Characteristics of Relief and Residual Low Back Pain After Discectomy in Patients With Lumbar Disc Herniation: Analysis Using a Detailed Visual Analogue Scale

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Abstract

Background: Recently, several authors have reported favorable results in low back pain (LBP) for patients with lumbar disc herniation (LDH) treated with discectomy. However, detailed changes over time in the characteristics and location of LBP before and after discectomy for LDH remain unclear. To clarify these points, we conducted an observational study to evaluate the detailed characteristics and location of LBP before and after discectomy for LDH, using detailed and bilateral visual analog scales (VAS).

Methods: Sixty-five patients with LDH treated with discectomy were included in this study. A detailed VAS for LBP was administered under 3 different postural conditions: in-motion, standing, and sitting. Bilateral VAS was also administered (affected versus opposite side) for LBP, lower extremity pain (LEP), and lower extremity numbness (LEN). The Oswestry Disability Index (ODI) was used to quantify clinical status. Changes over time in these VAS and ODI were investigated. Pfirrmann classification and Modic change as seen by magnetic resonance imaging (MRI) were reviewed before and 1 year after discectomy to evaluate disc and endplate condition.

Results: Before surgery, LBP on the affected side in motion were significantly higher than LBP while sitting. This heightened LBP on the affected side in motion was significantly improved after discectomy. On the other hand, the residual LBP while sitting at 1 year after surgery was significantly higher than the LBP in motion or while standing. At 1 year following discectomy, residual LBP while sitting was significantly greater in cases showing larger changes in Pfirrmann grade or Modic type.

Conclusions: Improvement of LBP on the affected side while in motion following discectomy suggests that radicular LBP is improved by nerve root decompression. Furthermore, the finding that residual LBP while sitting is reflective of the load and pressure put on the disc and endplate.

Background

Lumbar disc herniation (LDH) is one of the most common causes of low back pain (LBP) and sciatica. Surgical treatment is well known to be optimal for patients with LDH who fail to respond to conservative care. Favorable results for LBP, lower extremity pain (LEP), and lower extremity numbness (LEN) in patients with LDH treated with discectomy have been demonstrated [1, 2, 3, 4]. In most of those studies, only a conventional visual analog scale (VAS) and the Oswestry disability index (ODI) were used to evaluate LBP. Those studies were unable to discuss detailed changes in LBP and the characteristics of relief and residual LBP. On the other hand, recent reports have clarified the characteristics of LBP using a detailed VAS for some lumbar degenerative disorders, including spondylolysis and lumbar spinal stenosis (LSS) [5, 6, 7]. Nevertheless, there are few reports of the detailed changes and location of LBP before and after discectomy for LDH. Thus, we conducted an observational study to clarify the detailed characteristics and location of LBP, LEP, and LEN before and after discectomy for LDH using detailed and bilateral VAS.

Methods

Patient selection

The present study was approved by the ethical committee of XXXX University XXXXXX Medical Center (No. 2012071). Informed consent was obtained from all patients. A total of 114 patients under the age of 75 who were treated with discectomy for LDH from April 2010 to March 2018 was enrolled in this study. LDH was diagnosed by four orthopedic spine surgeons (XX, XX, XX, XX) based on neurological findings, the presence of persistent and unremitting LBP for more than 3 months, X-ray images, and magnetic resonance imaging (MRI). All the patients were treated with a traditional amount of conservative care. Those who were not improved by sufficient conservative treatment and wished to undergo surgical treatment were included in this study. Patients with the comorbidities LSS or degenerative spondylolisthesis (DS) were excluded. Patients who were diagnosed with a lateral herniation treated with fusion surgery were eliminated, as were those with thoracic myelopathy and hip osteoarthritis. Patients with recurrent herniation were excluded, and unfortunately so were those who had a recurrence of herniation and underwent revision surgery within 1 year of their primary surgery. All cases, excluded from the study due to these complications, are broken down as follows: 5 cases with LSS or DS, 7 cases with lateral herniation, 1 case with thoracic myelopathy, 1 case with hip osteoarthritis, and 7 cases of recurrent herniation. Five cases (4.3%), unfortunately, had a rapid (less than one -year post op) recurrence of herniation. In addition, 5 cases were excluded because of a lack of data and 18 cases because of a loss to follow-up. Ultimately, 65 cases were included in the present study.

Surgical procedure of discectomy

All the operative procedures were performed under a surgical microscope as described in detail elsewhere [8]. Fifty nine of 65 cases were performed with a hemi approach. In the first 31 cases, the surgeries were performed using the conventional microdiscectomy. In the 28 cases treated since 2015, the surgeries were performed using a tubular retractor (METRx MD system, Medtronic, US) to minimize damage to the paraspinal muscles on the approached side. Six of the cases experienced bilateral symptoms with a central herniation and we, therefore, performed bilateral fenestration and bilaterally extirpation of herniation.

Evaluation of clinical outcome

In this study, buttock pain was included in LEP and, therefore, the definition of LBP in this study does not include buttock pain. Based on past reports, a detailed VAS (100 mm) for LBP under 3 postural conditions: in-motion, standing, and sitting were administered (Fig. 1A) [5, 6]. In addition, the location (left versus right side) of LBP, LEP, and LEN were administered and analysis were performed divided into the affected (approached) and opposite side (Fig. 1B) [6]. In the patients with bilateral symptoms who underwent bilateral laminectomy and herniation extirpation, we established the affected side as the one that was more symptomatic and more extensively herniated on MRI. The ODI was also used to assess clinical improvement including activities of daily living. All VAS and ODI values were administered before surgery, at 3 months, at 6 months, and at 1-year of follow-up. We investigated the relationship between the VAS scores and surgical level as well as the following 3 surgical procedure groups: conventional discectomy with hemi-laminectomy (C), discectomy using a tubular retractor (T), and discectomy with bilateral laminectomy (B).

Evaluation of imaging findings

We investigated MRI before surgery and at the 1-year follow-up, except for 3 patients who were unable to undergo MRI because of a pacemaker insertion (1 patient) or claustrophobia (2 patients). In total we analyzed 62 cases. We investigated disc degeneration using the Pfirrmann classification [9]. Vertebral endplate changes were assessed using Modic types [10]. All the MRI evaluations were performed by 3 independent examiners (XX, XX, and XX) who were not informed about the clinical data of the patients. All the cases were divided into two groups: C group and N group according to their changes of Pfirrmann grade or Modic type before and after discectomy. Differences between the two groups were evaluated.

Statistical analyses

Results are presented as the mean ± standard deviation. A paired *t* test was used to compare each detailed VAS score before and after surgery. A one-factor ANOVA was used to compare the relationship between VAS scores and the 3 different surgical levels and procedures. A repeated ANOVA with a post hoc Turkey–Kramer test was used to determine changes over time for each VAS and the ODI. A Student *t* test was used to compare changes in Pfirrmann grade or Modic type with residual LBP, as measured by VAS. $P < 0.05$ was considered significant in the tests of statistical inference. All statistical analyses were performed using the JMP software package (ver. 14.2.0, SAS Institute Inc., Cary, NC, USA).

Results

Patient characteristics

Table 1 showed the characteristics of all the 65 patients. There was no significant difference between sex and the affected side. Herniations at L4-5 and L5-S were more frequent than at L3-4 in this series. There were no cases of L1/2 or L2/3 herniation included in this study. Disc degeneration by Pfirrmann classification showed that grade 2 was most frequent and there were no cases of grade 1. Fourteen cases showed endplate changes as evaluated by Modic type. There were no cases of surgical site infection in this series, nor were there other critical complications such as thromboembolic events or nerve root injuries.

Evaluation of clinical outcomes (VAS and ODI)

Detailed LBP VAS scores before surgery were 62.8 ± 29.9 in motion, 61.6 ± 31.6 while standing, and 26.6 ± 32.9 while sitting; notably, LBP in motion was significantly higher than LBP while sitting ($p < 0.05$). The heightened LBP seen during motion as well as the LBP experienced while standing and sitting was significantly improved following discectomy ($p < 0.05$). On the other hand, the detailed LBP VAS at 1 year after surgery was 13.2 ± 19.5 in motion, 13.8 ± 18.9 while standing, and 17.3 ± 22.0 while sitting; notably, the residual LBP while sitting at 1 year after surgery was significantly higher than the LBP reported during motion and while standing ($p < 0.05$) (Fig. 2A). On the other hand, the bilateral LBP VAS before surgery was 46.9 ± 34.0 on the affected side and 17.4 ± 27.0 on the opposite side. This shows that LBP on the affected side was significantly higher than it was on the opposite side ($p < 0.01$). Bilateral LBP was improved significantly on both sides following surgery, and LBP relief was maintained until the 1-year final follow-up (Fig. 2B).

Figure 3 shows the changes over time in bilateral LEP (Fig. 3A) and LEN (Fig. 3B) after discectomy. LEP and LEN on the affected side were also significantly greater before surgery ($p < 0.01$). The significant improvements of LEP and LEN were shown on both sides and were maintained until the 1-year final follow-up ($p < 0.01$), however, residual LEP and LEN were greater on the affected side ($p < 0.01$). In the clinical evaluation, the ODI also showed significant improvements following discectomy (Fig. 4).

Taking into account the results of the detailed LBP VAS, we investigated the changes over time of LBP VAS scores during motion and while standing. The changes over time of the detailed LBP VAS and surgical level are shown in Fig. 5. There was no significant difference in LBP before surgery at different surgical levels. However, the residual LBP VAS during motion and while sitting at 1 year after surgery was significantly heightened at the L3/4 level ($p < 0.01$).

Changes over time in detailed LBP VAS scores and surgical procedures (C, T, and B groups) are shown in Fig. 6. LBP during motion was significantly higher before surgery in group T ($p < 0.05$), and therefore the residual LBP at 3 months after surgery was also higher in group T. However, at 1 year after discectomy, the residual LBP became almost equal for all 3 surgical procedures.

Evaluation of correlation between MRI findings and VAS

The changes over time in Pfirrmann grade and Modic type are shown in Table 2. Overall, significant changes in both Pfirrmann grade and Modic type were observed ($p < 0.05$). Seventeen cases had changes in Pfirrmann grade following discectomy. We divided them into two groups: Pfirrmann grade changing (PC group) and not changing (PN group). After discectomy, 12 cases changed in Modic type, and we also divided them into two groups: Modic type changing (MC group) and not changing (MN group).

Taking into account the finding that residual LBP while sitting was heightened at 1 year after discectomy, we investigated the relationship between the Pfirrmann grade, Modic type, and LBP VAS while sitting at 1 year after discectomy. Our results are outlined as follows: LBP VAS scores while sitting at 1 year after discectomy were 31.5 ± 21.1 in the PC group and 12.9 ± 20.7 in the PN group; notably, they were significantly higher in the PC group ($p < 0.05$, Fig. 7A). In addition, LBP VAS scores while sitting at 1 year after discectomy were 30.8 ± 25.7 in the MC group and 14.9 ± 20.5 in the MN group, showing they were significantly higher in the MC group ($p < 0.05$, Fig. 7B).

Discussion

To our knowledge, this study is the first to evaluate the characteristics and location of LBP in patients with LDH treated with discectomy. According to the previous study analyzed detailed and bilateral VAS scores for LSS patients, LBP in patients with LSS before surgery was significantly greater while standing, but pain was reduced by decompression surgery, with LBP improving equally on the affected and opposite sides [6]. In our study, LBP during motion was significantly greater in patients with LDH before surgery, and the LBP in motion on the affected side was reduced by discectomy. This pattern of LBP relief suggests that radicular LBP is improved by nerve root decompression surgery, as mentioned in previous reports [1, 6]. Despite this similarity regarding nerve root decompression, however, greater LBP during motion that occurred with LDH patients was different than the increased LBP while standing found in LSS patients. For this reason, we speculate that nerve root compression in patients with LDH usually occurs with a more acute onset compared to LSS. In addition, this difference in LBP characteristics may be influenced by the degree of disc and endplate degeneration in LDH patients compared to LSS patients because LDH patients tend to be younger than LSS patients.

Another noteworthy point gleaned from our findings was that residual LBP was most pronounced while sitting. A recent report has indicated that higher intradiscal pressure while sitting may result in LBP in the presence of lumbar degenerative disc diseases [11]. It was reported that pathological mechanisms of discogenic low back pain included sensory nerve ingrowth into the disc, upregulation of neurotrophic factors like nerve growth factor and inflammatory cytokines, and mechanical stress [12, 13]. Our findings of residual LBP while sitting and changes in Pfirrmann grade, when taken in combination, leads us to conclude that it is likely the load and pressure on the disc were causal in residual LBP while sitting. Alternatively, it is also well known that Modic changes influence LBP [14]. Ohtori et al. reported favorable surgical outcomes for LDH complicated with Modic type I [15]. Although LEP improvement was obtained in patients with Modic change in our study, the residual LBP in MC group leads us to believe that changes in load and inflammation at the endplate may also be causal in residual LBP while sitting.

Recent reports indicated that performing a minimally invasive discectomy using a tubular retractor under a microscope or endoscope are feasible in the treatment of LDH [16, 17]. Including conventional discectomy, in our study we compared these 3 surgical procedures. Residual LBP at 3 months after surgery was greater in group T because the baseline of LBP before surgery was significantly greater in this group. However, the residual LBP at 1 year follow up was equal with all 3 surgical procedures. This, along with previous reports, suggests that surgical invasion of the paraspinal muscles does not influence residual LBP [6, 16]. While no reports were found describing the relationship between surgical levels and residual LBP, in our study, residual LBP was significantly greater in patients with herniations at L3/4. It is hard to explain this phenomenon. However, we speculate that this may have been the case because patients with L3/4 herniations were highly complicated and also had L4/5 or L5/S disc degenerations. Further investigation with a larger sample size is needed to understand this phenomenon.

The present study has several limitations. First, this study is observational, and we did not evaluate detailed and bilateral LBP VAS scores of patients who solely underwent conservative treatment. In our study some of the patients underwent conservative treatment at another hospital, and they wished to undergo surgical treatment as soon as possible, leaving them no time to evaluate further conservative treatment. Further prospective investigation will be needed. Second, the present study excluded patients complicated with dynamic instability or patients with lateral herniations who underwent fusion surgery because we wanted to avoid LBP caused by instability of discs and facet joints [18]. Furthermore, the present study also excluded cases which, unfortunately, had a recurrence of herniation in the short term (less than a year) because we wanted to evaluate residual LBP in the absence of herniation recurrence. If those cases had been included, the results would have been confounded by the fact that they had severe VAS scores under all 3 postural conditions. Third, the present study did not evaluate sagittal alignment. Sagittal imbalance such as pelvic incidence and lumbar lordosis mismatch may contribute to postoperative LBP [19]. Using detailed VAS scores, Aoki et al. indicated that sagittal imbalance after a short segment fusion surgery resulted in residual LBP while standing [20]. Considering our finding that residual LBP while sitting was present at 1 year after discectomy, we speculate that residual LBP is less affected by sagittal alignment. Finally, the follow up after discectomy was incomplete. When patients undergo discectomy and have significant pain relief, they sometimes drop out of care at the outpatient clinic. 18 of 114 (15.7%) cases in our study dropped out. Generally, two years of follow-up is recommended for this type of study. However, in this study, we were compelled to set the follow-up period to 1 year because of a decreasing follow-up rate. Further investigation, like a prospective cohort study that follows all the cases fully will be needed to resolve this follow-up rate problem.

Conclusions

In LDH patients, LBP in motion on the affected side was significantly greater before surgery and was reduced following discectomy. This LBP relief suggests a radicular nature to the LBP that is improved by nerve root decompression surgery. The residual LBP at 1 year after discectomy was most dominant while sitting. This, in combination with our findings regarding the relationship between residual LBP and changes in Pfirrmann grade and Modic type, suggests that the load and pressure to the disc and endplate play a causal role in residual LBP while sitting. To resolve the follow-up rate problem, a prospective cohort study that follows all the cases more fully will be needed.

Abbreviations

LDH

Lumbar disc herniation, LBP:low back pain, LEP:lower extremity pain, LEN:lower extremity numbness, VAS:Visual analog scale, ODI:Oswestry disability index, LSS:lumbar spinal stenosis, MRI:magnetic resonance imaging, DS:degenerative spondylolisthesis,

Declarations

Ethic approval and consent to participate

This study was approved by the ethical committee of Toho University Sakura Medical Center (No. 2012071). Verbal informed consent was obtained from all participants because the investigation of VAS and ODI are noninvasive and beneficial for all the patients to know their real condition. The ethical committee approved this procedure.

Consent to publication

Not applicable.

Availability of data and materials

The datasets used during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' Contributions

HT, YaA, YaS, KI, SuO, YE, SM, TaF, TsuA, TeA, ToF, MasK, MY, and SeO conceived of the study. HT drafted the manuscript. KeM, YoS, FE, and MamK performed the literature search. YE, HN, and KoM evaluated MRI. YaA, MI, JS, AN, MS, YoA, KK, and KN contributed to clinical management of the case. YaA, SuO, TsuA, MasY and SeO revised the manuscript critically and approved the modified text. All authors have read and approved the final manuscript.

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References

1. Toyone T, Tanaka T, Kato D, Kaneyama R. Low-back pain following surgery for lumbar disc herniation. A prospective study. The Journal of bone and joint surgery American volume 2004, 86-a(5):893–896.
2. Kikuchi S. The Recent Trend in Diagnosis and Treatment of Chronic Low Back Pain. Spine Surgery Related Research. 2017;1(1):1–6.
3. Oba H, Takahashi J, Tsutsumimoto T, Ikegami S, Ohta H, Yui M, Kosaku H, Kamanaka T, Misawa H, Kato H. Predictors of improvement in low back pain after lumbar decompression surgery:

Prospective study of 140 patients. Journal of orthopaedic science: official journal of the Japanese Orthopaedic Association. 2017;22(4):641–6.

4. Parker SL, Mendenhall SK, Godil SS, Sivasubramanian P, Cahill K, Ziewacz J, McGirt MJ. Incidence of Low Back Pain After Lumbar Discectomy for Herniated Disc and Its Effect on Patient-reported Outcomes. Clin Orthop Relat Res. 2015;473(6):1988–99.
5. Aoki Y, Sugiura S, Nakagawa K, Nakajima A, Takahashi H, Ohtori S, Takahashi K, Nishikawa S. Evaluation of nonspecific low back pain using a new detailed visual analogue scale for patients in motion, standing, and sitting: characterizing nonspecific low back pain in elderly patients. Pain Res Treat. 2012;2012:680496.
6. Takahashi H, Aoki Y, Saito J, Nakajima A, Sonobe M, Akatsu Y, Inoue M, Taniguchi S, Yamada M, Koyama K, et al. Unilateral laminectomy for bilateral decompression improves low back pain while standing equally on both sides in patients with lumbar canal stenosis: analysis using a detailed visual analogue scale. BMC Musculoskelet Disord. 2019;20(1):100.
7. Sugiura S, Aoki Y, Toyooka T, Shiga T, Otsuki K, Aikawa E, Oyama T, Kitoh K, Chikako S, Takata Y, et al. Characteristics of low back pain in adolescent patients with early-stage spondylolysis evaluated using a detailed visual analogue scale. Spine. 2015;40(1):E29–34.
8. Blamoutier A. Surgical discectomy for lumbar disc herniation: surgical techniques. Orthopaedics & traumatology, surgery & research: OTSR 2013, 99(1 Suppl):S187-196.
9. Pfirrmann CW, Metzdorf A, Zanetti M, Hodler J, Boos N. Magnetic resonance classification of lumbar intervertebral disc degeneration. Spine. 2001;26(17):1873–8.
10. Modic MT, Steinberg PM, Ross JS, Masaryk TJ, Carter JR. Degenerative disk disease: assessment of changes in vertebral body marrow with MR imaging. Radiology. 1988;166(1 Pt 1):193–9.
11. Tonosu J, Inanami H, Oka H, Katsuhira J, Takano Y, Koga H, Yuzawa Y, Shiboi R, Oshima Y, Baba S, et al. Diagnosing Discogenic Low Back Pain Associated with Degenerative Disc Disease Using a Medical Interview. PloS one. 2016;11(11):e0166031.
12. Ohtori S, Miyagi M, Inoue G. Sensory nerve ingrowth, cytokines, and instability of discogenic low back pain: A review. Spine Surgery Related Research. 2018;2(1):11–7.
13. Aoki Y, Nakajima A, Ohtori S, Takahashi H, Watanabe F, Sonobe M, Terajima F, Saito M, Takahashi K, Toyone T, et al. Increase of nerve growth factor levels in the human herniated intervertebral disc: can annular rupture trigger discogenic back pain? Arthritis research therapy. 2014;16(4):R159.
14. Ohtori S, Inoue G, Ito T, Koshi T, Ozawa T, Doya H, Saito T, Moriya H, Takahashi K. Tumor necrosis factor-immunoreactive cells and PGP 9.5-immunoreactive nerve fibers in vertebral endplates of patients with discogenic low back Pain and Modic Type 1 or Type 2 changes on MRI. Spine. 2006;31(9):1026–31.
15. Ohtori S, Yamashita M, Yamauchi K, Inoue G, Koshi T, Suzuki M, Orita S, Eguchi Y, Ochiai N, Kishida S, et al. Low back pain after lumbar discectomy in patients showing endplate modic type 1 change. Spine. 2010;35(13):E596–600.

16. Overdevest GM, Peul WC, Brand R, Koes BW, Bartels RH, Tan WF, Arts MP. Tubular discectomy versus conventional microdiscectomy for the treatment of lumbar disc herniation: long-term results of a randomised controlled trial. J Neurol Neurosurg Psychiatry. 2017;88(12):1008–16.
17. Kim M, Lee S, Kim HS, Park S, Shim SY, Lim DJ. A Comparison of Percutaneous Endoscopic Lumbar Discectomy and Open Lumbar Microdiscectomy for Lumbar Disc Herniation in the Korean: A Meta-Analysis. BioMed research international 2018, 2018:9073460.
18. Johnsson KE, Willner S, Johnsson K. Postoperative instability after decompression for lumbar spinal stenosis. Spine. 1986;11(2):107–10.
19. Schwab F, Patel A, Ungar B, Farcy JP, Lafage V. Adult spinal deformity-postoperative standing imbalance: how much can you tolerate? An overview of key parameters in assessing alignment and planning corrective surgery. Spine. 2010;35(25):2224–31.
20. Aoki Y, Nakajima A, Takahashi H, Sonobe M, Terajima F, Saito M, Takahashi K, Ohtori S, Watanabe A, Nakajima T, et al. Influence of pelvic incidence-lumbar lordosis mismatch on surgical outcomes of short-segment transforaminal lumbar interbody fusion. BMC Musculoskelet Disord. 2015;16:213.

Tables

Table 1. Patient characteristecs

Age		43.6 ± 14.7
Sex	Male	34
	Female	31
Dominant side	Lt	33
	Rt	26
	Blt	6
Herniation level	L3/4	6
	L4/5	28
	L5/S	31
Pfirrmann classification before surgery	2	2
	3	39
	4	19
	5	2
	Unable	3
Modic type before surgery	None	48
	1	3
	2	10
	3	1
	Unable	3

Table 2. Time course changes of

A. Pfirrmann grade

		1 year after surgery				
		2	3	4	5	Total
Before surgery	2		2			2
	3		26	13		39
	4			17	2	19
	5				2	2
	Total		28	30	4	62

B. Modic type

		1 year after surgery				
		None	1	2	3	Total
Before surgery	None	40	4	3	1	48
	1		2	1		3
	2		1	8	1	10
	3		1			1
	Total	40	8	12	2	62

Figures

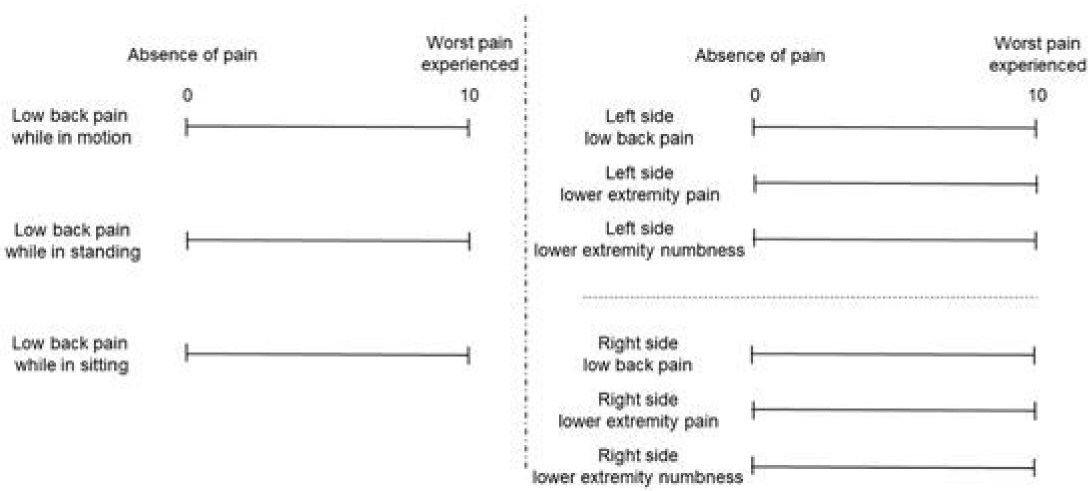

Figure 1

VAS scores. (A) Detailed LBP VAS (0–100 mm) scores. LBP was scored independently under 3 different postural conditions: in-motion, standing, and sitting. (B) LBP, LEP, and LEN VAS (0–100 mm) scores bilaterally on the approached and opposite sides.

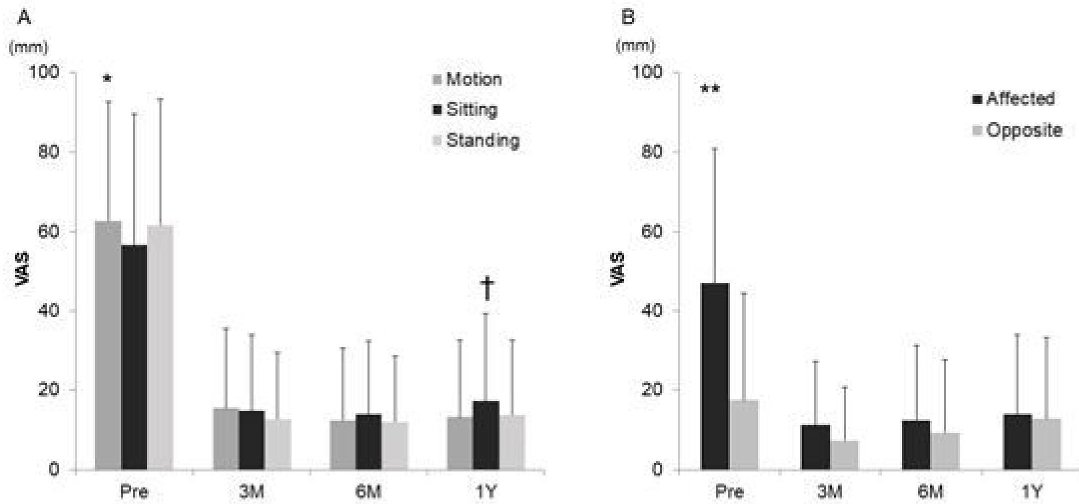

Figure 2

(A) Changes in detailed LBP VAS scores. LBP during motion before surgery was significantly greater than LBP while sitting (*paired t test, $p < 0.05$). LBP VAS scores under all 3 postural conditions were improved significantly after discectomy (repeated major ANOVA, $p < 0.01$). On the other hand, residual LBP while sitting was significantly greater than LBP while sitting at 1 year after discectomy (†paired t test, $p < 0.05$). (B) Changes in bilateral LBP VAS scores. LBP on the affected side before surgery was significantly greater than LBP on the opposite side (*paired t test, $p < 0.05$). Bilateral LBP was significantly improved equally on both sides (repeated major ANOVA, $p < 0.01$).

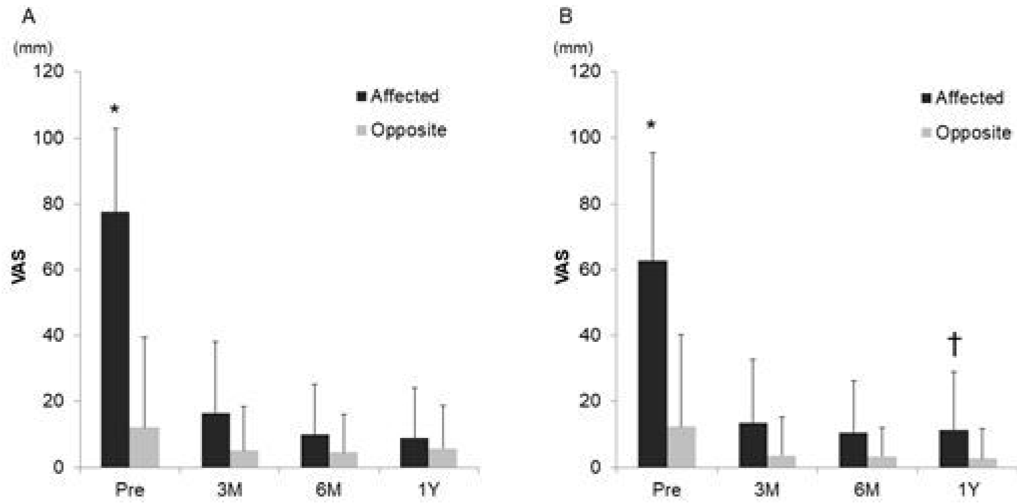

Figure 3

Changes in bilateral VAS scores of LEP (A), and LEN (B). LEP and LEN on the affected side before surgery were significantly greater than on the opposite side (*paired t test, $p < 0.05$). After discectomy, both LEP and LEN on the affected side were significantly improved (repeated major ANOVA, $p < 0.01$). However, residual LEP and LEN at 1 year after surgery were significantly greater than they were on the opposite side (†paired t test, $p < 0.05$).

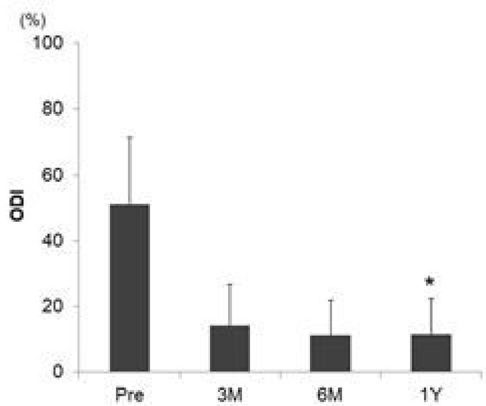

Figure 4

Changes in ODI. Scores on the ODI was significantly improved by discectomy (*repeated measure single-factor ANOVA, $p < 0.01$).

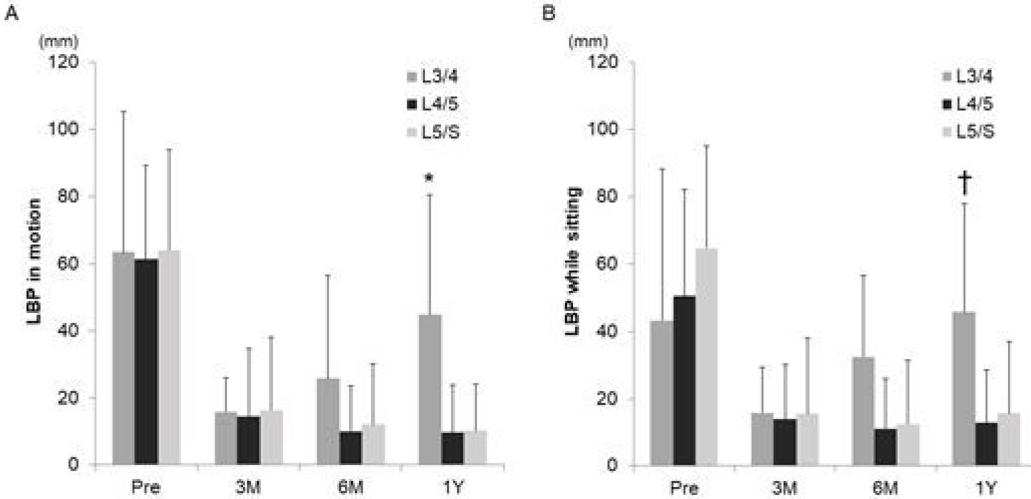

Figure 5

(A) Changes in LBP during motion and surgical levels. LBP during motion at 1 year after surgery was significantly greater in cases of herniation at the L3/4 level (*one factor ANOVA, $p < 0.05$). (B) Changes in LBP while sitting and surgical levels. LBP while sitting at 1 year after surgery was also significantly greater in cases of L3/4 herniation level (†one factor ANOVA, $p < 0.05$).

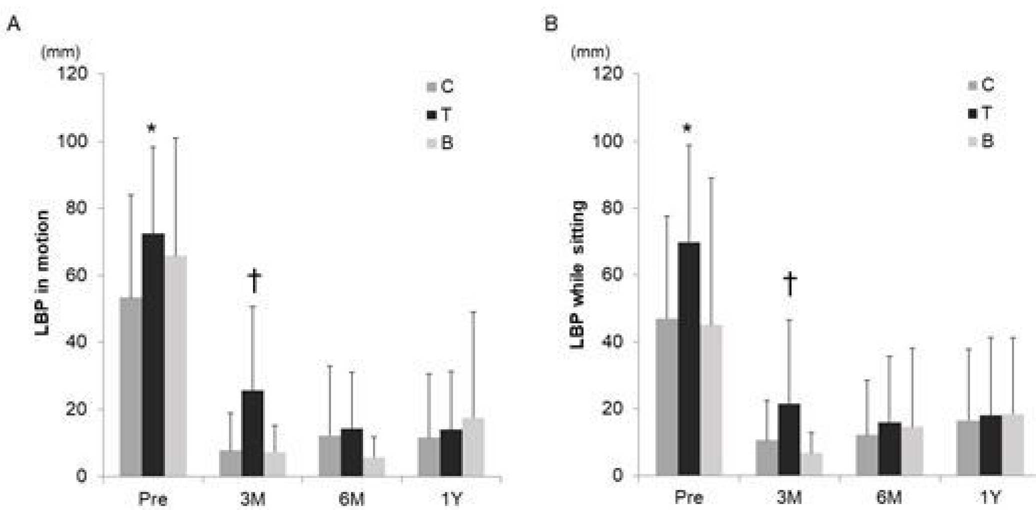

Figure 6

(A) Changes in LBP during motion and surgical procedures. (B) Changes in LBP while sitting and surgical procedures. C: conventional discectomy, T: microscopic discectomy using a tubular retractor, B: bilateral laminectomy and discectomy. LBP both during motion and while sitting before surgery were significantly greater in group T (*one factor ANOVA, $p < 0.05$). Thus, the residual LBP at 3 months after surgery was significantly greater in group T (†one factor ANOVA, $p < 0.05$). However, LBP was improved with all 3 surgical procedures and LBP became equally level at 1 year after surgery.

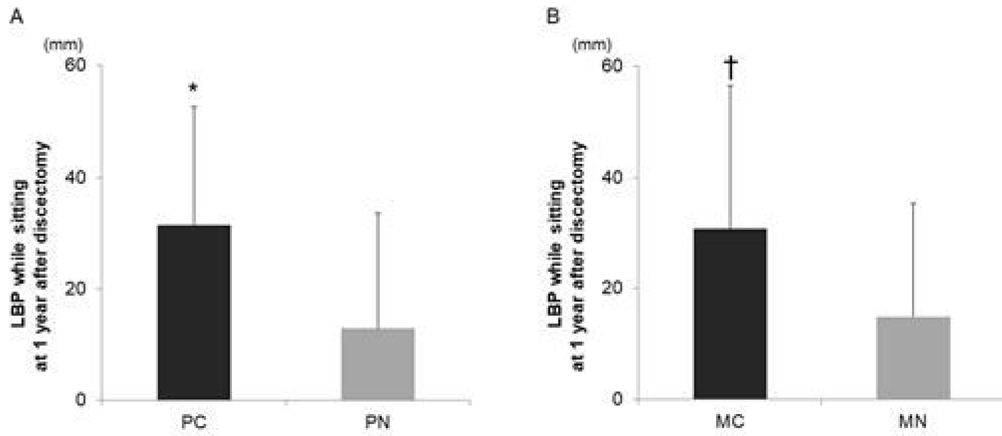

Figure 7

(A) Relationship between LBP while sitting at 1 year after surgery and Pfirrmann classification changes. PC: Pfirrmann classification changing group, PN: Pfirrmann not changing classification group. Residual LBP while sitting in the PC group was significantly greater than that in the PN group (*student t test, $p < 0.05$). (B) Relationship between LBP while sitting at 1 year after surgery and Modic type changes. MC: Modic type changing group, MN: Modic type not changing group. The residual LBP while sitting in the MC group was significantly greater than that in the MN group (†student t test, $p < 0.05$).