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Relationship of endplate changes and low back pain after discectomy

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ABSTRACT

Objectives: Discectomy is a conventional surgery for lumbar disc herniation. However, recurrence and residual back pain are the main postoperative complications. The contribution of endplate changes to the occurrence of these complications remains controversial. This study aimed to investigate the effect of endplate changes after discectomy.

Patients and Methods: We conducted a retrospective evaluation of 128 patients who had endplate changes after undergoing discectomy in our hospital. The patients were divided into three groups according to severity of abnormality according the Weishaupt classification (mild, moderate, and severe). The Oswestry Disability Index (ODI) and visual analog scale (VAS) were used to evaluate the efficacy of different surgical methods.

Results: Seventeen patients dropped out of the follow-up study. Satisfactory efficacy was observed in most patients, but 16 patients underwent reoperation. Significant differences were observed among the three groups in terms of low back pain severity and ODI ($p < 0.05$), but not radicular leg pain severity. The severe group had a higher recurrence rate of disc herniation (23.5%) than the mild and moderate groups (10.3% and 10.4%, respectively).

Conclusion: Discectomy had a noticeable efficacy. However, severe endplate changes, which indicated fissures on the endplate, damaged the lumbar stability and resulted in a higher recurrence rate and residual back pain. For such cases, internal fixation surgery should be considered.

1. Introduction

Lumbar disc herniation (LDH) is a degenerative disease and one of the main causes of low back pain (LBP). With the notable increase in the aged population and lifestyle changes, the incidence of LDH is gradually increasing [1]. Lumbar discectomy, first described by Mixter and Barr in 1934, is a conventional surgical technique for the treatment of LDH [2], which has been used for > 80 years. Residual back pain and recurrent herniation are the main postoperative complications [3–6]. However, the mechanism of postoperative complications remains unclear. The endplate includes the cartilaginous and bony endplates, and is located between the vertebral body and the intervertebral disc. As the disc itself is avascular, nutrition is mainly provided via the cartilaginous endplates [7,8]. Hence, the endplate and disc are closely related. Therefore, the endplate may be associated with complications after discectomy.

Endplate changes are vertebral subchondral bone marrow changes that are visible on magnetic resonance imaging (MRI). This common phenomenon was first described by Roos in 1987 [9]. The contribution of endplate changes to the occurrence of complications after discectomy remains controversial. Ohtori et al. investigated 45 cases, and their results showed that patients with or without endplate changes showed similar improvements in LBP score after discectomy [10]]. Rahme et al. reached a similar conclusion that neither the preoperative presence of endplate changes nor their postoperative courses appeared to affect the clinical outcome [11]. However, Yao et al. examined 111 patients with recurrent herniation after successful discectomy and reported that endplate changes were one of the risk factors that resulted in recurrence [12]. Chin et al. found a trend toward greater efficacy in patients without endplate changes [13].

None of the above-mentioned studies considered the severity of endplate changes. Thus, we hypothesize that the contradictory results may have arisen from the severity of the endplate changes. Weishaupt et al. observed the different extents of vertebral subchondral bone marrow signal abnormalities on MRI and subdivided them into four grades to evaluate the severity of endplate changes. Their results showed that moderate and severe endplate abnormalities may be helpful in predicting painful disc derangement [14]. The classification,

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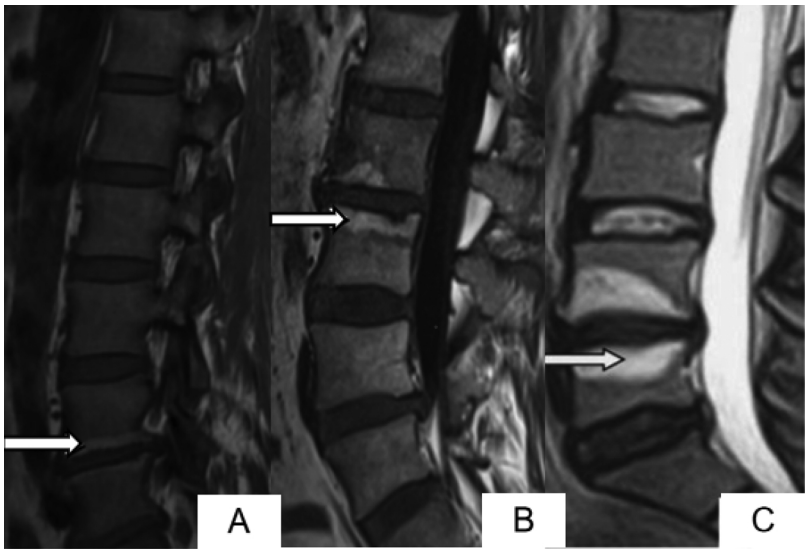

Fig. 1. A: Largest cranial or caudal extent of endplate abnormality involving ≤25% of the vertebral height as measured on the midsagittal image. B: Largest cranial or caudal extent of endplate abnormality involving between 25% and 50% of the vertebral height measured on the midsagittal image. C: Largest cranial or caudal extent ≥50% of the vertebral height as measured on the midsagittal image.

combined with discography, was then used to assess discogenic LBP. In this study, we retrospectively analyzed 128 cases by using the classification described by Weishaupt to investigate whether different extents of abnormalities affect the clinical outcomes after discectomy.

2. Patients and methods

Weishaupt et al. subdivided endplate and adjacent bone marrow abnormalities visualized on sagittal MRI into four grades as follows: none, no evidence of endplate abnormality on both T1- and T2-weighted images; mild, largest cranial or caudal extent of endplate abnormality involving ≤25% of the vertebral height; moderate, largest cranial or caudal extent of endplate abnormality involving between 25% and 50% of the vertebral height; severe, largest cranial or caudal extent ≤50% of the vertebral height. When an abnormality was present on both sides of the intervertebral disc, the larger cranial or caudal extent was used for further evaluation (Fig. 1).

We enrolled 128 patients with endplate changes who met the inclusion criteria and underwent discectomy at the First Affiliated Hospital of Soochow University between December 2010 and December 2014. The patients were divided into three groups according to severity of endplate changes as follows: group A (mild group) consisted of 33 patients with mild changes; group B (moderate group), 56 patients with moderate changes; and group C (severe group), 39 patients with severe changes.

The inclusion criteria were as follows: 1) age from 20 to 55 years; 2) LBP worse than the leg pain before surgery; 3) history of conservative treatment (for at least 3 months) without any improvement; and 4) single segmental disc herniation. The exclusion criteria were as follows: 1) history of abdominal or back surgery; 2) specific spinal disorders such as scoliosis, spondylolisthesis, lumbar instability, infection, or tumor; 3) lumbar instability before surgery.

We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research.

ODI and VAS were used to assess the treatment efficacy. Preoperative general characteristics and postoperative information at 1 day, 1 month, 12 months, and 36 months after operation were recorded. The ODI improvement rate was calculated as ([original ODI − follow-up ODI]/original ODI). The VAS score improvement rate was calculated as ([original VAS score − follow-up VAS score]/original VAS score), and the recurrence rate in 3 years was calculated as (reoperative patients/total patients). Postoperative flexion-extension radiography was performed to evaluate the stability changes compared with preoperative stability.

All the patients underwent MRI investigations before surgery to confirm the diagnosis. The patients were placed in the prone position. The lamina and ligamentum flavum were exposed. Next, the incision was oriented laterally and cephalad to advance the laminectomy and enlarge the approach without progression toward the pars interarticularis. The lamina was then partially removed in a proximal direction, and the proximal margin of the ligamentum flavum was exposed. The ligamentum flavum was then gently removed in the interlaminar space to expose the dural sac and exiting root. Once the partial laminectomy was performed and hemostasis was achieved, the underlying disc space, dural sac, and nerve root were readily visible. The dural sac and exiting nerve root were gently protected and retracted medially by a nerve root retractor. Pituitary rongeurs were then introduced into the herniated disc space superiorly and inferiorly to remove all the remaining herniated disc fragments. The remaining annular attachments were detached using a small-bladed lancet, and re-exploration of the intervertebral space was performed to remove loose fragments and complete the discectomy. The dorsal lumbar fascia was subsequently sutured, and the wound was closed in multiple layers.

Analysis of variance was used to compare the measurement data among three groups. The chi-square test was used to compare the enumeration data among the three groups. A p value of < 0.05 was considered statistically significant. All analyses were performed using the statistical program SPSS version 20.0 (Microsoft, USA).

3. Results

Seventeen patients dropped out of the follow-up because of unforeseen reasons and were thus excluded from this study. Three patients from the mild group, five from the moderate group, and eight from the severe group sought a secondary operation for recurrent herniation, and their ODI and VAS scores before reoperation were considered part of the latest follow-up. No significant differences in age, sex, BMI, work labor, smoking, involved segment, and degree of disc herniation were found among the three groups ($p > 0.05$; Table 1). At the latest follow-up, the improvement rates in ODI were 74.7%, 73.6%, and 69.4% in the mild, moderate, and severe groups, respectively. The improvement rates in LBP were 63.0%, 60.8%, and 53.9%, respectively, and those in leg pain VAS score were 67.1%, 65.3%, and 64.1%, respectively. No significant difference was observed in leg pain among the three groups ($p > 0.05$). However, a significant difference was found among the three groups with respect to ODI and LBP ($p < 0.05$) (Table 2). The recurrence rate of disc herniation in the severe group (23.5%) was

Table 1
Preoperative general characteristics of three groups.

	Group A	Group B	Group C
No.	29	48	34
Male	14	21	14
Age (mean ± SD)	38.1(21-48)	36.6(24-49)	39.2(26-52)
Degree of herniation			
Protruded	2	2	2
Extruded	13	25	18
Sequestrated	14	21	14
Location, No.			
L3-4	3	5	2
L4-5	11	16	14
L5-S1	15	27	18
Smoking	9	14	10
Heavy work	10	17	13
BMI	22.8 ± 4.3	21.9 ± 3.9	22.3 ± 4.1

Table 2
Preoperative and latest postoperative clinical information of three groups.

	Group A	Group B	Group C
Before surgery			
LBP VAS	7.3 ± 2.1	7.4 ± 2.5	7.6 ± 3.1
Leg Pain VAS	7.6 ± 1.9	7.5 ± 1.7	7.8 ± 2.0
ODI	33.2 ± 7.9	33.4 ± 9.1	33.7 ± 10.3
After surgery			
LBP VAS	2.7 ± 1.8	2.9 ± 1.5	3.5 ± 1.9*
Leg Pain VAS	2.5 ± 1.2	2.6 ± 0.9	2.8 ± 1.1
ODI	8.4 ± 2.1	8.8 ± 9.1	10.3 ± 8.5*

* statistically significant difference ($p < 0.05$).

Table 3
Postoperative clinical information at latest follow-up of three groups.

	Group A	Group B	Group C
Back pain IR	63.0%	60.8%	53.9%*
Leg pain IR	67.1%	65.3%	64.1%
ODI IR	74.7%	73.6%	69.4%*
Recurrence rate	10.3%	10.4%	23.5%

* statistically significant difference ($p < 0.05$), IR = improvement rate.

much higher than those in the mild (10.3%) and moderate groups (10.4%; Table 3). No stability changes were observed in the comparison between the preoperative and postoperative flexion-extension radiographs.

4. Discussion

The endplate has been reported to be associated with LBP. Our previous studies identified four different types of endplate lesions through direct assessments of cadaveric spines, including Schmorl's nodes, fractures, erosion, and calcification. The results demonstrated that endplate lesions were associated with back pain, and due to their close association with adjacent disc degeneration, presented a clear dosage effect. Furthermore, different types of endplate lesions appeared to have different magnitudes of associations with disc degeneration and LBP [15,16]. The relationship of endplates and discectomy to the presence of a dosage effect remains unknown.

In the present study, we examined the changes in LBP, disability, and recurrence rate after discectomy in patients with LDH who had different degrees of severity of endplate changes on the basis of imaging studies. Our research showed that the 3-year overall recurrence rate was 14.4% (16/111 cases), and all the patients underwent a reoperation. The LBP improvement rate in the severe group (53.9%) was significantly lower than those in the mild (63.0%) and moderate groups (60.8%,). The ODI improvement rate showed similar results. However, the recurrence rate in the severe group (23.5%) was much higher than those in the mild and moderate groups (10.3% and 10.4%), although the difference was not statistically significant. The results showed a poorer outcome in the patients with severe endplate changes than in the patients in the other groups.

The lack of resolution of back pain in the group with severe endplate changes may account for the differences in response to leg pain and ODI. We performed a detailed physical examination and medical history taking to exclude osteoarthritis. Cao et al. compared discectomy and lumbar interbody fusion performed for patients with endplate changes, and claimed that discectomy could remove the protruding disc compressing the nerve roots while efficiently releasing the radicular leg pain [17].

Endplate changes have been reported to be associated with pathologies such as disruption and fissuring of the endplate with vascular granulation tissue [18]. Inflammatory factors are important causes of endplate changes and could spread into vertebral cancellous bone through fissures [19]. A high number of endplate fissures allows for greater contact of the nucleus pulposus with the vertebral bone marrow and involves more inflammatory factors, resulting in greater diffusion through the vertebrae. As the disc itself is avascular, it largely depends on the nutrients supplied by the cartilaginous endplate; the vascular channels in the cartilaginous endplate are particularly important for the nucleus pulposus [7,8]. Endplate defects and inflammatory factors could affect the nutrition pathway and could ultimately lead to disc degeneration. Jensen et al. observed that the likelihood of adjacent disc degeneration is higher when more of the vertebral endplate signal changes extend into the vertebrae [20]. Severe endplate changes were observed to cause greater damage to disc nutrition. Thus, the adjacent disc continues to suffer poor nutrition even after discectomy, as the endplate is not treated.

Lumbar instability may account for the high recurrence rate and residual back pain in patients with severe endplate changes after discectomy. Discectomy surgery may influence lumbar stability [21]. The remaining disrupted disc must continuously bear the weight and support the trunk for the rest of the patient's life. Kotilainen et al. demonstrated that patients with severely degenerated discs are more likely to develop lumbar instability after discectomy [22]. As the disc degeneration progresses from normal to an increasingly severe stage, the motion of the lumbar spine progresses from a normal to an unstable phase with higher mobility [23]. Tanaka et al. used 140 cadaveric lumbar motion segments to examine the grade of disc degeneration in relation to the segmental motion of the lumbar spine and observed that greater motion was generally associated with disc degeneration [24]. Hayashi et al. found that translational instability was associated with severe disc degeneration and suggested that endplate changes played an important role in spinal instability [25]. Kim et al. examined 153 patients who underwent microdiscectomy to investigate the risk factors of recurrent LDH, and the results of a multivariate analysis showed that segment instability was an independent and the most relevant factor of recurrent LDH [26]. Limited to a short follow-up, we observed no stability changes on postoperative flexion-extension radiography. We believe that discectomy surgery resulted in lumbar instability and led to recurrence.

5. Conclusions

Discectomy has a marked efficacy, particularly in the relief of radicular leg pain. However, severe endplate changes result in poor efficacy and may contribute to poor disc nutrition, and damage the lumbar stability after discectomy. Thus, for patients with severe endplate changes, internal fixation surgery should be considered.

6. Limitations

The present study has some limitations. It was not a randomized

controlled study, and the number of patients was small. Moreover, we did not consider the types of endplate changes. This study was a preliminary research with a short follow-up; thus, further investigation is required to support our hypothesis.

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Declaration of Competing Interest

The authors declare that they have no competing interests.

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Jun Zou was responsible for designing the study, writing the protocol and report, screening potentially eligible studies. Yufeng Chen was responsible for conducting the search, writing the protocol and report. Huilin Yang and Yue Wang contributed to data extraction and provided feedback on the report.

References

[1] T. Aizawa, S. Kokubun, H. Ozawa, T. Kusakabe, Y. Tanaka, T. Hoshikawa, Increasing incidence of degenerative spinal diseases in Japan during 25 years: the registration system of spinal surgery in tohoku university spine society, Tohoku J. Exp. Med. 238 (2) (2016) 153–163.
[2] W.J. Mixter, J.S. Barr, Rupture of intervertebral disc with involvement of spinal canal, N. Engl. J. Med. 211 (Suppl) (1934) 210–215.
[3] K.S. Suk, H.M. Lee, S.H. Moon, N.H. Kim, Recurrent lumbar disc herniation: results of operative management, Spine 26 (6) (2001) 672–676.
[4] E.C. Papadopoulos, F.P. Girardi, H.S. Sandhu, A.A. Sama, H.K. Parvataneni, P.F. O'Leary, Outcome of revision discectomies following recurrent lumbar disc herniation, Spine 31 (13) (2006) 1473–1476.
[5] J.D. Law, R.W. Lehman, W.M. Kirsch, Reoperation after lumbar intervertebral disc surgery, J. Neurosurg. 48 (1978) 259–263.
[6] K.R. Swartz, G.R. Trost, Recurrent lumbar disc herniation, Neurosurg. Focus 15 (3) (2003) E10.
[7] S. Roberts, J. Menage, J.P. Urban, Biochemical and structural properties of the cartilage end-plate and its relation to the intervertebral disc, Spine 14 (1989) 166–174.
[8] G. Schmid, A. Witteler, R. Willburger, C. Kuhnen, M. Jergas, O. Koester, Lumbar disc herniation: correlation of histologic findings with marrow signal intensity changes in vertebral endplates at MR imaging, Radiology 231 (2) (2004) 352–358.
[9] Kressel H. de Roos, C. Spritzer, M. Dalinka, MR imaging of marrow changes adjacent to end plates in degenerative lumbar disc disease, AJR Am. J. Roentgenol. 149 (1987) 531–534.
[10] S. Ohtori, M. Yamashita, K. Yamauchi, G. Inoue, T. Koshi, M. Suzuki, Low back pain after lumbar discectomy in patients showing endplate modic type 1 change, Spine 35 (13) (2010) E596–600.
[11] R. Rahme, R. Moussa, R. Bou-Nassif, J. Maarrawi, T. Rizk, G. Nohra, What happens to Modic changes following lumbar discectomy? Analysis of a cohort of 41 patients with a 3 to 5year follow-up period, J. Neurosurg. Spine 13 (5) (2010) 562–567.
[12] Y. Yao, H. Liu, H. Zhang, H. Wang, Z. Zhang, Y. Zheng, Risk factors for the recurrent herniation after microendoscopic discectomy, World Neurosurg. 95 (2016) 451–455.
[13] K.R. Chin, D. Tomlinson, C. Deirmengian, J.B. Shatsky, C.A. Deirmengian, Success of lumbar microdiscectomy in patients with modic changes and low-back pain, A Prospective Pilot Study. Spine J 6 (5) (2006) 139–144.
[14] D. Weishaupt, M. Zanetti, J. Hodler, K. Min, B. Fuchs, C.W.A. Pfirrmann, Painful lumbar disc derangement: relevance of endplate abnormalities at MR imaging, Radiology 218 (2) (2001) 420–427.
[15] Y. Wang, T. Videman, M.C. Battie, Lumbar vertebral endplate lesions: prevalence, classification and association with age, Spine 37 (17) (2012) 1432–1439.
[16] Y. Wang, T. Videman, M.C. Battie, Lumbar vertebral endplate lesions associations with disc degeneration and back pain history, Spine 37 (17) (2012) 1490–1496.
[17] P. Cao, Z. Chen, Y.H. Zheng, et al., Comparison of simple discectomy and instrumented posterior lumbar interbody fusion for treatment of lumbar disc herniation combined with Modic endplate changes, Chin. Med. J. 127 (15) (2014) 2789–2794.
[18] M.T. Modic, P.M. Steinberg, J.S. Ross, T.J. Masaryk, J.R. Carter, Degenerative disc disease: assessment of changes in vertebral body marrow with MR imaging, Radiology 166 (1988) 193–199.
[19] Y.H. Zhang, C.Q. Zhao, L.S. Jiang, X.D. Chen, L.Y. Dai, Modic changes: a systematic review of the literature, Eur. Spine J. 17 (10) (2008) 1289–1299.
[20] T.S. Jensen, T. Bendix, J.S. Sorensen, C. Manniche, L. Korsholm, P. Kjaer, Characteristics and natural course of vertebral endplate signal (Modic) changes in the Danish general population, BMC Musculoskelet. Disord. 10 (2009) 81.
[21] W.W. Lu, K.D. Luk, D.K. Ruan, Z.Q. Fei, J.C. Leong, Stability of the whole lumbar spine after multilevel fenestration and discectomy, Spine 24 (13) (1999) 1277–1282.
[22] E. Kotilainen, A. Alanen, M. Erkintalo, S. Valtonen, M. Kormano, Association between decreased disc signal intensity in preoperative T-2-weighted MRI and a 5-year outcome after lumbar minimally invasive discectomy, Minim. Invasive Neurosurg. 44 (1) (2001) 31–36.
[23] L. Lao, M.D. Daubs, T.P. Scott, E.L. Lord, J.R. Cohen, R. Yin, Effect of disc degeneration on lumbar segmental mobility analyzed by kinetic magnetic resonance imaging, Spine 40 (5) (2015) 316–322.
[24] N. Tanaka, H.S. An, T.H. Lim, A. Fujiwara, C.H. Jeon, V.M. Haughton, The relationship between disc degeneration and flexibility of the lumbar spine, Spine 1 (1) (2001) 47–56.
[25] T. Hayashi, M.D. Daubs, A. Suzuki, T.P. Scott, K.H. Phan, M. Ruangchainikom, Motion characteristics and related factors of Modic changes in the lumbar spine, J. Neurosurg. Spine 22 (5) (2015) 511–517.
[26] K.T. Kim, S.W. Park, Y.B. Kim, Disc height and segmental motion as risk factors for recurrent lumbar disc herniation, Spine 34 (24) (2009) 2674–2678.