between C/PDH group and FLDH group were comparable ( $p>0.05$  for all).

During perioperative period, the operation time and hospital stay in FLDH group were similar to those in C/PDH group (Table II,  $p>0.05$  for both). The total cost in FLDH group also showed no significant

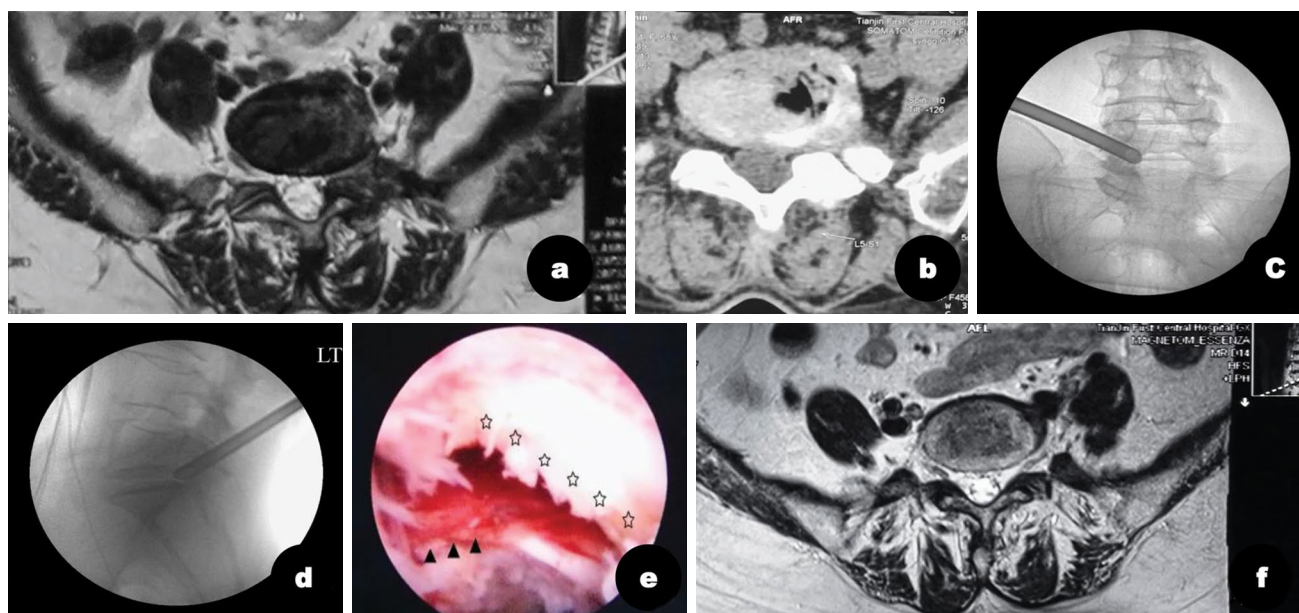
TABLE II							
Perioperative variables of patient groups							
	C/PDH group (n=182)			FLDH group (n=22)			<i>p</i>
	n	%	Mean $\pm$ SD	n	%	Mean $\pm$ SD	
Operation time (min)			103.8 $\pm$ 9.5			110.4 $\pm$ 8.2	
Hospital stay (day)			8.6 $\pm$ 1.1			7.9 $\pm$ 0.9	
Total costs (RMB)			9848.2 $\pm$ 1873.3			9756.5 $\pm$ 2057.7	
Complications	1	0.55		1	4.55		

C/PDH: Central or paracentral herniation; FLDH: Far lateral lumbar disc herniation; SD: Standard deviation; RMB: Renminbi.

TABLE III							
Analysis of outcomes in patients with C/PDH and FLDH							
	C/PDH group (n=182)			FLDH (group n=22)			<i>p</i>
	n	%	Mean $\pm$ SD	n	%	Mean $\pm$ SD	
VAS score							
Baseline			7.5 $\pm$ 1.2			7.14 $\pm$ 1.4	0.42
3 <sup>rd</sup> day			1.6 $\pm$ 1.2*			1.02 $\pm$ 1.0*	0.71
1 <sup>st</sup> month			1.4 $\pm$ 1.1*			1.82 $\pm$ 1.3*	0.32
3 <sup>rd</sup> month			2.2 $\pm$ 1.0*			2.31 $\pm$ 1.4*	0.46
6 <sup>th</sup> month			2.3 $\pm$ 1.5*			2.62 $\pm$ 1.2*	0.34
12 <sup>th</sup> month			2.1 $\pm$ 1.2*			1.69 $\pm$ 1.0*	0.62
ODI score							
Baseline			71.3 $\pm$ 13.5			77.5 $\pm$ 12.4	0.15
6 <sup>th</sup> month			24.4 $\pm$ 21.2*			25.3 $\pm$ 14.4*	0.22
12 <sup>th</sup> month			22.7 $\pm$ 11.3*			21.4 $\pm$ 9.2*	0.13
Macnab criteria							
Excellent	70	38.46		10	45.45		0.97
Good	84	46.15		8	36.36		0.38
Fair	14	7.69		4	18.18		0.42
Poor	14	7.69		0	0		0.78

C/PDH: Central or paracentral herniation; FLDH: Far lateral lumbar disc herniation; SD: Standard deviation; VAS: Visual Analog Scale; ODI: Oswestry Disability Index; \*  $p<0.05$  (vs. baseline).





**FIGURE 2.** Case example of with FLDH who received TESSYS technique combined with SNRB. (a, b) Lumbar MRI and CT reconstruction showed a foraminal type FLDH at the disc herniation level L5-S1, compressing the L5 nerve root. (c, d) X-ray positive and lateral imaging of the sleeve insertion position during the operation. (e) L5 exit nerve root (shown by triangle) and the ligamentum flavum after forming (shown by five-pointed star). (f) MRI showed that the left intervertebral foramina was completely decompressed, and the nerve root compression was relieved at 1-year follow-up after surgery.

FLDH: Far lateral lumbar disc herniation; TESSYS: Transforaminal endoscopic spine system; SNRB: Selective nerve root block; MRI: Magnetic resonance imaging; CT: Computed tomography.

difference compared to that of C/PDH group ( $p=0.48$ ). For intraoperative complications, one case in C/PDH group suffered from rupture of the lumbar dura mater, which was repaired timely; and the patient showed no obvious discomfort after operation. In the FLDH group, one case showed worsening postoperative pain symptoms, and the symptoms gradually alleviated after three-day mannitol and nutritional nerve symptomatic treatment. No severe complications, such as intervertebral disc-space infection, local hematoma and thrombosis, were observed in any of the groups.

Compared to baseline, all patients showed the significantly improved VAS score  $\leq 3$  and ODI scores after TESSYS technique combined with SNRB (Table III,  $p<0.05$ ). Notably, no significant differences were observed in the VAS and ODI scores between the C/PDH group and FLDH group at each postoperative follow-up timepoint ( $p>0.05$  for all). According to the modified MacNab criteria, the patients in both groups were all assessed at the final follow-up timepoint of 12 month (Table III). The FLDH group achieved the overall excellent and good rate comparable to C/PDH group (81.81% *vs.* 84.62%,  $p=0.99$ ).

Figure 2 illustrated a 68-year-old female case example with FLDH who received TESSYS technique combined with SNRB. The patient presented with pain and numbness on the anterolateral side of the left leg and the first and second toes of the left foot for five months, with progressive exacerbation for one month and intermittent claudication for 400 meters. The VAS score of lower extremity pain decreased from 5 to 6 before surgery to 3, 2, 2, 1, and 1 on Day 3, at 1, 3, 6, and 12 months, respectively after surgery. The ODI scores decreased from 65 before operation to 11 after operation. Lumbar MRI and CT reconstruction showed a foraminal type FLDH at the disc herniation level L5-S1, compressing the L5 nerve root (Figure 2a, b). The MRI imaging showed the left intervertebral foramina was completely decompressed, and the nerve root compression was relieved at one-year follow-up after surgery (Figure 2f).

## DISCUSSION

Since the first FLDH case reported by Abdullah et al. in 1974,<sup>[18]</sup> the knowledge about the clinical characteristics of FLDH is far enough until the introduction of CT and MRI, and the diagnosis rate

of FLDH is significantly increased. Far lateral lumbar disc herniation often refers to a more difficult and challenging surgical procedure, compared to the more common C/PDH.<sup>[19]</sup> Although various surgical approaches for FLDH have been extensively described,<sup>[20]</sup> there is currently no consensus approach. The current study demonstrated that TESSYS technique combined with ultrasound-guided SNRB was a safe and feasible surgical approach for FLDHs with similar clinical outcomes and costs with C/PDH patients.

Far lateral lumbar disc herniation is often accompanied by severe radiation pain in the lower limbs, 55% with dyskinesia, and 75% with sensory disturbance.<sup>[21]</sup> Since the protrusions are presented mainly inside or outside the intervertebral foramen, the symptoms vary greatly and inconsistent studies have reported most FLDH commonly found at different levels.<sup>[15,22-24]</sup> In this study, all patients with a mean age of  $62.3 \pm 5.4$  years old were at L4-L5 level and L5-S1 level, and the characteristics of patients were similar to the Park et al.'s<sup>[24]</sup> study. To be different, FLDHs were reported to be common in older population and more frequently in the upper lumbar region (L1/2, L2/3 & L3/4 levels).<sup>[23]</sup> The sample recruited may result in the difference above. The distance between the surgical incision and the paraspinous process is different in different surgical segments. Compared to L4-L5, L5-S1 has a larger inclination angle due to the blocking head of the iliac crest. The L4-5 puncture point is 10 to 12 cm away from the paraspinous process, and the L5-S1 puncture point is 12 to 14 cm away from the paraspinous process. Therefore, during foraminoplasty, the direction of the bone drill should be adjusted to cephalad as far as possible, without causing discomfort to the patient, to microscopic treatment of the cephalic nerve root axilla. It has been reported that the overall outcome in FLDH patients may be also influenced by age factor.<sup>[23]</sup> There were no significant differences between the FLDH group and C/PDH group in our study.

The TESSYS technique is effective to remove of protrusions through intervertebral foraminotomy, and relieve the clinical symptoms caused by nerve root compression, thereby making the maximum balance between nerve root decompression and biomechanical destruction.<sup>[25,26]</sup> Compared to the traditional translaminar approach or transverse process approach technique, TESSYS illustrates the advantages of less trauma, less damage, faster recovery, and less long-term impact. For C/PDH patients, TESSYS technique is well-tolerated by

patients and entails less trauma and quicker postoperative recovery.<sup>[16]</sup> The TESSYS technique is associated with better mid-term efficacy with the small incision, a shorter hospital stay, and quicker, earlier recovery than open fenestration discectomy.<sup>[14]</sup> In Wang et al.'s<sup>[27]</sup> study, the efficacy of TESSYS technique in population aged  $\leq 45$  group and aged  $>45$  group showed an overall 84% and 71%, respectively. For FLDH patients, good-to-excellent results were achieved in 89.5% (17/19) FLDH patients who received TESSYS technique.<sup>[13]</sup> Even in a clinical study of FLDH in children, the safety and effectiveness of TESSYS technique were confirmed, and the excellent or good rate reached 91.6%.<sup>[15]</sup> These evidences strongly support our conclusion. Notably, FLDH patients who received TESSYS technique demonstrated the comparable excellent or good rate according to Macnab criteria to C/PDH group in our study.

Although CT or MRI imaging examination can clearly diagnose FLDH, when the patient has severe degeneration of the lumbar spine and multiple levels of intervertebral disc herniation or complicated clinical manifestations, the diagnosis and treatment strategy of clinicians is difficult to make a decision. Therefore, a clear diagnosis before surgery is extremely important. Postacchini and Montanaro<sup>[28]</sup> proposed, for the first time, that when FLDH patients underwent physical examination, the spine was usually asymptotically aggravated during flexion and extension exercises, but scoliosis to the affected side often led to aggravation of typical low back and leg pain symptoms and obvious paravertebral tenderness, providing reference for clinical diagnosis and therapy of LDH. The SNRB can help clarify the diseased disc and contribute to the surgical plan.<sup>[29]</sup> In the present study, all of the 22 FLDH patients underwent SNRB before the operation. After surgery, the VAS score of the affected limb all dropped to  $\leq 3$ , confirming that the segment was the responsible diseased segment. The SNRB provided a diagnostic basis for clarifying the responsible intervertebral disc. Moreover, the ultrasound-guided positioning was more accurate and high security with no adverse reaction such as local anesthetics entering the blood during the treatment. As expected, our findings showed comparable clinical outcomes in VAS score and ODI score between FLDH patients and C/PDH patients. Meanwhile, there were no statistically significant differences postoperatively at the follow-up timepoints between FLDH patients and C/PDH patients, which was also supported by Chen et al.'s<sup>[11]</sup> study. In addition, the operation time, hospital

stay, surgical costs and complications showed no significant difference between FLDH patients and C/PDH patients, suggesting the advantages of TESSYS technique combined with SNRB for treating FLDH, even patients at L5-S1 level.<sup>[30]</sup>

For FLDH patients, it is extremely important to shape the intervertebral foramen and to treat the protrusions during the operation. Considering the operable space of the intervertebral foramen reduced by the protrusion of FLDH and compression often accompanied by nerve root irritation, during the process of establishing the channel, the operator is requested to be particularly careful so as not to damage the exiting nerve root. In our practice, to avoid nerve root damage and improve the comfort of the operation, the traditional decompression mode "from the inside-out" process can be broken during the treatment under the transforaminal endoscope, and change to the decompression mode of "from outside-to-inside", which has also been confirmed by other scholars.<sup>[31,32]</sup>

Nonetheless, there are some limitations to this study. The sample size in this study is relatively small, despite the low incidence of FLDH. Therefore, further studies with large sample are needed. As the surgical procedure, TESSYS had a long learning curve and higher requirement in operation skills. Moreover, it has some risk for damaging the blood vessels in the spinal canal, the running nerve root and dural sac. Thus, the operation process must be completed by experienced physicians proficient in relevant anatomical knowledge to avoid the omission of protrusions and irreversible nerve damage.

In conclusion, our study findings demonstrate that TESSYS technique combined with ultrasound-guided SNRB for FLDH is safe and feasible with caution, although the risk of nerve root injury may be worried. Ultrasound-guided SNRB can play a guiding role and effectively improve the diagnosis rate of FLDH. It is of trans-age significance to relieve the suffering of patients using minimally invasive technology at both the economic level and the social level.

**Ethics Committee Approval:** The study was approved by the Ethics Committee of Tianjin First Central Hospital (date: 20190813, no: 2019N100KY). The study was conducted in accordance with the principles of the Declaration of Helsinki.

**Patient Consent for Publication:** A written informed consent was obtained from each patient.

**Data Sharing Statement:** The data that support the findings of this study are available from the corresponding author upon reasonable request.

**Author Contributions:** Provided input into the concept and design of the study, and provided the materials: J.L., Y.H.; Collected and assembled the data: J.L., Q.W., Z.W.; Analyzed the data: J.L., Q.W.; Carried out literature review: Z.W., J.L., Q.W., D.L.; Wrote the article: J.L., Q.W., D.L.; All authors have critically revised the article, read and approved the final version at the time of submission.

**Conflict of Interest:** The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

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