Observational Study

Microendoscopic Discectomy Combined with Annular Suture Versus Percutaneous Transforaminal Endoscopic Discectomy for Lumbar Disc Herniation: A Prospective Observational Study

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Background: Microendoscopic discectomy (MED) and percutaneous transforaminal endoscopic discectomy (PTED) are 2 of the most popular minimally invasive spinal surgery techniques. We are investigating whether minimally invasive early annular closure can achieve a better clinical effect in the treatment of lumbar disc herniation (LDH).

Objective: To compare the clinical and imaging outcomes between MED combined with annular suture and PTED in the treatment of LDH.

Study Design: A prospective observational study with follow-up of 36 months.

Setting: The First People's Hospital of Lianyungang in China.

Methods: A total of 135 prospective consecutive patients underwent MED + annular suture or PTED. Patients were assessed postoperatively at 3 days and 3, 6, 12, 24, and 36 months. The outcome measures were visual analog scales for back pain (VAS-back) and leg pain (VAS-leg) scores, the Oswestry Disability Index (ODI) score, the Medical Outcomes Study 36-Item Short-Form Health Survey bodily pain (SF36-BP), and physical function (SF36-PF) scales, disc height, and recurrence rate.

Results: One hundred and six patients have completed the 3-year follow-up. The operation time and length of stay in the MED + annular suture group were longer than that in the PTED group ($P < 0.001$ and $P < 0.001$). VAS-back score, VAS-leg score, ODI score, SF36-BP, and SF36-PF significantly improved at follow-up time points after surgery compared to before surgery, but no significant differences were found at postoperative and 36 months between the groups. The disc height in the MED + annular suture group was significantly greater than that in the PTED group after 3 months. Within 36-month follow-up, imaging re-herniation was reported in 4 patients in the MED + annular suture group, and 9 patients in the PTED group ($P = 0.170$). Symptomatic re-herniation occurred in one patient in the MED + annular suture group and in 4 patients in the PTED group ($P = 0.190$).

Limitations: First, this was not a randomized controlled trail, which could provide more evidence-based conclusions. Second, we did not accurately measure and compare the amount of nucleus pulposus removed, although less nucleus pulposus was removed in MED + annular suture.

Conclusion: PTED has the advantages of shorter length of incision, shorter operation time, and shorter length of stay. MED + annular suture is associated with greater preservation of disc height, and showed certain advantages of lower recurrence rate, although there was no statistical difference.

Key words: Microendoscopic discectomy, percutaneous transforaminal endoscopic discectomy, lumbar disc herniation, annulus fibrosus, suture

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Lumbar disc herniation (LDH) is one of the most common diseases, and minimally invasive treatment of it is the focus of current research. Microendoscopic discectomy (MED) and percutaneous transforaminal endoscopic discectomy (PTED) are 2 of the most popular minimally invasive spinal surgery techniques that have been used in the treatment of LDH. Several studies reported that both MED and PTED are effective and safe surgical procedures for the treatment of LDH (1-11). Theoretically, it is necessary to repair annulus fibrosis after discectomy in order to reduce recurrent herniation and maintain the height of the intervertebral space. In recent years, conventional lumbar discectomy combined with annular closure have been reported, and the recurrence rate after discectomy was reduced by using an annular closure device or directly suturing the annulus (12-17). But Bailey et al (18) reported that the difference of the rate of re-herniation surgery between discectomy and discectomy with annular repair was not statistically significant at 2 years. This study was prospectively designed to compare MED combined with annular suture and PTED for LDH, to explore a minimally invasive treatment approach that not only has good effect, but also can reduce disc re-herniation.

Methods

Study Design

The clinical research ethics committee at the First People's Hospital of Lianyungang approved the clinical study, and all procedures performed in studies involving human patients were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. All participants provided written informed consent at study entry. LDH was confirmed by the presence of localized radicular symptoms and radiographic confirmation via magnetic resonance imaging (MRI) and/or computer tomography (CT). One hundred and thirty-five prospective consecutive patients were divided into 2 groups based on their own final choice after a complete explanation before surgery. In the MED + annular suture group, patients underwent posterior microendoscope limited discectomy and annular suture. In the PTED group, patients underwent lateral posterior transforaminal endoscopic lumbar discectomy. All operations were performed by the same group of doctors. Patients were eligible for inclusion if they presented with persistent sciatica with radiographically confirmed herniation and were aged 18 to 75 years. Patients with the following characteristics were excluded: massive herniation with cauda equina syndrome, previous back operation, extraforaminal disc herniation, scoliosis greater than 20 degrees, lumbar instability or spondylolisthesis, obese patients with BMI $\geq$ 28 kg/m^2, endplate inflammation with Modic change greater than type 2, and potential infection around the lumbar incision.

Surgical Techniques

MED with Annular Suture

The patient was placed prone on the operating table and under general anesthesia. C-arm fluoroscopy was used to confirm the target segment. A 1.8-cm skin longitudinal incision was made beside the spinous process, then the endoscopic system was installed. After removing part of the lamina and ligamentum flavum, the intervertebral disc was exposed through pulling the root and dural sac to the midline. If there is no rupture, the middle part of the annulus fibrosus should be cut longitudinally for about 5 mm, and the protruding loose nucleus pulposus were taken out with small endoscopic forceps. The posterior margin of the annulus fibrosus was smooth and the nerve root was relaxed. The incision or rupture of annulus was sutured by using the annular suture device (2020 Medical Technology Company, Beijing, China) (Fig. 1a). The puncture needle penetrated the annulus and inserted the first anchor. Another fixed anchor was placed on the opposite side, and the suture should be perpendicular to the incision. The stitcher button was turned to make the 2 anchors close. Then the button was turned to make the suture penetrate from the anchor; and finally, the anchor was slowly pulled out, and both sides of the incision were penetrated by the suture. The suture knot was pushed to the annulus fibrosus by the knot pusher to tighten the suture. When the annular incision was closed with certain tension, the free end of the suture was cut with a certain tension (Fig. 1b).

PTED

The patient was also place prone on the operating table, and C-arm fluoroscopy was used to locate the target segment. The distance from the skin entry point to midline was determined by the preoperative axial MRI or CT as well as the size of the patient and the dimension of the intervertebral foramen. After administering

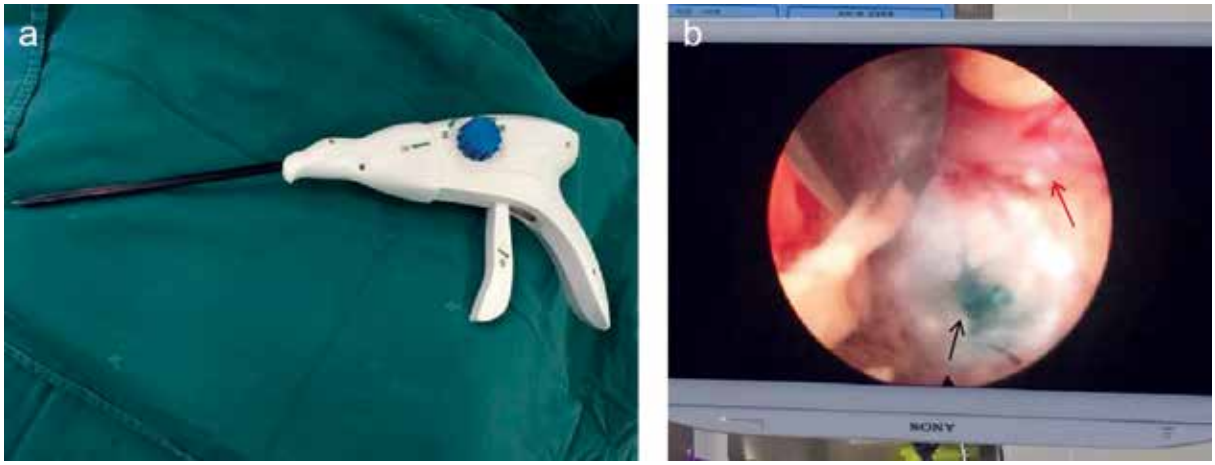

Fig. 1. *The annular suture device and endoscopic photos. A. The annular suture device. B. The endoscopic photos of annular suture. The black arrow refers to suture knot and the red arrow refers to the nerve root.*

local anesthesia, an 18-gauge needle was inserted by posterolateral approach under fluoroscopic guidance passing just under the surface of the superior facet. The needle was then replaced with a 0.8 mm guidewire, and then a 0.8 cm skin incision was made along the guidewire, followed by sequential dilatation of the tract. A tapered cannulated obturator was then passed over the guidewire, and a 7.5-mm working cannula was subsequently passed over the obturator, until the tip of the working cannula passed through the pedicle and entered the spinal canal. If not, sequential reamers were used to enlarge the foramen. An endoscope (Joimax System; Joimax, Karlsruhe, Germany) was positioned at the annular defect site. Endoscopic forceps were used to remove the herniated nucleus pulposus, and the free nucleus pulposus of the rear of intervertebral disc was removed through the annular fissure. If there was no break in the annulus, a small break was made with the radiofrequency head to remove the nucleus pulposus. After complete herniotomy, the decompressed dural sac and nerve root became freely movable.

Outcome Assessment

Patients were assessed postoperatively at 3 days and 3, 6, 12, 24, and 36 months. The outcome measures were visual analog scales for back pain (VAS-back) score and leg pain (VAS-leg) score, the Oswestry Disability Index (ODI) score, the Medical Outcomes Study 36-Item Short-Form Health Survey bodily pain (SF36-BP) and physical function (SF36-PF) scales, disc height, calculated as the average of the anterior and posterior disc heights, measured on standing lateral radiographs. Complications including re-herniation were recorded at follow-up where appropriate. Recurrence of disc herniation was divided into imaging recurrence and symptomatic recurrence. The recurrence of imaging is only the re-herniation of imaging, without clinical symptoms. Symptomatic recurrence is defined as newly occurred at the same side radiculopathy with at least 3-point leg VAS and a herniation on the same disc space.

Statistical Analysis

The clinical and radiographic records were compared by independent 2 sample t test, analysis of variance (ANOVA) was used to conduct the stratified analysis, and Chi-square test was used to compare the counting data, with $P < 0.05$ considered statistically significant. SPSS (version 17.0) software was used for all analyses.

Results

A total of 135 prospective consecutive patients who underwent MED + annular suture or PTED between February 2015 to September 2016 were included in this series. Of the 135 patients, 64 were included in the MED + annular suture group and 71 in the PTED group. Four cases failed and suturing was given up in the MED + annular suture group. At 36 months, data were available for 51 patients in the MED + annular suture group and 54 in the PTED group. No significant differences were noted in age, gender ratio, and disc

Table 1. *Demographics and characteristics in MED+ Annulus Suture and PTED group.*

	MED+Annulus Suture	PTED	*P*-value
Number	51	54	
Age (years)	42.0 ± 11.6	45.6 ± 12.2	0.120
Symptom duration (weeks)	17.9 ± 4.1	19.6 ± 4.7	0.043
Operation level			0.372
L3-L4	6	6	
L4-L5	26	25	
L5-S1	19	23	
Operation time (minutes)	99.2 ± 10.8	77.0 ± 11.7	0.000
Length of stay (days)	11.5 ± 2.2	6.7 ± 1.7	0.000

MED = microendoscopic discectomy; PTED = percutaneous transforaminal endoscopic discectomy

level between the 2 groups. The preoperative symptom duration was significantly different between the MED + annular suture group (17.9 ± 4.1 weeks) and the PTED group (19.6 ± 4.7 weeks) ($P = 0.043$). The operation time and length of stay in the MED + annular suture group (99.2 ± 10.8 minutes and 11.5 ± 2.2 days) were longer than that in the PTED group (77.0 ± 11.7 minutes and 6.7±1.7 days) ($P < 0.001$ and $P < 0.001$). Patient's statistics are summarized in Table 1.

There were no significant differences in VAS-back score and VAS-leg score, ODI score, and SF36-BP and SF36-PF between the 2 groups before surgery, and they significantly improved at follow-up time points after surgery compared to before surgery, but no significant differences were found at postoperative and 36 months between the groups (Table 2).

No significant difference was noted in preoperative disc height between the 2 groups (MED + annular suture: 13.1 ± 1.9 vs. PTED: 12.7 ± 1.8 mm, $P = 0.200$) (Table 3). The disc height was not significantly different between the groups in the first 3 days after surgery, but that in the MED + annular suture group was significantly greater than in the PTED group after 3 months (Table 3).

Within 36-month follow-up, imaging re-herniation was reported in 4 patients in the MED + annular suture group, and 9 cases in the PTED group ($P = 0.170$) (Table 4). Symptomatic re-herniation was in one patient in the MED + annular suture group, and 4 cases in the PTED group ($P = 0.190$) (Table 4), 2 of which had early weight

Table 2. *Comparison of clinical outcomes between 2 groups.*

	MED+ Annulus Suture (n = 51)	PTED (n = 54)	*P* value
VAS back pain			
Preop	4.9 ± 1.2	4.6 ± 1.3	0.165
Postop	2.1 ± 0.8	1.9 ± 0.8	0.194
36 months	1.8 ± 0.7	1.6 ± 0.6	0.135
VAS leg pain			
Preop	6.6 ± 1.1	7.0 ± 1.3	0.064
Postop	1.6 ± 0.8	1.4 ± 0.8	0.183
36 months	1.3 ± 0.8	1.2 ± 0.8	0.395
ODI			
Preop	49.1 ± 9.8	50.6 ± 9.1	0.404
Postop	17.6 ± 3.4	18.9 ± 3.8	0.090
36 months	16.0 ± 3.6	16.2 ± 4.6	0.784
SF-36 PF			
Preop	51.7 ± 8.7	49.0 ± 9.0	0.124
Postop	71.9 ± 11.8	74.1 ± 10.3	0.305
36 months	94.6 ± 6.7	96.0 ± 4.9	0.213
SF-36 BP			
Preop	48.2 ± 9.6	49.6 ± 9.3	0.458
Postop	76.7.5 ± 11.7	75.2 ± 10.8	0.489
36 months	95.5 ± 6.5	96.9 ± 4.3	0.209

MED = microendoscopic discectomy; PTED = percutaneous transforaminal endoscopic discectomy; VAS = visual analog scales; ODI = Oswestry Disability Index; SF-36 PF = Medical Outcomes Study 36-Item Short-Form Health Survey physical function; BP = bodily pain

bearing within 2 months after surgery, and then underwent reoperation.

There was no dural tears and nerve root injuries in 2 groups. Two patients in each group complained of numbness; symptoms were obviously alleviated after 3 months.

Typical case 1: A 38-year-old woman underwent with MED + annular suture; VAS-back score was 4 points before surgery and 2 points, one point, and one point immediately after surgery, 6 months, and 36 months. VAS-leg score was 6 points before surgery and 2 points, one point, and one point immediately after surgery, 6 months, and 36 months. The disc height was 13.2 mm before surgery and 12.8 mm, 12.7 mm, and 12.2 mm at 3 days, 3months, and 36 months after surgery (Fig. 2).

Typical case 2: A 49-year-old woman underwent with PTED; VAS-back score was 5 points before surgery and 2 points, one point, and one point immediately

Table 3. *Disc height changes from preoperative to 36-month follow-up.*

	MED+Annulus Suture (mm) (n = 51)	PTED (mm) (n = 54)	*P* value
Preoperative	13.1 ± 1.9	12.7 ± 1.8	0.200
Postoperative			
3 days	12.8 ± 1.8	12.3 ± 1.7	0.185
3 months	12.6 ± 1.7	11.9 ± 1.4	0.014
6 months	12.6 ± 1.7	11.7 ± 1.4	0.004
12 months	12.3 ± 1.6	11.6 ± 1.3	0.035
24 months	12.1 ± 1.5	11.3 ± 1.3	0.008
36 months	12.0 ± 1.5	11.2 ± 1.3	0.007

MED = microendoscopic discectomy; PTED = percutaneous transforaminal endoscopic discectomy

after surgery, 6 months, and 36 months. VAS-leg score was 7 points before surgery and 2 points, one point, and one point immediately after surgery, 6 months, and 36 months. The disc height was 13.0 mm before

Table 4. *Disc re-herniation*

	MED+ Annulus Suture (n = 51)	PTED (n = 54)	*P*- value
Imaging re-herniation	4	9	0.170
Symptomatic re-herniation	1	4	0.190

MED = microendoscopic discectomy; PTED = percutaneous transforaminal endoscopic discectomy

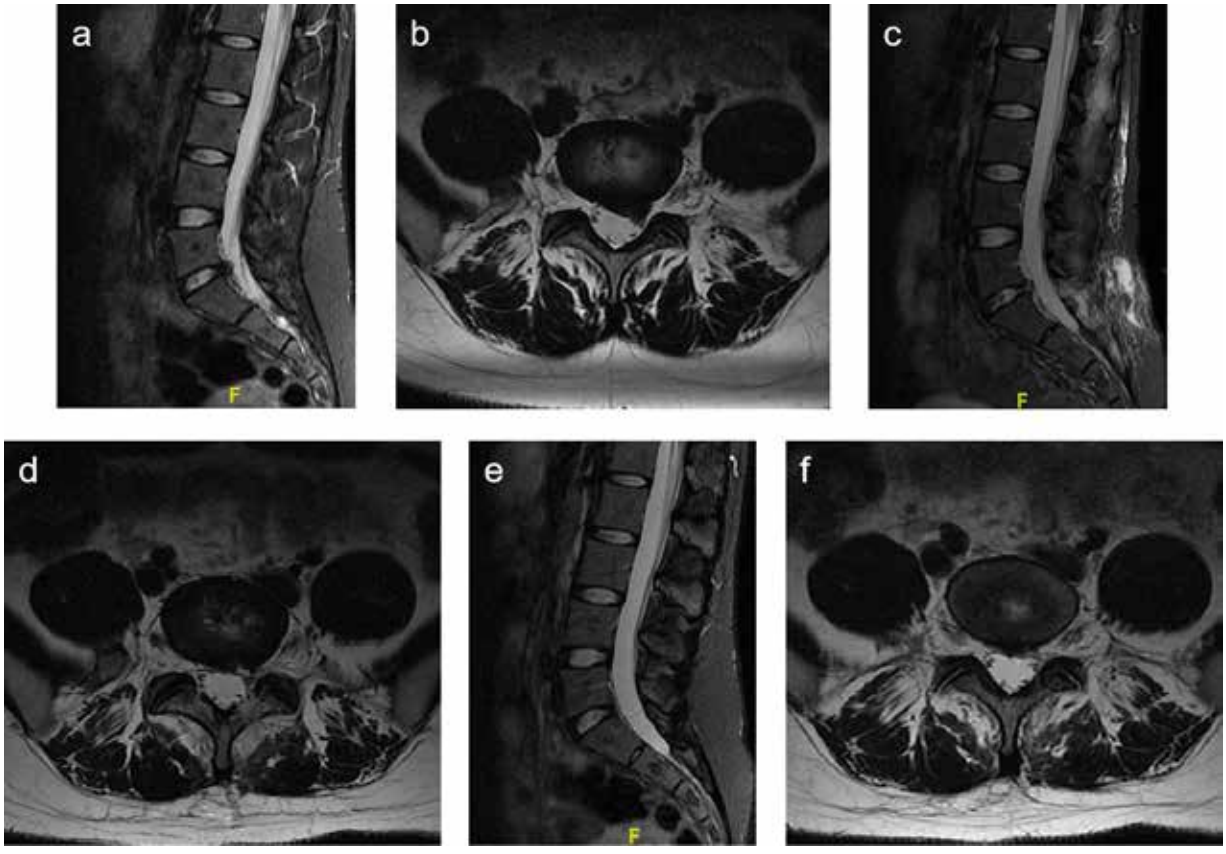

Fig. 2. *A 38-year-old woman with lumbar disc herniation of L5-S1 underwent MED + annular suture. The preoperative and postoperative MRI of the lumbar spine showed that the herniated disc was removed; the disc height was well maintained and there was no recurrent disc herniation at 36 months after surgery. MRI = magnetic resonance imaging.*

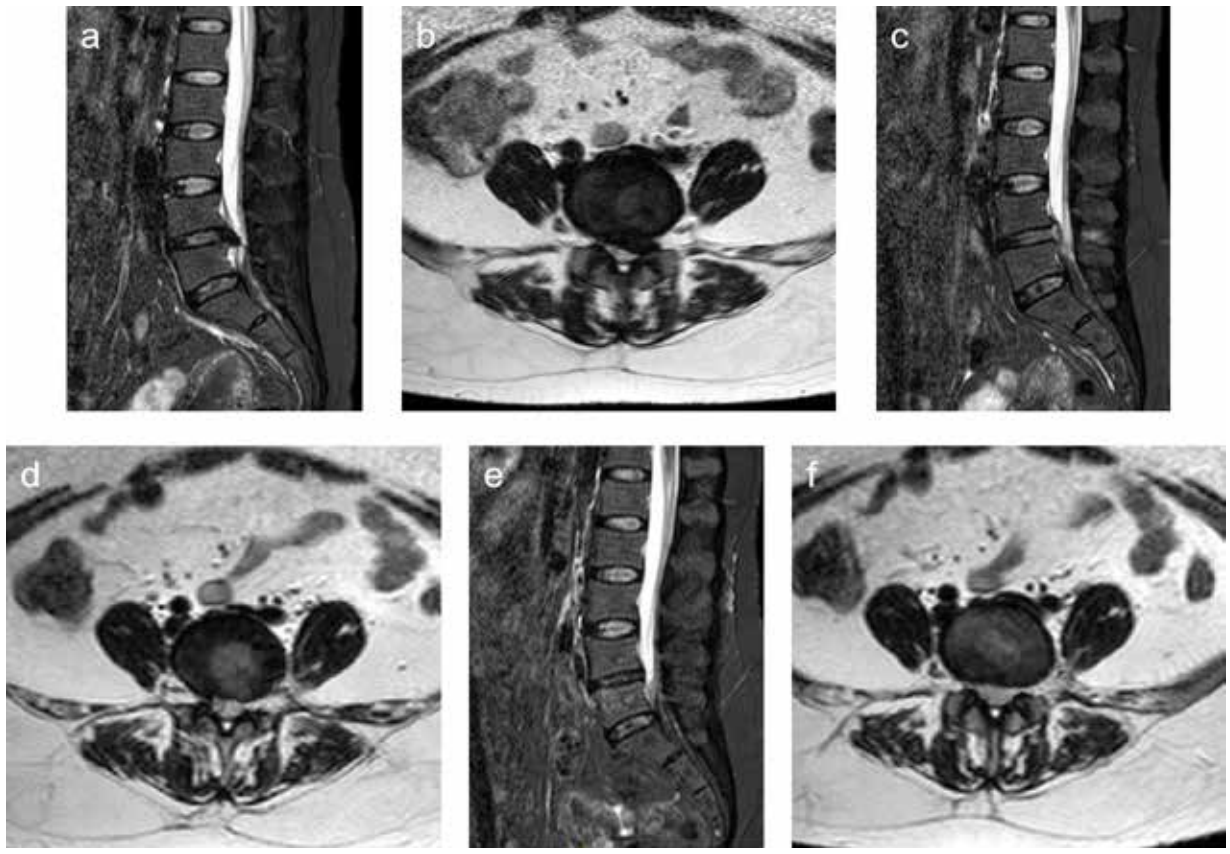

Fig. 3. *A 49-year-old woman with lumbar disc herniation of L4-5 underwent PTED. The preoperative and postoperative MRI of the lumbar spine showed that the herniated disc was removed and there was no recurrent disc herniation at 36 months after surgery. MRI = magnetic resonance imaging*

`surgery and 12.4 mm, 12.0 mm, and 11.3 mm at 3 days, 3 months, and 36 months after surgery (Fig. 3).

Discussion

Foley et al (19) first described microendoscope discectomy in 1997, which causes less trauma to the paraspinous muscles splitting through dilators for visualized operation. PTED, introduced by Yeung and Tsou (6), is more minimally invasive, with posterior column lumbar structures preserved (20-23). Some studies have confirmed the safety and efficacy of these 2 methods (24-28). The incision with MED is usually 1.8 cm, and the ligamentum flavum need to be excised and part of the lamina is usually bitten. PTED's incision is usually only about 0.8 cm, and there is no damage to the posterior structure and less interference to the nerves, so it is a more minimally invasive technique. PTED can be performed under local anesthesia through a lateral approach, which is different from MED under epidural anesthesia or general anesthesia, so PTED is safer to some extent.

In recent years, the annular repair has become increasingly recognized as a valuable adjunct to discectomy in prevention of recurrent disc herniation (13-17). The annular break is mostly in the center or lateral of the annular posterior edge, and the channel of MED is larger, so it is more conducive to suture the break through the posterior approach. For inclusive disc herniation, it is ideal to suture annulus fibrosus after nucleus pulposus removal through a small incision. For this type of case, PTED can also remove the nucleus pulposus through a small break of the annulus fibrosus, and a supplementary use of radiofrequency coagulator to narrow the gap. When there is a large defect in the annulus fibrosus, the suture cannot be completed.

In our study, PTED and MED + annular suture can achieve satisfactory postoperative pain relief and functional improvement, and no significant differences were found at postoperative and 36-month follow-up between the groups. When the annulus fibrosus was closed, the inflammatory factors released from the disc were reduced, and the stimulation of nerve roots was less. Continuous water irrigation during PTED also eliminates most of the inflammatory factors, so the nerve root stimulation after PTED is also small. The suture knot of the annulus may stimulate the nerve root or dural sac to some extent, but this response has not been found in our study.

The operation time and length of stay in the MED + annular suture group were longer than that in the PTED group. The longer operation time of MED + annular suture may be related to the addition of a suture procedure. There is no uniform standard to determine length of stay in different hospitals. We think that the trauma of MED + annular suture is slightly greater than PTED, so the length of stay in hospital and bed time are appropriately prolonged.

Through annular suture, the annulus fibrosus was closed immediately and the nucleus pulposus removed was less, which was beneficial to maintain the height of intervertebral space (29,30). The disc height in the MED + annular suture group was significantly greater than in the PTED group after 3 months in our study. The maintenance of the disc height is beneficial to maintain the stability of lumbar spine and reduce the degeneration of adjacent segments. Therefore, the annular suture may have a better long-term effect.

It has been reported that the recurrence rate is 0% – 9.7% in 2 years after repair of annulus fibrosus (17,18,31), and 0.8% –11% after PTED (8,32-34). Cho et al (35) reported that the rate of re-herniation after suturing the fibrous ring under the small incision was 3.3%, which was significantly lower than that of the conventional discectomy by 20%.

In this study, 7.8% imaging re-herniation was reported in the MED + annular suture group and 16.7% in the PTED group within 36-month follow-up (P = 0.170) (Table 4). Symptomatic re-herniation was 2.0% in the MED + annular suture group, and 7.4% in the PTED group (P = 0.190). The recurrence rate of MED + annular suture was lower than that of PTED, but there was no statistical difference. It needs to be confirmed by a larger sample study. In our study, PTED retained annulus fibrosus as much as possible, so most of annulus fibrosus may realize self-repair or scar repair. Whether removing more nucleus pulposus can reduce recurrence is uncertain. McGirt et al (36) reported a greater incidence of long-term recurrent back and leg pain after aggressive disc removal but a greater incidence of recurrent disc herniation after limited disc removal, but Fountas et al's study (37) showed no correlation between the amount of the removed disc and the long-term outcome, recurrence rate, or postoperative instability. In our study, PTED removed the herniated nucleus pulposus and the free nucleus pulposus in annulus fibrosus, and the amount of nucleus pulposus removed may be slightly more than that of MED + annulus suture. We should accurately measure and compare the amount of nucleus pulposus removed in future study. In PTED group, 2 of 4 patients with symptomatic recurrence had early weight bearing. Although postoperative recurrence is related to many factors (34), early weight bearing may be a high risk factor. This study excluded patients with BMI $\geq$ 28 kg/m^2, so the results may not be applicable to an obese population. In our country, it is difficult to use randomization principles because we cannot arrange operative plans for all patients. A randomized controlled trial should be considered to provide more evidence-based conclusions.

Conclusions

Both MED + annular suture and PTED can achieve satisfactory postoperative pain relief and functional improvement. PTED is superior to MED + annular suture with shorter length of incision, shorter operation time, and shorter length of stay. MED + annular suture is associated with greater preservation of disc height, and showed certain advantages of lower recurrence rate although there was no statistical difference.

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