Treatment of calcified lumbar disc herniation by intervertebral foramen remolding a retrospective study

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Research Article

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Abstract

Background

Percutaneous endoscopic lumbar discectomy is a new treatment method for lumbar disorders but remains controversial, similar to other minimally-invasive treatments for calcified lumbar discs. This study aimed to investigate the use of the percutaneous intervertebral foramen lens technology for secondary molding of the intervertebral foramen in the treatment of calcified lumbar discs.

Methods

The study included 104 patients who were divided into two groups. Group A comprised 50 patients (age: 49.9 ± 14.5 years, 30 [60%] females) with calcified lumbar disc herniation and group B comprised 54 patients (age: 53.2 ± 15.3 years, 32 (59%) females) with non-calcified lumbar disc herniation diagnosed by computed tomography and magnetic resonance imaging. Patients underwent a percutaneous endoscopic lumbar discectomy at our hospital from January 1, 2017, to December 31, 2019. Demographic characteristics before the surgery and perioperative outcomes were retrospectively reviewed. The treatment outcome was analyzed using the numerical rating scale (NRS) score, Oswestry Disability Index (ODI) score, and modified Macnab criteria.

Results

Patients in groups A and B showed significant improvement in both the NRS and ODI scores after the surgery and maintained relatively low ODI and NRS scores during subsequent follow-ups. In group A, 94% of patients rated the results as “excellent” or “good” according to the modified Macnab criteria at the 3-month follow-up. One patient developed neck pain during the surgery, which was diagnosed as spinal hypertension syndrome, and the surgery was suspended until the patient’s condition improved. In group B, 92.6% of patients rated the results as “excellent” or “good” according to the modified Macnab criteria at the 3-month follow-up. In both the groups, no patient reported any dural leak, infection, or other related complications.

Conclusions:

Our results indicate that transforaminal remolding is effective in the treatment of non-calcified lumbar disc herniations, with few intraoperative and postoperative complications and that secondary reconstruction of the intervertebral foramen under visual conditions using microscopic knife is an effective method for treating calcified lumbar disc herniation, with few intraoperative and postoperative complications.

Introduction

Calcified lumbar disc herniation is characterized by vertebral canal bone occupancy and is a special type of lumbar disc herniation with a calcified site[1,2]. Previous studies have reported an incidence ranging

from 4.7% to 15.9%. The incidence of the disease is gradually increasing and has a younger trend[3-5]. Unlike calcification, which occurs in children, the course of the disease in adults is usually long, and calcification rarely resolves spontaneously[6]. Studies on calcified disc herniation mainly focus on the thoracic vertebrae, while calcified disc herniation on the lumbar vertebrae is rare and difficult to treat[7-9]. The majority of doctors use traditional open fusion surgery for treatment[10]. Although it is recognized for its good efficacy, it is accompanied by many complications, such as intractable pain in the lower back and degeneration in adjacent stages[2,9,10].

Calcified lumbar disc herniation is easily confused with posterior ring apophysis separation and lumbar disc herniation with calcification. Calcified lumbar disc herniation and posterior ring apophysis separation can be distinguished by CT[11,12]. CT findings of posterior ring apophysis separation: there were obvious bone defects at the posterior margin of the vertebral body. The bone protruding into the spinal canal is usually located at the edge of the protruding disc and is roughly complementary to the bone defect at the posterior edge of the vertebral body. CT findings of calcified lumbar disc herniation: Calcified foci are usually punctured or lamellar in the interior of the herniated disc, and there is no bone defect at the posterior edge of the vertebral body. Most of the patients with lumbar disc herniation with calcification are female children[13,14]. Calcification is concentrated in the thoracic vertebra and generally resolves around the age of 20[13-16] and is usually accompanied by vertebral plate irregularities and possible intervertebral body fusion[17,18].

Percutaneous foraminal endoscopic treatment of calcified lumbar disc herniation is not as satisfactory as that of conventional lumbar disc herniation[8]. This may be due to the limited scope of microscopic operation, intraoperative interference with normal bony structures, and tension of nerve roots. How to decompress the compressed nerve root accurately on the premise of reducing nerve disturbance in the spinal canal and maintaining normal movement of the spine while alleviating the symptoms has become a common problem faced by spinal surgeons. This study retrospectively analyzed the efficacy of the transforaminal approach in the treatment of calcified and noncalcified lumbar disc herniation and discussed the removal method of calcified lesions to provide a reference for clinical treatment.

Materials And Methods

This retrospective study recruited 104 consecutive patients from January 1, 2017, to December 31, 2019, according to the following inclusion criteria: 1) single-stage percutaneous endoscopic lumbar discectomy; 2) imaging data confirmed single-segment lumbar disc herniation and ruled out other spinal diseases such as lumbar spondylolisthesis; and 3) significant lumbago and leg pain but no significant improvement after 6 months of conservative treatment. The 104 patients were divided into groups A and B. The specific grouping details are presented in the block diagram in Fig. 1.

Table 1 shows the baseline data of patients in groups A and B: 50 patients in group A and 54 patients in group B. There were no significant differences in age, sex, surgical level, and body mass index between the two groups.

Outcome assessment:

Documented demographic characteristics and perioperative outcomes were evaluated. Leg pain before and after the surgery was assessed using the numerical rating scale (NRS) with a score ranging from 0 to 10. Functional disability before and after the surgery was measured by the Simplified Chinese Version of the Oswestry Disability Index (ODI). Surgical outcomes were also evaluated according to the modified Macnab criteria, as described previously.

Follow-up:

Patients were followed up at 1 week, 3 months, 6 months, and 1 year after surgery. The NRS and ODI scores were assessed at the four follow-ups, whereas outcomes were evaluated according to the Macnab criteria only at the 3-month follow-up.

Statistical analysis

Data were statistically analyzed using the SPSS 25 program (USA, IBM corporation). Data normality was tested using the Shapiro-Wilk test. Parametric data are presented as mean $\pm$ standard deviation, whereas nonparametric data are presented as median (interquartile range). Nonparametric data and ordinal categorical variables were tested using the Mann-Whitney U test. A p value of <0.05 was considered statistically significant.

Surgical procedure

The surgery was performed using an endoscopic surgery system (outer diameters of endoscope width 7mm). After entering the operating room, the patient was placed in the lateral decubitus position, the hip and knee were flexed, and a lumbar pillow was placed under the diseased segment to aid access to the intervertebral foramen. Fluoroscopy was used for body surface projection. A vertical line through the extension of the upper endplate line of the lower vertebral body was made, and the body surface projection of the base of the articular process on the responsibility space and the body surface projection of the center of the responsibility space were established as the extension line. Intersection points of L4-5, L3-4 and L2-3 were approximately 12–14 cm, 10–12 cm and 8–10 cm from the posterior midline, respectively, and the intersection point of the two lines was the established as the puncture point. After routine disinfection, 20 ml local anesthesia was administered with 1% lidocaine, 18 G puncture needles were placed obliquely along the superior articular process of the superior responsibility space, and 0.5% lidocaine was injected for local anesthesia of the foraminal area. The skin was cut approximately 8 mm at the insertion point and a one-level cannula was placed along the positioning needle. Positioning was confirmed by fluoroscopy. The base of the superior articular process was polished with bone drills of 6 mm, 7 mm, and 8 mm in turn to conduct the first foraminal molding, establish the working

channel(Working channel width 5mm), place the endoscopic system, and deal with the soft tissues in the foraminal area. The ventral bone at the base of the superior articular process was excised with a bone knife under a endoscope, and the foramina were reshaped so that a relatively sufficient perspective and operating space could be obtained (also under the microscope). For large calcification foci, the soft tissue around the calcified intervertebral disc was first treated to expose the base of the calcification foci connected to the vertebral body. The bone knife and cannula were rotated under the microscope to separate the calcification foci and remove them in small pieces. Small free calcifications could be removed directly. As viewed by microscopy, the blood vessels on the surface of the nerve root were recovered, and the nerve root pulsed regularly (Fig. 2). The straight leg raising test was negative during the operation, and the nerve root could slip freely. The ruptured annulus was carefully repaired by radiofrequency ablation, and the endoscopic system was withdrawn. A drainage tube was placed, the incision was sutured, and the surgery was completed.

Results

Demographic and pathophysiological data:

Demographic and pathophysiological data are presented in Table 1, and patients' perioperative outcomes are shown in Table 2. The average operation duration of group A was 64.9 ± 17.2 minutes and of group B was 57.2 ± 15.8 minutes. The operation duration of group A was slightly longer than that of group B, and the difference was statistically significant ($p < 0.05$). There were no significant differences in Age, Sex, Segments, BMI, Blood loss, Hospital stay, Drainage between the two groups ($p > 0.05$).

Clinical results:

We followed up the patients for at least 1 year. The pain severity of both the groups was assessed using NRS scores, and the follow-up data are presented in Table 3. The mean preoperative NRS score of group A was 7.3 ± 1.3 , and it decreased to 2.3 ± 0.8 1 week after the surgery and to 1.0 ± 0.6 at the 12-month follow-up. The mean NRS score of group B decreased from 7.2 ± 0.9 to 2.1 ± 1.5 in the 1 week post-operation period and to 0.9 ± 0.8 at 12 months after the surgery. There were no significant differences in NRS scores between the two groups before the surgery and at 1 week, 3 months, 6 months, and 12 months after the surgery ($p > 0.05$).

The functional disability of the two groups before and after the surgery was measured using the Simplified Chinese Version of the ODI, and their changes are presented as a bar chart in Fig. 3.

In group A, the good-to-excellent rate, as evaluated by the patients, was 94%. Two patients showed fair results, and one patient reported poor outcome (Fig. 4 A). In group B, the good-to-excellent rate, as evaluated by the patients, was 92.6%. Four patients showed fair results, and no patients reported poor outcome (Fig. 4 B)

Complications

During the surgery, one patient in group A developed neck pain; therefore, the surgery was terminated immediately and the height of normal saline used for irrigation was lowered. Thereafter, the patient's symptoms were significantly relieved, the surgery continued smoothly, and no postoperative complications occurred. The other patients did not develop any intraoperative and postoperative complications, such as infections and dural leaks. Patients in group B had a smooth operation, with no operative complications.

Discussion

At present, the most widely used approaches for endoscopic treatment of calcified lumbar disc herniation are the transforaminal approach and the translaminar approach[19]. One of the most important aspects of the operation is the establishment of the working channel, which allows the calcification to be fully exposed under the microscope. Ruetten et al. [20,21] reported the surgical method of the translaminar approach, which was generally in the prone position, and the intraoperative anatomy was similar to that of traditional open surgery, which was in line with the operating habits of most operators and had a better effect on axillary and central lumbar disc herniation. However, patients with calcified lumbar intervertebral disc herniation often have a longer course of disease, severe vertebral degeneration, and narrow lamina space. To successfully place the pipeline, part of the upper and lower lamina, part of the medial part of the superior articular process and even the medial part of the pedicle should be removed [22]. This degree of osteotomy may cause injury not only to the exit root but also to the walking root. The medial superior articular process and medial pedicle crypt are thick and hard, and it is difficult to establish the channel through osteotomy. In addition, pulling on the nerve root to expose calcification on the ventral side of the nerve root can easily cause nerve injury. Therefore, we performed a transforaminal approach to remove the bone at the ventral base of the superior articular process with a canard-bill cannula and a microscopic osteotomy with continuous visibility. This approach mainly has the following advantages: 1. Facet joints were not damaged during the process, and the postoperative effect on vertebral stability was small. The approach from the physiological and anatomical space does not affect the structure behind the spine, does not damage the ligamentum flavum, and reduces postoperative scar adhesion in the spinal canal [23]. Even if the operation fails, it is relatively easy to turn to open surgery. The base of the superior articular process is far from the exit nerve root, so the probability of nerve injury by osteotomy here is relatively low, and the operation time is shortened [24]. The duck-bill cannula approximately envelops the superior articular process and acts as a barrier between the superior articular process and the nerve root during osteotomy to reduce nerve disturbance. The use of the microscopic power system and the side laser system may lead to transient deterioration of neurological function, and the cost is high [7,25]. However, under the microscope, osteotomy saves time and causes less disturbance to nerve roots. Visualize the whole operation to improve the safety factor of the operation. In the process of treatment, we also encountered some problems. As the intervertebral foramina of the lower lumbar spine were gradually reduced, the blocking effect of the superior articular process became increasingly serious.

Especially in the L5-S1 segment, due to the obstruction of the iliac ridge and the large transverse process of L5, it becomes more difficult to establish the channel [26]. Most physicians used the interlaminar approach to solve this problem [27,28]. We adopted a lateral decubitus position and raised the patient's lumbar pad so that the intervertebral space could be fully opened to minimize the impact of the position on the operation. The lateral opening was reduced to avoid obstruction of the iliac ridge to the cannula as much as possible, but it was still difficult to address the relatively extensive calcification. Therefore, on the basis of not destroying the articular surface as much as possible, we moderately expanded the resection range of the ventral articular process on the upper S1. Studies have shown that resection of the anteromedial 1/3 of the superior articular process, the anterior part of the lower facet joint, and the part between them can increase the foraminal area by 45% without affecting the stability of the spine [23,29]. We controlled the range of facet excision within 1/3 in most patients, and during the postoperative follow-up, there was no obvious vertebral instability in the patients. However, it is interesting that we excised more than 1/3 of the upper articular process of S1 for some patients and excised part of the joint capsule, but no obvious vertebral instability occurred in the process of postoperative follow-up, which we believe may be due to the low activity of the L5-S1 segment, as well as the postoperative rehabilitation exercise guidance for each patient.

According to reports by Dabo et al., when central or paracentral calcified lumbar disc herniation is treated with an interlaminar approach, early postoperative paraesthesia is more likely to occur than conventional soft lumbar disc herniation, and the postoperative drug utilization rate is higher [8]. Chen et al. [30] found in their study that postoperative lower limb sensory dysfunction mainly occurred in the translaminar approach. When the nerve root is pulled across the midline, the risk of nerve root injury is greatly increased [31,32]. We think this may be related to calcification type lumbar disc, oppression dural sac, highlight the material hard and dural sac to produce a kind of "half package", when revealed calcification for larger degree of nerve root and dural sac pull, when calcifications is located in the central, in order to expose calcifications, will increase the degree of the pull. Therefore, it is very important to obtain the right angle and sufficient operating space before removing calcifications. Chen et al. [30] reported that the peak method can reduce the traction of nerve roots and reduce postoperative neurological deterioration and other complications in calcification removal. However, intraoperatively, we found that the base of calcification was generally located at the posterior edge of the vertebral body, and some calcifications could even span the entire vertebral space. To expose the peak of calcification at this time, not only is the amount of osteotomy required during foraminal secondary forming increased, but the pulling of nerve roots is also inevitable. Therefore, after the formation of the secondary intervertebral foramen, the base of the calcified foci was exposed, and the calcified foci were excised by means of cannula rotation combined with a microscopic bone knife. The part of the base of the calcified foci that was connected with the vertebral body was excised to make the calcified foci free, and the calcified foci were removed by partitioning under the microscope(fig.5 and fig.6). For large calcification foci that are difficult to segment, the cannula can be removed with nucleus pulposus forceps, and the channel can be placed again after removal. This approach reduces the risk of more osteotomies affecting the stability of the vertebral body and has relatively little impact on nerve roots. Fibroannular damage may be associated with an increased

risk of reherniation and may accelerate disc degeneration [33]. Removal of the area where the calcified focus connects to the posterior edge of the vertebral body may damage the normal annulus, so careful annulus plasty is required to avoid postoperative re-protrusion due to annulus damage.

In our study, both group A (calcified) and group B's (noncalcified) patients achieved good outcomes, but the operation time of group A was longer than that of group B, which may be due to the need for careful nerve separation in the treatment of calcified foci and the more complex process of foraminal secondary molding compared with group B. During at least one year of follow-up, NRS and ODI scores in both groups were significantly improved after surgery compared with those before surgery. Percutaneous foraminal reconstruction for calcified lumbar disc herniation can achieve good results in the short term with fewer complications.

However, our study also had some limitations. First, the sample size was small, and the relationship between the size, location and the shape of the calcification foci and prognosis was not further discussed. Second, the short follow-up time made it impossible to further analyze the long-term efficacy of the technique. In future studies, we will increase the sample size and extend the follow-up time to classify calcified lumbar disc herniation according to the characteristics of calcified foci and explore the relationship between different types and prognosis.

Declarations

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Availability of data and materials

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

Authors' contributions

Author AL Y, B C designed the study. Author AL Y and X S

collected the clinical data and conducted the statistical analysis. Author AL Y wrote the manuscript. Author AL Y, B C revised the manuscript; All authors critically read the manuscript to improve intellectual

content. All authors read and approved the final manuscript.

Ethics approval and consent to participate

This research was approved by the ethics committee of Chengde Medical University Affiliated Hospital. All participants agreed with the data and publication of the manuscript. All methods were performed in accordance. All methods were performed in accordance with the relevant guidelines and regulations. Informed consent was obtained from all subjects and/or their legal guardian(s).

Patient consent for publication

Written informed consent was obtained from all participants. Informed consent was obtained from all subjects and/or their legal guardian(s).

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1

Preoperative demographic characteristics

		A (calcified) n=50	B (non- calcified) n=54	p-value
Age ^a (years)		49.9±14.5	53.2±15.3	0.202
Sex ^b n	Male	20	22	0.939
	Female	30	32	
Segments ^b (n)	L1-L2	4	2	0.717
	L2-L3	1	1	
	L3-L4	4	5	
	L4-L5	14	21	
	L5-S1	27	25	
BMI ^a (kg/m ²)		25.8±3.1	26.2±3.7	0.133
^a Exhibited in the format of “Mean ± standard deviation” and tested by Student’s t test ^b Chi-squared test Data are presented as number of patients; BMI body-mass index.				

Table 2

Perioperative outcomes

	A[calcified]	B(non- calcified]	p-value
Blood loss (ml) ^b	20[2-50]	20[5-50]	0.714
Hospital stay (days) ^b	6[3-9]	5.5[3-12]	0.389
Drainage (ml) ^b	12.5[2-60]	15[5-60]	0.989
Duration of operation (min) ^a	64.9±17.2	57.2±15.8	0.021
^a Exhibited in the format of “Mean ± standard deviation” and tested by Student’s t test ^b Exhibited in the format of “Median (Min-Max)” and tested by Mann-Whitney U test			

Table 3

The preoperative and postoperative NRS data

Group	Before treatment	Post Operation			
		1week	3month	6month	12month
A	7.3±1.3	2.3±0.8	2.1±0.8	1.2±0.8	1.0±0.6
B	7.2±0.9	2.1±1.5	1.9±0.9	1.0±0.9	0.9±0.8
P-value ^a	0.651	0.475	0.159	0.253	0.533
Exhibited in the format of “Mean ± standard deviation” and tested by Student’s t test					

Figures

Figure 1

Flow chart of the study

Figure 2

Intraoperative views.

A: The intervertebral foramen was remolded with a microscopic bone knife. B: After secondary molding, the calcified disc pressing on the nerve root was exposed. C: Calcified discs were removed in fragments. D: After decompression, the nerve roots showed good pulsation.

Figure 3

ODI scores in groups A and B

Blue is group A, red is group B. The ODI score of group A was expressed as mean $\pm$ standard deviation. In the preoperative and postoperative 1 week, after 3 months, 6 months after operation, and postoperative 12 months were 67.4% $\pm$ 13.3%, 32.0% $\pm$ 9.0%, and 20.4% $\pm$ 8.8%, 11.0% $\pm$ 6.3%, and 6.8% $\pm$ 5.2%. The ODI score of group B was expressed as mean $\pm$ standard deviation. In the preoperative and postoperative 1 week, after 3 months, 6 months after operation, and postoperative 12 months were 67.7% $\pm$ 14.4%, 31.1% $\pm$ 10.8%, 19.6% $\pm$ 7.8%, 10.7% $\pm$ 5.8%, 5.9% $\pm$ 5.4%.

Figure 4

Modified Macnab criteria

A:Modified Macnab criteria of group A. B:Modified Macnab criteria of group B

Figure 5

Preoperative CT and MRI images

Preoperative sagittal (A) and axial (B) views by computed tomography. Preoperative sagittal (C) and axial (D) views by magnetic resonance imaging. The calcified lumbar disc compression nerve is indicated by the white arrow and white circle. The patient was a 70-year-old woman with preoperative CT and MRI showing a calcified lumbar disc herniation with nerve compression.

Figure 6

Postoperative CT and MRI images

Postoperative sagittal (A) and axial (B) views by computed tomography. Postoperative sagittal (C) and axial (D) views by magnetic resonance imaging. The vertebral margin to which the calcified lesion was attached was removed by casing rotation. The patient's pain was improved after surgery compared with that before surgery, and the compression site obtained sufficient decompression.