

Comparison of the Clinical Effect of Simple Nucleotomy for the Treatment of Single-segment Lumbar Disc Herniation Using a Microscope and Percutaneous Transforaminal Endoscope

Kong dece

Shanghai Pudong New Area Gongli Hospital

Tianning Chen

Graduate School of Ningxia Medical University

Xinhui Zheng

Graduate School of Ningxia Medical University

Shuyi Liu

Shanghai Pudong New Area Gongli Hospital

Tieyi Yang

yan Zhang

Shanghai Pudong New Area Gongli Hospital

Jin Shao (✉ shaojin_1977@126.com)

Shanghai Pudong New Area Gongli Hospital

Research article

Keywords: Lumbar disc herniation, Microscope, percutaneous transforaminal endoscope, Simple nucleotomy, Single-segment

Posted Date: August 2nd, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-50586/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Comparison of the clinical effect of simple nucleotomy for the treatment of single-segment lumbar disc herniation using a microscope and percutaneous transforaminal endoscope

Dece Kong^{1#}, Tianning Chen^{2#}, Xinhui Zheng², Shuyi Liu¹, Tieyi Yang^{1*}, Yan Zhang¹, Jin Shao^{1*}

¹Department of Orthopedics, Pudong New Area Gongli Hospital, School of Clinical Medicine, Shanghai University, Shanghai 200135, China

²Graduate School of Ningxia Medical University, Yinchuan, Ningxia Hui Autonomous Region 750004, China

Dece Kong and Tianning Chen should be considered co-first authors.

***Correspondence:**

Jin Shao, shaojin_1977@126.com, Add: No. 219, Miaopu Road, Pudong New Area, Shanghai, Tel: 8621-58858730-5196

Tieyi Yang, yangtieyi@163.com, Add: No. 219, Miaopu Road, Pudong New Area, Shanghai, Tel: 8621-58858730-5166

[Abstract] Objective: To compare the clinical effect of single-segment lumbar intervertebral herniation with simple nucleotomy using a microscope and percutaneous transforaminal endoscope. **Methods:** From May 2016 to October 2018, a total of 120 patients who underwent simple nucleotomy in our hospital for single-segment lumbar disc herniation were selected. According to the surgical methods, they were randomly divided into 2 groups: the microscopical treatment group included 60 cases, aged 28-65 years, with an average of 48.73 ± 12.35 years; the percutaneous transforaminal endoscopic treatment group included 60 cases, aged 29-67 years, with an average of 49.36 ± 11.76 years. The differences in the JOA score, ODI index, VAS score, serum CPK content, operation time, intraoperative bleeding, incision length, intraoperative X-ray fluoroscopy, hospital stay, and 1-year recurrence (secondary revision surgery) between the two groups were analysed. **Results:** On the second day after surgery, the serum CPK contents were higher than before surgery in both groups ($P < 0.01$), and the CPK content was higher in the microscopical treatment group than in the percutaneous endoscopic treatment group ($P < 0.01$). The JOA score

at 1 year after surgery was significantly higher than before surgery, and the ODI index and VAS score at 1 year after surgery were significantly lower than before surgery in each group ($P<0.01$). Compared with the percutaneous endoscopic treatment group, the intraoperative bleeding and the lengths of incision and hospital stay were significantly increased ($P<0.01$) and the operation time ($P<0.05$) and number of X-ray fluoroscopies during the operation ($P<0.01$) were significantly reduced in the microscopic treatment group. At 1 year after surgery, compared with the microscopic treatment group, 2 cases of complications were found in the percutaneous endoscopic surgery group. One case was a postoperative recurrence, and the other one case was endoscopic operative failure, which received a second revision surgery using a microscope. **Conclusion:** Simple nucleotomy for the treatment of single-segment lumbar intervertebral herniation has good clinical effects using a microscope and percutaneous transforaminal endoscope. The percutaneous transforaminal endoscope has the advantages of less trauma, less bleeding, and shorter hospital stay, while the microscope has the advantages of shorter operation time and less intraoperative X-ray fluoroscopy.

[Key words] Lumbar disc herniation; Microscope; percutaneous transforaminal endoscope; Simple nucleotomy; Single-segment

Lumbar disc herniation is one of the most common degenerative diseases of the spine, often causing low back pain and corresponding neurological symptoms in the innervation area ^[1]. Generally, surgical treatment is required if regular conservative treatment for 3-6 months is invalid ^[2]. In 1977, Yasargil ^[3] and Caspar ^[4] reported that the nucleus pulposus was removed under the microscope. Although it is still regarded as the gold standard for surgical treatment of lumbar disc herniation ^[5], there may still be some complications, such as instability caused by excision of the articular joint and extensive epidural fibrosis ^[6]. Since the application of percutaneous transforaminal endoscopic technology in recent years ^[7-8], it has become more mature, with the characteristics of local anaesthesia surgery, less trauma, less bleeding, fast recovery, and shorter hospital stay ^[9], but there may still be risks of nerve root injury, dural tear and postoperative recurrence ^[2]. To further explore the efficacy of two surgical methods for the treatment of lumbar disc herniation, this article analysed retrospective studies from May 2016 to October 2018 in our department. A total of 120 patients with single-segment lumbar disc herniation were treated by simple nucleus pulposus

removal, and the clinical effects of two surgical methods for the treatment of single-segment lumbar disc herniation were compared.

Materials and Methods

From May 2016 to October 2018, a total of 120 patients were treated in the orthopaedics department of Pudong New Area Gongli Hospital due to single-segment lumbar disc herniation. All the cases were diagnosed with single-segment lumbar disc herniation with clinical symptoms, signs, and imaging examinations and regular conservative treatment for 3-6 months was ineffective. The cases were randomly divided into 2 groups according to the operational method: a microscopic group, aged 28-65 years, with an average of 48.73 ± 12.35 years; and a percutaneous transforaminal endoscopic group, ages 29-67 years, with an average of 49.36 ± 11.76 years; there were 60 patients in each group.

Inclusion and exclusion criteria

Inclusion criteria (1) Patients with single-segment lumbar disc herniation; (2) All the patients signed an informed consent to the surgical treatment plan.

Exclusion criteria (1) Patients with lumbar disc herniation with two or more segments; (2) Patients with lumbar spondylolisthesis and unstable segments.

The implementation of the research plan complies with the relevant ethical requirements of Shanghai Pudong New Area Gongli Hospital.

Surgical methods

At the time of admission, all the relevant examinations were completed. Routine X-ray radiography, three-dimensional reconstruction CT and MRI examination of the lumbar spine were performed. After a joint consultation with three senior spine surgeons, the segment, type, and location of lumbar disc herniation were identified.

Microscopic nucleotomy All the operations were performed under general anaesthesia with the patients positioned prone. The position of the intervertebral space at the level of the herniated disc is determined by a guide wire under an image intensifier (anteroposterior view). Then, the following steps were performed. (1) a skin incision of 3 cm longitudinal and posterior median was made; (2) skin and subcutaneous tissue were incised layer by layer to paravertebral muscle on the symptomatic side; (3) using the surgical microscope; (4) the upper vertebral body of intervertebral space was carefully excised with a few lamina to expose the vertebral canal; (5) using the nerve exfoliator explore the prominent nucleus pulposus, which pressing on the nerve; (6) the exiting nerve root with the accompanying branch of the

segmental lumbar artery was then dissected, mobilized and retracted cranio-laterally; (7) the herniated disc was mobilized and removed by forceps; (8) after removal of the herniated disc, the nerve root was freed all around using ball-pointed hooks of different lengths; if foraminal fragments were present, careful undercutting could be performed without damaging the facet joints; and (9) all wounds were irrigated and closed in layers.

Percutaneous transforaminal endoscopic nucleotomy During the procedures, patients were in the prone position under local anaesthesia, and they could express their feelings to the surgeons. Fluoroscopy was employed to determine the operative level. After local anaesthesia with 1% lidocaine, an 18-gauge spinal needle was then introduced into the annulus fibrosus along a trajectory of 15 to 30 degrees from the sagittal plane of the body under the guidance of fluoroscopy. The needle tip was located on the lateral side of the facet joints in the positive position and the upper part of the anterior superior facet joints in the lateral position. Then, the following steps were performed. (1) a guide wire was introduced into the spinal needle, and the spinal needle was then removed; (2) a skin incision was made at the incision point marked previously; (3) the superior facet joints were cut stepwise with the guide wire grinding drill, the anterior position did not exceed the inner edge line of the pedicle, and the lateral position did not exceed the posterior edge of the vertebral body; (4) a cannulated obturator was introduced into the skin incision along the guide wire; the cannulated obturator was inserted into the disc after reaching the annulus fibrosus; (5) a bevel-ended working cannula was inserted into the disc along the cannulated obturator, and the obturator was removed; (6) an endoscope was then inserted into the bevel-ended working cannula to explore the surrounding situation of the target disc; (7) the prominent nucleus pulposus was removed with endoscopic forceps; (8) haemostasis was attempted by bipolar radiofrequency to repair the fibrous annulus; (9) the endoscope was withdrawn after the herniated fragment was removed; (10) the incision was closed with a sterile suture; and (11) off-bed activities could be performed on the second day after the surgery under the protection of waist support.

Postoperative treatment After the operation, the patient was asked to rest in bed and was treated symptomatically, such as swelling and neurotrophic symptoms. On the third day after surgery, the patient began to practice walking with waist protection and increased the amount of daily activities in a gradual manner. It was suggested that the

patient should avoid weight-bearing for the waist and back and engaging in vigorous physical exercise within 3 months after surgery.

Creatine phosphokinase The content of serum CPK ^[10] was detected on the second postoperative day. The differences in perioperative indexes, such as operation time, intraoperative bleeding, incision length, number of X-ray fluoroscopies during surgery, length of hospital stay, and recurrence after 1 year (secondary operation) were observed.

Efficacy evaluation

Japanese Orthopedic Association (JOA) score ^[11] Low back pain, including subjective symptoms, objective findings, daily life limitations and bladder function assessment, was evaluated. The highest score is 29 points, and the lowest score is 0 points. The lower the score, the more obvious the dysfunction.

Oswestry Disability Index (ODI) ^[12] The lumbar function and short-term postoperative efficacy were evaluated. A total of 10 items were assessed, each with a score of 0 to 5 points; the highest score is 50 points; ODI = actual score / 50*100%. The higher the score, the more obvious the dysfunction.

VAS (Visual analogue scale) ^[13] The pain levels in the waist, leg and wound were assessed. Ten points represents the most severe pain, and 0 points represents no pain.

Statistical method The data are expressed as $\bar{x}\pm s$. The comparison between the 2 groups was performed by independent sample *t* test, and the comparison between before and after operation was performed by paired *t* test. At the test level of $\alpha=0.05$, $P<0.05$ was considered statistically significant.

Results

2.1 General information There was no significant differences in gender, age or surgical segment between the 2 groups ($P>0.05$) (Table 1).

Table 1 General information between the 2 groups

Group	Microscope (n=60)	Percutaneous transforaminal endoscope (n=60)
Sex		
Male	28	31
Female	32	29
Age	48.73±12.35	49.36±11.76
Surgical segment		

L3/4	17	16
L4/5	27	31
L5/S1	16	13

2.2 Follow-up time All the patients were followed up from 13 to 32 months, with an average of 21.6 months.

2.3 Serum CPK test On the second day after surgery, the serum CPK contents in both groups were significantly higher than those before surgery ($P<0.01$), and the content in the microscopic group was significantly higher than that in the percutaneous transforaminal endoscopic group ($P<0.01$) (Table 2).

Table 2 Comparison of serum CPK between the two groups before and after surgery (U/L, $\bar{x}\pm s$)

Group	Number	Preoperative	Postoperative	t value	P value
Microscope	60	132.37 \pm 48.81	853.29 \pm 173.65 *	30.96	<0.01
Percutaneous transforaminal endoscope	60	127.62 \pm 37.56	563.63 \pm 95.37 * #	32.95	<0.01
t value		0.5974	11.33		
P value		0.5514	<0.01		

* Comparison of postoperative and preoperative values within each group: $P<0.01$; # Postoperative comparison between 2 groups: $P<0.01$

2.4 JOA score, ODI index and VAS score The postoperative JOA scores of the microscopic group ($t=52.99$, $P<0.01$) and the percutaneous transforaminal endoscopic group ($t=63.29$, $P<0.01$) were significantly higher than those before surgery. The postoperative ODI indexes of the microscopic group ($t=23.06$, $P<0.01$) and the percutaneous transforaminal endoscopic group ($t=17.26$, $P<0.01$) were significantly lower than those before surgery. The postoperative VAS scores of the microscopic group ($t=26.22$, $P<0.01$) and the percutaneous transforaminal endoscopic group ($t=42.65$, $P<0.01$) were significantly lower than those before surgery. There was no significant difference in the preoperative and postoperative JOA scores, ODI indexes and VAS scores between the 2 groups ($P>0.05$) (Table 3).

Table 3 Postoperative efficacy comparisons between the 2 groups

Group	Microscope (n=60)		Percutaneous transforaminal endoscope (n=60)	
	Preoperative	Postoperative	Preoperative	Postoperative
JOA score	9.5 \pm 1.8	24.3 \pm 1.2 *	9.1 \pm 1.6	24.1 \pm 0.9 *
ODI index	72 \pm 16	20 \pm 7 *	71 \pm 20	23 \pm 8 *

VAS score 6.0 ± 1.2 1.6 ± 0.5 * 5.8 ± 0.5 1.5 ± 0.6 *

* Comparison of postoperative and preoperative scores within each group: $P < 0.01$

2.5 Surgery time, intraoperative bleeding, incision length, intraoperative X-ray fluoroscopy times, hospital stay There was no significant difference in the operation time between the 2 groups. The intraoperative time ($P < 0.05$) and the number of X-ray fluoroscopies ($P < 0.01$) in the microscopic group were significantly lower than those in the percutaneous transforaminal endoscopic group, while the intraoperative bleeding, incision length and hospital stay in the percutaneous transforaminal endoscopic group were significantly reduced compared with the microscopic group ($P < 0.01$) (Table 4).

Table 4 Comparison of the surgery-related indicators between the 2 groups

Group	Microscope	Percutaneous transforaminal endoscope	<i>t</i> value	<i>P</i> value
Number	60	60		
Surgery time (min)	70.36 ± 31.78	81.27 ± 24.85※	2.095	0.0383
Intraoperative bleeding (ml)	39.83 ± 10.53	15.65 ± 3.26#	16.99	<0.01
Incision length (cm)	2.68 ± 0.37	0.63 ± 0.24	36.01	<0.01
Intraoperative X-ray fluoroscopy times	3.7 ± 1.6	23.6 ± 5.5#	26.91	<0.01
Hospital stay (d)	6.5 ± 2.3	3.2 ± 1.5#	9.309	<0.01
Endoscopic surgery failed	0	1		
Relapse within 1 year after surgery	0	1		

Comparison between the 2 groups: ※ $P < 0.05$, # $P < 0.01$

2.6 Typical cases At the 1 year postoperative follow-up, in the percutaneous transforaminal endoscopic group, 1 patient had relapsed and was discharged after conservative treatment (Fig 1); 1 patient failed surgery and underwent a second revision using a microscope (Fig 2). There was no postoperative recurrence or secondary revision surgery in the microscopic group (Table 4).

3 Discussion

3.1 Microscope and percutaneous transforaminal endoscope are safe and effective treatments for lumbar disc herniation

The microscope was first applied to lumbar discectomy surgery in the 1970s^[3-4]. Compared with open surgery under the naked eye, the microscope had obvious advantages in spinal surgery^[14], and it is still the gold standard for surgical treatment of lumbar disc herniation^[5]. The percutaneous transforaminal endoscopic technology has been applied to lumbar discectomy since the beginning of the 21st century^[7-8]. It has the advantages of less trauma, less bleeding, and shorter hospital stay^[9]. The two surgical techniques work differently, and there are many differences in the specific operational processes. The main differences between the microscope and percutaneous transforaminal endoscope^[15-16] are as follows: (1) Imaging: the former is three-dimensional imaging, and the latter is a two-dimensional plane; (2) Operational mode: the former is direct vision, and the latter is reverse video; (3) Surgical field of view: the former is large, and the latter is small; (4) Operational space: the former is sufficient, and the latter is limited; (5) Operational cooperation: the former can cooperate tacitly in the same field of view by two surgeons, and the latter is completed independently; (6) The indications for surgery of the former are broader than the latter. In this study, at the 1-year follow-up, the JOA scores, ODI indexes and VAS score of the two groups were significantly improved compared with those before surgery, and the difference was statistically significant. There were no significant differences in the JOA scores, ODI indexes and VAS scores between the two groups, whether before or after surgery. There were no complications, such as nerve root injury, dural tear, infection, and lumbar spine instability in both groups, suggesting that both microscope and percutaneous transforaminal endoscope are safe and effective treatments for lumbar disc herniation.

3.2 Serum Creatine phosphokinase (CPK) content is a sensitive indicator for evaluating the degree of paravertebral muscle injury after spinal surgery

Previous studies have shown that serum CPK levels increased most significantly during lumbar spine fusion surgery but also increased to varying degrees during minimally invasive lumbar spine surgery^[17] and generally return to normal levels within a week after surgery^[10]. This study showed that on the second day after surgery, the serum CPK contents of the 2 groups were significantly higher than before. The increased value of the microscopic group was significantly higher than that of the percutaneous transforaminal endoscopic group, and the difference was statistically significant, which was essentially consistent with the previous research results. In

addition, some scholars have found that the postoperative serum CPK content of male patients is much higher than that of females due to their higher muscle tissue content [18]; however, in this study, there was no significant difference between the serum CPK content of males and females, whether before or after surgery. For patients with high risk of lumbar spine surgery, some scholars suggest taking dynamic and systematic measurements of CPK contents and establishing a standard measurement interval to assess the degree of muscle injury more effectively [19]. Further research is needed in future work.

3.3 Postoperative recurrence and failure of endoscopic surgery often occur in the treatment of lumbar disc herniation with percutaneous transforaminal endoscope Percutaneous transforaminal endoscopic surgery is excellent for the treatment of lumbar disc herniation [20], but recurrence after surgery and failure of endoscopic surgery have occurred [21]. Postoperative recurrence is one of the most common complications of percutaneous transforaminal endoscopic surgery, which is generally defined as the protrusion of the same area of the intervertebral disc that was last surgically removed after a period of improvement of the postoperative symptoms, with an incidence of approximately 5.8-6.2% [22-24]. As the most heavily loaded segment, the recurrence rate of the L4/5 intervertebral disc after percutaneous transforaminal endoscopic nucleotomy is the highest, but it may also be related to the fact that most surgical segments of percutaneous transforaminal endoscopic nucleotomy are at the L4/5 level [25]. In this study, there was 1 case of recurrence in the percutaneous transforaminal endoscopic group. An elderly man after simple nucleotomy of L4/5 intervertebral disc herniation accidentally sprained his waist more than one month after the operation and appeared to have symptoms similar to his preoperative neurological symptoms. He refused the second revision and was discharged after conservative treatment. The definition of endoscopic surgery failure [26] is as follows: (1) persistent neurostimulation symptoms within 2 weeks after surgery that require a second revision surgery; (2) no significant improvement in postoperative pain symptoms; and (3) imaging confirmed residual nucleus pulposus fragments. In this study, an elderly obese woman with L5/S1 intervertebral disc herniation (BMI of 28.62 kg/m²) in the percutaneous transforaminal endoscopic group experienced pain and numbness in the left lower limb from the first day after surgery. Postoperative MRI showed that the residual nucleus pulposus fragments remained on the left side of the L5S1 intervertebral space, which met the diagnostic criteria for

endoscopic surgery failure. The second revision surgery using the microscope was performed on the 13th postoperative day, and the symptoms of pain and numbness in the left lower limb disappeared. In addition to the obesity factor ^[25], the patient may have a greater relationship with the L5/S1 intervertebral space. Although the percutaneous transforaminal endoscopic technique has made great progress in the treatment of lumbar disc herniation, it is still very challenging to perform in the L5/S1 intervertebral space, mainly due to its unique anatomy, including the blocking of the iliac crest, huge facet joints and inclined intervertebral spaces; sometimes, the establishment of a bone tunnel on the iliac crest was required, resulting in increased difficulty and failure of the operation ^[27]. In this study, there were fewer cases of L5/S1 intervertebral space in the percutaneous transforaminal endoscopic group than in the microscopic group, which was also related to the above reasons. The author recommends that for patients with L5/S1 disc herniation, the imaging data should be fully evaluated before surgery, and percutaneous transforaminal endoscopic surgery should be carefully selected.

3.4 Limitations and deficiencies of this study In this study, due to many shortcomings, such as the design of the experimental study and the number of samples, it is necessary to use multi-centre, large-sample, prospective cohort studies and other methods in future work to further confirm the clinical efficacy of simple nucleotomy for the treatment of single-segment lumbar disc herniation a using microscope and percutaneous transforaminal endoscope.

4 Conclusion

In summary, both the microscope and percutaneous transforaminal endoscope are effective treatments for lumbar disc herniation, and each has its own advantages. The percutaneous transforaminal endoscope was superior in intraoperative bleeding, incision length, and hospital stay, while the microscope was slightly stronger in terms of operation time, intraoperative X-ray fluoroscopy, postoperative recurrence, and second revision.

Abbreviations

JOA: Japanese Orthopedic Association; ODI: Oswestry Disability Index; VAS: Visual analogue scale; CPK: Creatine phosphokinase

Acknowledgements

Not applicable

Authors' contributions

Dece Kong, Jin Shao, and Tieyi Yang designed the study protocol. Shuyi Liu, Yan Zhan and Tieyi Yang performed the clinical surgical. Dece Kong, Tianning Chen, Xinhui Zheng, and Jin Shao analyzed the data. Dece Kong and Tianning Chen wrote the first draft of the manuscript. Jin Shao provided revision for intellectual content and final approval of the manuscript. All authors had final approval of the submitted and published versions. Tieyi Yang and Jin Shao had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Funding

This study was supported by Subject Leadership Project of Shanghai Pudong New Area (PWRd2016-06), The Featured Clinical Discipline Project of Shanghai Pudong (PWYts2018-03). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author upon reasonable request.

Ethics approval

The study design was approved by ethics committee of Shanghai Pudong New Area Gongli Hospital. All participants provided written informed consent prior to initiation of study procedures.

Consent for publication

This paper is approved by all authors for publication.

Competing interests

The authors declare that they have no competing interests.

Author details

¹Department of Orthopedics, Pudong New Area Gongli Hospital, School of Clinical Medicine, Shanghai University, Shanghai 200135, China. ²Graduate School of

Ningxia Medical University, Yinchuan, Ningxia Hui Autonomous Region 750004, China

References

1. Kose G, Tastan S, Temiz NC, et al. The Effect of Low Back Pain on Daily Activities and Sleep Quality in Patients With Lumbar Disc Herniation: A Pilot Study. *J Neurosci Nurs*. 2019, 51(4):184-189.
2. Kanno H, Aizawa T, Hahimoto K, et al. Minimally invasive discectomy for lumbar disc herniation: current concepts, surgical techniques, and outcomes. *Int Orthop*. 2019, 43(4):917-922.
3. Yasargil MG. Microsurgical operation of herniated lumbar disc. *Adv Neurosurg*. 1977, 4:81-82.
4. Caspar W. A new surgical procedure for lumbar disc herniation causing less tissue damage through a microsurgical approach. *Adv Neurosurg*. 1977, 4:74-80.
5. Elkatatny AAAM, Hamdy TM, Moenes KM. Comparison between Results of Microdiscectomy and Open Discectomy in Management of High-Level Lumbar Disc Prolapse. *Open Access Maced J Med Sci*. 2019, 7(17):2851-2857.
6. Meyer G, DA Rocha ID, Cristante AF, et al. Percutaneous Endoscopic Lumbar Discectomy Versus Microdiscectomy for the Treatment of Lumbar Disc Herniation: Pain, Disability, and Complication Rate-A Randomized Clinical Trial. *Int J Spine Surg*. 2020, 14(1):72-78.
7. Jang JS, An SH, Lee SH. Transforaminal percutaneous endoscopic discectomy in the treatment of foraminal and extraforaminal lumbar disc herniations. *J Spinal Disord Tech*. 2006, 19(5):338-343.
8. Hoogland T, Schubert M, Miklitz B, et al. Transforaminal posterolateral endoscopic discectomy with or without the combination of a low-dose chymopapain: a prospective randomized study in 280 consecutive cases. *Spine (Phila Pa 1976)*. 2006, 31(24):E890-897.
9. Asano LYJ, Bergamaschi JPM, Dowling Á, et al. Transforaminal Endoscopic Lumbar Discectomy: Clinical Outcomes and Complications. *Rev Bras Ortop (Sao Paulo)*. 2020, 55(1):48-53.

10. Griffith M, Shaw KA, Baird M, et al. Defining the Normal Trends of Serum Creatine Kinase Levels Following Spinal Surgery. *Asian Spine J.* 2019, 13(3):386-394.
11. Komatsu J, Iwabuchi M, Endo T, et al. Clinical outcomes of lumbar diseases specific test in patients who undergo endoscopy-assisted tubular surgery with lumbar herniated nucleus pulposus: an analysis using the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire (JOABPEQ). *Eur J Orthop Surg Traumatol.* 2020, 30(2):207-213.
12. Werner DAT, Grotle M, Gulati S, et al. Can a Successful Outcome After Surgery for Lumbar Disc Herniation Be Defined by the Oswestry Disability Index Raw Score?. *Global Spine J.* 2020, 10(1):47-54.
13. Heller GZ, Manuguerra M, Chow R. How to analyze the Visual Analogue Scale: Myths, truths and clinical relevance. *Scand J Pain.* 2016, 13:67-75.
14. Akinduro OO, Kerezoudis P, Alvi MA, et al. Open Versus Minimally Invasive Surgery for Extraforaminal Lumbar Disk Herniation: A Systematic Review and Meta-Analysis. *World Neurosurg.* 2017, 108:924-938.e3.
15. Rasouli MR, Rahimi-Movaghar V, Shokraneh F, et al. Minimally invasive discectomy versus microdiscectomy/open discectomy for symptomatic lumbar disc herniation. *Cochrane Database Syst Rev.* 2014, (9):CD010328.
16. Ahn Y. Endoscopic spine discectomy: indications and outcomes. *Int Orthop.* 2019, 43:909-916.
17. Choi KC, Shim HK, Hwang JS, et al. Comparison of Surgical Invasiveness Between Microdiscectomy and 3 Different Endoscopic Discectomy Techniques for Lumbar Disc Herniation. *World Neurosurg.* 2018, 116:e750-e758.
18. Adogwa O, Johnson K, Min ET, et al. Extent of intraoperative muscle dissection does not affect long-term outcomes after minimally invasive surgery versus open-transforaminal lumbar interbody fusion surgery: A prospective longitudinal cohort study. *Surg Neurol Int.* 2012, 3(Suppl 5):S355-361.
19. Portella ST, Escudeiro GP, Mansilla R, et al. Predictive Factors for Muscle Injury After Posterior Lumbar Spinal Surgery. *World Neurosurg.* 2019, 129:e514-e521.
20. Qin F, Zhang Z, Zhang C, et al. Effect of time to first ambulation on recurrence after PELD. *J Orthop Surg Res.* 2020, 15:83.
21. Pan M, Li Q, Li S, et al. Percutaneous Endoscopic Lumbar Discectomy: Indications and Complications. *Pain Physician.* 2020, 23:49-56.

22. Yin S, Du H, Yang W, Duan C, Feng C, Tao H. Prevalence of Recurrent Herniation Following Percutaneous Endoscopic Lumbar Discectomy: A Meta-Analysis. *Pain Physician*. 2018, 21(4):337-350.
23. Zhou C, Zhang G, Panchal RR, et al. Unique Complications of Percutaneous Endoscopic Lumbar Discectomy and Percutaneous Endoscopic Interlaminar Discectomy. *Pain Physician*. 2018, 21(2):E105-E112.
24. Yao Y, Zhang H, Wu J, et al. Minimally Invasive Transforaminal Lumbar Interbody Fusion Versus Percutaneous Endoscopic Lumbar Discectomy: Revision Surgery for Recurrent Herniation After Microendoscopic Discectomy. *World Neurosurg*. 2017, 99:89-95.
25. Kim HS, You JD. Predictive Scoring and Risk Factors of Early Recurrence after Percutaneous Endoscopic Lumbar Discectomy. *Biomed Res Int*. 2019, 2019:6492675.
26. Lee SH, Kang BU, Ahn Y. Operative failure of percutaneous endoscopic lumbar discectomy: a radiologic analysis of 55 cases. *Spine (Phila Pa 1976)*. 2006, 31(10):E285-290.
27. Choi KC, Park CK. Percutaneous Endoscopic Lumbar Discectomy for L5-S1 Disc Herniation: Consideration of the Relation between the Iliac Crest and L5-S1 Disc. *Pain Physician*. 2016, 19(2):E301-308.

Figure legends

Fig 1 Postoperative recurrence of L4/5 nucleotomy by percutaneous transforaminal endoscope A. Preoperative MRI sagittal image showing lumbar disc herniation of the L4/5 level (long arrow); B. Preoperative MRI cross-sectional image showing lumbar disc herniation of the L4/5 level at the right side (large asterisk); C. Postoperative MRI sagittal image showing mild lumbar disc herniation of the L4/5 level (short arrow); D. Postoperative MRI cross-sectional image showing small nucleus pulposus fragments on the right side (small asterisk).

Fig 2 Operative failure of L5/S1 nucleotomy by percutaneous transforaminal endoscope A. Preoperative MRI sagittal image showing lumbar disc herniation of the L5S1 level (long arrow); B. Preoperative MRI cross-sectional image showing lumbar disc herniation of the L5S1 level on the left side (large asterisk); C. Postoperative MRI sagittal image showing lumbar disc herniation of the L5S1 level (short arrow); D. Postoperative MRI cross-sectional image showing large residual nucleus pulposus fragments on the left side (small asterisk).

Figures

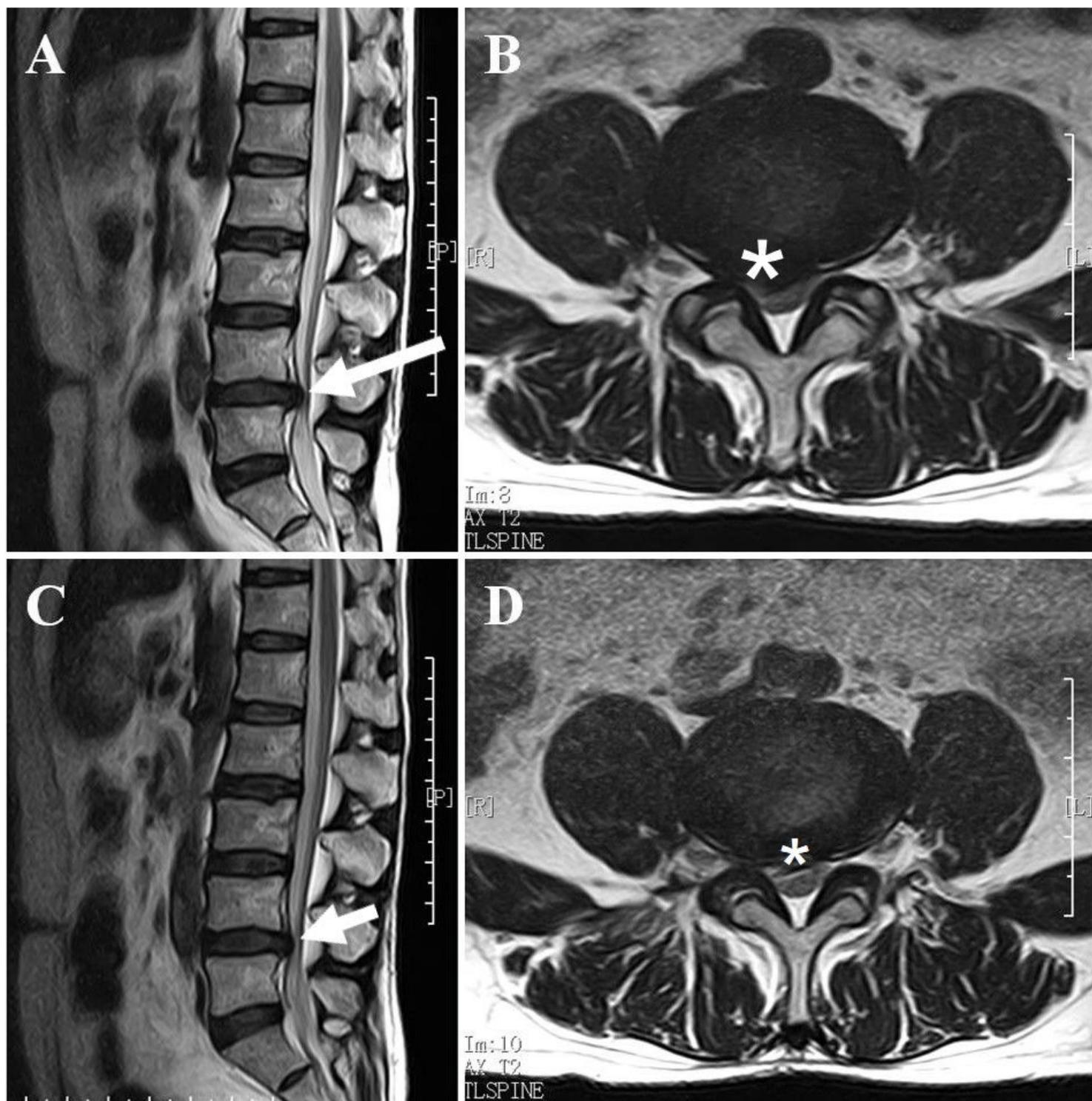


Figure 1

Postoperative recurrence of L4/5 nucleotomy by percutaneous transforaminal endoscope A. Preoperative MRI sagittal image showing lumbar disc herniation of the L4/5 level (long arrow); B. Preoperative MRI cross-sectional image showing lumbar disc herniation of the L4/5 level at the right side (large asterisk); C. Postoperative MRI sagittal image showing mild lumbar disc herniation of the L4/5 level (short arrow); D.

Postoperative MRI cross-sectional image showing small nucleus pulposus fragments on the right side (small asterisk).

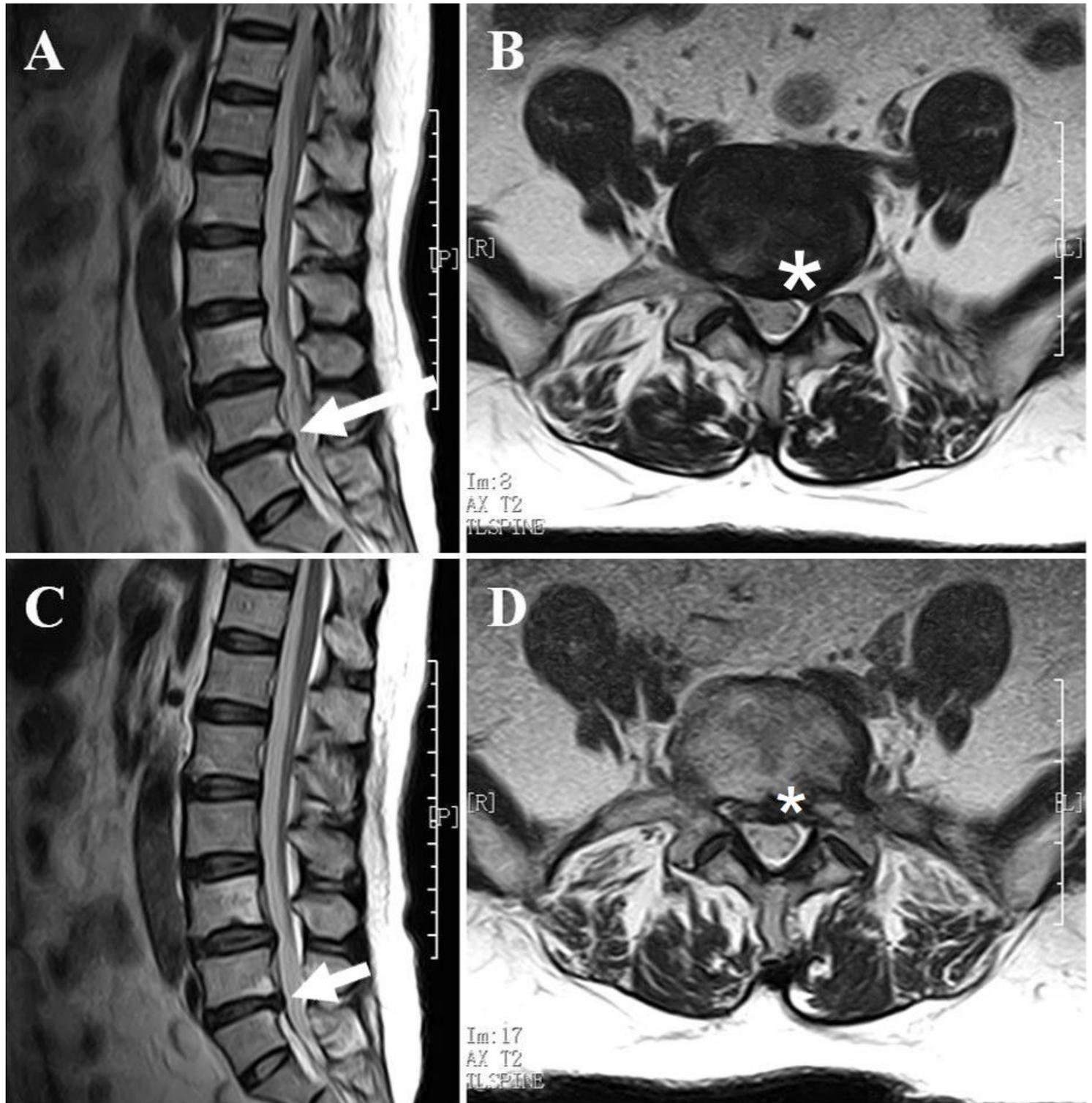


Figure 2

Operative failure of L5/S1 nucleotomy by percutaneous transforaminal endoscope A. Preoperative MRI sagittal image showing lumbar disc herniation of the L5/S1 level (long arrow); B. Preoperative MRI cross-sectional image showing lumbar disc herniation of the L5/S1 level on the left side (large asterisk); C.

Postoperative MRI sagittal image showing lumbar disc herniation of the L5S1 level (short arrow); D. Postoperative MRI cross-sectional image showing large residual nucleus pulposus fragments on the left side (small asterisk).