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Early use of endoscopic unilateral laminectomy combined with bilateral decompressionin patients with adjacent segment disease after lumbar fusion

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Abstract:	Objectives The purpose of this study was to investigate the safety and clinical effectiveness of endoscopic unilateral laminectomy with bilateral decompression (END-ULBD) in patients with adjacent segment disease (ASD) after lumbar fusion. Methods: We conducted a retrospective study and collected data on 9 patients with adjacent segment disease (ASD) after lumbar fusion who were hospitalized in our hospital from January 2021 to January 2022. All 9 patients, aged 54 to 77 years, received Endo-ULBD treatment, with an average age of 59.2±3.6 years. The ASD segments are L2/3 segment 1, L3/4 segment 5, and L5/S1 segment 3. The operation time and blood loss were recorded intraoperatively. For analysis, the visual analog scale (VAS), Oswestry Disability Index (ODI), and modified MacNab Lower Extremity Pain Criteria score were recorded at the last follow-up visit.Results: The surgery was successful in 9 patients. There was no neurological injury or dural rupture resulting in cerebrospinal fluid leakage. The average operation time was (90.25±118.0) minutes, the average blood loss was (35.3±5.3) ml, and the average hospitalization time was (14.4±2.1) days. The results also showed that ODI and VAS scores decreased significantly 1 week after surgery. All indicators were statistically improved 1 month after surgery ($p<0.05$).

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There was no statistically significant difference in ODI and VAS scores 1 month and 3 months after surgery. At the final follow-up, according to the modified MacNab criteria, 7 cases had excellent curative effect and 2 cases had good curative effect.Conclusions: In clinical practice, we found that Endod-Ulbd can be combined with a single portal vein

endoscopy for ASD patients with bilateral lower limb symptoms after lumbar fusion, providing a new option for patients.

Keywords: lumbar fusion surgery, adjacent segment disease, spinal endoscopy, unilateral laminotomy and bilateral decompression, lumbar spinal stenosis

Introduction:

As China gradually enters an aging society, degenerative lumbar diseases show an increasing trend. Posterior lumbar interbody fusion surgery (PLIF) and transforaminal lumbar interbody fusion surgery (TLIF) were regular methods for the treatment of degenerative diseases like lumbar canal stenosis, lumbar instability, in past decades. In these surgeries, the mobility of surgical segments of the spine are constrained by the rigid fixation of the pedicle screw. Therefore, the stress of adjacent segments become more concentrated inevitably, accelerating their degeneration. In terms of radiology, these degenerative diseases show as manifests as disc herniation, spinal stenosis, spondylolisthesis, instability, scoliosis, and vertebral compressive fractures(1, 2), and has an incidence rate of 5.9% per year. The Adjacent Segment Disease (ASD) refers to the degeneration of the imaging findings at the proximal and/or distal ends of the fused segments and their corresponding clinical syndromes. The most common form of ASD is lumbar disc herniation combined with spinal stenosis. The operating rate is 1.8% per year. The course of the disease is protracted and the effect of conservative treatment is uncertain. Traditional surgeries in these patients, such as open fusion and lumbar fusion, can result in irreversible soft tissue damage around the spine, avulsion, and postoperative scarring. In addition, older patients often refuse further major surgery due to the risk of wound infection, bleeding, cerebrospinal fluid leakage, and nerve damage. Therefore, how to solve the symptoms of ASD after posterior lumbar fusion with less trauma and improve the quality of life of patients is the focus of this study. In this study,

we report satisfactory clinical outcomes in 9 cases of post-lumbar fusion ASD surgery using single-channel endoscopic spine surgery. In clinical practice, we found that Endod-Ulbd can be combined with a single portal vein endoscopy for ASD patients with bilateral lower limb symptoms after lumbar fusion, providing a new option for patients.

1 Clinical data

1.1 Patient sifting

Patient inclusion criteria: 1) lumbar segmental fusion and fixation surgery; 2) accompanied by neurological symptoms and intermittent claudication in the limbs; 3) imaging confirmed spinal stenosis in the adjacent segment of the fusion segment, but no symptom recurrence at the surgical segment; 4) Conservative Symptoms remain unchanged or worsen after treatment.

Patient exclusion criteria: 1) Dynamic films showing signs of lumbar instability; 2) Symptoms of cauda equina injury; 3) Symptoms and signs inconsistent with imaging records; 4) Abnormal cardiopulmonary function, coagulation disorder, or other diseases not suitable for surgery.

1.2 Data of patients

A summary of patient data is shown in Table 1 . Among them, 3 were male and 6 were female, aged 54 to 77 years old, with an average age of 62.1±1.2 years. The ASD segment location was L2/3 in 1 case, L3/4 in 5 cases, and L5/S1 in 3 cases. The average disease duration was 9.7 ± 0.5 years. After preoperative preparation, surgery was performed on patients whose symptoms were consistent with the imaging data. Otherwise, 2 mL of lidocaine must be injected into the target intervertebral space.

Table.1 Baseline data of patients included in the study.

	Case1	Case2	Case3	Case4	Case5	Case6	Case7	Case8	Case9

Gender	Female	Female	Male	Female	Female	Male	Male	Female	Female
Age（years）	61	54	55	77	71	59	71	62	58
Surgical segments	L5/S1	L2/3	L3/4	L3/4	L3/4	L3/4	L5/S1	L5/S1	L3/4
ASD courses（Months）	2.5	6	3	12	16	6	24	12	6
Responsibility gap localization test	No	Yes	Yes	No	No	Yes	Yes	No	Yes

2 Methodology

2.1 Surgical method

The patient received local and intravenous anesthesia in the prone position, and the surgical site was confirmed by fluoroscopy. Because the patient had bilateral symptoms, surgery was performed on the side with the most severe symptoms. The puncture was 2 cm from the AP projection of the joint target space surface. The target point for puncture is the inner edge of the upper and lower facet joints. Insert the guidewire along the puncture needle. Insert the cannula into the 1.5 cm long groove created by the incision.

First, the operator’s side is decompressed, and after identifying the ligamentum flavum, a circular saw is used to remove part of the lamina on both sides of the ligamentum flavum. At the same time, part of the facet joint was removed. Ideally, the surgeon’s decompression should sever the ligamentum flavum from cranial to caudal. Local resection medial to the facet joint facilitates decompression of the lateral recess. After confirming that the lateral recess and root are completely decompressed, adjust the microscope and polish the junction of the lamina and spinous process, the base of the spinous process, and the ventral side of the contralateral lamina in sequence.

The working channel is then placed over the dura mater and the opposite side is decompressed using the “over-the-top” concept. The deep ligamentum flavum should be preserved and the dura mater and underlying nerves protected. To expose the nerve root, use basket forceps and nucleus pulposus forceps to move the ligamentum flavum lateral to the lateral recess.We use a high-speed drill and a rongeur to polish the medial surface of the facet joint and the osteophytes at the facet joint. Then use nucleus pulposus forceps to bite off the

ligamentum flavum of the lateral recess to fully decompress the root and expand the lateral recess. Finally, the ligamentum flavum is completely removed.

Complete relief of epidural edge compression and nerve root penetration marks successful operator-side decompression. Another criterion is possible contralateral decompression, specifically of the contralateral superior facet, ventral, and spinal base.

On the other hand, successful decompression of the contralateral foraminal was demonstrated when the contralateral stem was palpable and the nerve roots passing through it were mobilized. The dural sac was observed to bulge after surgery, which did not affect the craniocaudal spinal canal, and both nerve roots were freed. At the end of the procedure, the endoscope is removed and the drainage tube is left in the incision and closed with sterile sutures.

2.2 Postoperative treatment

During the surgery, the patient received a single dose of antibiotics and strict bed rest was recommended postoperatively. Dehydration, anti-swelling, and neurotrophic medications should be provided. If there is no cerebrospinal fluid leakage, the drainage tube can be removed 24-48 hours after surgery. Encourage the patient to get out of bed and move around as soon as possible. The next day, patients should begin exercises to strengthen the psoas muscles. Patients should avoid bending and lifting during the first month after surgery. The spinal canal needs to be decompressed during subsequent three-dimensional CT examinations of the lumbar spine.

2.3 Assessment of treatment and Statistics analysis

The operation time and intraoperative blood loss were recorded during the operation. The visual analog scale (VAS), Oswestry Disability Index (ODI), and modified MacNab standard score were evaluated three times at 1 week, 1 month, and 3 months after surgery. These three

parameters were used as indicators for treatment evaluation in the form of mean ± standard deviation. Use the Kolmogorov-Smirnov test to examine the data and remove points that do not follow a normal distribution. Then, ODI and VAS were compared by repeated measures analysis of variance (ANOVA). The significance level (α) was set to 0.05.

3 Results

All 9 ASD patients successfully underwent endoscopic ULBD surgery on a single portal vein. No nerve damage, dural tear, cerebrospinal fluid leakage, etc. occurred during the operation. Only one patient developed severe pain in both lower limbs and swelling around the surgical site due to local hematoma compression after surgery. However, these symptoms gradually subsided after the sutures were removed and a drain placed about two hours later. The patient's operation time was 75 to 135 minutes, the intraoperative blood loss was 20 to 50ml, and the hospitalization time was 12 to 21 days, with an average of (90.25±118.0) minutes, (35.3±5.3) ml, and (14.4±2.1) days.

Follow-up was successful in all 9 patients. The ODI and VAS evaluation results are shown in Table 2. One week after surgery, ODI and VAS scores decreased significantly. In addition, all indicators were statistically improved 1 month after surgery, with p value < 0.05. All 9 patients were followed up successfully. The ODI and VAS evaluation results are shown in Table 2. One week after surgery, both ODI and VAS scores decreased significantly. In addition, all indicators were statistically improved 1 month after surgery, with p values <0.05. There was no significant difference in ODI and VAS scores between 1 month and 3 months after surgery. At the final follow-up, according to the modified MacNab criteria, 7 cases had excellent results and 2 cases had good results.

Table.2 Scores of ODI and VAS in follow-up assessment

Indicator	Preoperative	1-week post-op	1-month post-op	3-month post-op	F-value	p-value
Lumbar/Leg VAS	6.9±1.2	1.1±0.9	1.7±0.3	1.5±0.5	523.112	<0.001

ODI Index	51.22±5.46	9.27±1.76	9.16±2.02	8.28±1.97	1771.192	<0.001

4 Discussion

Posterior lumbar interbody fusion (PLIF) is a common treatment for degenerative lumbar disease and can provide long-term relief and stabilization of affected areas of the spine. However, postoperative recurrence and autism present a challenge for spine surgeons. A previous study(3) reported that the incidence of recurrent radicular pain after lumbar fusion surgery was 5-18%, of which the incidence of symptomatic ASD was 30%. Wang et al.(4)pointed out that ASD increased significantly after PLIF, and its incidence plays an important role in the performance of PLIF(5). For symptomatic autism spectrum disorder (ASD), traditional treatment approaches are very similar to “repair”surgery, including extension of decompression to the diseased segment and additional fusion and internal fixation. However, this approach is difficult to accept for patients who have already undergone surgery. In 1981, Crocker proposed the concept of precise neuraxial decompression. Based on this concept, effective decompression of the nerve root can be achieved by simple resection of the ventral part of the superior facet process. Therefore, the use of minimally invasive surgical techniques such as transforaminal endoscopy to address this problem has shown clinical effectiveness.

In our case, the patient had bilateral lower extremity symptoms before surgery. In addition, imaging examinations showed simultaneous hypertrophy of the ligamentum flavum, bilateral intervertebral foramina stenosis, and reduction in spinal canal volume. Therefore, complete decompression is difficult to achieve with foraminal endoscopy alone, let alone open surgery. The author believes that fusion surgery is not necessary for patients with only lower extremity symptoms without spinal instability or deformity. In addition, deeper resection can exacerbate spinal instability, and fusion surgery alone cannot prevent the occurrence of ASD.

Therefore, Endo-ULBD combined with single-door spinal endoscopy as a minimally invasive method should be the best choice for patients because it can decompress the bilateral spinal canal. The results of this study confirm the effectiveness of this method in ASD cases with bilateral lower limb symptoms after lumbar fusion.

Endoscopic unilateral laminectomy combined with bilateral decompression is based on the concept of minimally invasive spinal decompression. This can be achieved through various procedures using microscopes or endoscopic instruments such as spinal endoscopy or percutaneous spinal endoscopy. Martin(6)performed ULBD surgery under full endoscopic surgery for the first time and explained its feasibility. In this study, improvements in intraoperative visibility and light sources significantly increased the capabilities and efficiency of endoscopic surgery. This surgical approach has two advantages. One is that by using a single-channel approach, damage to posterior spinal structures during bilateral decompression can be minimized. Symptoms such as iatrogenic spinal instability and epidural scarring can be significantly reduced. On the other hand, this approach allows direct decompression of the dorsal and ventral structures of the thecal sac and is suitable for hypertrophy of the ligamentum flavum and facet joints. The posterior structures of the spine, such as the spinous processes, are preserved, and the central spinal canal and bilateral intervertebral foramina are effectively expanded to achieve bilateral decompression.

Recommendations for surgical treatment of similar cases are as follows:

1) If atypical symptoms occur, it is recommended to conduct a target gap positioning test. In this experiment, a 12 mL puncture needle was used to inject approximately 2 mL of lidocaine into the intended surgical target site. When symptoms subside, the problem disc can be identified. 2) For endoscopic surgeries involving large channels, routine drainage for 24-48

hours is recommended. This is because partial bone resection inevitably results in local bleeding. In our case, this approach helped to compress the deep hematoma.

3) It is recommended to remove the ligamentum flavum behind the bilateral bony structures to shorten the exposure time of the spinal canal. This can shorten the duration of visual impairment caused by hemorrhage. On the other hand, the ligamentum flavum also protects neuronal structures.

4) The surgeon recommends resection of bony structures on one side, including partial removal of the upper and lower facet joints. Using laminar rongeurs, remove bony structures from the skull and coccyx to the ligamentum flavum. Next, the contralateral inferior articular process is partially resected. After resection of the ligamentum flavum, the medial edge of the superior articular process on the contralateral side was exposed. Under a microscope, use a depth-limiting osteotome to remove the medial edge of the upper facet joint process on the opposite side to expose the nerve root passing through, and decompress and expand the contralateral intervertebral foramen.

Treatment of the disc is only recommended by removal of herniated or free fragments of the nucleus pulposus. Spinal nerves are usually not compressed after decompression of posterior structures. Taking too many steps while treating the spinal discs can lead to spinal instability. Minimally invasive treatments are the future of spine surgery and are becoming increasingly popular with patients. We have found in clinical practice that Endod-Ulbd combined with single portal vein endoscopy can be used for ASD patients with bilateral lower limb symptoms after lumbar fusion, providing them with a new option.

However, our study has some limitations. First, this study examined a limited number of cases. In the future, with more case studies and more evidence from other research institutions, our conclusions will be more convincing. In addition, there is no comparison

with traditional open decompression surgery.As the study progresses, the follow-up period will be extended to 1 to 2 years. This will help evaluate the long-term performance of the proposed surgical approach and its long-term impact on spinal stability.

Availability of Data and Materials

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

Ethics Approval and Consent to Participate

Not applicable to the study.

Funding

Not applicable to the study.

Conflict of interest

The authors declare no conflicts of interest statement.

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Figures legends

Figure 1: Postoperative secondary disc protrusion and spinal canal stenosis at L3/4 following L2/3 decompression and fusion surgery.

Figure 2: CT scan after L3/4 single-channel spinal endoscopic decompression

Figure 3: Removed osseous tissue

Figure 4: Incision site on the body surface

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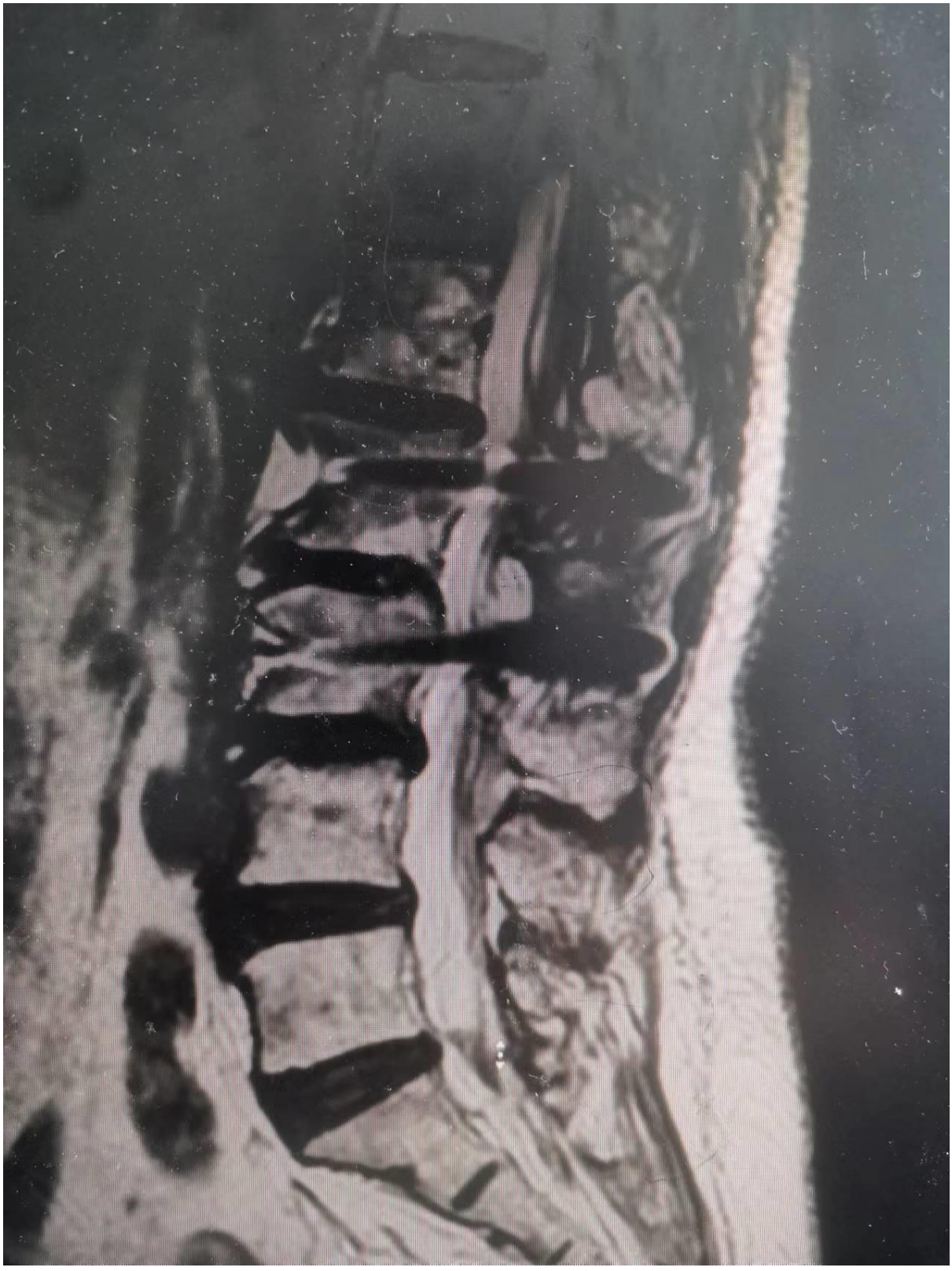

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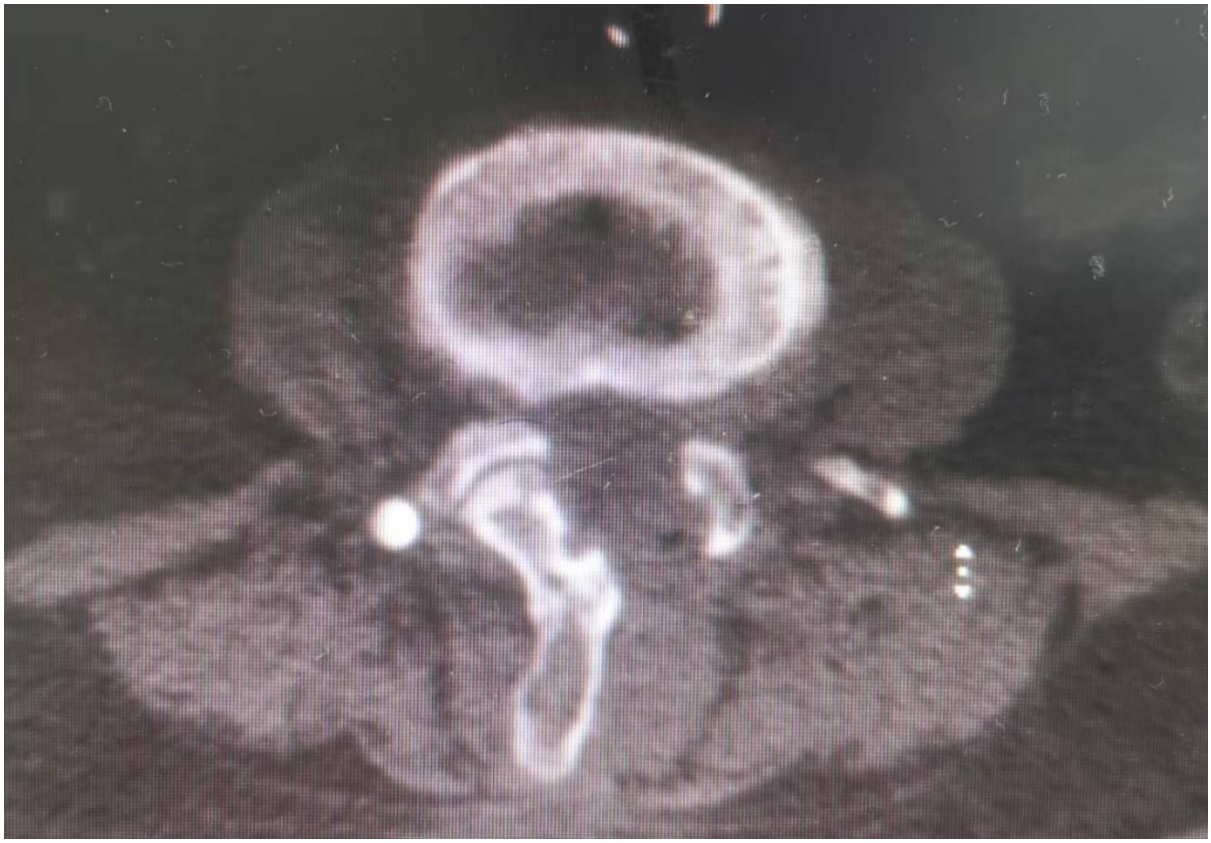

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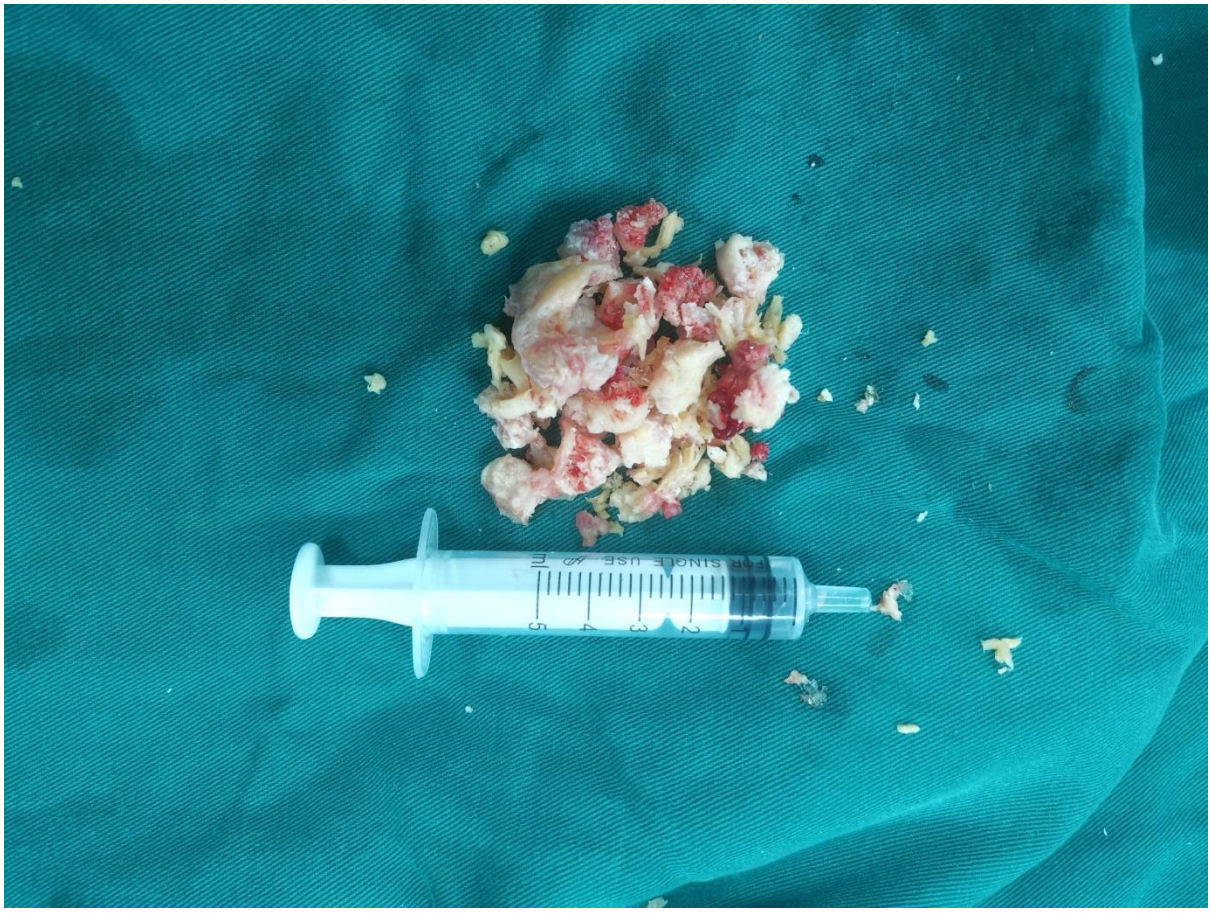

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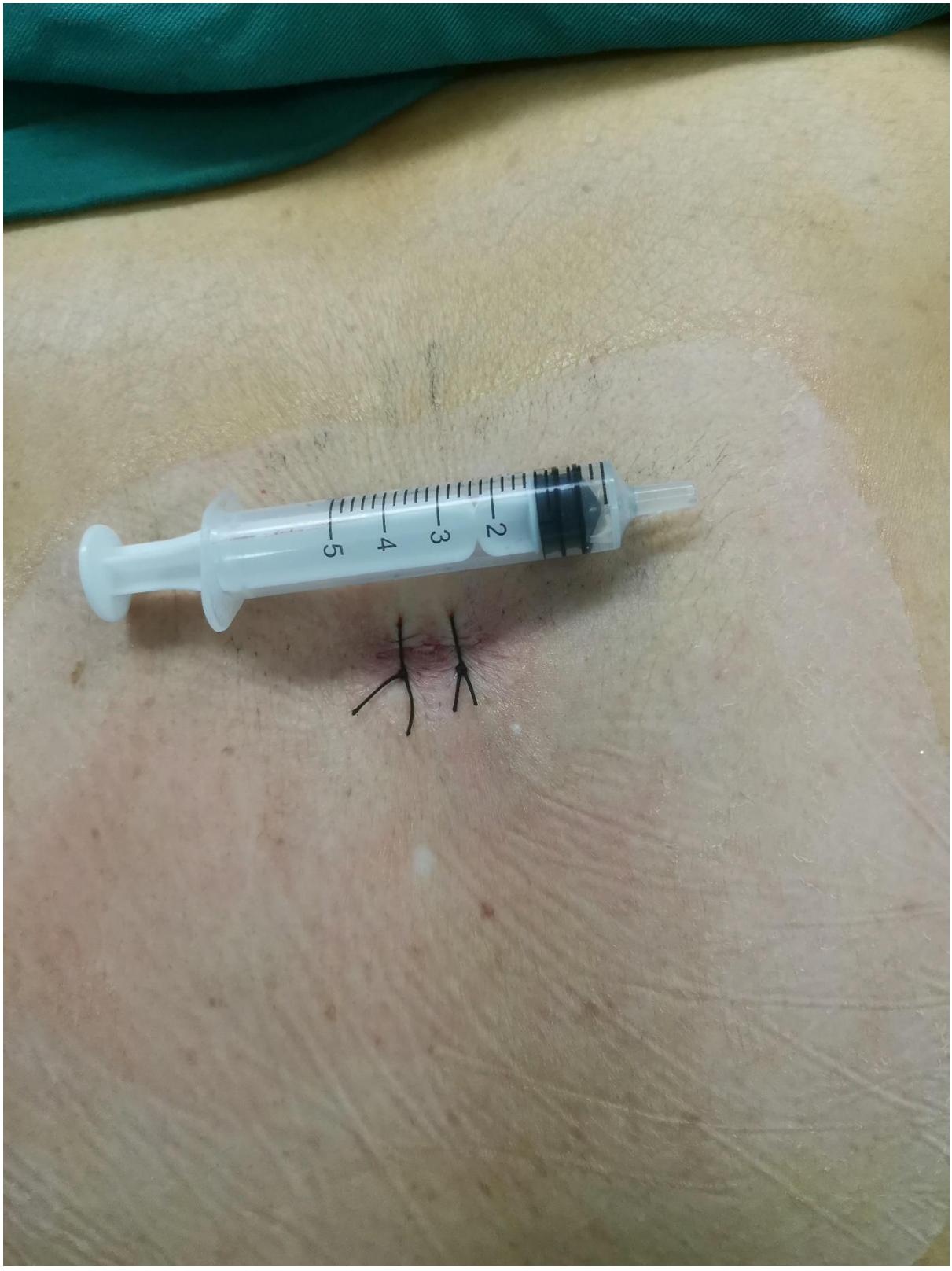

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Comparison	Lumbar/Leg VAS (q-value, p-value)	ODI Index (q-value, p-value)

1 week post-op vs. Pre-op	0.815, <0.05	0.623, <0.05	1 week post-op vs. Pre-op	0.815, <0.05
3 months post-op vs. Pre-op	0.911, <0.05	0.532, <0.05	3 months post-op vs. Pre-op	0.911, <0.05
1 month post-op vs. 1 week post-op	4.175, 0.802	6.406, 0.716	1 month post-op vs. 1 week post-op	4.175, 0.802
3 months post-op vs. 1 month post-op	3.971, 0.321	5.196, 0.132	3 months post-op vs. 1 month post-op	3.971, 0.321