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Percutaneous endoscopic lumbar discectomy and minimally invasive transforaminal lumbar interbody fusion for massive lumbar disc herniation

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ABSTRACT

Objectives: To compare the clinical outcomes of patients with massive lumbar disc disease undergoing percutaneous endoscopic lumbar discectomy and minimally invasive transforaminal lumbar interbody fusion at a single clinic.

Patients and methods: From January 2008 to January 2014, 360 consecutive patients with massive lumbar disc herniation were treated with PELD(184 patients) or MIS-TLIF(176 patients). Data collected prospectively for analysis included clinical and radiographic results after revision surgery and complications.

Results: During the follow-up period, postoperative data between two treatment groups showed no significant difference in the mean total postoperative VAS score for leg pain, JOA and ODI scores. The recovery rate was 89.3% in the PELD and 93.4% in MIS-TLIF groups, respectively. Satisfaction rates were 86.3% in the PELD group and 92.2% in the MIS-TLIF group. Four cases of dural tear were observed in the MIS-TLIF group. Recurrence manifested in 14 patients in the PELD group, and one patient in this group also suffered permanent neurologic deficit. One case of postoperative intervertebral infection was recorded in the MIS-TLIF group.

Conclusion: A comparison of PELD and MIS-TLIF for treating massive lumbar disc herniation revealed that both showed favorable clinical outcomes but had different sets of complications. Compared to MIS-TLIF, PELD had the following advantages: (1) its feasibility under local anesthesia and (2) the rarity of "fusion disease," such as ASD. However, the PELD is also revealed several problems, including a relatively lower success rate and satisfaction,a relative higher rate of postoperative long-term chronic low back pain and the possibility of recurrence, despite low opportunity. Therefore, the main difference between these two treatments was related to postoperative complications and the satisfaction and recovery rates. We suggest that, in the future, multi-center studies, recruiting a larger number of patients, should be undertaken to better understand the clinical relevance of these complications.

1. Introduction

A disc herniation that occludes > 50% of the spinal canal and impinges on neural structures is defined as a massive disc herniation [1,2]. The most common presenting symptom of massive lumbar disc herniation is sciatica which may or may not be accompanied by neurologic deficits, of which cauda equina syndrome is among the most serious manifestations [3,4]. The effectiveness of conservative treatments for massive lumbar disc herniation has been confirmed in previous case reports and case series [5–7]; however, due to patients with severe radicular pain and fearing severe dural sac compression resulting in significant neurological dysfunction, more massive lumbar disc herniation is prone to surgery. The choice of operation approach, however, remains controversial.

Massive disc herniation may have detrimental effects on long-term prognosis due to massive loss of the nucleus pulposus and defects in the annulus fibrosus from blown-out herniation, resulting in an increased risk of postoperative spinal instability and chronic back pain [8,9]. As a result, discectomy along with spinal fusion (rather than discectomy alone) is sometimes the preferred treatment for massive disc herniations [10]. Compared to traditional posterior lumbar interbody fusion, the use of minimally invasive surgical techniques as MIS-TLIF, first described by Holly, represents the most recent modification of methods used to achieve lumbar interbody fusion and isbased upon the premise that a smaller, less traumatic incision affords better recovery and outcomes [11,12].

Reports of percutaneous endoscopic lumbar discectomy (PELD) for the treatment of massive lumbar disc herniation (even with cauda

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equina syndrome) are growing in number [13–15]. PELD is a minimally invasive spinal technique, and has many advantages compared with open lumbar discectomy such as rapid rehabilitation, reduced surgery-induced tissue injury, and facilitation of revision operations [16–18]. However, to date, many investigators have not recommended PELD for massive lumbar disc herniation as it was considered to be potentially high-risk and with many potential complications.

However, owing to the lack of greater numbers of follow-up studies on PELD and the scarcity of studies comparing the effects of both PELD and MIS-TLIF for surgical treatment of massive herniated discs, this study compares the clinical outcomes of patients who underwent one of these procedures.

2. Patients and methods

2.1. Clinical data

Our clinical study proposal was approved by the medical ethics committee of our institution. Written informed consents were obtained from all patients prior to inclusion in the study. The patients were assigned by a single-blind quasi-randomization within the spine department. Briefly, after the patients passed the inclusion/exclusion criteria and gave consent for the study, they were numbered serially at the spine department, and alternate numbers were assigned to the PELD and MIS-TLIF groups. To conceal the allocation at all participating hospitals, the surgeons were not informed of the group to which a patient was assigned until immediately before surgery. Three hundred and sixty consecutive patients with new onset lumbar disc herniation were treated between January 2008 and January 2014. Inclusion criteria for this study were: (1) intracanal disc herniation that occupied > 50% of the spinal canal, (2) leg or back pain associated with massive LDH, and (3) failure of conservative treatment over a 6 week period. Exclusion criteria for this study were: (1) disc herniation with disc calcification, (2) recurrent disc herniation,(3) cauda equina syndrome, and (4) instability. Patients were treated with PELD (operated on using a Joimax system, Joimax GmbH, Karlsruhe, Germany) or MIS-TLIF (operated on using Quadrant retractor and Sextant percutaneous pedicle screw systems; Medtronic SofamorDanek, Memphis, TN, USA). Patients had a mean age of 52.6 years. All patients in both groups presented with radiating pain as a predominant complaint, with varying degrees of low back pain and other neurological complaints. All patients underwent conservative treatment for at least 6 weeks without success before consideration for surgical intervention.

2.2. Surgical techniques

2.2.1. MIS-TLIF

The operative approach and technique of this procedure were described in our previous publication [19]. After induction of general anesthesia, patients were positioned prone on a radiolucent frame. The anatomic midline, pedicle outlines, and skin incision points (parallel to the pedicular midline and between the two pedicles superior and inferior to the affected disc space, respectively) were marked via C-arm fluoroscopic guidance at the spinal level for decompression and instrumentation. This incision was utilized during decompression, disc space preparation, autografting, placement of the interbody cage, and installation of pedicle screws without making additional incisions. A 3 cm longitudinal paramedian incision was created for placement of the Quadrant retractor system. The procedure was accomplished under direct visualization (without microscopyor microendoscopy). Using an osteotome, the medial aspect of the facet joint on the symptomatic side was carefully excised. The lateral portion of the facet joint was then removed with Kerrison punch forceps, and a complete facetectomy were performed. If the facet joint had previously been resected, remaining portions were located and removed. Blunt dissection was helpful in pinpointing the location of laminectomy. It often proved useful to locate the scar-bone interface and began to dissect the scar plane away from normal bony structures. According to radicular symptomatology of the patient, pedicle-to-pedicle and/or lateral and central canal decompression were performed after identification of the lateral border of the dura and traversing nerve roots. An aggressive full discectomy was then performed in Kambin's triangle. Interbody distractors were introduced into the discspace. Sufficient autologous bone graft obtained from the removed facet (or if required, autografted from the iliac crest) was packed in the anterior third of the disc space. A single PEEK cage (OIC, Stryker Inc., USA) filled with autologousbone graft was inserted obliquely across the disc space. In the event of bilateral limb radiculopathy, the relatively worse side was chosen for installation of the interbody grafted cage. Decompression was then performed on the contralateral side. After the Quadrant system was removed, the pedicular entry point was directly contacted with the surgeon's index finger through the same incision. A modified cannulated needle (used for percutaneous veterbroplasty) was advanced through the pedicle into the vertebral body under fluoroscopic guidance, followed by insertion of a blunt-tipped guide wire into the ventral third of the vertebral body. Using the percutaneous pedicular-screw system, appropriately sized cannulated M-8 pedicle screws were installed along the guidewire into the pedicle under fluoroscopic guidance. A representative case is shown in Fig. 1.

2.2.2. PELD

We used the same surgical techniques that were previously described by Thomas Hoogland et al. [20,21]. The procedure was performed under local anesthesia in the prone position on a radiolucent table in all patients. Patients were informed of all procedure steps prior to treatment initiation. Patients communicated with the surgeon throughout the entire procedure. After infiltration of the entry point (10–12 cm from the midline) with local anesthetics, an 18-gauge spinal needle was introduced under fluoroscopic guidance. The final target point of the spinal needle was the medial pedicular line on the anteroposterior image and the posterior vertebral line on the lateral image. Proceeding steps were as follows : 1) a guide wire was inserted through the spinal needle, 2) the spinal needle was removed, 3) a small skin incision was created at the entry point, 4) a tapered cannulated obturator was inserted along the guide wire, 5) after contacting the annulus, the obturator was inserted into the disc with hammering, and 6) a bevel-ended, oval-shaped working cannula was inserted into the disc along the obturator. The obturator was removed and an endoscope was inserted through the cannula. The herniated disc was removed using small forceps. Targeted fragmentectomy was performed in all cases. After the herniated fragment was all removed, the endoscope was removed as well, and a sterile dressing was applied with a 1-point suture. A representative case is shown in Fig. 2.

2.3. Clinical and radiological evaluation

Data collected prospectively for analysis were age, gender, operation level, duration of follow ups, pre-operative JOA and ODI scores, clinical and radiographic results after revision surgery, and presence or absence of complications. Back and leg pain was quantified with visual analog scores (VAS) collected from the patients preoperation, postoperation, and in last follow-up. The Oswestry disability index (ODI), version 2.0, was used both before and after surgery to provide the surgeon information about how the patient's leg or back complaints affected his/her ability to manage everyday life. Questions concerning sexual relations(Section 8) were omitted from this study; allowing for a total possible score of 45. Patients with satisfactory outcome was evaluated as either "EXCELLENT" or "GOOD", according to modified Macnab classification [22]. In this Classification system, "EXCELLENT" meant the status of no pain, no restriction of activity, where as "GOOD" refers to the situation suffering from occasional back or leg pain, with no interference on the patient's ability of normal work. Clinical

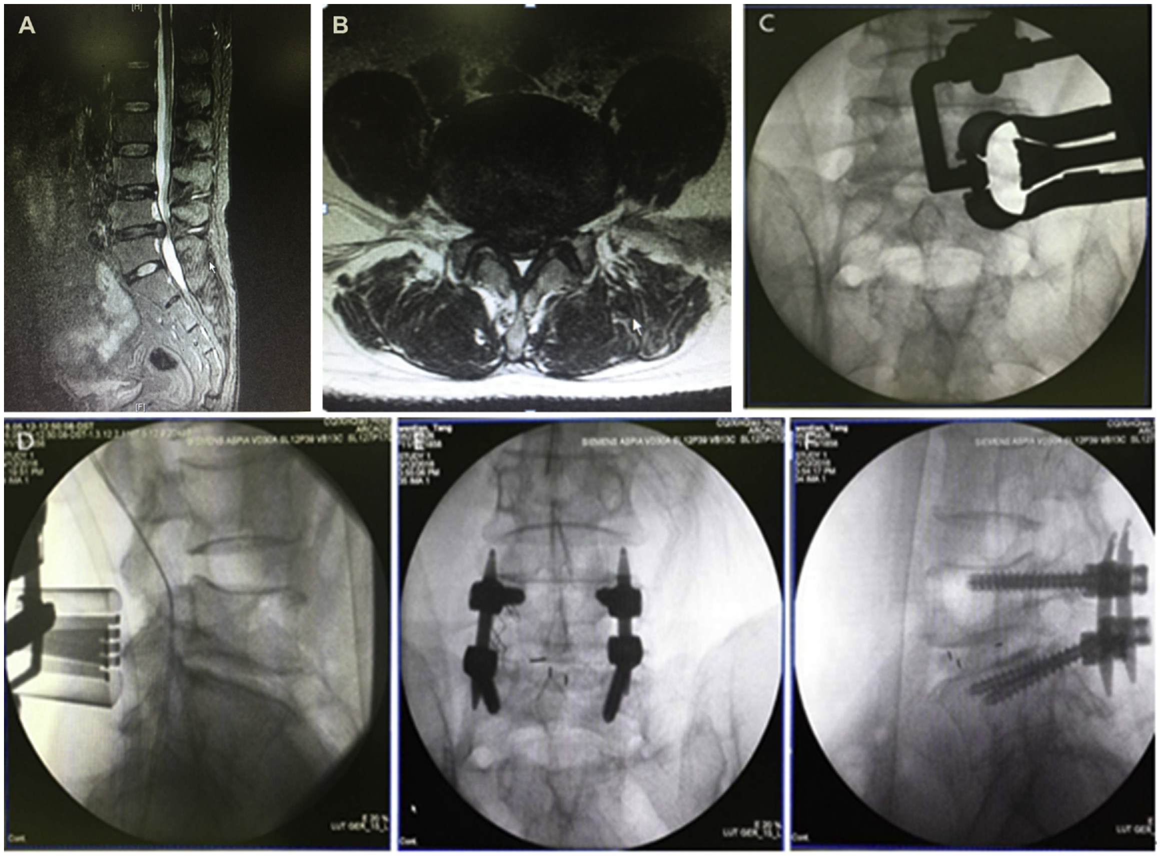

Fig. 1. Sagittal (A) and axial (B) MRI scan of a 52-year-old female with massive lumbar disc herniation. Anteroposterior (C) and lateral (D) radiographs after the Quadrant retractor system was placed. Anteroposterior (E) and lateral (F) radiographs after Mis-TLIF and percutaneous pedicle screw fixation.

symptoms were evaluated by direct questioning and examination using the criteria of the Japanese Orthopaedic Association (JOA) back scores. The JOA total score was 29 points and the lowest was 0 points. The lower the score, the more obvious the dysfunction. Improvement index = post-treatment score - pre-treatment score, post-treatment score improvement rate = [(post-treatment score - pre-treatment score) / 29 - pre-treatment score] × 100%. An improvement rate greater than 60% was defined as recovery. Preoperative radiological evaluation included anteroposterior, lateral, and flexion–extension plain radiographs, CT scans, and magnetic resonance imaging (MRI).

2.4. Criteria for adjacent segment disease

Adjacent Segment Disease (ASD) was defined as a radiologic change in which the narrowing of disc height was > 3 mm, the progressive slipping of adjacent segments was > 3 mm (in comparison with preoperative lateral flexion and extension radiographs), and the posterior opening of adjacent segments was > 5°. These definitions were based on previous reports [23]. For the definition of imaging lumbar instability, we follow the Frymoyer' standard: the intervertebral displacement of the lumbar hyperextension and overflexion X-ray is more than 3 mm or the angle changes more than 15° [24].

2.5. Statistical analysis

Statistical analyses were performed using SPSS 11.0 for Windows. Data are shown as mean ± SEM. The Student *t* test was used for the comparison of continuous variables, while Fisher's exact test was used to evaluate differences of clinical outcomes and fusion rates between the two groups. P values under 0.05 were accepted as statistically significant.

3. Results

Demographic and procedural data of the two compared groups are listed in Table 1. Mean follow-up time was 46.5 months and ranged from 12 to 70 months. Comparison of preoperative data between both groups showed no significant differences in age, gender, operation level, preoperative JOA and ODI scores, or leg and back pain VAS.

Only postoperative back pain was observed to be significantly more prominent in the PELD group. The recovery rate was 89.3% in the PELD group, less than that of the MIS-TLIF group(93.4%). The PELD group had lower rates of satisfaction when compared to the MIS-TLIF, at 86.3% and 92.2%, respectively. Dates of postoperative clinical outcome reporting are listed in Table 2.

Four cases of small dural tears were observed in the Mis-TLIF group during spinal decompression. The overlying fascia was closed tightly without additional exposure and repair. Postoperatively, patients remained supine on strict bed rest for several days. Cerebrospinal fluid leakage only lasted 3–5 days and stopped within a week without any neurological sequelae or wound complications. One dural tears and no spinal fluid leaks were observed in the PELD group. 14 patients in the PELD group experienced recurrent herniation, while no cases of recurrence were noted in the MIS-TLIF group. One patient in the PELD group suffered a permanent neurologic deficit during placement of the working channel. After PELD surgery, the strength of ankle dorsiflexion decreased from Grade 5 to Grade 1, with no significant recovery noted even after 52 months of follow-up. In the MIS-TLIF group, no similar events were noted. One case of postoperative intervertebral infection was recorded in the MIS-TLIF group and was successfully treated by reoperation. 6 cases with suspected lumbar instability and 5 cases of symptomatic ASD were found in the PELD and the MIS-TLIF groups, respectively. Dates of complications collected from the two groups are

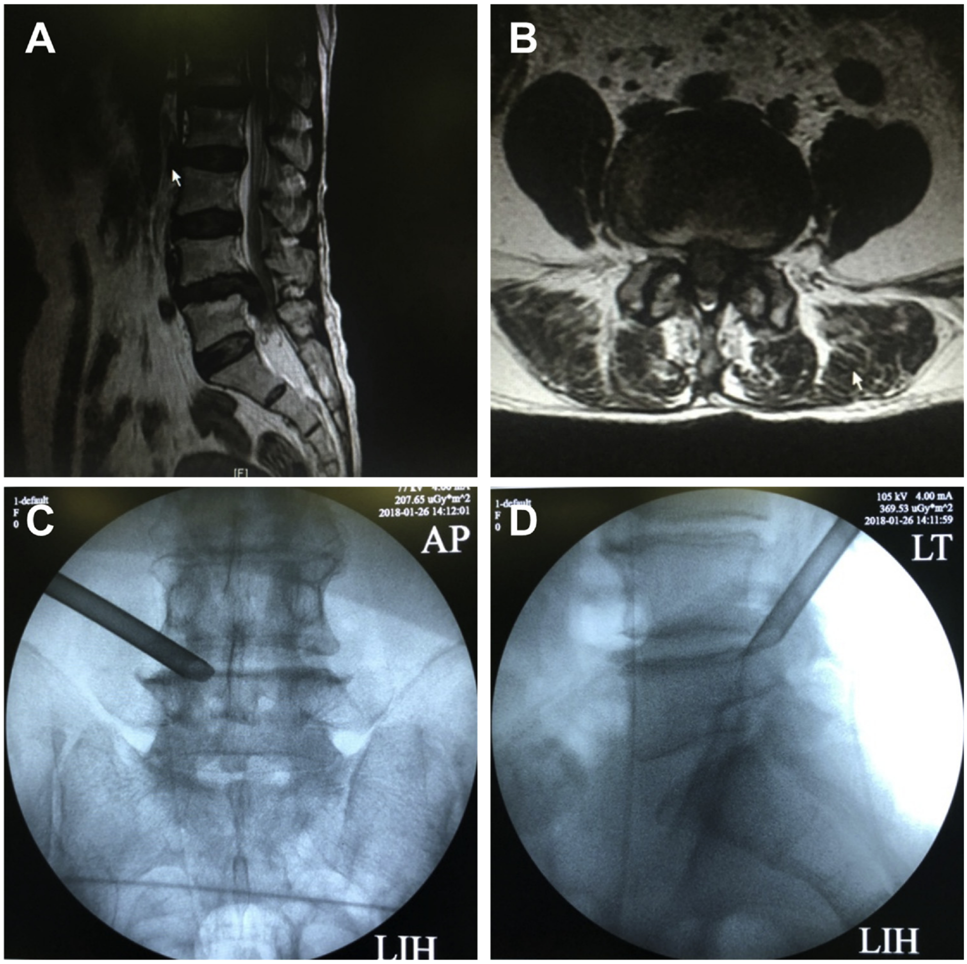

Fig. 2. Sagittal (A) and axial (B) MRI scan of a 58-year-old male with massive lumbar disc herniation.Anteroposterior (C)and lateral(D) fluoroscopic view of transforaminal approach to the L4-5 disc levelduring disc decompression.

Table 1
Patient demographic data.

	PELD	MIS-TLIF	P
No. of patien	184	176	
Age	42.2y	43.1y	0.329
Gender (M/F) (% male)	111/73	108/68	0.947
Level(L4-5/L5-S1)	106/78	101/75	0.825
Duration of fellow up	45.6m	44.7m	0.872
Preoperation JOA score	15.8 ± 1.8	15.3 ± 2.1	0.597
Preoperation ODI score	40.7 ± 5.2	39.8 ± 5.1	0.478
Preoperation leg pain VAS	6.8 ± 2.1	6.7 ± 2.2	0.226
Preoperation back pain VAS	4.9 ± 1.1	5.0 ± 1.2	0.517

Table 2
Postoperative clinical outcome.

	PELD	MIS-TLIF	P
Postoperation JOA score	26.7 ± 4.7	27.3 ± 5.1	0.371
Postoperation ODI score	12.4 ± 3.2	11.4 ± 3.5	0.245
Postoperation leg pain VAS	1.4 ± 0.8	1.2 ± 0.7	0.129
Postoperation back pain VAS	3.1 ± 1.1	1.3 ± 0.7	0.031
Satisfactory rate %	86.3%	92.2%	0.063
Recovery rate %	89.3%	93.4%	0.059

Table 3
Complications collected from the two groups.

	PELD	MIS-TLIF	P
Recurrent disc herniation	14(7.61%)	0	0.000
Dural tear	1(0.54%)	4(2.27%)	0.172
Neurologic deficit	1(0.54%)	0	0.514
intervertebral infection	0	1(0.57%)	0.486
Instability	6(3.26%)	0	0.018
ASD	0	5(2.87%)	0.026

listed in Table 3.

4. Discussion

Surgery for treatment of massive lumbar disc herniation is believed to be more urgently required than that for general lumbar disc herniation due to greater severity of back and leg pain as well as the increased risk of cauda equina syndrome. Such surgery also faces more risks and challenges, such as intraoperative neural injury or cauda equina syndrome, chronic low back pain, and postoperative segmental instability(if only discectomy or facetectomy without fusion is performed) [25]. Michael J's study suggested that the history of a surgical discectomy is related to the source of chronic low back and discogenic pain as the common estetiology [26]. Iwao Satoh's study indicated that massive lumbar disc herniation is an indication of lumbar fusion [27]. Compared with conventional posterior lumbar fusion surgery, a minimally invasive transforaminal lumbar fusion (MIS-TLIF) technique has been described to reduce iatrogenic soft tissue injury occurring with muscle stripping and retraction during routine spinal exposure. Several studies suggested MIS-TLIF to be comparable with Open-TLIF in terms of midterm clinical outcomes and fusion rates, but possessing the additional benefits of reduced blood loss and initial postoperative pain, earlier rehabilitation, and shorter hospitalization. Because of the significantly different surgical strategies of the aforementioned two surgical methods of MIS-TLIF and PELD, factors such as anesthesia, blood loss, hospitalization and other factors were not compared.

Results of this study revealed a higher incidence of chronic low back pain in PELD group patients when compared to the MIS-TLIF group. This may have been due to intervertebral disc degeneration, defects and scarring of the annulus fibrosus, lumbar instability, and other factors. Many scholars considered heavy loss of the nucleus pulposus and massive defects in the annulus fibrosus during surgical discectomy for massive lumbar disc herniation to result in an increased risk of postoperative spinal instability and chronic back pain [28,29]. Although, only 3.8% of patients in the PELD group suffered from postoperative lumbar spinal instability, this complication was reported less frequently than with open back discectomy, possibly due to significantly less bony structure damage during PELD. However, Kyung-Chul Choi compared percutaneous endoscopic lumbar discectomy and open lumbar microdiscectomy for massive lumbar disc herniation with results suggesting improvement in back pain significantly greater in the PELD group than in the open lumbar microdiscectomy group [13]. Data from this study show that the VAS score of low back pain in the PELD group compares data between two groups in Kyung-Chul Choi's study. In Sang-Ho Lee's study, a percutaneous endoscopic unilateral intra-annular subligamentous herniotomy was utilized for the treatment of large central disc herniation in six patients [29]. Outcomes of the operation were all satisfactory. Results revealed that a concentric outer-layer annular approach in PELD supports the recovery of the annulus via facilitation of an active repair process. Of course, massive disc prolapse cases are often encountered, with tissue prolapse containing the nucleus pulposus and even the annulus and potentially resulting in greater severity of chronic low back pain of some patients in the study.

Re-herniation following lumbar discectomy remains a significant problem in the treatment of herniated nucleus pulposus. Previous studies have shown that recurrence of radiculopathy and re-herniation rates following discectomy can be as high as 17%–33%, and 7%–26%, respectively [29,30]. To date, recurrence rates of massive disc herniation have not discussed separately. Investigators have attempted to focus on and identify factors correlating with re-herniation, such as patient selection, diagnostic imaging, and type of decompression performed. Eugene J. Carragee considered aggressive removal of remaining intervertebral disc matter to decrease the risk of re-herniation [31]. For PELD, a limited discectomy, re-herniation was at 7.6% in this study, significantly lower compared to the Carragee study. This may be related to PELD better protecting the integrity of the annulus fibrosus and the posterior longitudinal ligament as compared with traditional discectomy. The findings of the Carragee study suggest the degree of annular competence after discectomy and the type of herniation appear to have predictive value concerning recurrence of post-operative of sciatica.

Although there were no recurrent cases in the MIS-TLIF group, 3 patients were noted to possess symptomatic ASD during the fellow-up period. In a recent review, the incidence of symptomatic ASD after lumbar fusion varied significantly, with arange of 5.2%–18.5% [32,33]. Many factors potentially influence such findings, including postoperative sagittal alignment, age, obesity, preexisting degeneration of adjacent discs, menopause, laminar inclination, sacral inclination, and facet tropism. PLIF and the length of fusion have also been regarded as potentialrisk factors for ASD. As no cases of ASD were noted in the PELD group, it might very well be a more advantageous procedure.

5. Conclusions

A comparison of PELD and MIS-TLIF for treating massive lumbar disc herniation revealed that both showed favorable clinical outcomes but had different sets of complications. Compared to MIS-TLIF, PELD had the following advantages: (1) its feasibility under local anesthesia and (2) the rarity of "fusion disease," such as ASD. However, the PELD also revealed several problems, including a relatively lower success rate and satisfaction,a relative higher rate of postoperative long-term chronic low back pain and the possibility of recurrence, despite the low opportunity. Therefore, the main difference between these two treatments was related to postoperative complications and satisfaction and recovery rates. We suggest that, in the future, multi-center studies, which recruit a larger number of patients, should be undertaken to better understand the clinical relevance of these complications.

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