Minimally Invasive versus Traditional Surgery: Efficacy of PELD and PLIF in Treating Pyogenic Spondylodiscitis

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Background: Pyogenic spondylodiscitis is a chronic inflammation of the intervertebral disc or discs and the adjacent vertebrae. This retrospective study aimed to compare the effectiveness of percutaneous endoscopic lumbar debridement (PELD) versus posterior lumbar interbody fusion (PLIF) in 40 patients with pyogenic spondylodiscitis (PSD).

Material/Methods: Medical records of patients who underwent PELD (n=18) or PLIF (n=22) for PSD between 2018 and 2023 were reviewed. The recorded outcomes encompassed surgical duration, intraoperative blood loss, Oswestry Disability Index (ODI) measurements, Visual Analog Scale (VAS) assessments, C-reactive protein (CRP) levels, duration of hospitalization, erythrocyte sedimentation rate (ESR), American Spinal Injury Association (ASIA) grading, lumbar sagittal parameters, and the incidence of complications.

Results: The PELD group had shorter surgical duration, less intraoperative blood loss, and shorter length of hospital stay compared to the PLIF group \((P<0.01)\). At the last follow-up, both groups had significant improvement in ESR, CRP levels, and ASIA classification \((P<0.001)\), but there was no significant difference between the 2 groups \((P>0.05)\). The PELD group had lower ODI and VAS ratings at 1 month and 3 months, respectively \((P<0.01)\). The PLIF group had significant improvements in intervertebral space height and lumbar lordosis angle \((P<0.01)\).

Conclusions: Both PLIF and PELD surgical approaches demonstrate adequate clinical efficacy in the treatment of monosegmental PSD. PLIF can better ensure more spinal stability than PELD, but PELD offers advantages such as reduced minimal surgical trauma, shorter operative duration, and faster recovery after surgery.

Keywords: Bacterial Infections • Lumbar Vertebrae • Minimally Invasive Surgical Procedure

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Introduction

Spondylodiscitis is commonly associated with iatrogenic infections following spinal injections or spinal surgeries. Primary spondylodiscitis, caused by conditions such as diabetes, Human Immunodeficiency Virus, or immunodeficiency, is less common [1]. The annual incidence of pyogenic spondylodiscitis (PSD) ranges from 0.2 to 2.4 cases per 100,000 individuals, with a higher prevalence in males [2]. Alarmingly, the incidence is increasing, possibly due to an aging population, increased utilization of invasive surgical procedures, and advancements in diagnostic techniques [3]. PSD is often severe, and mortality rates are 2-20% [4-6]. According to guidelines, the diagnosis of PSD should be based on a combination of clinical, radiological, and microbiological findings [7]. Anti-infective medications are the cornerstone treatment of PSD [8-10]. However, due to the deep anatomical location of PSD and the characteristics of the intervertebral space, it can be challenging to achieve effective antibiotic concentrations [11]. Therefore, surgical intervention becomes necessary when conservative treatment fails and patients exhibit symptoms such as nerve compression, abscess formation, or adjacent vertebral involvement [12,13]. The goal of surgical treatment is identification of the causative pathogens, complete debridement, relief of nerve compression, and restoration of spinal stability [12]. Surgical approaches for PSD include PLIF [14], PELD [15], and minimally invasive surgery [16]. Recently, some scholars have proposed a surgical method that combines the advantages of minimally invasive debridement of infectious lesions and percutaneous posterior instrumented spinal fusion, known as percutaneous endoscopic interbody debridement and fusion (PEiDF) [17]. However, few patients have undergone this procedure, and the surgical efficacy requires further validation over a longer period of time [18]. The optimal surgical choice for PSD remains a subject of debate.

PLIF is a widely recognized, safe, and effective surgical technique for treating PSD [14]. It provides effective surgical debridement and can offer sufficient stability to unstable spinal segments when needed [14]. However, PLIF is an open surgical procedure and has risks [19]. With the rapid advancements in minimally invasive spine surgery, there have been recent reports on its application in PSD. According to reports, PELD is effective in controlling infection, except in cases of extensive infection and structural instability [20]. PELD can reduce trauma, anesthesia requirements, and blood loss, potentially avoiding prolonged immobilization during surgery for patients with PSD [21].

As far as we are aware, there is currently a lack of literature reporting comparable efficacy between PELD and open surgery for the treatment of PSD. Therefore, this retrospective study from a single center aimed to compare the effectiveness of PELD with PLIF in 40 patients with PSD between 2018 to 2023. Based on these data, treatment decision analysis can be performed for patients.

Material and Methods

This study was approved by the Institutional Review Board of the affiliated hospital. We explained the research procedures to all patients with PSD and obtained their written informed consent.

Patient Selection

A retrospective analysis was conducted on patients diagnosed with PSD and hospitalized in our orthopedic department from 2018 to 2023. The diagnosis of PSD was based on clinical examinations, including radiographic findings such as X-rays and MRI, as well as elevated levels of C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR). Furthermore, blood culture and needle biopsy were performed on all patients before surgery. All cases involved infection in a single lumbar disc segment, and the intervertebral space in that segment had not yet collapsed. Figure 1 shows the patient flowchart.

Inclusion Criteria

(1) The preoperative diagnosis of PSD was confirmed through postoperative pathological examination. (2) Intractable back pain with failed conservative treatment. The definition of conservative treatment failure in this context entails the occurrence of refractory infection, spinal instability, or neurological deficits in patients following antibiotic treatment. (3) Surgical intervention performed using PELD or PLIF techniques. (4) Follow-up duration of at least 12 months.

Exclusion Criteria

(1) Spinal metastatic tumor. (2) Spinal deformity and instability. (3) Magnetic resonance imaging (MRI) findings indicate the presence of an abscess located subdurally within the spinal canal. (4) Multiple or involvement of multiple intervertebral spaces by the epidural abscess.

Surgical Methods

PELD Group

The patient was positioned in the prone position, and under the guidance of a C-arm X-ray machine, the infected disc space was localized. Once the puncture site and trajectory were determined, local anesthesia with lidocaine was administered layer by layer. After successful puncture, 10 mL of lidocaine was...
injected onto the dura within the spinal canal, and a guidewire was inserted through the puncture needle into the epidural space. A longitudinal incision of approximately 7 mm was made around the guidewire as the central axis, and progressively dilating tubes were inserted. The C-arm X-ray machine was used for fluoroscopic guidance to ensure proper positioning, and if necessary, a visualized trephine was used for foraminal dilation. A protective sheath with a diameter of 7.5 mm was then replaced and inserted into the intervertebral foramen using a spinal endoscope. The disc space and intraspinal pathological tissues were thoroughly cleared, and if there were symptoms of nerve root compression, exploration and decompression of the affected nerve root were performed. Repeated lavage with saline solution was performed, and drainage tubes were inserted for continuous drainage. Postoperatively, broad-spectrum antibiotics were administered, which were adjusted to sensitive antibiotics based on the results of bacterial culture, and treatment was continued for 6 to 8 weeks.

**PLIF Group**

After endotracheal intubation under general anesthesia, the patient was positioned in the prone position with the aid of a U-shaped pad to suspend the abdomen. Using C-arm fluoroscopy, the affected segment was localized, and skin markings were made. Routine iodine disinfection and draping were performed, and a skin protective film was applied. A posterior midline incision was made in the lumbar region, and sequentially, the skin, subcutaneous tissue, and lumbodorsal fascia were incised. Bilateral paraspinal muscles were bluntly dissected beneath the periosteum until the lateral aspect of the bilateral facet joints, ensuring meticulous hemostasis during the procedure. After confirming accurate localization of the affected segment using C-arm fluoroscopy, pre-drilling was performed on both sides of the upper and lower vertebral bodies of the affected segment, and the drill holes were sealed with bone wax. Surgical instruments such as vertebral plate-holding forceps and osteotomes were used to remove the bilateral inferior facet joints of the upper vertebral body of the affected segment, as well as the lamina of the affected segment at the same level. The ligamentum flavum was excised to expose the dural sac and nerve roots. The nerve roots were gently separated to one side using a nerve dissector, and a small scalpel was used to circumferentially incise the annulus fibrosus of the affected segment’s intervertebral disc. The nucleus pulposus was removed with nucleus forceps, and surgical instruments such as rongeurs were used to address the cartilaginous endplates above and below the affected segment’s intervertebral space. Specimens were collected for bacterial culture and pathological examination. Vertebral pedicle screws were implanted into the

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**Figure 1.** Flow diagram of enrollment, follow-up, and analysis. Image produced by https://app.diagrams.net/.
prepared drill holes, and appropriately sized rods were pre-bent and placed above the rods. The upper screws were pre-tightened with caps, and autologous bone grafts were trimmed and implanted into the intervertebral space. The caps were tightened. Saline was used for repeated irrigation of the intervertebral space and the wound. Drainage tubes were placed on both sides of the incision. Once the absence of significant compression on the dural sac and nerve roots was confirmed, the dural sac was then protected with gelatin sponge, and the incision was meticulously closed using layered sutures.

Postoperative Management

All patients underwent continuous lavage of the intervertebral space with 0.9% physiological saline containing gentamicin for 24 h, lasting for 1 week. The decision to discontinue lavage was based on inflammatory markers and bacterial culture results. Upon 3 consecutive negative drainage fluid cultures postoperatively and a significant decrease in inflammatory markers compared to baseline, the drainage tube was removed. For patients with known pathogenic bacteria, effective antibiotics were administered preoperatively. If the pathogenic microorganism was not clearly identified through blood culture and needle biopsy, it was also possible to identify the causative agent from the pus culture obtained during surgery. Antibiotic injections were continued for 6-8 weeks postoperatively, guided by follow-up inflammatory markers. Antibiotics were discontinued when the inflammatory markers returned to the normal range. Two weeks after surgery, patients were permitted to ambulate with support from the lumbar brace. Following discharge, regular follow-up examinations included ESR, CRP, and lumbar spine MRI scans.

Clinical and Imaging Parameters

We documented the surgical duration, intraoperative blood loss, perioperative complications, and postoperative hospital stay. Follow-up assessments were conducted at 1, 3, 6, and 12 months postoperatively. We recorded the preoperative, postoperative, and each follow-up visit’s ESR and CRP levels for both groups. Additionally, Visual Analog Scale (VAS) scores and Oswestry Disability Index (ODI) were recorded. Neurological function was evaluated using the American Spinal Injury Association (ASIA) score preoperatively and at the final follow-up visit. The height of the intervertebral space (HIS) and lumbar lordosis angle (LL) were evaluated by imaging.

Statistical Analysis

The data are presented as means and standard deviations (SD). Statistical analysis was performed using SPSS 26.0 software. The t test (or Mann-Whitney U test) correlation analysis was conducted according to whether the variables were normally distributed. The differences between the 2 groups were compared using the independent samples t test and χ² test, while the differences between preoperative and postoperative parameters within the same group were evaluated using the paired t test. Significance was set at P<0.05.

Results

Patient Characteristics

The study enrolled a total of 40 patients, with 18 cases in the PELD group and 22 cases in the PILF group. All cases were followed up for a minimum of 1 year. There were no statistically significant differences observed between the 2 groups regarding age (P=0.641), gender (P=0.828), body mass index (BMI) (P=0.581), and American society of Anaesthesiologist (ASA) classification (P=0.618). All patients successfully underwent surgery, and there were no perioperative deaths. Compared to the PELD group, the PILF group had longer operative time (P<0.001), higher intraoperative blood loss (P<0.001), longer incision length, and longer postoperative hospitalization duration (P<0.001) (Table 1).

Clinical Outcome

No statistically significant differences were observed in the ESR and CRP levels between the PELD and PILF groups at the preoperative assessment and the final follow-up. However, both groups demonstrated significant improvement in ESR and CRP levels compared to the preoperative values at the last follow-up (P<0.001) (Table 2).

There were no statistically significant differences in preoperative and last follow-up ASIA grades between the 2 groups (P values of 0.840 and 0.812, respectively). Both groups showed significant improvement in ASIA grades at the last follow-up compared to the preoperative grades (P<0.001) (Table 3).

No statistically significant differences in VAS scores and ODI were observed between the PELD and PILF groups during preoperative, 6-month postoperative, and 1-year postoperative follow-ups (VAS scores: P values of 0.766, 0.117, and 0.611; ODI: P values of 0.604, 0.452, and 0.551). In contrast, the PELD group exhibited significantly lower VAS scores and ODI compared to the PILF group at 1 month and 3 months postoperatively (VAS scores: P<0.05 and P<0.001; ODI: P<0.001, and P<0.001) (Figure 2A, 2B).

Radiological Evaluation

In comparison to preoperative measurements, patients in the PILF group demonstrated a significant increase in HIS and LL at
Patients in the PELD group exhibited an increase in HIS and LL at the last follow-up compared to preoperative measurements, but the difference was not statistically significant. Postoperatively, all patients maintained good lumbar lordosis and intervertebral space height without the development of lumbar kyphosis deformity (Table 4).

Complications

The PELD group did not experience any postoperative complications. In the PILF group, there was 1 case of postoperative complication (a superficial wound infection), which was successfully treated and resolved with appropriate interventions.

Table 1. Summary of the baseline data.

<table>
<thead>
<tr>
<th>Items</th>
<th>PELD (n=18)</th>
<th>PLIF (n=22)</th>
<th>P value</th>
</tr>
</thead>
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<td>Age (years)</td>
<td>44.7±12.1</td>
<td>44.1±14.7</td>
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<tr>
<td>Sex M/F</td>
<td>11/18</td>
<td>12/22</td>
<td>0.828</td>
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<tr>
<td>BMI (kg/m²)</td>
<td>22.8±1.5</td>
<td>22.5±1.9</td>
<td>0.581</td>
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<td>ASA grade (n)</td>
<td></td>
<td></td>
<td>0.618</td>
</tr>
<tr>
<td>I</td>
<td>10</td>
<td>11</td>
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<tr>
<td>II</td>
<td>6</td>
<td>5</td>
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</tr>
<tr>
<td>III</td>
<td>2</td>
<td>5</td>
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<td>Comorbidities</td>
<td></td>
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<td>2</td>
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<tr>
<td>Diabetes (n)</td>
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<td></td>
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<tr>
<td>Hepatopathy (n)</td>
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<td></td>
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<td>Incision length (cm)</td>
<td>1.9±0.5</td>
<td>13.1±1.7</td>
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<td>Surgical duration (min)</td>
<td>55.9±7.7</td>
<td>95.3±22.9</td>
<td>&lt;0.001</td>
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<td>Intraoperative blood loss (ml)</td>
<td>106.5±19.8</td>
<td>350.5±88.0</td>
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<td>Hospital stay (d)</td>
<td>8.9±2.2</td>
<td>12.5±2.9</td>
<td>&lt;0.001</td>
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BMI – body mass index; ASA – American society of Anesthesiologists physical status classification system; n – the total number of patients.

Table 2. Comparison of ESR and CRP between the 2 groups.

<table>
<thead>
<tr>
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<th>PELD (n=18)</th>
<th>PLIF (n=22)</th>
<th>P value</th>
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<tr>
<td>Preoperative ESR</td>
<td>85.5±20.4</td>
<td>78.7±23.3</td>
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<tr>
<td>Last follow-up ESR</td>
<td>15.5±9.46*</td>
<td>14.7±2.7*</td>
<td>&lt;0.001</td>
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<tr>
<td>Preoperative CRP</td>
<td>54.3±16.5</td>
<td>61.3±15.1</td>
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<tr>
<td>Last follow-up CRP</td>
<td>9.7±3.4*</td>
<td>9.5±3.3*</td>
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ESR – erythrocyte sedimentation rate; CRP – C-reactive protein. Compared to preoperative, *P<0.05. P<0.05 was considered statistically significant.

the last follow-up (P<0.05). Patients in the PELD group exhibited an increase in HIS and LL at the last follow-up compared to preoperative measurements, but the difference was not statistically significant. Postoperatively, all patients maintained good lumbar lordosis and intervertebral space height without the development of lumbar kyphosis deformity (Table 4).

Complications

The PELD group did not experience any postoperative complications. In the PILF group, there was 1 case of postoperative complication (a superficial wound infection), which was successfully treated and resolved with appropriate interventions.

Table 3. Comparison of ASIA grade of the 2 groups.

<table>
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<td>Preoperative ASIA grade</td>
<td>P=0.840</td>
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<td></td>
</tr>
<tr>
<td>A</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>11</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Last follow-up ASIA grade*</td>
<td>P=0.812</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>0</td>
<td>0</td>
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<td>B</td>
<td>0</td>
<td>0</td>
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<td>C</td>
<td>0</td>
<td>0</td>
<td></td>
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<td>D</td>
<td>2</td>
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<tr>
<td>E</td>
<td>16</td>
<td>19</td>
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</table>

ASIA – American Spinal Injury Association. * Compared with preoperative, the P values for both groups were less than 0.001, indicating statistical significance.
In this study, we observed that PLIF had a longer surgical duration, promptly alleviates pain, and, importantly, enables surgical intervention. Surgery not only facilitates comprehensive eradication of pathological lesions and correction of deformities, but also restores spine sequence, improves neurological function, reduces recurrence rates, shortens hospitalization duration, promptly alleviates pain, and, importantly, enables diagnostic biopsy procedures [23-25]. Hence, current recommendations strongly advocate surgical intervention. As far as we are aware, this retrospective study is the first direct comparison between PELD and the conventional PLIF technique in the treatment of PSD patients.

In this study, we observed that PLIF had a longer surgical duration and greater blood loss compared to PELD, which may be attributed to the following reasons: (1) The PLIF group required dissection of the paraspinal muscles, whereas this step was not necessary in the PELD group [26, 27]; (2) In the PELD group, surgeons were able to immediately access the anterior portion of the abscess or lesion, facilitating debridement and irrigation under direct visualization, which was not feasible in the PLIF group; (3) The PLIF group needed segmental fixation using an internal fixation system [28]. On the other hand, the PELD group had shorter hospitalization duration, which may be due to less surgical trauma associated with the PLIF procedure. PELD surgery entailed fewer surgical incisions and lower surgical costs compared to the PLIF group, while also having lower requirements in terms of surgical tolerance [29]. These factors often make minimally invasive procedures more appealing to patients. Based on our preliminary results, PELD has many advantages in terms of minimally invasive approach, effective infection control, high pathogen identification rate, and relief of back pain [30]. If this minimally invasive surgical technique is applied to specific patients (ie, early stages of PSD with spinal stability), it can effectively provide immediate pain relief and allow for rapid mobilization [30]. Patients can be discharged relatively quickly after the surgery, thus improving the cost-effectiveness of the procedure. Additionally, compared to PLIF, PELD significantly reduces the surgical time, minimizes perioperative complications, and enables treatment of debilitated patients. In contrast, PEIDF requires general anesthesia and is ineffective for multi-segment PSD [18].

At the last follow-up, both the PELD and traditional PLIF groups demonstrated a significant reduction in CRP and ESR compared to preoperative levels, with no significant difference between the 2 groups. We believe the possible reasons for this observation are as follows: (1) All patients received appropriate and consistent antibiotic treatment both before and after surgery; (2) Both groups underwent thorough and definitive debridement of the infectious focus during the surgical procedure; (3) The enrolled patients exhibited preserved intervertebral disc

**Discussion**

The conventional treatment modalities for PSD primarily encompass conservative management and surgical intervention. In cases of PSD where only mild damage or infection is present in the early stages, it is advisable to pursue conservative treatment options such as bed rest, nutritional supplementation, and administration of sensitive antibiotics [22]. However, patients exhibiting ineffective response to conservative measures, along with symptoms of lumbar instability, nerve compression, or significant abscess formation, need surgical intervention. Surgery not only facilitates comprehensive eradication of pathological lesions and correction of deformities, but also restores spine sequence, improves neurological function, reduces recurrence rates, shortens hospitalization duration, promptly alleviates pain, and, importantly, enables diagnostic biopsy procedures [23-25]. Hence, current recommendations strongly advocate surgical intervention. As far as we are aware, this retrospective study is the first direct comparison between PELD and the conventional PLIF technique in the treatment of PSD patients.

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**Table 4. Comparison of HIS and LL between the 2 groups.**

<table>
<thead>
<tr>
<th></th>
<th>PELD (n=18)</th>
<th>PLIF (n=22)</th>
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<tbody>
<tr>
<td>Preoperative HIS</td>
<td>7.35±1.45</td>
<td>8.40±1.59</td>
</tr>
<tr>
<td>Last follow-up HIS</td>
<td>7.42±1.85</td>
<td>10.51±1.62*</td>
</tr>
<tr>
<td>Preoperative LL</td>
<td>26.63±5.32</td>
<td>25.68±6.45</td>
</tr>
<tr>
<td>Last follow-up LL</td>
<td>27.24±6.42</td>
<td>29.52±7.76*</td>
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</table>

HIS – the height of the intervertebral space; LL – lumbar lordosis angle. Compared to preoperative, * P<0.05. P<0.05 was considered statistically significant.

**Figure 2.** Comparison of VAS (A) and ODI (B) between the 2 groups. * Compared with preoperative, P<0.05. The figures were made with GraphPad Prism 6 version 6.01.
space and relatively stable spinal structures, which contributed to the healing of the PSD lesions in both surgical groups [31].

In comparison to the PLIF group, the PELD group in our study showed lower VAS scores and ODI at 1 and 3 months after surgery. However, at 6 months and 12 months, the differences were not statistically significant. Possible reasons for these findings are as follows: (1) In the short term, the PELD group had better relief from low back pain and improved lumbar function than the PLIF group due to less damage to the facet joint and paraspinal muscles [32,33]; (2) By 1 year after surgery, patients in the PLIF group had achieved spinal fusion, with their paraspinal muscles beginning to recover [34]. These results confirm the advantages of PELD over PLIF in terms of reduced surgical trauma and more rapid postoperative recovery. Antimicrobial therapy and spinal canal decompression potentially contributed to the significant improvement in ASIA scores observed in both groups at final follow-up. Both surgical approaches were safe for treating PSD, as there was no discernible difference in complication rates between the 2 groups. All complications were successfully managed with proactive treatment.

Although this study only included patients with non-collapsed intervertebral space, it is evident that the PLIF group exhibited more pronounced improvements in HIS and LL. Undoubtedly, PLIF can provide a more stable mechanical environment.

We consider the following indications for PELD in the treatment of PSD: (1) Elderly patients with multiple underlying comorbidities who are unable to tolerate general anesthesia; (2) Severe back pain that is unresponsive to conservative treatment; (3) Progressive paralysis or worsening neurological deficits; (4) Patients with single-level or single-compartment epidural abscess involvement, in the early stages of spinal infection, with mild to moderate vertebral body destructive changes; (5) Spinal stability is maintained, and there is no collapse of the intervertebral disc space.

This study has several limitations. Firstly, as a retrospective study, there is an inherent risk of potential biases and confounding factors. Furthermore, the study sample size was small and the follow-up duration was relatively brief. Thirdly, these conclusions would benefit from further validation through larger multicenter, prospective, randomized, controlled trials.

Conclusions

Both PLIF and PELD surgical approaches demonstrated adequate clinical efficacy in the treatment of monosegmental PSD. PLIF can better ensure spinal stability than PLED, but PELD offers advantages such as reduced minimal surgical trauma, shorter operative duration, and faster recovery after surgery.

Department and Institution Where Work Was Done

This retrospective study was performed at the Department of Orthopedics, the Second Affiliated Hospital of Nanchang University, Nanchang, Jiangxi, PR China.

Declaration of Figures’ Authenticity

All figures submitted have been created by the authors, who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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