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Retrospective Study

Percutaneous Endoscopic Lumbar Discectomy for Lumbar Disc Herniation with Modic Changes via a Transforaminal Approach: A Retrospective Study

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Background: The surgical selection for patients with lumbar disc herniation (LDH) with Modic changes (MCs) is still contentious. Percutaneous endoscopic lumbar discectomy via a transforaminal approach (TF-PELD) as a representative minimally invasive spine surgery technique for LDH has been standardized. However, its efficacy has not been thoroughly described in the patients with LDH with MCs.

Objectives: The goal of this study was to assess the clinical outcomes of TF-PELD in the treatment of LDH and MCs.

Study Design: Retrospective study.

Setting: Inpatient surgery center.

Methods: From January 2015 to December 2016, 276 patients with LDH showing normal or MCs signals in their bone marrow in our hospital were enrolled in this retrospective study. All patients suffered low back and leg pain because of LDH and underwent the TF-PELD procedure. Clinical outcomes were assessed according to the Visual Analog Scale (VAS) for back pain and leg pain, Oswestry Disability Index (ODI) for functional status assessment, and modified MacNab criteria for patient satisfaction.

Results: A total of 182 patients showed normal intensity, 44 patients showed Modic type 1 signals, and 50 patients showed Modic type 2 signals before surgery. The postoperative VAS and ODI scores were significantly improved compared with those preoperatively among the groups. In the Modic type 1 and 2 signals groups, however, the postoperative VAS scores for back pain and ODI scores showed an upward trend with the follow-up time extending. The recurrence rates were 4.4%, 9.1%, and 8.0% in the normal, Modic type 1 and 2 signals groups, respectively. The recurrence rates and satisfaction rates showed no significant difference among the groups at the final follow-up.

Limitations: This study has a small sample size and the follow-up period was too short. There is no comparison with other therapeutic options such as fusion surgery or the lack of any other treatment.

Conclusions: TF-PELD is an option for treatment of patients with LDH even if the patients show MCs. However, the postoperative back pain and functional status have the trend of deterioration with the time extending in patients with MCs, especially in the Modic type 1 signals.

Key words: Modic changes, Modic type 1, Modic type 2, transforaminal percutaneous endoscopic lumbar discectomy, lumbar disc herniation, back pain, recurrence, complication

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Percutaneous endoscopic lumbar discectomy via a transforaminal approach (TF-PELD) is a minimally invasive spinal procedure that preserves the stabilizing elements of the spine and avoids epidural scar formation (1-3). Advances in instrumentation such as a working cannula, endoscope, laser, and radiofrequency probe have popularized TF-PELD as a representative minimally invasive spine surgery technique for lumbar disc herniation (LDH), and the surgical technique involved has been standardized (4).

However, for patients with LDH showing Modic changes (MCs) in their bone marrow at the corresponding level, determination of discectomy or fusion surgery for treatment is still contentious. MCs first described by Modic et al (5,6) are vertebral endplate and vertebral bone marrow changes visible on magnetic resonance imaging (MRI). Many studies demonstrated that disc degeneration with MCs was frequently associated with instability and low back pain associated with instability (7-9). Traditional surgical treatments including various decompression methods by laminectomy and facet joint resection unavoidably increase spinal instability. Moreover, lumbar fusion and internal fixation are usually needed at the mean time for reconstruction of spinal stability. Although TF-PELD has been employed to minimize the manipulation of surrounding tissue, reduce postoperative pain, and decrease complication rates (10,11), its efficacy has not been thoroughly described in patients with LDH with MCs. The purpose of the current study was to assess the clinical outcomes of the TF-PELD procedure in the treatment of symptomatic LDH with MCs.

Methods

The study was approved by our institutional review board. From January 2015 to December 2016, 318 patients with LDH showing normal or MCs signals in their bone marrow in our hospital were enrolled in this retrospective study (Fig. 1). Inclusion criteria were: (1) unilateral radicular pain, (2) single-level intracanal disc herniation, and (3) failure of ≥ 6 weeks of conservative treatment. Patients with definite congenital anomalies, including lumbarization, spondylolysis, instability, foraminal/extraforaminal disc herniation, and lateral recess stenosis were excluded.

Surgical Procedures

The TF-PELD procedure was performed under local anesthesia with the patient in the prone position on a radiolucent table. Under anteriorposterior and lateral C-arm fluoroscopy, the surgical segment and puncture needle entry point was determined. The skin entry point was generally superior to the iliac crest and 10 to 13 cm from the midline. After infiltration of the entry point with 3 to 5 mL of 1.0% lidocaine, an 18-gauge spinal needle was introduced, further advanced through the foramen to the target superior vertebral notch and slid to the facet joint cautiously under C-arm fluoroscopic guidance. A guidewire was advanced through the 18-gauge needle, and a 7-mm incision was made in the skin at the entry site. The dilator and cannula were subsequently inserted. If the cannula was blocked by the facet joint because of a small angle, the intervertebral foramen was enlarged with a trephine. After placement of the working cannula, a working channel endoscope, with an eccentrically placed working channel and irrigation channels, was inserted . Under the endoscope, the herniated disc was removed using endoscopic forceps and rongeurs until the traversing nerve root relieved completely. When hemostasis was achieved, the endoscope and working cannula were removed, and the incision was closed in a layered fashion.

MRI Evaluation

For evaluation of disc herniation, we categorized the patients as having disc degeneration, bulging, protrusion, extrusion, or sequestration as described by MacNab criteria. Endplate abnormalities were divided into those with normal intensity signals on MRI (normal), those with Modic type 1 signals (low intensity on T1-weighted spin-echo images and high intensity on T2-weighted spin-echo images), those with Modic type 2 signals (high intensity on both T1- and T2-weighted spin-echo images), and those with Modic type 3 signals (low intensity on both T1- and T2-weighted spin-echo images). Evaluation of the type of disc herniation and endplate (bone marrow) was blinded and performed by 3 observers. If at least 2 of the observers agreed, their classification was used to define the intervertebral disc herniation and endplate changes.

Outcome Measurements and Follow-Up

Patient follow-up was performed by outpatient visits. In addition to the general parameters such as complications and recurrences, the Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) scores at 3 months, at one year, and during the final follow-up were evaluated. Patient satisfaction was evaluated using the modified MacNab criteria at the final follow-up.

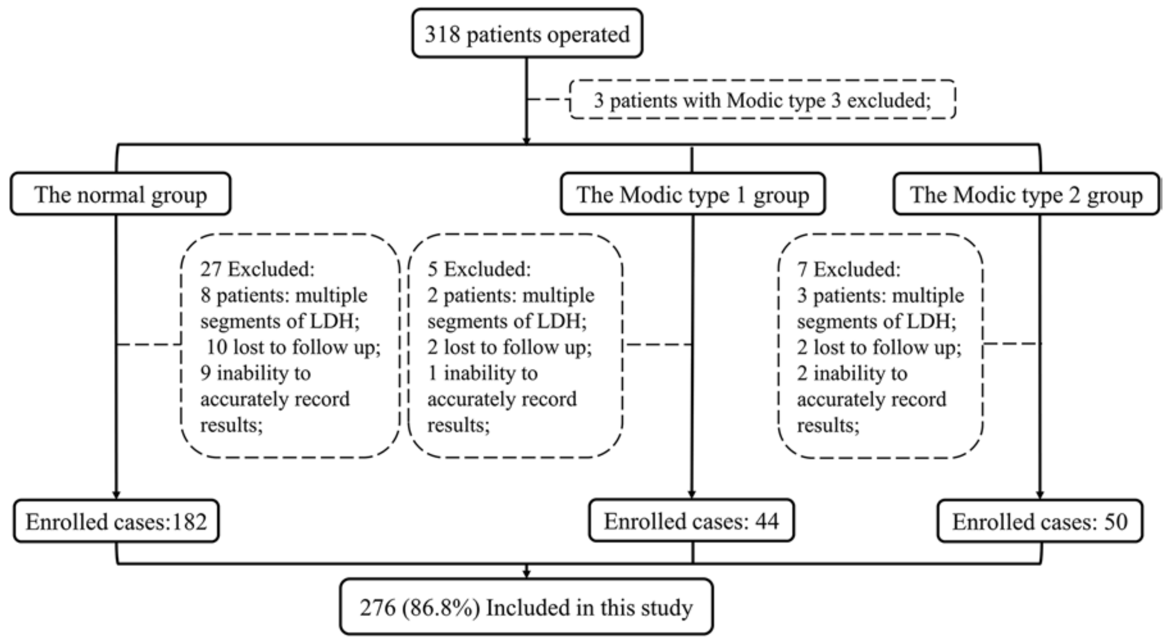

Fig. 1. *Flow chart of included study population.*

Statistical Analysis

SPSS Version 22.0 (IBM Corporation, Armonk, NY) software was used to analyze all the statistical data. Enumeration data were analyzed using the chi-square goodness of fit test. Measurement data were presented as mean ± standard deviation and analyzed using the t test. The paired t test was adopted to compare the statistical difference between preoperation and postoperation, whereas between-group data were analyzed using an independent-sample test. *P* value < 0.05 was considered as statistical significance.

Results

Patient Demographic Characteristics

A total of 276 patients completed a minimum of 2 years of follow-up and were enrolled in this study. A total of 182 patients showed normal intensity, 44 patients showed Modic type 1 signals, and 50 patients showed Modic type 2 signals before surgery (Fig. 1). Because of the relatively high rate of concurrent spinal stenosis and disc herniation, and a very small percentage of the number of patients seen, patients with Modic type 3 signals were excluded. Patients from the 3 groups had similar demographic characteristics as shown in Table 1. No statistically significant differences were noted in age, gender, body mass index, duration of symptoms, levels involved, and mean time of follow-up among the groups.

Clinical Outcomes

Table 2 details the preoperative and postoperative VAS and ODI scores of the patients. The VAS scores for leg pain were significantly improved from 6.7 ± 2.0, 6.9 ± 1.8, and 6.7 ± 1.9 preoperatively to 1.9 ± 1.5, 2.0 ± 1.3, and 2.1 ± 1.4 at 3 months after surgery in the normal group, Modic type 1 signals group, and Modic type 2 signals group, respectively, demonstrating a relatively consistent improvement during follow-up and without a significant difference among the 3 groups (*P* > 0.05). In the normal group, the VAS scores for back pain and ODI scores were significantly decreased from 5.0 ± 2.5 and 53.1 ± 17.6 preoperatively to 2.0 ± 1.6 and 16.9 ± 5.8 at 3 months after surgery, respectively, and maintained at final follow-up. In the Modic type 1 and 2 signals groups, the VAS score for back pain significantly decreased from 5.4 ± 2.2 and 5.2 ± 2.4 preoperatively to 2.2 ± 1.2 and 2.2 ± 1.4 at 3 months after surgery, and increased to 4.0 ± 2.0 and 3.0 ± 2.0 at the final follow-up, respectively. The ODI scores significantly decreased from 58.6 ± 16.4 and 56.0 ± 15.0 preoperatively to 18.5

Table 1. *Demographic characteristics of the 3 groups.*

Demographic Characteristics	Normal Group	Modic Type 1 Group	Modic Type 2 Group	P_1	P_2
Numbers	182	44	50		
Age (years)	38.8 ± 11.9	41.5 ± 13.6	42.9 ± 13.6	0.192	0.060
Male/female	114/68	28/16	30/20	0.902	0.734
Body mass index (kg/m²)	23.7 ± 3.9	24.5 ± 3.8	24.5 ± 4.0	0.229	0.184
Duration of symptoms (years)	8.3 ± 4.8	8.8 ± 5.4	9.5 ± 5.3	0.558	0.133
L3-4/L4-5/L5-S1	18/92/72	4/26/14	3/26/21	0.584	0.694
Classification					
degeneration	0	0	0	-	-
bulging	4	2	0	0.331	0.376
protrusion	102	21	24	0.204	0.197
extrusion	42	14	14	0.156	0.292
sequestration	34	7	12	0.428	0.258
Mean follow-up (months)	29.6 ± 6.7	30.2 ± 6.6	28.8 ± 6.7	0.589	0.421

P_1 and P_2 represented the *P* value between the normal group, the Modic type 1 group, and the Modic type 2 group, respectively.

Table 2. *Clinical outcomes of the 3 groups.*

	Normal Group	Modic Type 1 Group	Modic Type 2 Group	P_1	P_2
VAS for low back pain	-	-	-	-	-
Preop	5.0 ± 2.5	5.4 ± 2.2	5.2 ± 2.4	0.399	0.698
3-month Postop	2.0 ± 1.6*	2.2 ± 1.2*	2.2 ± 1.4*	0.342	0.502
1-year Postop	2.0 ± 1.2*	3.8 ± 1.2*	2.6 ± 1.4*	< 0.001	0.003
Final follow-up	2.0 ± 1.1*	4.0 ± 2.0*	3.0 ± 2.0*	< 0.001	0.001
VAS for leg pain	-	-	-	-	-
Preop	6.7 ± 2.0	6.9 ± 1.8	6.7 ± 1.9	0.498	0.877
3-month Postop	1.9 ± 1.5*	2.0 ± 1.3*	2.1 ± 1.4*	0.970	0.572
1-year Postop	1.8 ± 1.0*	1.8 ± 1.0*	1.8 ± 1.1*	0.825	0.893
Final follow-up	1.7 ± 1.0*	1.8 ± 1.2*	1.7 ± 1.2*	0.583	0.809
ODI	-	-	-	-	-
Preop	53.1 ± 17.6	58.6 ± 16.4	56.0 ± 15.0	0.063	0.294
3-month Postop	16.9 ± 5.8*	18.5 ± 6.7*	17.9 ± 6.7*	0.094	0.278
1-year Postop	15.5 ± 4.7*	26.5 ± 6.8*	22.4 ± 6.6*	< 0.001	< 0.001
Final follow-up	15.8 ± 5.6*	32.9 ± 10.7*	26.8 ± 8.3*	< 0.001	< 0.001

P_1 and P_2 represented the *P* value between the normal group, the Modic type 1 group, and the Modic type 2 group, respectively.
Abbreviations: Preop, preoperation; Postop, postoperation.
*Compared with Preop, $P < 0.05$.

± 6.7 and 17.9 ± 6.7 at 3 months after surgery, and increased to 32.9 ± 10.7 and 26.8 ± 8.3 at final follow-up, respectively. The postoperative VAS scores for back pain and ODI scores showed an upward trend with the follow-up time extending in patients with MCs, and were the highest in the patients with Modic type 1 signals among the 3 groups.

Complications and Recurrence

Postoperative transient dysesthesia is the most common complication after surgery, which occurred in 9 patients in the normal group, 2 patients in the Modic type 1 signals group, and 3 patients in the Modic type 2 signals group. Additionally, nerve root injury occurred in 3 patients in the normal group, one patient

Fig. 2. *Preoperative T1-weighted sagittal (A), T2-weighted sagittal (B), fat-suppressed sagittal (C), and axial (D) MRI of a woman aged 36 years who complained of left leg radiating pain, showed L4-5 disc herniation with Modic type 1 signals in the bone marrow. Intraoperative radiography showed an endoscopic working channel (E). Intraoperative endoscopic view showed the herniated disc was removed, and the left L5 nerve root was decompressed completely (F-G). Postoperative T2-weighted sagittal (H) and axial (I) MRI showed the decompression of nerve root and removal of the herniated disc at the L4-5 level.*

in the Modic type 1 signals group, and one patient in the Modic type 2 signals group. The complication rates were 6.6%, 6.8%, and 8.0% in the normal group, Modic type 1, and Modic type 2 signals groups, respectively. Recurrence occurred in 8 patients in the normal group, 4 patients in the Modic type 1 signals group, and 4 patients in the Modic type 2 signals group. The recurrence rates were 4.4%, 9.1%, and 8.0% in the 3 groups, respectively. According to the modified MacNab criteria, the excellent and good rate were 90.7%, 88.6%, and 92.0% in the 3 groups at the final follow-up, respectively (Table 3, Figs. 2 and 3).

Discussion

Lumbar discectomy is an effective and safe surgical treatment for low back pain and radiculopathy associated with herniated disc, particularly in symptoms refractory to conservative management, but with inconsistent outcomes for patients with LDH with preoperative presence of MCs (8,12-15). Many studies demonstrated that MCs were considered to be signs of mechanical instability and low back pain associated with instability (7-9). A wide excision of the paraspinal muscle and facet joints, and removal of the nucleus pulposus certainly increases spinal instability after the traditional lumbar discectomy. For reconstruction of spinal stability, lumbar fusion and internal fixation are usually needed, and even performing cementoplasty at the operative level has been suggested by some authors (16). However, it is also known that surgical fusion can cause mechanical disruption to adjacent vertebral levels, leading to increased risk of degenerative change over time in these locations (17,18). As a minimally invasive spine surgery technique, the TF-PELD procedure has several advantages, including less paravertebral muscle injury, preservation of stabilizing elements, and improving function. In the current study, we found that TF-PELD had good results for treatment of the patients with LDH, even though the patients showing MCs and similar clinical outcomes as patients with LDH with normal signals in their bone marrow showed no spinal instability after surgery in our series.

Compared with the normal group, however, our results also suggest that the postoperative VAS scores for back pain and ODI scores in the MCs groups showed an upward trend with the follow-up time extending, espe-

Table 3. *Perioperative outcomes and recurrences of the 3 groups.*

Perioperative Outcomes	Normal Group	Modic Type 1 Group	Modic Type 2 Group	P_1	P_2
Complication	12 (6.6%)	3 (6.8%)	4 (8.0%)	0.588	0.466
Transient dysesthesia	9	2	3		
Nerve root injury	3	1	1		
Recurrences (rate)	4.4%	9.1%	8.0%	0.168	0.244
MacNab evaluation E/G rate	90.7%	88.6%	92.0%	0.433	0.512
Excellence	113	24	32		
Good	52	15	14		
Fair	12	3	3		
Poor	5	2	1		

P_1 and P_2 represented the P value between the normal group, the Modic type 1 group, and the Modic type 2 group, respectively.
Abbreviation: E/G: excellent/good.

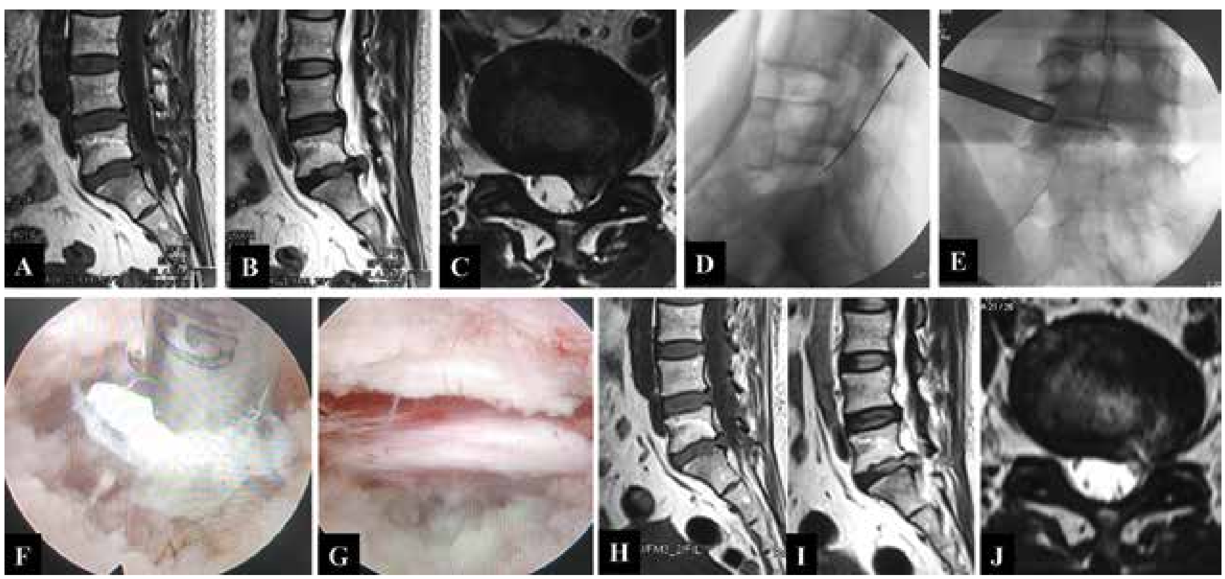

Fig. 3. *Preoperative T1-weighted sagittal (A), T2-weighted sagittal (B), and axial (C) MRI of a woman aged 52 years who complained of left leg radiating pain, showed L5-S1 disc herniation with Modic type 2 signals in the bone marrow. Intraoperative radiography showed an endoscopic working channel (D-E). Intraoperative endoscopic view showed the herniated disc was removed using endoscopic forceps (F), and complete decompression the left S1 nerve root (G). Postoperative T1-weighted sagittal (H), T2-weighted sagittal (I), and axial (J) MRI showed the decompression of nerve root and removal of the herniated disc at the L5-S1 level.*

cially in the Modic type 1 signals. It has been reported that MCs are associated with pathology of endplate osteochondritis including disruption and fissuring of the endplate with regions of degeneration and regeneration and vascular granulation tissue (5,19). In cases of LDH with endplate osteochondritis, its use is limited because a discectomy does not address the endplate osteochondritis associated with degenerative lumbar disease. Sorlie et al (13) reported patients with symptomatic LDH and endplate osteochondritis with MCs had significantly lower levels of back pain reduction after microdiscectomy compared with those without endplate osteochondritis showing MCs. In a prospective study by Ohtori et al (8), the patients with LDH with or without MCs showed a similar improvement of VAS, Japanese Orthopedic Association, and ODI scores after lumbar discectomy, but a fusion surgery was recommended for these patients with the Modic type 1 signals. Although postoperative back pain and functional status have the trend of deterioration in our patients with MCs, none required fusion surgery later for persistent back pain.

There are a number of potential complications and concerns with TF-PELD for LDH. Neural injury is the common complication that is related to the transforaminal percutaneous endoscopic surgery itself, regardless of the MC subtypes. In our study, the incidence of postoperative transient dysesthesia or nerve root injury was 6.8% (19 of 276), which was slightly higher than that reported for microscopic discectomy (0-1.7%) (20). Most neural injuries occurred in the first 100 cases of TF-PELD. Fourteen patients experienced transient dysesthesia in the area of nerve root innervation in the immediate postoperative period, and the symptoms disappeared after a few days. Five patients suffered acute pain or weakness of the ipsilateral lower limb when performing insertion of the guiding needle or working cannula into the target zone, which caused nerve root injury. After conservative treatments, all patients recovered completely during the follow-up period.

It should be noted that recurrence of LDH with MCs is still possible after the TF-PELD procedure. Kim et al (21) reported a retrospective study to analyze the recurrence risk factors undergoing percutaneous endoscopic discectomy in patients with LDH. The results showed that MCs were highly involved in the recurrence after successful surgery. The author concluded that the higher recurrence rate could be explained by the unstable environment caused by Modic type 1 signals. Another retrospective study reported by Yao et al (22) demonstrated that endplate osteochondritis was one of the potential risk factors for recurrence after the percutaneous endoscopic discectomy procedure. The results of the current study showed the recurrence rates were 9.1% and 8.0% in the Modic type 1 and 2 signals groups, respectively, higher than that in the normal group, but there was no statistical difference among the 3 groups, altered inconsistently with the earlier mentioned studies. Considering the reason, it was possibly associated with controlling for potential confounders of the different MCs subtypes, which obtained a relatively reliable result in our study.

However, there were some limitations to this retrospective study. First, the study has a small sample size, and the follow-up period was too short. It is possible that the nature of postoperative back pain and function might have been underreported in the patients with LDH with or without MCs. Second, this study was led by one spine surgeon who had a great deal of endoscopic spinal surgery experience, and thus there is some limitation in terms of generalizing his experience and these findings to all spine surgeons. Finally, there is no comparison with other therapeutic options such as fusion surgery or the lack of any other treatment.

Conclusions

In the current study, TF-PELD improved low back pain and radiculopathy in patients suffering from LDH. Even though the patients showed MCs in bone marrow, their clinical outcomes similarly improved compared with that in the patients without MCs in their bone marrow. However, the postoperative back pain and functional status have the trend of deterioration with the time extending in patients with MCs, especially in the Modic type 1 signals.

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