CLINICAL ARTICLE

Revision Surgery after Percutaneous Endoscopic Transforaminal Discectomy Compared with Primary Open Surgery for Symptomatic Lumbar Degenerative Disease

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Objective: To evaluate the clinical outcome of reoperation after percutaneous endoscopic lumbar discectomy (PELD) as compared with primary spinal decompression and fusion.

Methods: A retrospective study from December 2014 to December 2017 was conducted at Peking Union Medical College Hospital and comprised 39 patients with symptomatic lumbar degenerative disease (LDD): 13 post-PELD who underwent reoperation (revision surgery group) and 26 who received primary spinal decompression and fusion (primary open surgery group). The two groups were compared regarding: operative time, blood loss, transfusion, hospitalization, postoperative visual analog scale (VAS) scores, Oswestry Disability Index (ODI) scores, Japanese Orthopedic Association (JOA) improvement rate, and postoperative complications. The Mann–Whitney *U*-test was applied to analyze continuous parameters, and the χ^2-test for categorical parameters. Fisher's exact test was used for small data subsets.

Results: There was no statistically significant difference between the two groups in mean age (52.7 years *vs* 52.9 years), gender ratio (6 men-to-7 women *vs* 12 men-to-14 women), body mass index, medical history, preoperative diagnosis, or surgical spine level ($P > 0.05$). The mean operative time of the revision surgery group was significantly longer than that of the primary open surgery group (160.0 min *vs* 130.2 min, $P < 0.05$). The revision surgery group also had a significantly higher mean estimated blood loss, postoperative drainage, and length of hospital stay ($P < 0.05$). However, no significant differences were found between the two groups in terms of hemoglobin and hematocrit values, preoperatively and postoperatively. The rate of transitional neurological irritation was higher in the revision surgery group (61.5% *vs* 3.8%; $P < 0.05$), as was intraoperative durotomy and cerebrospinal fluid leakage (30.8% *vs* 3.8%, $P < 0.05$). At 1 month, the VAS and ODI scores of the primary open surgery group were significantly better than those of the revision surgery group, while the improvement in JOA scores was similar. After 6 and 12 months' follow-up, the VAS and ODI scores and the rates of JOA improvement were comparable.

Conclusion: Patients with LDD who received primary spinal decompression and fusion experienced lower rates of perioperative complications and shorter hospitalization compared with patients who underwent revision surgery after PELD, but the clinical outcomes at the last follow-up of both groups were satisfactory.

Key words: Lumbar degenerative disease; Lumbar surgery; Percutaneous endoscopic lumbar discectomy; Reoperation

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Introduction

Symptomatic lumbar degenerative disease (LDD) presents as low back pain and limited physical activity that is due to abnormal motion or compression of neurovascular structures[1]. LDD may be further characterized by stenosis of the spinal canal, herniated discs, and degenerative changes in the posterior arch[1]. In the United States, surgical treatment for LDD has increased more than twofold in recent years (2000–2009), and a variety of innovative surgical techniques have been introduced[2]. Worldwide, 266 million patients are diagnosed with LDD and low back pain per year, and low-income and middle-income countries have three times the incidence rate compared to high-income countries[3]. Thus, how to best address lumbar degenerative disease and finding appropriate methods for treatment remain global issues.

Percutaneous endoscopic lumbar discectomy (PELD) is a promising minimally invasive alternative to primary open surgery[4]. Results of PELD have been encouraging for treatment of lumbar disc herniation using an endoscopic posterolateral transforaminal approach, which can decrease the risk of repeated damage to the posterior and paraspinal structures, making it less traumatic than traditional open surgery, with less bleeding and faster postoperative recovery[5–8]. Meanwhile, PELD combined with 3-D traction after surgery could provide more satisfied decompression and reduce hospital stay[9].

However, the recurrence of herniation after PELD has been the cause of great concern for many clinicians. A nationwide sample cohort study in South Korea analyzed the long-term reoperation rates for lumbar herniated intervertebral disc disease. The cumulative incidence of reoperation for PELD was 16% at 10-year follow-up, which was not very different to that for other surgical techniques like open discectomy, laminectomy or fusion. However, open surgery was the most commonly used technique for reoperation[10].

The epidemiological prevalence and related risk factors of recurrent herniation after PELD are unclear. Cheng *et al.*[11] reported that after PELD percutaneous endoscopic discectomy (PELD group), 68 patients had homolateral real recurrent herniation (homolateral herniations at the same level), and recurrence was significantly more common than for other reoperative surgical techniques (70.6% in PELD group, 47.1% in microendoscopic discectomy [MED] group, and 37.8% in open group). A retrospective review performed on patients who had undergone PELD, including 10 228 patients with 1 year of follow-up, indicated that approximately 4.3% of cases were unsuccessful. The main reasons were incomplete removal of herniated discs and recurrence[12]. Kim *et al.* (2007)[13] point out that elderly patients, larger body mass index (BMI), and the presence of Modic change were more frequent in the recurrent group. Yao *et al.* (2017)[14] reach a similar conclusion and state that obesity with BMI ≥25 kg/m^2 is the most significant risk factor for recurrence after PELD. Older age (≥50 years old), limited experience of the surgeon (<200 cases), treatment period, and central location of herniation were also closely associated with recurrent herniation after successful PELD[14]. The overall mean interval until revision was 18.9 months (8.1 months in the PELD group *vs* 19.7 months in the MED group *vs* 33.1 months in the open group, $P < 0.01$).

Revision surgery is needed for most patients who suffer from recurrent low back pain or lower limb symptoms after PELD, if conservative treatment fails to relieve the patient's symptoms. However, few studies have evaluated the clinical outcomes of reoperation surgery after PELD, relative to primary open surgery, for treating symptomatic LDD. Outcomes of revision lumber open surgery tend to be worse than the initial procedure when there is a dural tear, nerve root injury, and other complications, which may be due to epidural or nerve root scarring from the first surgery[15,16].

Therefore, this retrospective study evaluated the clinical outcome of reoperation after PELD as compared with primary spinal decompression and fusion. The aim of the present study was to provide surgeons with: (i) insight for treating recurrent low back pain or lower limb symptoms for patients with LDD after PELD; (ii) useful and practical guidance regarding the perioperative clinical strategy for revision surgery after PELD; (iii) a summary of perioperative complications and discussion of how to avoid them.

Patients who had PELD and underwent reoperation were defined as the revision surgery group and those who received primary spinal decompression and fusion were defined as the primary open surgery group. We compare two groups with regard to operative time, blood loss, transfusion, hospitalization, postoperative visual analog scale (VAS) scores for low-back and leg pain, Oswestry Disability Index (ODI) scores, Japanese Orthopedic Association (JOA) improvement rate, and postoperative complications.

Patients and Methods

Patient Demographics

Each patient provided informed consent for participation in the study. This retrospective study was conducted in accordance with the Declaration of Helsinki (Ethical Principles for Medical Research Involving Human Subjects) and was approved by the Ethics Committee of the Peking Union Medical College Hospital.

From December 2014 to December 2017, the inclusion criteria for the reoperation surgery group were as follows: (i) patients previously with symptomatic LDD who underwent PELD; (ii) patients who presented with recurrent low back pain or lower limb symptoms due to lumbar disc herniation, lumbar spinal stenosis, or both lumbar disc herniation and spinal stenosis; (iii) MRI findings of re-herniation at the site of the previous PELD surgery; (iv) conservative treatment failed to relieve the recurrent pain; and (v) received open revision surgery. Exclusion criteria: (i) congenital lumbar scoliosis, spinal stenosis, or other deformities; (ii) lumber infection or tumor; (iii) serious osteoporosis; and (iv) lumbar spondylolisthesis. Finally, 13 patients were included.

The control group (primary open surgery group) comprised 26 patients from our database who had received primary open surgical treatment for spinal decompression and fusion during the same period and had the same surgeons for the treatment of LDD. The patients in the primary open surgery group were just matched with the revision surgery group for gender ratio, age, and surgical spine levels. The demographic and clinical data for both groups included BMI, histories of cardiovascular disease, smoking, and hypertension, spine surgery level, and diagnosis.

Surgical Procedures

The surgeries were performed under general anesthesia; the patients were placed prone on a radiolucent operating table; a midline skin incision was made; the paravertebral muscles were divided and the surgeon was cautious not to tear the dura mater; laminotomy or laminectomy was performed, and then discectomy with or without fusion; the incision was closed in layers after adequate nerve root decompression.

Clinical Assessment

Each participant was asked to complete three quality-of-life questionnaires before surgery and at each follow-up.

Oswestry Disability Index

The ODI is one of the principal condition-specific outcome measures used in the management of spinal disorders[17]. For each section of six statements, the total score is 5 (the first statement is marked with the score "0" and the last statement is marked as "5"). If more than one box is marked in each section, the highest score is taken. If all 10 sections are completed, the score is calculated as follows: total scored/50 (total possible score) × 100%. If one section is missed (or not applicable), the score is calculated as: total scored/45 (total possible score) × 100%. Therefore, the final score may be summarized as: [total score/(5 × number of questions answered)] × 100%. Rounding the percentage to a whole number is suggested for convenience. We defined that: 0%–20% means mild; 21%–40% means moderate; 41%–60% means severe; 61%–80% means very severe; and 80%–100% means patients with very exaggerated symptoms.

Visual Analogue Scale

The VAS score system is used in the social and behavioral sciences to measure low back pain and leg pain[18]. The VAS pain scoring standard (scores from 0 to 10) was as follows: 0 means painless; 1–3 means mild pain that the patient could endure; 4–6 means the patient was in pain that could be endured and was able to sleep; and 7–10 means the patient had intense pain and was unable to tolerate the pain.

Japanese Orthopedic Association

The JOA score was used to evaluate the neurological function of patients with lumbar degeneration and treatment effectiveness[19]. The system consists of four subsections, including 14 categories with overall headings of subjective symptoms, clinical signs, restriction of activities of daily living, and bladder function. The highest possible total score from categories for a normal person is 29 points. Therefore, the treatment improvement rate = [(post-treatment score − pre-treatment score)/(29 − pre-treatment score)] × 100%; and ≥ 75% means excellent, 50%–74% means good, 25%–49% means fair, and 0%–24% means poor.

The patients were followed at 1, 6, and 12 months postoperatively. In addition, operative time, estimated blood loss, length of hospital stay, and complications were documented.

Statistical Analysis

SPSS version 20.0 (Chicago, IL, USA) was used to compare the demographic data and clinical outcomes between the groups. The Mann–Whitney *U*-test was applied to analyze continuous parameters, and the χ^2-test for categorical parameters. Fisher's exact test was used for small data subsets ($n < 5$). $P < 0.05$ was considered statistically significant.

Results

Demographic Data

The revision surgery group included 13 patients and the primary open surgery group included 26 patients (Table 1). Between the two groups there was no statistically significant differences in mean age (52.7 years *vs* 52.9 years; $P > 0.05$) or gender ratio (6 men-to-7 women *vs* 12 men-to-14 women; $P > 0.05$). There were also no significant differences in BMI scores, medical history, preoperative diagnosis, or surgical spine level ($P > 0.05$).

Clinical Outcomes

The mean operative time of the revision surgery group was significantly longer than that of the primary open surgery group in Table 2 (160.0 min *vs* 130.2 mins, $P < 0.05$). The revision surgery group also had a significantly higher mean estimated blood loss (317.69 mL *vs* 250.12 mL, $P < 0.05$), postoperative drainage (354.85 mL *vs* 232.00 mL, $P < 0.05$), and length of hospital stay (9.46 days *vs* 7.69 days, $P < 0.05$). However, no significant differences were found between the two groups in terms of hemoglobin and hematocrit values, preoperatively and postoperatively.

Visual Analogue Scale

There were no differences between the groups with regard to preoperative VAS mean scores (6.9 *vs* 6.9, $P > 0.05$). At the 1-month follow-up, the VAS scores of the primary open surgery group were significantly better than those of the revision surgery group (2.2 *vs* 3.7, $P < 0.05$). At the 6-month and 12-month follow-ups, the VAS scores of the two groups were not significantly different (2.5 *vs* 2.7 in 6-month, 1.5 *vs* 1.6 in 12-month, $P > 0.05$) (Fig. 1A).

TABLE 1 Demographic characteristics and surgery-related factors of reoperation group and primary open surgery group

Demographic		Group A	Group B	*P* value
Subjects (cases)		13	26	—
Age (years, mean ± SD)		52.69 ± 15.93	52.85 ± 14.83	0.976
Gender (cases [%])	Male	6 (46.2)	12 (46.2)	1.000
	Female	7 (53.8)	14 (53.8)	
BMI (kg/m^2, mean ± SD)		26.38 ± 3.29	24.67 ± 3.10	0.120
Coronary disease (cases [%])		1 (7.7)	1 (3.8)	0.608
Hypertension (cases [%])		6 (46.2)	6 (23.1)	0.141
Diabetes mellitus (cases [%])		2 (15.4)	3 (11.5)	0.735
Diagnosis (cases [%])	LDH	6 (46.2)	12 (46.2)	0.791
	LSS	1 (7.7)	6 (23.1)	
	LDH & LSS	6 (46.2)	8 (30.8)	
Surgical level (cases [%])	L_3–L_5	2 (15.4)	4 (15.4)	0.736
	L_4–L_5	7 (53.8)	10 (38.5)	
	L_4–S_1	2 (15.4)	4 (15.4)	
	L_5–S_1	2 (15.4)	8 (30.8)	

Group A, reoperation group; Group B, primary open surgery group. BMI, body mass index; LDH, lumbar disc herniation; LSS, lumbar spinal stenosis.

Oswestry Disability Index

There were no differences between the groups in preoperative ODI scores (60.1% *vs* 61.5%, $P > 0.05$), but at the 1-month follow-up, the ODI scores of the primary open surgery group were better than those of the revision surgery group (25.5% *vs* 36.6%, $P < 0.05$). There were no differences in the ODI scores between the groups at the 6-month and 12-month follow-ups (14.7% *vs* 16.3% in 6-month, 8.8% *vs* 9.5% in 12-month, $P > 0.05$) (Fig. 1B).

Japanese Orthopedic Association

As for JOA improvement rate, there were no differences between the two groups at the 1-month (52.0% *vs* 58.1%, $P > 0.05$), 6-month (82.6% *vs* 88.9%, $P > 0.05$), and 12-month follow-up (90.8% *vs* 94.0%, $P > 0.05$) (Fig. 1C).

Postoperative Complications

No nerve root injury or cauda equina syndrome was observed (Table 3). However, transient nerve root irritation (numbness, weakness, and pain) was found in 61.5% (8 of 13) of patients in the revision surgery group, as compared with 3.8% (1 of 26) in the primary open surgery group ($P < 0.001$, Fig. 2). These patients were treated with oral gabapentin and mecobalamin and improved within 3 months postoperatively (Fig. 3). Of the 13 patients in the revision surgery group, 4 (30.8%) were found to have a thecal sac tear with cerebrospinal fluid leakage (Fig. 4). However, only 1 patient (3.8%) was so noted in the primary open surgery group ($P < 0.05$). No significant differences were found in terms of infections, cardiac complications, or urinary retention.

TABLE 2 Operative and post-operative features of reoperation for post-PELD group and primary open surgery group

Demographic		Group A	Group B	*P* value
Subjects (cases)		13	26	—
Levels fused (*n*, mean ± SD)		1.31 ± 0.48	1.31 ± 0.47	1.000
Operative time (min, mean ± SD)		160.0 ± 26.14	130.23 ± 25.61	0.003
Operative EBL (mL, mean ± SD)		317.69 ± 56.70	250.12 ± 102.96	0.034
Transfusion (U/patient, mean ± SD)		0.31 ± 0.75	0.08 ± 0.39	0.213
Allogenic blood transfusion (cases [%])		2 (15.4)	1 (3.8)	0.202
Postoperative drainage (mL, mean ± SD)		354.85 ± 234.62	232.00 ± 124.76	0.038
Hemoglobin (g/dL, mean ± SD)	Baseline	13.46 ± 1.98	13.77 ± 1.27	0.804
	Day 1 postoperative	12.24 ± 2.04	12.11 ± 1.52	0.828
	Discharge	11.85 ± 2.31	12.30 ± 1.42	0.464
Hematocrit (%, mean ± SD)	Baseline	40.39 ± 4.64	39.93 ± 3.70	0.738
	Day 1 postoperative	36.14 ± 5.07	35.20 ± 4.08	0.536
	Discharge	35.37 ± 7.01	35.74 ± 3.76	0.829
Length of stay (days, mean ± SD)		9.46 ± 3.41	7.69 ± 1.85	0.041

Group A, reoperation group; Group B, primary open surgery group. EBL, estimated blood loss

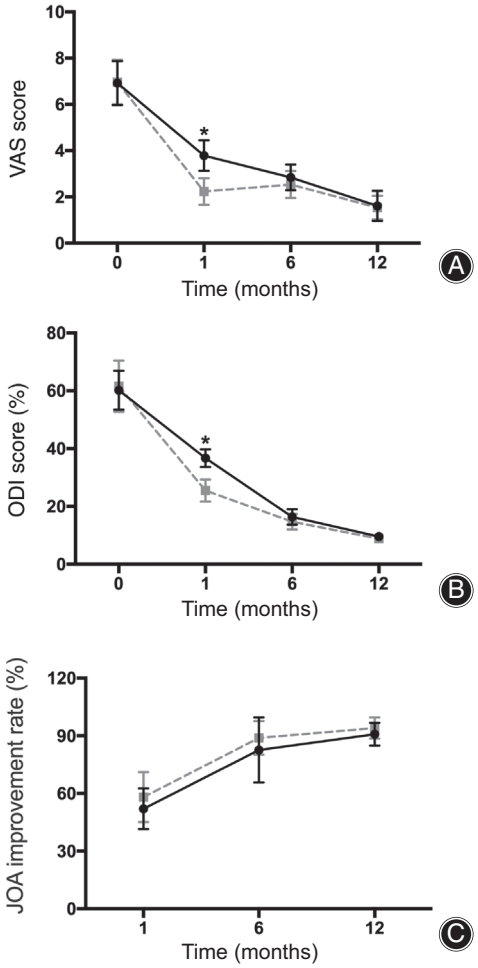

Fig. 1 Measurements of function of reoperation for post-percutaneous endoscopic lumbar discectomy (PELD) group and primary open surgery group. Visual analog scale (VAS) scores (A), Oswestry Disability Index (ODI) scores (B), and Japanese Orthopedic Association (JOA) improvement rate (C) were compared. Preoperative (baseline) VAS, ODI, and JOA scores of the two groups were comparable. At the 1-month post-operative follow up, the VAS and ODI scores of the primary open surgery group were significantly better than that of the revision surgery group, but the rates of JOA improvement were similar. At the 6-month and 12-month follow-ups, all scores of the two groups were statistically similar. $^{*}P < 0.05$. (—●—) Revision surgery group. (--■--) Primary open surgery group.

TABLE 3 Postoperative complications of reoperation group and primary open surgery group (cases [%])

Complications	Reoperation group (n = 13)	Control group (n = 26)	P value†
Neurological deficiency	8 (61.5)	1 (3.8)	0.000
CSF leakage	4 (30.8)	1 (3.8)	0.035
Incision infection	2 (15.4)	1 (3.8)	0.253
Urinary tract infection	2 (15.4)	1 (3.8)	0.253
Pneumonia	1 (7.7)	1 (3.8)	1.000
Cerebrovascular accident	1 (7.7)	0 (0)	0.333

Note: Total number of patients in these composites is not the sum of individual complications because some patients had more than one complication.; †Fisher exact test.; CSF, cerebrospinal fluid

Discussion

The recurrence rate after PELD is reportedly as much as 7.4%[20–22]. Revision surgery is very important for patients with symptomatic LDD who fail to recover through conservative therapy. However, few studies have evaluated the clinical outcome of open revision surgery for recurrent symptoms after PELD, relative to primary open surgery.

Challenging for Revision Surgery

Revision surgery is far more challenging than primary surgery. Epidural or perineural scar tissue can be a troublesome issue that can disturb dissection during a posterior approach, increasing the risk of dural tear or nerve injury[23]. The incidence of intraoperative incidental durotomy is as high as 20.0% in patients receiving repeated open lumbar surgery[24,25]. The rate of recurrent herniation after PELD was reported as 3.6%, which may be related to age (>50 years) and obesity [26]. Ebeling *et al.*[27] reported a complication rate of 13.0% after repeated discectomy, among which dural tears and infections are the most common problems.

Yao *et al.*[28] investigated minimally invasive spine surgeries for recurrent herniation and reported that the complication rates were 3.9%, 10%, and 14.3% in patients receiving, respectively, transforaminal lumbar interbody fusion, microendoscopic discectomy, and PELD. Consistent with these previous studies, the present study showed that the perioperative complication rate of patients who underwent repeated open surgery for PELD recurrence was higher than that of patients who underwent primary spinal decompression and fusion. Therefore, we believe patients and their family members should be routinely informed of the high risk of perioperative complications when planning open revision surgery after PELD. To prevent perioperative neurologic complications, patients scheduled for reoperation should be routinely encouraged to take steroid agents such as methylprednisolone or dexamethasone.

Ahn *et al.*[29] found that minimally invasive revision lumbar discectomy may be associated with increased operative time, longer hospital stay, and postoperative narcotic utilization, compared with the primary surgery. Longer operative time may also make a wide variety of complications more likely. Kim *et al.*[30] conducted a study with a large cohort (4588 patients) who underwent single-level lumbar fusion and found that prolonged operative time was associated with increased risk for overall, medical, and surgical complications, superficial surgical site infection, and postoperative transfusions. Consistent with these reports, in the present study the operative time and the duration of hospitalization of patients in the reoperation post-PELD group

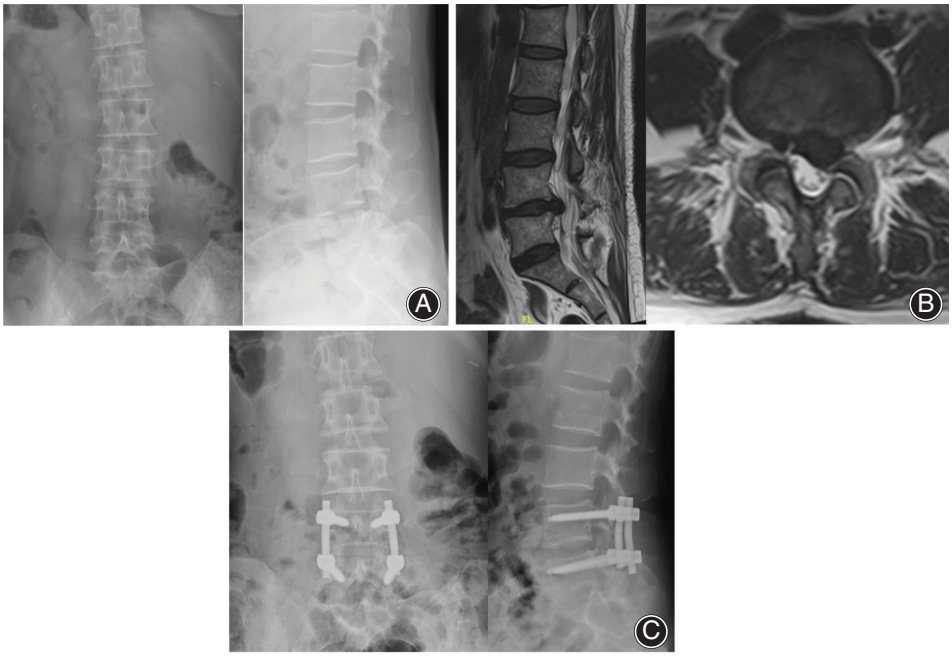

Fig. 2 Clinical imaging from 1 representative patient (female, 39 years old) more than 5 years after percutaneous endoscopic lumbar discectomy (PELD) (L_4–L_5), who complained of lumbago and left lower limb extremity pain for approximately 7 months. (A) X-ray images of lumbar vertebrae anteroposterior and lateral position plain films showed no spondylolisthesis. (B) T2-weighted sagittal (left) and axial (right) preoperative MRI of the lumbar spine showed the L_{4-5} disc herniation on the same segment of PELD. (C) The X-ray imaging indicated that the location of the internal fixator was excellent. On the third postoperative day, the acupuncture feeling on the left lower extremity was slightly reduced, and recovered in 2 weeks.

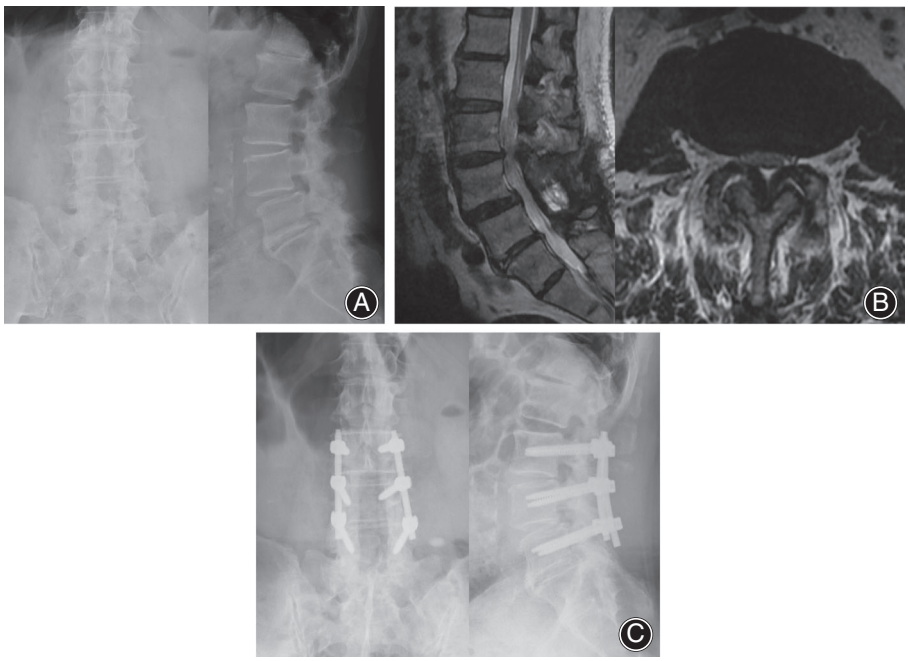

Fig. 3 A patient (male, 78 years old) who received PELD (L_4–L_5) 4 months previously and had lumbago and bilateral lower limb pain and intermittent claudication. (A) X-ray images of lumbar vertebrae anteroposterior and lateral position plain films showed scoliosis and severe degeneration. (B) Preoperative MRI showed that sagittal (left) and axial (right) of the lumbar spine there was severe lumbar spinal stenosis, especially in L_4–L_5. During the surgery, we discovered that severe lateral recess stenosis of the L_{4-5}, adhesion between scar tissue and dural and hard to be separated. (C) The X-ray imaging indicated that the location of the internal fixator was excellent but after 1 postoperative day, the numb feeling on the bilateral lower extremity reappearance, which recovered in 2 months.

were significantly longer than for primary surgery. Thus, we presume that longer operative time may be an important risk factor affecting the prognosis and overall complications of revision surgery. Strategies to reduce operative time and further investigations of risk factors are needed.

High-volume blood loss leads to more autologous or allogenic blood transfusions, with attendant risks of transfusion reactions and infections. A study by Yoshihara and Yoneoka[31] using data from the National Inpatient Sample found that revision spinal fusion was an independent risk factor for allogeneic blood transfusion. Basques *et al.*[32] compared the short-term morbidity of revision and primary posterior lumbar fusions and reported that the former had a significantly higher rate of blood transfusion. In contrast, in the present study, the rates of allogeneic blood transfusion were similar between the revision and primary surgery groups. This may be because the number of fused levels was relatively few. Therefore, we emphasize that surgeons should

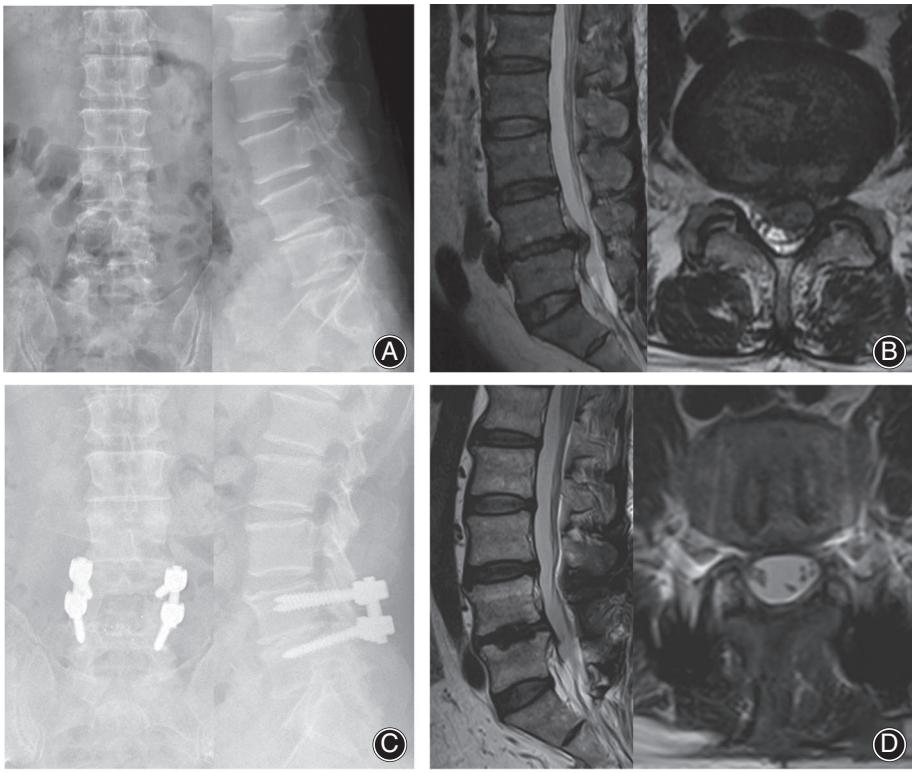

Fig. 4 A 62-year-old male patient who under percutaneous endoscopic lumbar discectomy (L_4–L_5) 1 months previously but still had lumbago and left lower limb extremity pain with intermittent claudication. (A) X-ray images of lumbar vertebrae anteroposterior and lateral position plain films showed instability of L_4–L_5. (B) T2- weighted sagittal (left) and axial (right) preoperative MRI of the lumbar spine showed the $L_{4–5}$ disc herniation and spinal stenosis. In the operation, the exploration revealed local scar formation and adhesion to the left nerve root and dural sac of L_5. (C) Location of the pedicle screws and cages were good. (D) MRI indicates that the location of the grafting bone block with intervertebral space was fine, and the synostosis of intervertebral space was also excellent.

be aware of the potential risk in these procedures. In particular, effective strategies to minimize blood loss during revision lumbar fusion are important.

In the current study, at the last follow-up there were no significant differences between the two groups regarding functional outcomes, as reflected by VAS scores, ODI scores, and JOA improvement rates. However, at the 1-month follow-up, the VAS and ODI scores of the primary open surgery group were significantly better than those of the revision surgery group, although the JOA improvement rates were similar. The lack of difference in JOA improvement may be a result of no patient suffering severe neurological damage. Compared with the revision surgery group, patients in the primary open surgery group experienced earlier recovery, perhaps because of transient nerve root irritation or cerebrospinal fluid leakage in the former. The lack of difference in functional outcomes at the last follow-up may be the result of all patients having recovered completely from any complication. Therefore, the final functional outcomes of the patients who underwent reoperative surgery after PELD were satisfactory.

Limitations

This study is limited in that the patients' lifestyle and family history were not recorded. We also did not investigate the effects of spinal deformity on the outcomes of the respective surgeries. In addition, this is a retrospective study, and financial factors and preoperative medications may have influenced the length of stay in hospital, as has been reported elsewhere[33]. Finally, all patients were relatively young, and these findings may not be applicable to elderly, more comorbid patients.

Conclusions

The present study provides an important perspective on the management of recurrence after PELD with open revision surgery. Compared with primary open surgery, post-PELD revision was associated with a higher perioperative complication rate and longer hospital stay. However, the patients' functional outcomes at the last follow-up were satisfactory. The disadvantages of reoperation should be carefully balanced against the potential advantages, and patients should be fully informed.

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