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Therapeutic effect of transforaminal endoscopic spine system in the treatment of prolapse of lumbar intervertebral disc

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Abstract. – OBJECTIVE: To investigate the clinical efficacy and safety of transforaminal endoscopic spine system (TESSYS) in treating the prolapse of lumbar intervertebral disc.

PATIENTS AND METHODS: 462 patients with prolapse of lumbar intervertebral disc who were treated in our hospital from June 2012 to May 2016 were enrolled. All patients were randomly divided into 2 groups: the study group (n=231) and the control group (n=231). Patients in the study group received TESSYS, while those in the control group received conventional surgical treatment with posterior approach. Venous blood was collected before the surgery and 6 h, 12 h, 24 h, and 48 h after surgery. C reactive protein (CRP), interleukin-6 (IL-6), creatine phosphokinase (CPK) and white blood cell (WBC) in each patient were measured. The operation time, intraoperative blood loss, length of stay, postoperative ambulation time and complications were compared between the two groups. Clinical efficacy before and after surgery (1st day, 1st month, 3rd month, and 6th month after surgery) was evaluated according to visual analogue scale (VAS), Oswestry disability index (ODI) and modified MacNab criteria.

RESULTS: The operation time, intraoperative blood loss, length of stay, postoperative ambulation time and complications of patients in the study group were less than those of the control group ($p<0.05$). There were no significant differences in VAS score and ODI score on the 1st day before surgery, 1st day, 1st, 3rd, and 6th month after surgery ($p>0.05$). According to the improved MacNab standard, the excellent and good rate was 87.88% in the study group and 84.85% in the control group, the difference was not statistically significant ($p>0.05$). There were no significant differences in CRP, IL-6, CPK and WBC between the two groups before surgery ($p>0.05$). Postoperative levels of CRP, IL-6, CPK, and WBC in study group were better than those in control group, the differences were statistically significant ($p<0.05$).

CONCLUSIONS: TESSYS has the advantages of less bleeding, less traumatic reactions, fewer complications, rapid postoperative recovery, and exact short-term effect in treatment for prolapse of lumbar intervertebral disc.

Key Words
Percutaneous transforaminal endoscopy, TESSYS technique, Prolapse of lumbar intervertebral disc, Inflammatory cytokines.

Introduction

Prolapse of lumbar intervertebral disc is one of the main causes of chronic low back pain. In recent years, with the change of working living styles, the prevalence of which has been significantly increased with a younger onset. With the development of science and technology, a series of effective treatments for prolapse of lumbar intervertebral has emerged. Posterior endoscopic discectomy is one of the most effective treatments. Besides, it also gradually attracted the attention of scholars worldwide because of the trauma, hemorrhage, destruction of the posterior spinal structure and slow recovery after the traditional open surgery[1,2].

In recent years, minimally invasive spine surgery has been advanced greatly[3,4]. Since the posterior endoscopic discectomy appeared in 1992, many scholars[5-7] have reported the technology and efficacy of intervertebral endoscopic discectomy. Currently, clinical intervertebral endoscopic discectomy was operated mainly according to the technology from Yeung et al[8] and Hoogland et al[9]. The technique of Yeung et al[8] was single or dual-channel technique (YESS technique) for the progressive removal of disc tissue from the interior to the posterior part. While the technology of Hoogland et al[9] was an expansion and extension based on Yeung's

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technology, which was a technique of removing and highlighting disc tissue sequentially from the intervertebral disc through a single channel (TESSYS technology). Application of a new generation of transforaminal endoscopic equipment allowing the gradual expansion of the foramen, so that the working tube can be directly into the spinal canal in front of the dural sac to remove the prolapse of the disc tissue.

This study aimed to explore the advantages of TESSYS percutaneous transforaminal endoscopy and traditional open surgery, thus providing the clinical option in treatment for prolapse of lumbar intervertebral disc.

Patients and Methods

Clinical Data and Grouping

A total of 462 patients with prolapse of lumbar intervertebral disc treated in our hospital from June 2011 to May 2014 were enrolled. They were randomly divided into study group and control group, with 231 cases in each group. Among them, there were 126 males and 105 females in study group, aged 32-65 years old, with an average of 45.5 ± 4.8 years old; 84 cases were central herniation, 98 were paramedian herniation, 49 were extremely lateral herniation; 56 were L3-L4 herniation, 126 were L4-L5 herniation, 49 were L5-S1 herniation. For control group, there were 119 males and 112 females, aged 30-66 years old, with an average of 44.8 ± 4.6 years old; 70 cases were central herniation, 98 were paramedian herniation, 63 were extremely lateral herniation; 56 were L3-L4 herniation, 133 were L4-L5 herniation, 42 were L5-S1 herniation. There was no significant difference in basic characteristics of patients between the two groups (p>0.05) (Table I). This study was approved by the Ethics Committee of Anqiu People's Hospital. Signed written informed consents were obtained from all participants before the study.

Inclusion Criteria

Inclusion criteria were applied in patients as follows: 1- history of prolapse of lumbar intervertebral disc > 1 year; 2- painvisual analogue scale (VAS) score was greater than or equal to 6; 3- prolapse of lumbar intervertebral disc was diagnosed by Computed Tomography (CT) as nucleus pulposus prominent or calcified lesion, and Magnetic Resonance Imaging (MRI) as a prominent nucleus pulposus oppression dural (Figure 1); 4- invalid formal conservative treatment for at least 4 to 8 weeks.

Table I. Comparison of general information and rate of complications in lumbar disc herniation patients between transforaminal endoscopic spine system and fenestration discectomy group.

Clinicopathologic features	Number of cases	TESSY (n=231)	FD (n=231)	*p*-value
Age (years)				0.512
<45	259	126	133	
≥45	203	105	98	
Gender				0.514
Male	245	126	119	
Female	217	105	112	
Clinical features				0.221
Central herniation	154	84	70	
Paramedian hernaiation	196	98	98	
Foraminal hernination	112	49	63	
Segment				
L3/L4	112	56	56	
L4/L5	259	126	133	0.695
L5/S1	91	49	42	
Complications				
No complication	385	217	168	<0.01*
With complication	77	14	63	

*p<0.05

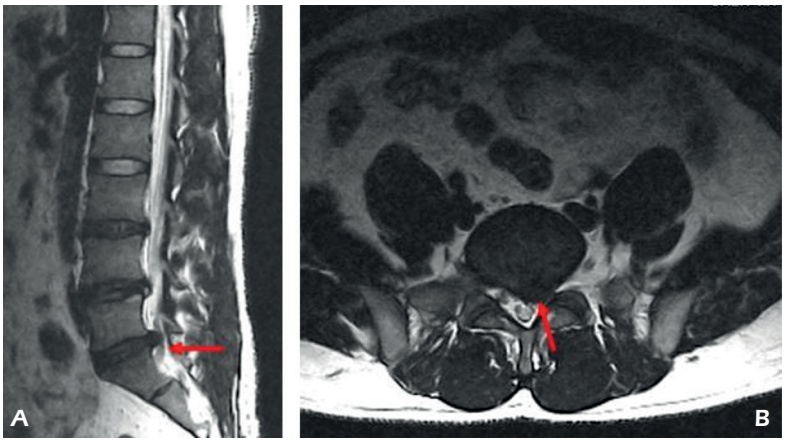

Figure 1. MRI showed herniated lumbar disk image (**A**, sagittal position; **B**, horizontal position).

Exclusion Criteria

Exclusion criteria were applied in patients as follows: 1- spinal tumors with occupying lesions; 2- mild symptoms of prolapse of lumbar intervertebral disc; 3- pain visual analogue scale (VAS) score was less than 6; 4- poor mental retardation; 5- coagulation dysfunction.

Procedure in Study Group

Patients in study group were in a prone position. Operation bed was adjusted so that patient's waist was moderately inflexed and abdomen was slightly suspended. Patients were in a comfortable position to reduce the intraoperative irritability. Kirschner wire was used preoperatively with C-arm X-ray machine to locate the target disc, followed by marking the puncture point and puncture direction. Conventional surgery area disinfection, sterile surgical towels and 1% lidocaine were applied for local anesthesia. Lateral posterior approach was accepted. Puncture was guided under fluoroscopy, and the puncture angle was generally 30 to 40 degrees with the horizontal plane. After that, C-arm lateral fluoroscopy was used to determine the puncture needle to directly go through the intervertebral foramen into the prominent intervertebral disc or intervertebral disc. 1 mL methylene blue was injected into the intervertebral disc for angiography. In order to avoid leakage of contrast agent through the broken fibrous leak into the spinal canal, the amount of contrast agent should be limited. After inserting the guide wire through the puncture needle, we pulled out the puncture needle, cut 0.8 cm skin along the guide wire, and then placed the expansion cannula, the grinding and for a minotomy system in sequence. Finally, the working cannula was inserted. Fluoroscopy was used to determine the correct position of the working tube (Figure 2). The endoscope

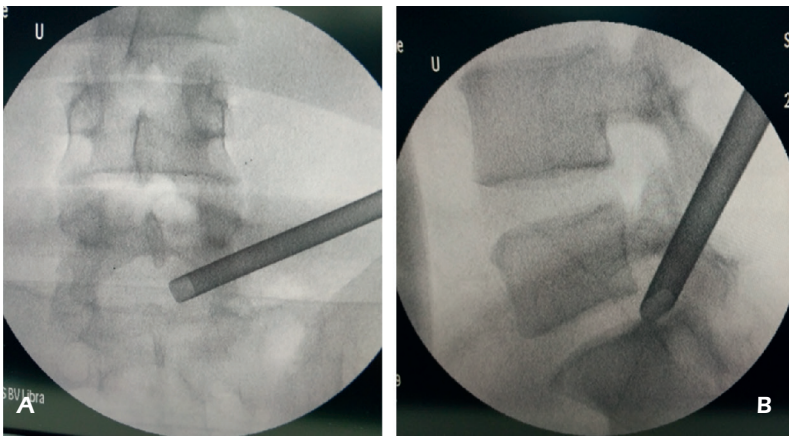

Figure 2. Location of work tunnel (**A**, anteroposterior position; **B**, lateral position).

was connected with a monitor in order to remove the blue-stained degeneration of the nucleus pulposus as much as possible). Detection was performed to ensure adequate nerve root decompression. After that, 0.9% sodium chloride was injected repeatedly to rinse incision and channel, pulled out the instrument, and stitched the wound.

Procedure in Control Group

Patients in control group underwent laminectomy. Patients were in a prone position with general anesthesia; intervertebral disc observation and marking were performed by C-arm X-ray machine. Interspace spinous process of the lesion was considered as the midpoint for the median back incision. Diseased the lateral laminae to the articular process, the inferior margin of the upper lamina and the medial protrusion of the lower joint were exposed by an electric knife. We then removed ligamentum flavum, and separated the dura and nerve root. After that, diseased disc was revealed, lateral recess or nerve root foramen was expanded, and protruding nucleus pulposus was removed by nucleus pulposus forceps. Silicone tube drainage was performed to close the incision.

Patients in control group were given antibiotics for 2 consecutive days. Antibiotics were not given in patients from study group. Dexamethasone sodium phosphate and mannitol were used for dehydration in the two groups after conventional administration for 3 consecutive days. 24 h after the surgery, straight leg lift training was carried out to prevent nerve root adhesion, musculus back muscle training was tutored. Patients from study group could get out of bed 48 h after the surgery, while patients in control group could get out of bed after 2 weeks. Waist circumference was required, and bending and violent waist-twist action was avoided within 6 weeks after the surgery.

Efficacy Assessment Standards

The operation time, intraoperative blood loss, length of stay, postoperative ambulation time and complications were compared between the two groups. Clinical efficacy before and after surgery (on the 1st day before surgery, 1st day, 1st month, 3rd month, and 6th month after surgery) was evaluated according to visual analogue scale (VAS), Oswestry disability index (ODI) and modified MacNab criteria. Modified MacNab score[10] was used for pain assessment. The evaluation standard was applied as follows: Excellent: femoral nerve traction test was negative, leg sensory exercise was normal, muscle strength was normal, low back pain disappeared; Good: femoral nerve traction test was negative, muscle strength was 4 + level, occasionally minor back pain but did not affect work and life; Fair: nerve traction test was significantly improved compared with preoperative, muscle strength was 4 level, low back pain was relieved before surgery, and occasionally usage of painkillers; Poor: no change or even worse condition after surgery, painkillers were needed. Serum was extracted from the elbow venous blood before surgery and 6 h, 12 h, 24 h, 48 h after surgery in both groups. The serum was collected by centrifugation of blood sample and the C reactive protein (CRP), interleukin-6 (IL-6), creatine phosphokinase (CPK) were detected by enzyme-linked immunosorbent assay (ELISA) (R&D Systems, Minneapolis, MN, USA).

Statistical Analysis

The data were analyzed by statistical product and service solutions (SPSS) 22.0 statistical software (IBM, Armonk, NY, USA), χ^2-test was performed in counting data. Measurement data were expressed as mean ± standard deviation ($\bar{x}\pm s$) and analyzed by *t*-test. $p<0.05$ indicated statistically significant difference.

Results

Prevalence of Complications in Study Group was Significantly Lower than that in Control Group

To investigate whether there was a difference in the prevalence of complications between the two groups, we performed the χ^2 analysis. Surgeries in both groups were successfully completed, and follow-up was conducted for 6 months. In study group, there were 14 cases of lower extremity sensory abnormalities after the surgery, and the symptoms disappeared after conservative treatment. In the control group, 7 cases showed leakage of dura mater, which were cured after conservative treatment. Additionally, there were 56 cases in control group presented chronic low back pain, who were relieved after musculus back muscle training. The prevalence of postoperative complications in study group was significantly lower than that of control group, and the difference was statistically significant (Table I).

Operation Time, Blood Loss, Length of Stay, Postoperative Ambulation Time in Study Group Were Significantly Less Than Those of Control Group

The study found that the mean operation time in study group was (55 ± 8) min, which was shorter than that in control group (125 ± 22) min (Figure 3A). The mean intraoperative blood loss was (15 ± 5) mL in study group, which was shorter than that in the control group (260 ± 35) mL (Figure 3B). The average length of stay in study group was (3 ± 1.5) d, which was also shorter than that in control group (14 ± 1.8) d (Figure 3C). The mean postoperative ambulation time was (2 ± 1.5) days in study group, which was shorter than that in control group (12 ± 4.5) days (Figure 3D). The above differences were all statistically significant.

Inflammation Levels In Study Group Were Significantly Lower Than Those of Control Group

We next explored the level of inflammation in patients from the two groups. There were no significant differences in preoperative IL-6 (Figure 4A), CRP (Figure 4B), CPK (Figure 4C), WBC (Figure 4D) between the two groups (p>0.05). The postoperative levels of IL-6, CRP, CPK and WBC at different time points in study group were better than those of control group; the differences were statistically significant (p<0.05).

No Significant Difference in Treatment Effect Between Study Group and Control Group

To explore the difference in efficacy between the two groups, we compared VAS and ODI scores for the effects of the two groups. The results showed that there were no significant differences in VAS score (Figure 5A) and ODI score (Figure 5B) between the two groups on the 1st day before surgery, 1st day, 1st month, 3rd month, and 6th month after surgery (p>0.05). According to the Macnab criteria, 147 cases were excellent, 56 were good, 28 were fair and 0 was poor in study group, the excellent and good rate of which was 87.88% (203/231). While 126 cases were excellent, 70 were good, 35 were fair and 0 was poor in control group, the excellent and good rate of

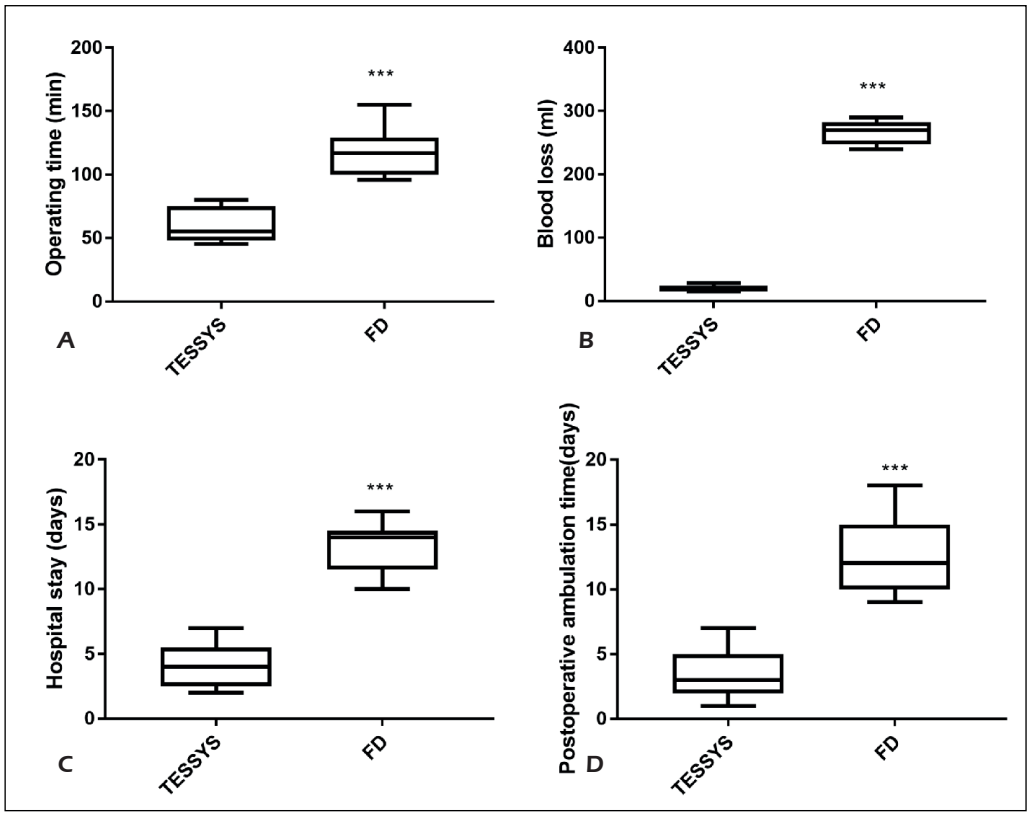

Figure 3. Comparison of surgery-related indicators in lumbar disc herniation patients between study group and control group (**A**, Operation time (min); **B**, Blood loss (mL); **C**, Length of stay (days); **D**, Postoperative ambulation time (min).

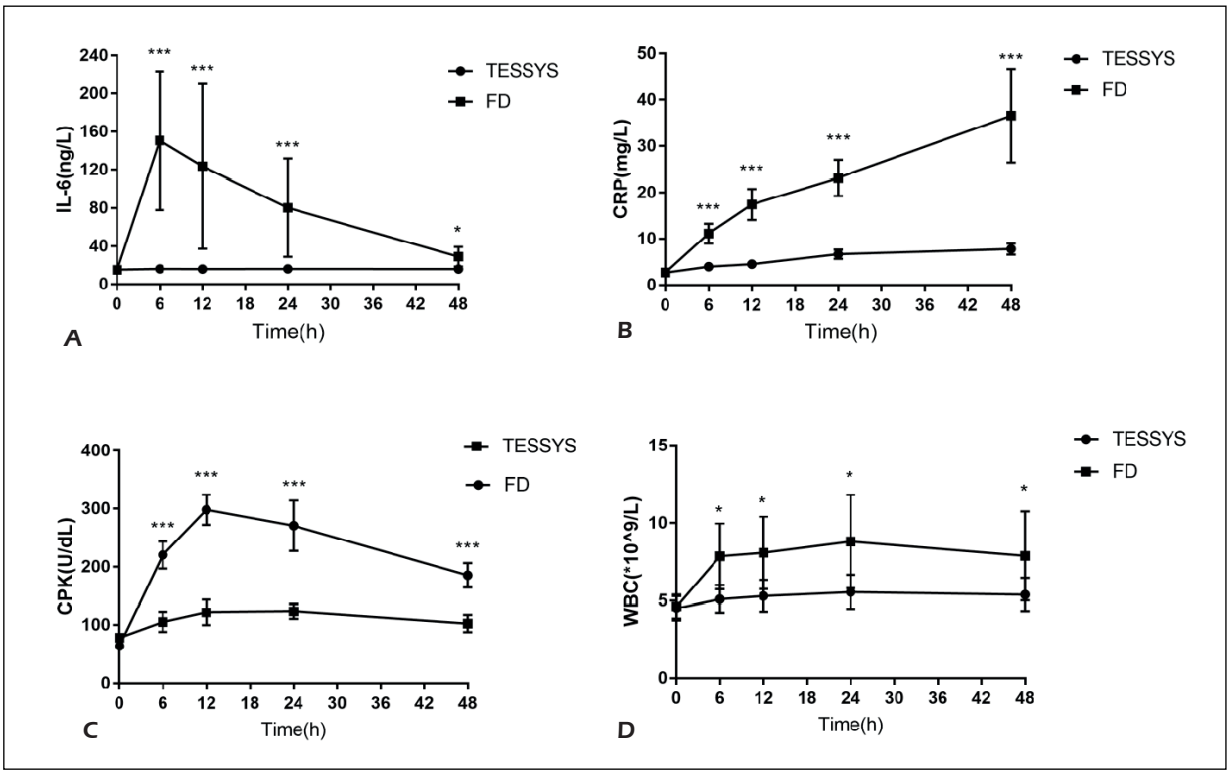

Figure 4. Comparison of preoperative and postoperative levels of IL-6. **A**, C-reactive protein (CRP). **B**, Creatine phosphokinase (CPK). **C**, White blood cell (WBC). **D**, between study group and control group.

which was 84.85% (196/231) (Table I). It was suggested that there is no significant difference in efficacy between study and control method.

Discussion

Prolapse of lumbar intervertebral disc is one of the main causes of chronic low back pain. The protruding of the medullary cavity by the ruptured fibrous ring causes the local inflammatory response after the compression of the dural sac and the nerve root, thereby resulting in pain symptoms. The causes of pain in prolapse of lumbar intervertebral disc include physical and chemical factors, of which, chemical factors play important roles. Therefore, most patients with prolapse of lumbar intervertebral disc can achieve a better outcome

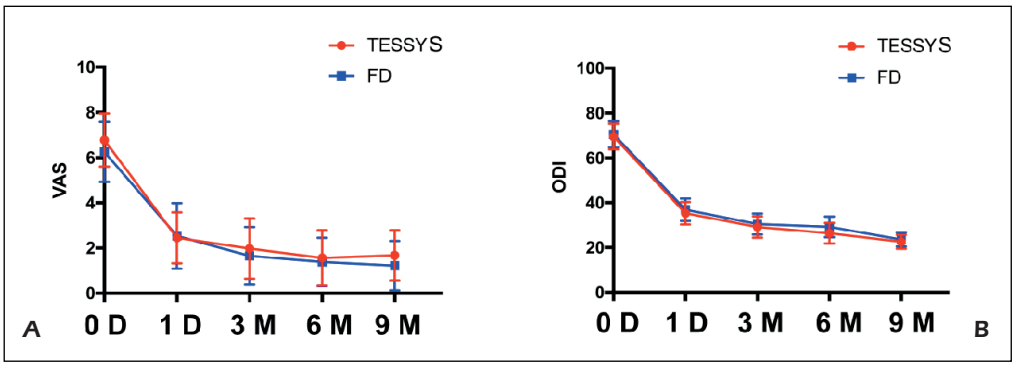

Figure 5. Comparison of visual analogue scale score (VAS). **A**, Oswestry disability index (ODI). **B**, Between transforaminal endoscopic spine system and fenestration discectomy group.

by actively conservative treatment to eliminate local inflammatory reaction. However, there are still some patients whose life quality was significantly affected. For example, patients with severe prolapse, narrow spinal canal or dural sac, or complicated with hypertrophy of the yellow ligament and other structures of the spinal canal can lead to reduced intervertebral disc space, thus resulting in a recurrent attack and worse condition. The fundamental treatment is to remove the prominent nucleus pulposus, relieve the dural sac and nerve root pressure load. Although results of open surgery for the treatment of prolapse of lumbar intervertebral disc are satisfied, large trauma will result in wide dissection of extensive back, lumbar muscles and ligaments, as well as destruction of spine, which eventually leads to adverse effects on stability of the spine, and even lumbar instability or spondylolisthesis[1]. The prevalence of postoperative complications is high[11]. Postoperative formation of a large number of epidural scar tissues would lead to the corresponding clinical symptoms, which increases the difficulty of reoperation[12]. With the introduction of spinal endoscopy system and the gradual development and improvement, the small incision of which would not destroy the normal anatomy of the spine. Meanwhile, the diseased disc can be easily removed with rapid postoperative recovery and fewer complications. Percutaneous intervertebral mirror system has received widespread attention due to its exact clinical effect, as well as overcoming many drawbacks of open surgery. Yeung et al[8] summarized 307 cases of percutaneous transforaminal endoscopic treatment of prolapse of lumbar intervertebral disc, the excellent rate of which was 89.3%. Hermantin et al[11] compared the effect of open surgery and percutaneous endoscopic surgery in the treatment of prolapse of lumbar intervertebral disc. The results showed that the satisfactory rate was 97.0% in the treatment group and 93.0% in the open surgery group. The postoperative excellent rate of study group was 87.88%, which was consistent with previous reports.

No damage is made on the stable structure of the spine by percutaneous intervertebral mirror system, thus achieving a truly minimal invasive spine. Hoogland et al[13] cut the front and bottom structure of superior articular process partly through different types of cutter. Foramen was expanded so that the working channel can go through the foramen magnified into the spinal canal within the dura intracranial space. TESSYS technology can be performed under direct vision of the prominent disc tissue removal, especially for the huge and free prolapse discs that can be directly removed. During surgery, the adequacy of decompression is determined by monitoring the dural sac and nerve root conditions. The main advantages of TESSYS technology are as follows. First, the working channel enters the spinal canal through the intervertebral foramen with the posterior approach. No interference with the lumbar and posterior muscles as well as the ligaments and facet joints are made, thus maintaining the stability of the vertebral body. The trauma of TESSYS is small and the recovery time is short. Patients treated with TESSYS can get out of bed in a short period. Surgical safety of TESSYs is high, as the approach of working channel is below the intervertebral foramen so that to avoid the exit triangle close to kambin safety nerve. Moreover, patients can achieve feedback and reduce the nerve root damage if touching the nerve root during the surgery. Large amount of saline rinse during the surgery could not only make the field of vision more clearly, but also wash away a large number of inflammatory substances, relieve pain immediately after surgery, and reduce the prevalence of inflammation. Intraoperative radiofrequency ablation can stop bleeding during the surgery to make the field more clearly, and also denervate the nerve fibers of the fibrous ring to rapidly relieve the pain symptoms. The most common complication of TESSYS for prolapse of intervertebral disc is sensory abnormalities in dominating areas by outlet nerve roots, that is, sunburn syndrome. Choi et al[14] reported that the postoperative burning-like nerve root pain rate was 8.0%. At present, it is believed to be associated with the intraoperative pulling stimulation of outlet nerve roots when placing the working channel, or stimulation of nerve roots by intraoperative radiofrequency ablation, both can be cured by conservative treatment[15]. Other common complications are inadequate surgical decompression and postoperative recurrence. It has been reported that postoperative recurrence rate of TESS was 8.0%, mostly due to intraoperative impaired disc tissue removal, which was more seen in the Lumbar 5 and Sacral 1, especially in the presence of high iliac and Lumbar 5 transverse process hypertrophy. Due to the iliac and transverse occlusion of the working channel, the prominence of the disc cannot be reached; removal of disc tissue was not clean, and eventually led to ineffective surgery[16].

TESSYS technology removes part superior processes articularis through the use of reamer to expand the foramen and to place the working channel into the spinal canal. Therefore, careful intraoperative care must be applied to prevent damage to the dural sac, nerve roots and blood

vessels. The effectiveness and success of surgery depend on the surgeon's proficiency in endoscopic manipulation and the ability to stereotactically local anatomical structures.

Surgery should always be carried out under fluoroscopy, usually, ipsilateral pedicle internal connection should not be exceeded under the positive position. During the surgery, reamer should be applied carefully, observation under fluoroscopy should be immediately carried out when a sense of frustration is felt. After that gently tap the cutter blade with a hammer until it reaches the specified position. Furthermore, overdose of disc removal can cause intervertebral disc collapse, vertebral instability, and triggers clinical symptoms. In our study, posterior 1/3 intervertebral disc and some loose intervertebral disc tissues were removed to prevent postoperative recurrence except for removing the protruding portion of the spinal canal.

In summary, compared with the traditional open surgery, TESSYS had the advantages of small trauma, rapid recovery, early out-of-bed activity and fewer postoperative complications. However, its long learning and proficiency require doctors to familiarize themselves with the knowledge of local anatomy of the lumbar spine, the intraoperative operation and the rich surgical experience. Moreover, TESSYS reduces the occurrence of cerebrospinal fluid leakage, nerve root injury, intraspinal hematoma, postoperative neuritis and other related complications.

Conclusions

We confirmed that TESSYS has the advantages of less bleeding, less traumatic reactions, fewer complications, rapid postoperative recovery and exact short-term effect in treatment for prolapse of lumbar intervertebral disc.

Conflict of Interests:
The authors declared no conflict of interest.

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