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Original Article

Long-term radiological changes and clinical effect after microendoscopic discectomy (MED): a cross-sectional study

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Abstract: This study was designed to evaluate the post-operative radiological changes and assess the risk of post-operative back pain in patients who underwent microendoscopic discectomy (MED). We classified 132 patients into three groups based on follow-up duration. The patients in Groups 1-3 were followed up for 0-5, 5-10, and 10-15 years, respectively. Their clinical outcomes were assessed based on their self-reported scores on visual analog scales (VASs) to quantify back pain. Twelve radiological parameters indicating degenerative changes or instability in the operated segments were recorded at various time points. The patients were further classified into two groups based on their VASs: those with back pain and those without back pain. The independent risk factors for post-MED back pain were identified through bivariate logistic regression from among the risk factors selected via univariate analysis. The identified risk factors were then used to develop a scoring system that used regression coefficients to predict the probability of post-MED back pain. On the clinical effect assessment, the mean VAS scores for back pain in Groups 1-3 were 1.62 ± 0.69, 2.81 ± 1.44, and 3.07 ± 1.16, respectively. The scores in Group 1 differed significantly from those of Groups 2 and 3 ($p < 0.01$). On the radiological assessments, the mean posterior disc height ratios (PDHRs) in Groups 1-3 were 0.77 ± 0.21, 0.72 ± 0.18, and 0.67 ± 0.22, respectively ($p = 0.01$). A traction spur was observed in 17 of the 42 patients in Group 1, in 46 of the 48 patients in Group 2, and in 40 of the 42 patients in Group 3 ($p < 0.01$). Lateral listhesis was detected in 1 of the 42 patients in Group 1 and in 4 of the 42 patients in Group 3 ($p = 0.04$). Modic type 1 changes were observed in 15 (36%) patients in Group 1, 18 (38%) patients in Group 2, and 5 (12%) patients in Group 3 ($p = 0.01$). Modic type 2 changes were found in 5 (12%) patients in Group 1, 18 (38%) patients in Group 2, and 16 (38%) patients in Group 3 ($p = 0.01$). Modic type 3 changes were observed in 3 (7%) patients in Group 3 ($p < 0.01$). Other radiological parameters showed no significant differences. PDHR, traction spur, Modic changes, and lateral listhesis were considered the independent risk factors for post-MED back pain and were used as the basis for scoring system development. The established system was then utilized to divide the patients into two groups: -6.55 to -3.58 and > -3.58 points on the probability of post-surgical back pain. The accuracy of the scoring system was 62%. This cross-sectional study demonstrated that clinical effect deteriorates over time. High back pain scores corresponded to exacerbating clinical outcomes, and this condition was correlated with radiological findings of degeneration in the operated segments.

Keywords: Microendoscopic discectomy, back pain, risk factors, logistic regression model

Introduction

Microendoscopic discectomy (MED) is a safe and successful endoscopic approach with fine outcomes in treating lumbar disc herniation [1]. Compared with standard open discectomy, the MED procedure has better clinical outcomes, such as smaller incisions, less tissue trauma, shorter hospital stays, and faster recovery, all of which have been extensively investigated [2, 3]. It has been reported that approximately 5%-36% of all patients who undergo open discectomy complain of long-term back pain post-discectomy [4], and we found that a small proportion of patients who undergo MED complain of persistent back pain on long-term follow up at our hospital.

Long-term back pain post-discectomy correlates with radiological findings of degeneration

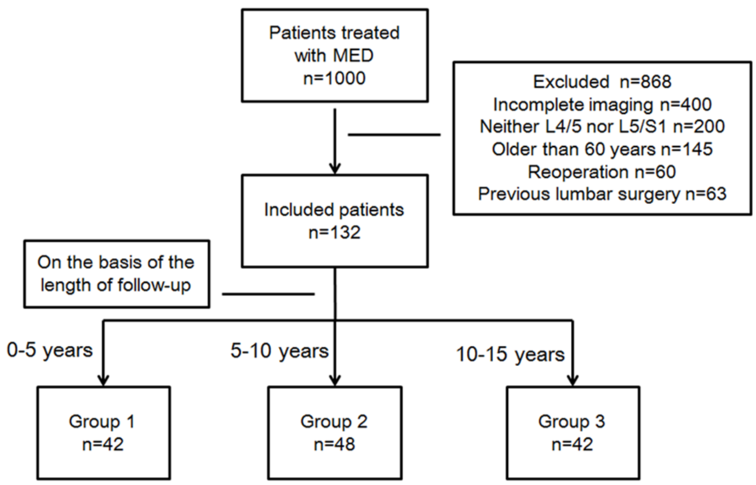

Figure 1. Flowchart of the study population. MED = microendoscopic discectomy.

Table 1. Clinical characteristic of patients in each group

Baseline characteristics	Group 1 n = 42	Group 2 n = 48	Group 3 n = 42	*p* value
Mean age, years	42.9 ± 14.6	44.4 ± 11.2	44.1 ± 11.9	0.84[a]
Male sex, n (%)	25 (59.5)	35 (72.9)	33 (78.6)	0.144[b]
Smoker, n (%)	16 (38)	18 (37.5)	15 (35.7)	0.97[b]
Herniated type				
Protrusions	13	16	13	0.96[b]
Extrusions	25	27	23	0.90[b]
Sequestrations	4	5	6	0.77[b]
Herniated level				
L4/5	20	26	18	0.56[b]
L5/S1	22	22	24	0.56[b]

[a]One way ANOVA, [b]Chi-square test.

and instability at the operated segment [5], but back pain has a very low specificity, and whether these radiological changes are linked to post-MED back pain remains unclear. To the best of our knowledge, studies have yet to compare radiological findings and clinical outcomes at different time points after surgery.

Our spine institute started to perform the MED procedure in 2000, but we have not reported any long-term evaluation of the clinical and radiological outcomes of MED. In this study, the incidences of several radiological observations were retrospectively reviewed to evaluate postoperative radiological changes systematically. Univariate and multivariate analyses were also performed to assess the risk of post-MED back pain.

Materials and methods

Participants

The experimental protocol and the study were approved by the Clinical Ethics Committee of Southeast University. For this type of study, formal consent is not required. We retrospectively examined a total of 132 patients who underwent MED for single-level lumbar disc herniation (LDH) at our spine center from February 2000 to April 2014 were selected (**Figure 1**). The following inclusion criteria were used: a single-level MED at either L4-5 or L5-S1, in which the last follow-up examination was between May 2015 and May 2016. Patients who had undergone a previous lumbar surgery, were older than 60 years at the time of the initial MED, or had been subjected to a reoperation within 15 years were excluded. Based on the length of follow-up, the included patients were divided into three groups: Groups 1-3 were followed up for 0-5, 5-10, and 10-15 years, respectively. The baseline characteristics of the included patients are shown in **Table 1**.

Clinical assessment

Clinical outcomes were assessed by having patients score any pain in their lower back and legs on visual analog scales (VASs) at the last time point of follow up as an outpatient. Meanwhile, patients were instructed to fill out the Short Form-36 (SF-36) questionnaire.

Radiological assessment

Local kyphosis was assessed at the operated segment by measuring the angle of the operated segment, that is, the angle between the lower endplate of the upper vertebral body and the upper endplate of the lower vertebral body. Lumbar lordosis was measured as the angle between the upper endplate of L1 and the lo-

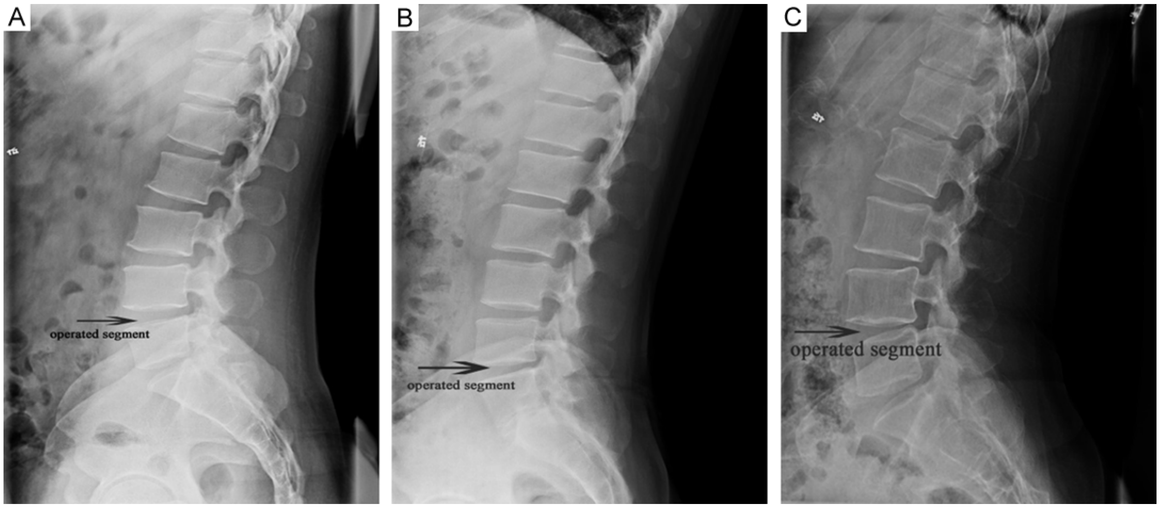

Figure 2. The original photos of different groups. Operated segment is L4/5, with the passing of time; the height of the intervertebral disc is reduced gradually (A: Group 1; B: Group 2; C: Group 3).

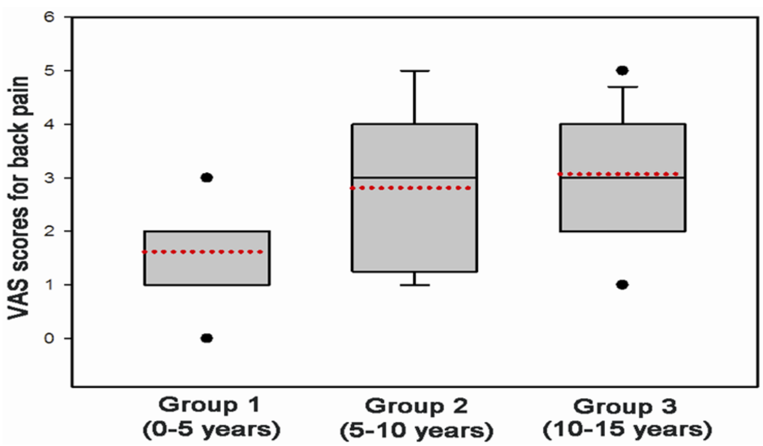

Figure 3. Box plots representing Visual Analogue Scale (VAS) for back pain at each assessment point. The red dotted line showed the mean of the three groups. The mean VAS scores for back pain in Groups 1-3 were 1.62 ± 0.69, 2.81 ± 1.44, and 3.07 ± 1.16, respectively. The Kruskal-Wallis test was used.

wer endplate of L5. The anterior disc height ratio (ADHR) was calculated as follows: anterior disc height of the operated segment divided by the anterior disc height of the upper segment. The posterior disc height ratio (PDHR) was calculated as follows: posterior disc height of the operated segment divided by the posterior disc height of the upper segment (**Figure 2**).

We only used the last follow-up lumbar radiographs of the three groups as assessment parameters in our study. The assessments were then performed with plain radiographs and were performed by two experienced and independent orthopedic surgeons. The observers were blinded to the clinical results and were not involved in the process of pre- or post-operative decision-making. The means of all measurements were calculated and incorporated into the final statistical analysis.

Statistical analysis

One-way ANOVA was employed to analyze the differences among the groups. A post hoc Bonferroni method was used to conduct multiple testing. The Kruskal-Wallis test was performed to analyze the differences among the groups when the data distribution was skewed. The chi-squared test was used to compare ratios among groups. Bivariate logistic regression models were adopted for examining the association between identified radiological findings and back pain. To facilitate the use of point numbers to calculate the scores, we multiplied the regression coefficients of the logistic regression model by 2 and rounded the resultant values. A p value less than 0.05 was used to indicate a statistically significant difference in the logistic regression model.

Results

VAS assessment

In the last follow-up, the mean VAS scores for back pain in Groups 1-3 were 1.62 ± 0.69, 2.81 ± 1.44, and 3.07 ± 1.16, respectively. The sc-

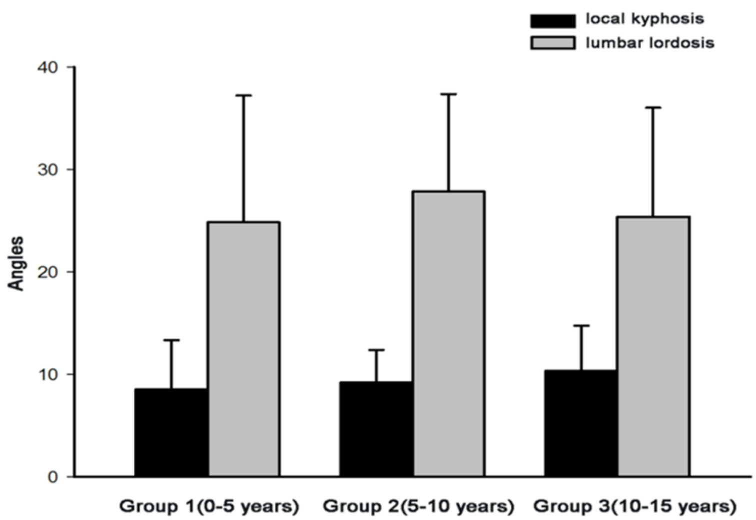

Figure 4. The mean local kyphosis and lumbar lordosis angles at the operated level in Groups 1-3. The mean local kyphosis angles at the operated level in Groups 1-3 were 8.52° ± 4.80°, 9.21° ± 3.17°, and 10.31° ± 4.43°, respectively. The mean lumbar lordosis angles in Groups 1-3 were 24.83° ± 12.39°, 27.83° ± 9.53°, and 25.38° ± 10.64°, respectively. The Kruskal-Wallis test was used.

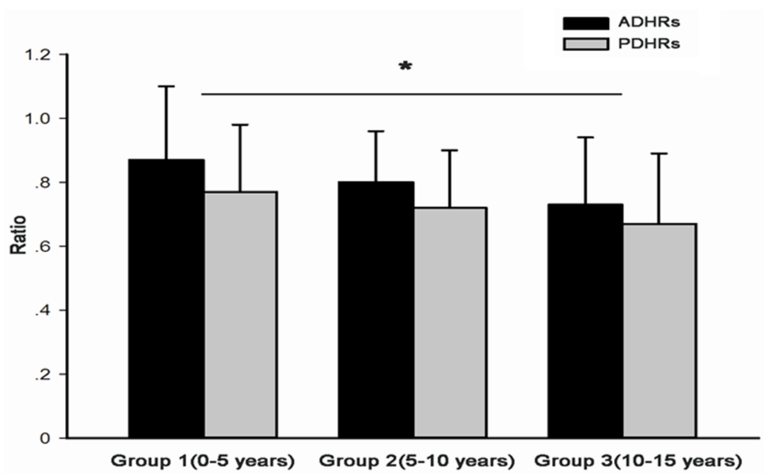

Figure 5. The mean ADHRs and PDHRs in Groups 1-3. The mean ADHRs in Groups 1-3 were 0.87 ± 0.23, 0.80 ± 0.16, and 0.73 ± 0.21, respectively (Groups 1 vs 3, $p = 0.02$, Bonferroni method after ANOVA). The mean PDHRs in Groups 1-3 were 0.77 ± 0.21, 0.72 ± 0.18, and 0.67 ± 0.22, respectively (Groups 1 vs 3, $p = 0.01$, Bonferroni method after ANOVA).

ores in Group 1 differed significantly from the scores in Groups 2 and 3 ($p < 0.01$). The scores of Groups 2 and 3 did not differ significantly (**Figure 3**).

X-ray radiological assessments

The mean local kyphosis angles at the operated level in Groups 1-3 were 8.52° ± 4.80°, 9.21° ± 3.17°, and 10.31° ± 4.43°, respectively. This finding suggested that local kyphosis increased with time. However, no significant differences in local kyphosis angles were observed among the three groups ($p = 0.14$). The mean lumbar lordosis angles in Groups 1-3 were 24.83° ± 12.39°, 27.83° ± 9.53°, and 25.38° ± 10.64°, respectively. Lumbar lordosis did not significantly differ among the three groups ($p = 0.37$, **Figure 4**). The lateral wedging angles in Groups 1-3 were 1° (0°-7°), 1° (0°-3°), and 0.5° (0°-7°), respectively ($p = 0.01$).

The mean ADHRs in Groups 1-3 were 0.87 ± 0.23, 0.80 ± 0.16, and 0.73 ± 0.21, respectively. This parameter significantly differed between Groups 1 and 3 ($p = 0.02$). The mean PDHRs in Groups 1-3 were 0.77 ± 0.21, 0.72 ± 0.18, and 0.67 ± 0.22, respectively. This parameter also significantly differed between Groups 1 and 3 ($p = 0.01$; **Figure 5**).

Traction spur was observed in 17 of the 42 patients in Group 1, in 46 of the 48 patients in Group 2, and in 40 of the 42 patients in Group 3. These rates suggested an increased prevalence of traction spurs among the patients in Groups 2 and 3. The prevalence of claw spur was significantly different among Groups 1, 2, and 3 ($p < 0.01$). A claw spur was observed in 5 of the 42 patients in Group 1, in 4 of the 48 patients in Group 2, and in 5 of the 42 patients in Group 3. The prevalence of claw spurs was not significantly different among the three groups ($p = 0.81$). Endplate sclerosis was detected in 5 of the 42 patients in Group 1, in 25 of the 48 patients in Group 2, and in 35 of the 42 patients in Group 3 ($p < 0.01$).

Anterior listhesis was noted in 2 of the 42 patients in Group 1, in 1 of the 48 patients in Group 2, and in 1 of the 42 patients in Group

Table 2. Univariate analysis of risk factors for the back pain post-surgery

Characteristic	OR	95% CI	*p* value*
Local Kyphosis	1.069	0.982-1.165	0.122
Lumbar Lordosis	1.026	0.993-1.060	0.128
Lateral wedging	0.963	0.769-1.207	0.746
ADHR	0.275	0.049-1.551	0.143
PDHR	4.476	0.773-25.918	0.094
Anterior listhesis	0.472	0.048-4.660	0.498
Retrolisthesis	0.987	0.963-1.012	0.304
Latera listhesis	6.160	0.669-56.719	0.068
Traction spur	3.032	1.468-6.261	0.002
Claw spur	1.094	0.357-3.354	0.875
Sclerosis	1.034	0.489-2.186	0.931
Modic change	2.677	1.272-5.633	0.009

*Univariate analysis was used. ADHR: The anterior disc height of operated segment divided by upper segment. PDHR: The posterior disc height of operated segment divided by upper segment.

3 (p = 0.74). Retrolisthesis was documented in 1 patient in Group 2. This condition was not found in any of the patients in Groups 1 or 3 (p = 0.36). Lateral listhesis was observed in 1 of the 42 patients in Group 1 and in 4 of the 42 patients in Group 3 (p = 0.04).

MRI radiological assessments

Modic type 1 changes were detected in 15 (36%) patients in Group 1, in 18 (38%) patients in Group 2, and in 5 (12%) patients in Group 3 (p = 0.01). Modic type 2 changes were found in 5 (12%) patients in Group 1, in 18 (38%) patients in Group 2, and in 16 (38%) patients in Group 3 (p = 0.01). Modic type 3 changes were observed in 3 (7%) patients in Group 3 (p < 0.01).

Analysis of risk factors for post-surgical back pain

The factors with p < 0.2 on the univariate analysis were local kyphosis, lumbar lordosis, ADHR, PDHR, lateral listhesis, traction spur, and Modic changes (**Table 2**). Eight factors with p < 0.200 were analyzed through binary logistic regression to eliminate potential confounding factors. PDHR, traction spur, Modic change, and lateral listhesis were verified as independent factors that could be used to predict post-surgical back pain. The regression coefficients (B-values) of the logistic regression model were multiplied by 2 and rounded to facilitate the use of point numbers for score calculation (**Table 3**). The patients were then divided into two groups: one group with a score < -3.58 points and the other group with a score of > -3.58 points. The right decision was made for patients without back pain in the lower-score group (< -3.58 points) and with back pain in the other group (-3.58 points). We calculated the model accuracy to assess the accuracy of the system. The overall discriminatory power of the final model was 0.62 (95% confidence interval, CI: 0.53 to 0.71).

Discussion

This study presents two novelties. (1) This study is the first to predict the probability of post-MED back pain by establishing a scoring system based on the regression coefficients of significant variables in a logistic regression model. Illness status can be evaluated exactly and objectively by combining the scoring system and clinical inquiry responses. Clinical inquiry can be partially supported by the scoring system. (2) This study describes long-term radiological changes after MED and their correlation with VAS.

In this study, patients with long-term follow-up presented moderate-to-severe radiographic degenerative and unstable changes more frequently than subjects with short-term follow-up. These changes were closely linked to an increased incidence of back or leg pain. MED, as a minimally invasive procedure, was introduced approximately 20 years ago in our institute. Similarly to previous studies [4, 6], our study revealed that patients who undergo lumbar discectomy frequently complain of back pain or leg pain. Scar tissue formation is part of the normal healing process after spine surgery. Scar tissue is generally thought to be the potential cause of patient pain if the tissue binds to lumbar nerve roots with fibrous adhesions [7]. Compared with conventional lumbar discectomy, MED causes less disruption of the back muscles. In this study, scar formation was disregarded as a potential factor because of the minimally invasive approach for MED. Instead, the degeneration and instability of the lumbar spine was considered the main cause of pain.

Disc space was also found to be an independent risk factor for post-MED back pain (p =

Table 3. Multivariate stepwise forward Logistic regression analysis of risk factors for the back pain

Variable	OR	95% CI	B	Scores	p value*
PDHR	0.025	0.002-0.278	-3.689	-7	0.003
Traction spur					
With	0.386	0.177-0.843	-0.952	-2	0.017
Without	1		0	0	
Modic change					
Present	2.392	1.054-5.431	0.872	2	0.037
Absent					
Lateral listhesis	1		0	0	
With	11.77	0.888-155.977	2.466	5	0.061
Without	1		0	0	

*Logistic regression analysis was used. B-values were regression coefficients.

0.003). As time progressed, the disc space narrowed after discectomy was performed, and this condition increased the load transmission on the corresponding facet joints. As a consequence, post-operative degenerative spondylitis occurred. In previous studies, patients encountered > 25% intervertebral space height loss after they undergo discectomy [8], and disc space narrowing is associated with back pain [9].

This study revealed that lateral listhesis (p = 0.061) and traction spur (p = 0.017) were independent risk factors for low back pain. Lateral listhesis is considered an indicator of segmental instability of the lumbar spine and a risk factor related to the progression of scoliosis. In our study, the weight of lateral listhesis in the scoring system was high. This finding strongly supported the link between this radiological parameter and back pain. A traction spur is also an indicator of the previous existence of instability in a stable lumbar spine. The weight of the traction spur was negative because traction spur is considered a protective factor that relieves low back pain among the numerous variables affecting low back pain.

Modic changes, designated dichotomous, were also considered an independent risk factor for back pain (p = 0.037). Our results are supported by the results described in other studies [10-12], which demonstrated that Modic changes are linked to low back pain. Modic changes possibly represent acute or chronic inflammatory changes in degenerative disc disease, as demonstrated by histopathological specimens of subchondral bone marrow with fibrovascular replacement [13]. In our study, M-odic type 1 changes were most commonly found in Group 1, and Modic type 2 changes were more frequent in Groups 2 and 3. Modic type 3 changes were seldom found in the three groups. These results likely occur because Modic type 1 changes may further degenerate into Modic type 2 changes over time after MED is completed; this phenomenon is attributed to the dynamic characteristics of Modic changes [14]. However, we cannot conclude that Modic changes mostly occur after surgery; hence, aging and heredity should also be considered [15].

Some features of this study design were not ideal. For instance, we conducted a cross-sectional investigation rather than a randomized controlled trial. As such, we might have limitations in the identification of causal relationships. Although our study was considered a cohort study, the data were obtained from LDH without a healthy control group. Therefore, radiological changes could not be assumed to be directly correlated with surgery. Although strict inclusion and exclusion criteria were applied, heterogeneous factors should be considered. Negative results were easily obtained because of the limited number of patients; additional data should thus be acquired over time to clarify this problem. Two different spine surgeons performed the operations in the study. Although they used the same technique and materials, some subtle differences in MED may have been introduced because of the surgeons' personal experiences. Although our study did not reflect the natural course of LDH, our findings provided an appropriate design for the investigation of long-term radiological outcomes in patients who undergo MED.

This longitudinal study demonstrated that post-MED outcomes deteriorate over time. High back pain scores corresponded to exacerbating clinical outcomes, and this condition was correlated with the radiological findings of degeneration in the operated segments. Bivariate logistic regression confirmed that PDHR, traction spur, Modic changes, and lateral listhesis were independent factors that could be used to predict the occurrence of post-surgical back pain.

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Disclosure of conflict of interest

None.

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