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Changes in Back Pain After Percutaneous Endoscopic Lumbar Discectomy and Annuloplasty for Lumbar Disc Herniation: A Prospective Study

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Abstract

Objective. Percutaneous endoscopic lumbar discectomy and annuloplasty (PELDA) is a minimally invasive spinal technique for lumbar disc herniation. Following discectomy, the relief of leg pain is common; however, the relief of back pain is less predictable. The purpose of this study was to evaluate changes in back pain and to examine the predisposing factors for postoperative back pain following PELDA.

Design. In this prospective study, 58 patients with leg and back pain associated with disc herniation underwent PELDA. The patients were divided into two groups: unfavorable and favorable. Patients were defined as having unfavorable outcomes if the percentage improvement of back pain <50% or the postoperative Oswestry Disability Index (ODI) >20% at postoperative 24 months. The preoperative demographic, clinical, and radiologic factors for each group were statistically analyzed.

Results. Fifty-two patients were enrolled in this study. The mean visual analog scale scores for back pain and the ODI scores significantly improved from 6.6 and 55.9% preoperatively to 2.5 and 12.7% at the 24-month follow-up. The surgical satisfaction rate was 78.4% at the final follow-up. Eighteen (34.6%) patients had unfavorable outcomes. Patients with advanced disc degeneration of operative levels had significantly worse outcomes than those with mild disc degeneration (odds ratio: 6.316, 95% confidence interval 1.25–31.86, $P < 0.05$). The severity of postoperative back pain was negatively correlated with surgical satisfaction (correlation coefficient: –0.564, $P = 0.00$).

Conclusion. PELDA can relieve back pain as well as leg pain through direct decompression and thermal ablation of the annular defect. Disc degeneration can be expected to influence clinical outcomes following PELDA.

Key Words. Back Pain; PELDA; Disc Degeneration

Introduction

Percutaneous endoscopic lumbar discectomy (PELD) has many advantages when compared with open lumbar discectomy. The advantages of PELD include quick rehabilitation, reduced anatomical trauma, facilitation of revision operation, and relative preservation of disc height when treating lumbar disc herniation [1,2]. Minimal invasive lumbar discectomy resulted in less postoperative back pain when compared with open lumbar discectomy [3]. Following discectomy, the relief of leg pain is common; however, the relief of back pain is less predictable. The cause of low back pain is unclear, and the pain may vary in intensity, often being severe enough to disrupt normal daily activities. Management of postoperative back pain has been associated with substantial health care costs [4]. Although a few reports have evaluated back pain after open lumbar discectomy [5–7], there are few studies of back pain following PELD [8,9]. Therefore, in this prospective study, we evaluated changes in back pain and examined the predisposing factors for postoperative back pain after percutaneous endoscopic lumbar discectomy and annuloplasty (PELDA).

Methods

After obtaining approval from our Institutional Review Board for this study, written informed consent was obtained. In this prospective study, we enrolled 58 patients who underwent PELDA between August 2007 and January 2008 to treat lumbar disc herniation. There were 35 male and 23 female patients whose ages ranged from 17 to 68 years (mean 35 years). All patients

presented with sciatica and back pain that did not improve with conservative treatment for a minimum of 6 weeks. All patients underwent plain radiographs, magnetic resonance imaging (MRI), and computed tomography (CT). For inclusion in the study, the patients were required to have an obvious disc herniation that caused compression of a nerve root corresponding to the dermatomal distribution of the leg symptoms. The exclusion criteria included foraminal, extra-disc herniation, multilevel disc herniation, spinal stenosis, spondylolisthesis, scoliosis, prior lumbar surgery, spinal infection, spinal tumor, and a history of hip or knee arthritis.

Radiologic Assessment

The radiological assessments were performed preoperatively by an independent observer other than the treating surgeons. The disc height and disc height index were evaluated using the method described by Inoue et al. [10]. The herniated disc type was classified as protrusion, extrusion, and migration, which meant the location was superior or inferior beyond the disc space with continuity of the disc [11]. The location was classified as central or paracentral. The size was measured as the degree of herniated disc compromising the spinal canal (≥50% and <50%; [12]). The degree of disc degeneration was evaluated at the herniated disc level using sagittal T2-weighted MRI (repetition time 3,514.4 ms, echo time 110.0 ms) with an Intera 1.5 Tesla (Philips, Eindhoven, The Netherlands) and a slice thickness of 4 mm. The degenerative status of the disc was classified into five grades, according to the classification system suggested by Pfirrmann et al. [13]. Adjacent level disc degeneration was characterized as the presence of a high-intensity zone or a black disc, which was defined by a grade higher than Pfirrmann grade III for the whole lumbosacral spine except for the operative level in the sagittal T2-weighted image. Signal changes in the vertebral end plate observed with MRI were classified as described by Modic et al. [14]. Lateral recess stenosis was defined as a lateral recess measurement of less than 3 mm on the bone window setting of the CT scan. Facet arthropathy was classified as described by Pathria et al. [15]. The mean facet angle between the right and left was measured using the method of Karacan et al. [16], and facet tropism was defined as a difference between the right and left facet angles. The cross-sectional areas (mm^2) of the multifidus muscle and psoas muscle at the level of the L4-5 disc space were measured on the T2-weighted axial image. The axial scans were aligned parallel to the vertebral end plate. The MRI scan measurements were made using PiView system software (Infinitt Co., Ltd., Seoul, Korea).

Clinical Assessment

Questionnaires with outcome measurements evaluating pain intensity and functional disability were completed preoperatively at the 1-, 6-, and 24-month follow-up visits, or during telephone interviews by the independent observer. At each follow-up, the back and leg pain intensity was measured using a visual analog scale (VAS, 0–10 points), and the functional status was assessed using the Oswestry Disability Index (ODI, 0–100%) with the Oswestry Low Back Pain Disability Questionnaire. Subjective surgical satisfaction was assessed by asking the patient the following question: "How satisfied were you by this operation?" We divided the patients into two categories: favorable outcome and unfavorable outcome. Unfavorable outcomes were defined if the percentage improvement of the postoperative VAS score for back pain was less than 50% compared with the preoperative VAS score, or if the postoperative ODI score was more than 20% when assessed at the 24-month follow-up. Favorable outcomes were defined as the absence of all unfavorable outcomes.

We analyzed the demographic, clinical, and preoperative radiographic variables that influenced back pain following PELDA. The sample size was calculated in consideration of our main hypothesis: that the proportion of advanced disc degeneration (Pfirrmann grade > III) in the unfavorable group would be larger than in the favorable group. We analyzed the data with a two-sample proportion test. The proportion of advanced disc degeneration in the favorable group was 0.4, and the proportion in the unfavorable group was 0.8, according to a small pilot study. A significant difference between the two groups can be detected at 5% significance level and at 80% power in a total sample of 36 patients. Assuming a follow-up success rate of approximately less than 60% in the study, a total of 58 patients were selected for the study.

Occupational activity was divided into three categories according to the following physical criteria, i.e., light work (office job), medium strenuous work (including household tasks), and heavy work (construction workers, farmers; [17]).

One blinded radiologist analyzed the preoperative radiological findings. Statistical analyses were performed using SPSS for Windows (version 17.0 K, SPSS, Inc., Chicago, IL, USA). Depending on the variables, intergroup differences were analyzed. A result was considered statistically significant if the P value was less than 0.05.

Surgical Techniques

In all of the patients, the PELDA procedure was performed under local anesthesia in the prone position on a radiolucent table. Before beginning the treatment, the patients were informed of all the steps in the procedure. The patients communicated with the surgeon during the entire procedure. The skin entry point was generally 10–12 cm from the midline. After infiltration of the entry point with local anesthetics, an 18-gauge spinal needle was introduced under the guidance of a fluoroscopic image. 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. Next, an epidurogram was performed using contrast media to confirm the location of the exiting root and the traversing root. After inserting the spinal needle into the disc, the nucleus pul-

Table 1 The overall clinical results after PELDA

	VAS_{Back}	VAS_{Leg}	ODI (%)	Satisfaction Rate (%)
Preop	6.6 ± 1.8	7.6 ± 1.9	55.9 ± 17.0	
Postop 1 month	4.2 ± 2.7	3.3 ± 2.8	34.0 ± 19.8	68.5 ± 23.1
Postop 6 months	2.8 ± 2.0	1.7 ± 1.3	19.1 ± 18.8	73.4 ± 18.5
Postop 2 years	2.5 ± 2.0	1.8 ± 1.1	12.7 ± 10.9	78.4 ± 21.8

ODI = Oswestry Disability Index; PELDA = percutaneous endoscopic lumbar discectomy and annuloplasty; VAS = visual analog scale.

posus was stained blue with a 1-mL mixture of contrast media and indigo carmine for discography. Then the following steps were performed: 1) a guide wire was inserted through the spinal needle; 2) the spinal needle was removed; 3) a small incision was made in the skin at the entry site; 4) a tapered cannulated obturator was inserted along the guide wire; 5) after touching the annulus, the obturator was inserted into the disc by hammering; and lastly 6) a bevel-ended, oval-shaped working cannula was inserted into the disc along the obturator after which the obturator was removed. Next, an endoscope was inserted through the cannula. The pathologic nucleus was stained for easy discrimination. The blue-stained disc was removed using endoscopic forceps and a side-firing holmium:yttrium-aluminum-garnet (Ho:YAG) laser using the "in and out" technique by working from the central portion to the lateral portion of the disc space on the anteroposterior image [2]. The inflamed nucleus was observed as being anchored by the annular fissure. The herniated disc and fibrotic scar tissues were released and removed using endoscopic forceps and side-firing Ho:YAG laser. In the meantime, the inflamed annulus and fibrotic tissues containing free nerve endings and new vessels were treated with a bipolar radio frequency (RF) probe and laser. After the herniated fragment was completely removed, the endoscope was removed, and a sterile dressing was applied with a 1-point suture.

Results

Fifty-two of the 58 patients were included in the follow-up. The remaining six patients were excluded due to loss to follow-up: two patients at 1 month, three patients at 6 months, and one patient at 24 months. The mean age of the 52 patients included in the follow-up was 36.2 years (range, 17–68 years), and there were 33 (63.5%) male patients and 19 (36.5%) female patients. One (1.9%) patient underwent PELDA treatment at L2-3, six (11.5%) underwent treatment at L3-4, 41 (78.9%) underwent treatment at L4-5, and four (7.7%) underwent treatment at L5-S1. The mean VAS scores for back pain preoperatively and postoperatively at the 1-, 6-, and 24-month follow-ups were 6.6 ± 1.8, 4.2 ± 2.7, 2.8 ± 2.0, and 2.5 ± 2.0, respectively. The mean VAS scores for leg pain preoperatively and at the 1-, 6-, and 24-month postoperative follow-ups were 7.6 ± 1.9, 3.3 ± 2.8, 1.7 ± 1.3, and 1.8 ± 1.1, respectively. The mean ODI scores preoperatively and the 1-, 6-, and 24-month postoperative follow-ups were 55.9 ± 17, 34 ± 19.8, 19.1 ± 18.8, and 12.7 ± 10.9, respectively. The postoperative satisfaction rates at 1, 6, and 24 months were 68.5 ± 23.1%, 73.4 ± 18.5%, and 78.4 ± 21.8%, respectively (Table 1). The improvement rate of back pain and ODI scores for the patients is shown in Table 2. Recurrent disc herniation occurred in three patients (5.8%) requiring surgery.

Eighteen patients (34.6%) had unfavorable outcomes. Three of the 18 patients subsequently underwent open surgery. These patients had operative discs with severe degenerative and Modic changes; two patients underwent lumbar microdiscectomy for recurrent disc herniation, and one patient had a total disc replacement for intractable back pain. The remaining 15 patients in the unfavorable outcome group continued conservative therapy and therapeutic exercise. There were no postoperative complications, such as infections, hematomas, or neurological complications. The demographic and geometric parameters of the favorable and unfavorable outcome groups are provided in Table 3. There was no significant difference in any of these parameters between the two groups. There was only a significant difference in the degree of disc degeneration between the two groups ($P < 0.05$). Patients with advanced disc degeneration of an operative level had significantly worse outcomes than those with mild disc

Table 2 The number of patients by improvement rate (%) of back pain and functional state

Improvement (%)	VAS_{back}	ODI
Complete relief	6	0
≥90	2	19
≥80	4	9
≥70	5	10
≥60	9	3
≥50	11	3
≥40	2	1
≥30	3	3
≥20	1	1
≥10	1	2
No change	0	0
Aggravation	8	1

ODI = Oswestry Disability Index; VAS = visual analog scale.

degeneration (odds ratio: 6.316, 95% confidence interval 1.25–31.86, $P < 0.05$; Table 4). Sixteen (45.7%) of the 35 patients with advanced disc degeneration (Pfirrmann grade > 3) showed unfavorable outcomes, while only two (11.8%) of the 17 patients with mild disc degeneration had unfavorable outcomes ($P < 0.05$). The other radiographic parameters had no significant influence on the outcome, including the existence of adjacent segment degeneration, herniation disc type, location, size, Modic change, disc height, facet arthropathy, and psoas and multifidus muscle volume. The back pain and ODI scores were significantly different between the two groups since the 6-month postoperative follow-up (Table 5). There was no significant difference in the preoperative clinical parameters between the two groups ($P < 0.05$). Additionally, we observed that postoperative back pain had an influence on surgical satisfaction. The severity of postoperative back pain was negatively correlated with surgical satisfaction (correlation coefficient: –0.564, $P = 0.00$).

Discussion

The association of back pain and lumbar disc herniation is still unclear. Rauschning suggested that when annular fissures occur, blood vessels, which are frequently accompanied by nociceptive pain fibers, sprout into the disc. The annular tears are sealed by cellular tissue, which is richly vascularized and innervated [18]. Additionally, pain sensations have been reported in the posterior longitudinal ligament (PLL) and the dura mater. Therefore, the back pain associated with disc herniation may originate from an annular tear or compression of the dura mater and PLL. Some authors have also reported that nerve root compression with disc herniation might be a cause of back pain [7,19].

PELD was reported to be effective in treating the leg pain associated with disc herniation [2,20]. Additionally, percutaneous endoscopic annuloplasty has been reported to

Table 3 The demographic and geometric parameters of the favorable and unfavorable groups

	Favorable Group	Unfavorable Group	*P* Value
N	34	18	
Age (years)	36.4 ± 15.9	35.8 ± 11.5	NS
Male	21	12	NS
Female	13	6	
Symptom duration (months)	5.4 ± 3.3	5.6 ± 5.1	NS
Preoperative dominant pain			NS
Back pain	8	3	
Leg pain	26	15	
History of trauma or accident	3	1	NS
Smoking	15	7	NS
Worker	24	12	NS
Heavy work	5	2	
Medium work	9	6	
Light work	10	4	
Level			NS
L2-3	1	0	
L3-4	4	2	
L4-5	27	14	
5-S1	2	2	
Body mass index (BMI) (BMI: kg/m^2)	24.3 ± 3.5	23.9 ± 2.3	NS

NS = non-specific.

Table 4 Preoperative radiologic parameters of favorable and unfavorable groups

	Favorable Group (34)	Unfavorable Group (18)	*P* Value
ASD* (–)	9	6	NS
ASD (+)	25	12	
Disc herniation			
Type			
Protrusion	10	7	NS
Extrusion	18	9	
Migration	6	2	
Location			
Central	9	5	NS
Paracentral	25	13	
Size			
<50% canal compromise	31	16	NS
≥50% canal compromise	3	2	
Lateral recess stenosis	5	2	NS
Disc height	11.2	10.9	NS
Disc height index	0.3	0.3	NS
Disc degeneration			
≤3	15	2	0.016†
>3	19	16	
Facet arthropathy			
<2	20	11	NS
≥2	14	7	
Modic change			
(–)	27	14	NS
(+)	7	4	
Facet angle (°)	42.1	43.9	NS
Facet tropism (°)	4.7	5.3	NS
CSA‡ of psoas m. (mm^2)	1,466.6	1,355.9	NS
CSA of multifidus m. (mm^2)	787.6	720.4	NS

* ASD: Adjacent segment degeneration.
† Comparison made using chi-square test.
‡ CSA: Cross sectional area.
NS = non-specific.

Table 5 Preoperative and postoperative clinical features of favorable and unfavorable groups

	Favorable Group	Unfavorable Group	*P* Value
Preop			
VAS of back	6.7 ± 1.9	6.5 ± 1.7	NS
VAS of leg	7.4 ± 2.1	8.1 ± 1.3	NS
ODI (%)	55.6 ± 18.4	56.6 ± 17.0	NS
Postop 1 month			
VAS of back	3.8 ± 2.7	5.0 ± 2.6	NS
VAS of leg	3.4 ± 3.1	3.2 ± 2.3	NS
ODI (%)	31.7 ± 16.3	38.6 ± 25.0	NS
Satisfaction rate (%)	72.2 ± 22.1	61.4 ± 24.1	NS
Postop 6 months			
VAS of back	2 ± 1.3	4.3 ± 2.4	0.002*
VAS of leg	1.8 ± 1.1	1.7 ± 1.5	NS
ODI (%)	15.4 ± 18.5	26.2 ± 17.7	0.01*
Satisfaction rate (%)	78.2 ± 17.7	64.3 ± 16.8	0.008*
Postop 2 years			
VAS of back	1.5 ± 1.4	4.3 ± 1.8	0.017*
VAS of leg	1.8 ± 1.1	1.7 ± 0.9	NS
ODI (%)	7.9 ± 6.1	21.9 ± 12.2	0.015*
Satisfaction rate (%)	83.8 ± 20.5	68.2 ± 21.2	0.011*
Improvement (%) of back VAS	81.2 ± 17.7	33.8 ± 23.3	0.006*

* Comparison made using Mann–Whitney *U*-test.
NS = non-specific; ODI = Oswestry Disability Index; VAS = visual analog scale.

result in satisfactory outcomes in treating discogenic back pain [9,21]. Ahn and Lee suggested that when treating central disc herniation, positive results can be expected in younger patients [9]. Wang et al. reported that after PELD, discogenic low back pain improved, as measured by a change in the VAS score from 7.3 to 1.6, and the success rate was 65.4% [8].

To be precise, the technique we applied in this study should be called PELDA. PELDA not only decompresses the dural sac and intradiscal pressure, but it also ablates new vessel nerve formation and granulation around the annular fissure [18,22]. Kapural et al. reported that the bipolar RF was effective in treating painful degenerative disc disease (DDD) in a study with a short-term follow-up [23]. In a randomized and placebo-controlled trial, 40% of patients had greater than 50% pain relief after undergoing thermal ablation for painful DDD [24]. While intradiscal electrothermal therapy and percutaneous nucleoplasty are blind procedures under fluoroscopic guidance and indirect decompression, PELDA directly removed the compressing extradural fragment and anchoring disc fragment in the annular fissure. PELDA achieved 1) decompression through removal of the disc fragment and reduction of the intradiscal pressure; and 2) thermal ablation with RF and laser, which repaired the annular defect of neoinnervation and neovascularization. Postoperative mechanical back pain following open discectomy is not uncommon. Parker et al. reported that 32% of patients reported above moderate back pain after lumbar discectomy, and 9% suffered severe back pain and subsequently underwent fusion surgery [4]. Moreover, Hanley and Shapiro reported that 14% of patients suffered from disabling back pain after discectomy [6].

Our results demonstrate that PELDA alleviated back pain and improved functional status, and these results were clinically significant and stable at the 24-month follow-up. Using strict criteria, we observed a favorable outcome (>50% pain relief and ODI score <20%) for back pain in 65.4% of patients. Back pain became worse in eight patients (15.4%) compared with their preoperative pain. These patients had moderate back pain, and reported that their VAS scores increased from 3 to 7. Previous research has reported the following predisposing factors for back pain following lumbar discectomy: heavy work [17], long smoking history [6], wide discectomy [25], being female, workmen's compensation [6,26], and disc degeneration [27]. Patients with advanced disc degeneration of an operative level had unfavorable outcomes and low surgical satisfaction in this study. Young patients with advanced degenerative discs before surgery were likely to experience severe postoperative back pain after discectomy [28]. Coppes et al. reported that severely degenerated discs have more extensive disc innervations with neuroanatomic substrates for discogenic pain [29]. In PELDA, only the level of disc degeneration affects the postoperative back pain. Disc degeneration may not only cause back pain, but it also may aggravate back pain by loading the facet joint and affecting the vertebral body.

There are some limitations in this study. Firstly, the study had a short follow-up period. Secondly, postoperative radiologic changes were not considered. Thirdly, psychological factors, postoperative analgesic use, and workmen's compensation were not considered.

Conclusion

PELDA can relieve back pain associated with disc herniation as well as leg pain through decompression and thermal ablation of annular defects in selected patients. For patients with advanced disc degeneration, PELDA is more likely to result in unfavorable outcomes and lead to postoperative back pain following surgery.

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