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ORIGINAL ARTICLE

The influence of adjacent level disc disease on discectomy outcomes

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Abstract
Purpose The state of adjacent level discs and its impact on surgical outcomes following single-level lumbar discectomy have not been previously investigated. The purpose of the present study was to determine if a significant relationship exists between the degree of preoperative adjacent level disc degeneration and post-operative clinical outcomes following lumbar discectomy.
Methods This study retrospectively used preoperative magnetic resonance imaging (MRI) and prospectively collected data from a randomized clinical trial at two tertiary-care academic hospitals. Patients who underwent a primary, single-level lumbar discectomy were included. Exclusion criteria included prior lumbar surgery. Outcome measures were the Modified Oswestry Disability Index (ODI) score and Visual Analog Scale (VAS) scores for back and leg pain. These were recorded at baseline and at 3 months, 1, and 2 years postoperatively. An independent reviewer graded adjacent level disc degeneration on all preoperative MRIs using the Pfirrmann grading scale. These data were then analyzed for correlation with each outcome measure.
Results Forty-seven patients were included in the study. No statistically significant correlations were found when comparing preoperative 3-month or 1-year postoperative scores or change from baseline of any outcome measure between Pfirrmann grades. Only about half the patients had 2-year follow-up, but at that time point a statistically significant difference in back VAS scores was observed between Pfirrmann groups. No other significant differences were observed at that point.
Conclusions The degree of preoperative adjacent level degeneration does not significantly affect functional or pain relief outcomes following lumbar discectomy up to 1 year after surgery.

Keywords Adjacent level disease · Lumbar spine · Discectomy · Quality of life · Outcomes

Introduction

Lumbar disc herniation has a lifetime incidence of approximately 1–2 % and is the most commonly operated-on spinal diagnosis [1]. Lumbar disc herniations are commonly associated with underlying degenerative disc disease and, with advanced imaging techniques such as magnetic resonance imaging (MRI), can be found in both symptomatic and asymptomatic individuals [2]. While the natural course of lumbar disc herniations causing radiculopathy is usually favorable with nonoperative treatment, surgery is performed in approximately 10 % of recalcitrant cases with success rates ranging from 80 to 90 % [3, 4]. In order to determine which patients are best suited for surgical intervention, numerous studies examining predictive factors for favorable surgical outcomes in symptomatic patients undergoing discectomy have been conducted.

Previous investigations have identified patient demographic variables, socioeconomical factors, radiographic characteristics of the herniation, as well as symptomatology and physical exam findings as predictors of surgical

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outcome [3–12]. Though most patients report improvement in lower extremity pain, residual back pain seems to be common. In one long-term study, 75 % of patients reported residual back pain at 10 years, with 12 % stating it was severe [13]. While many factors are likely responsible for residual back pain following discectomy, it is plausible that degeneration of adjacent discs could be a contributor. To our knowledge, however, the influence of adjacent level disc degeneration following lumbar discectomy has yet to be investigated.

Based on these observations, we developed this study to determine if a relationship exists between preoperative adjacent level disc degeneration and postoperative clinical outcomes following lumbar discectomy. We hypothesized that higher grades of adjacent level disc degeneration would lead to worse clinical outcomes in terms of back pain following lumbar discectomy.

Materials and methods

Data were obtained retrospectively from an ongoing prospective, randomized clinical trial performed at two tertiary-care academic institutions. Inclusion criteria for the original study included patients 18 years and older with radicular pain or neurologic deficit who underwent a single-level lumbar discectomy. Exclusion criteria included cauda equina syndrome, malignancy, prior lumbar surgery and/or multiple level disc herniations. Primary outcome measures included the Modified Oswestry Low Back Pain Disability Index (ODI) score (range 0–100) and Visual Analog Scale (VAS) score for back and leg pain (range 0–100). All outcome measures were recorded at 3 months, 1, and 2 years postoperatively. Additionally, demographic data such as employment status, occupation, and workers compensation status were recorded. Study data were collected and managed using REDCap electronic data capture tools [14]. REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing (1) an intuitive interface for validated data entry; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages; and (4) procedures for importing data from external sources.

An independent reviewer who was not involved in the surgeries reviewed all preoperative MRIs. The original Pfirrmann grading scale [15] was used to grade the degree of disc degeneration of the adjacent levels cephalad and caudal to the herniation (Fig. 1), except in the case of L5-S1 herniations, where only the cephalad disc was graded. We then categorized the patients by grade (1–5) by the average grade (rounded up) of the two adjacent levels in cases where both cephalad and caudal discs were graded (Table 1). Each grouping of patients was then analyzed for possible correlation with ODI scores, back and leg VAS scores, and the calculated change from baseline for all metrics at all postoperative time points.

Fig. 1 T2 weighted MRI, paramedial sagittal image. Index level with herniated disc is L4/L5. Cephalad level graded as Pfirrmann 4. Caudal level graded as Pfirrmann 2

Table 1 Distribution of patients per Pfirrmann grading level is depicted with subsequent follow-up

Number of patients at study time points by grade				
Grade	Baseline	3 months	1 year	2 years
2	10 (17 %)	9 (18 %)	9 (21 %)	6 (20 %)
3	13 (22 %)	12 (23 %)	10 (23 %)	8 (27 %)
4	29 (48 %)	26 (51 %)	20 (47 %)	13 (43 %)
5	8 (13 %)	4 (8 %)	4 (9 %)	3 (10 %)
Total	60	51	43	30

Percent values represent the grade at each follow-up time point. Sum of column percent is 100

Statistical analysis

All statistical analysis was conducted using the SigmaPlot 12 statistical package (Systat Software, San Jose, CA). The analysis of variance (ANOVA) test was used to assess the variance between adjacent level Pfirrmann grades in ODI, VAS leg, and VAS back scores at baseline; no difference was found between groups. Thus, it was assumed that any difference subsequently found between groups was due to the effect of the adjacent level.

Either the ANOVA test for Means or the ANOVA test for Ranks was used, depending on the normality of the data

as assessed using the Shapiro–Wilk test. Normal data were assessed using means; data not passing the normality test was assessed using ranks.

Results

Sixty patients (33 M, 27 F) were identified that met study criteria. The average age of patients was 45.67 years with a standard deviation of 11.1. The youngest patient was 23 and the oldest was 76, for a 53 year range. The distribution of patients per grade is demonstrated in Table 1. There was an equal distribution of discectomies performed at L4/5 and L5/S1 (28 each) as well as at L2/3 and L3/4 (2 each).

We found no statistically significant difference in leg VAS or ODI scores between Pfirrmann-grade groups at any postoperative time point, regardless of which way patients were categorized. Additionally, at 3-month and 1-year follow-up, there was no statistically significant difference between groups for back VAS scores. However, at the 2-year follow-up mark, there was a statistically significant difference between groups for back VAS with patients categorized both ways (Table 2). Furthermore, when analyzing changes from baseline at each post-operative time relative to baseline, there was no statistically significant difference found between any groups, either categorized by averages or worse grades, at any time point.

When looking at the outcomes graphically, it is apparent that at 2 years after surgery the back VAS scores are highest in the group who preoperatively had Grade 3 adjacent levels (Fig. 2). However, this upward trend is not evident in Leg VAS (Fig. 3) or, more imporantly, in ODI scores (Fig. 4).

An additional analysis was conducted using the worse, instead of the average, Pfirrmann grade and these were consistent indicating that using the average or worse disc grade does not affect the outcome (data not shown).

Discussion

We first analyzed the relationship between Pfirrmann grades and our outcome measures using the average grade of the two adjacent discs for each patient because that value could give us an overall amount of degeneration for that part of the back, which is important because neither disc acts completely independently of the other disc. We subsequently analyzed the same relationship using the worse Pfirrmann grade of the two adjacent discs for each patient because it is plausible that the worse disc would be the one that caused a patient pain. In both cases, the only statistically significant relationship was between

Table 2 Mean outcome of back, leg VAS and ODI scores by Pfirrmann grade at follow-up time points

Mean outcome by Pfirrmann grade					
	2	3	4	5	*P* value
Baseline					
Back VAS	50.89	44.50	43.76	54.38	0.670*
Leg VAS	76.11	72.69	61.17	60.75	0.277*
ODI	58.36	51.40	49.68	51.50	0.667^
3 months					
Back VAS	10.44	15.00	19.27	17.00	0.746*
Leg VAS	16.11	23.17	15.73	19.75	0.761*
ODI	13.33	23.33	16.96	21.06	0.467*
1 year					
Back VAS	8.89	14.90	16.10	10.00	0.720*
Leg VAS	15.11	24.00	19.40	13.75	0.886*
ODI	11.04	23.60	12.60	12.00	0.269*
2 years					
Back VAS	2.17	33.75	14.92	5.00	**0.011***
Leg VAS	8.17	29.00	14.31	28.67	0.361*
ODI	5.22	20.89	13.30	10.67	0.169^
3-month change					
Back VAS	45.50	29.45	23.77	33.50	0.390^
Leg VAS	61.25	50.58	44.81	45.75	0.505^
ODI	43.95	27.85	32.99	31.94	0.305^
1-year change					
Back VAS	39.75	25.11	27.55	39.25	0.733^
Leg VAS	61.13	48.40	45.45	48.00	0.596^
ODI	48.02	25.62	37.13	35.00	0.065^
2-year change					
Back VAS	42.40	16.29	27.62	30.67	0.565^
Leg VAS	61.20	44.00	53.38	27.00	0.372^
ODI	51.04	25.89	37.68	30.00	0.132^

Bold *P* value indicates statistical significance ($P<0.05$)

* ANOVA by ranks; ^ ANOVA by means

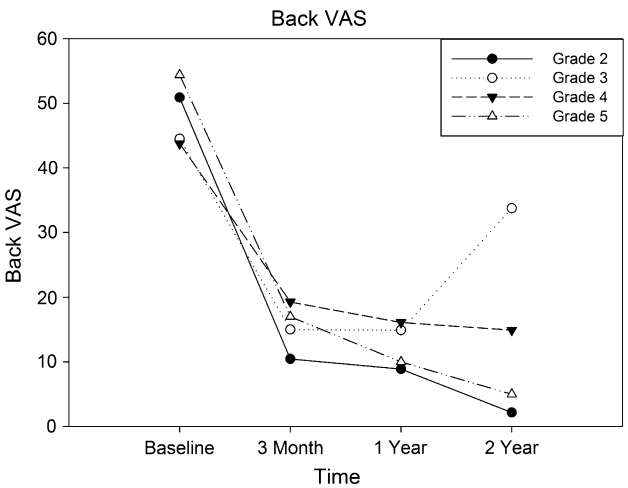

Fig. 2 Change in Back VAS over time

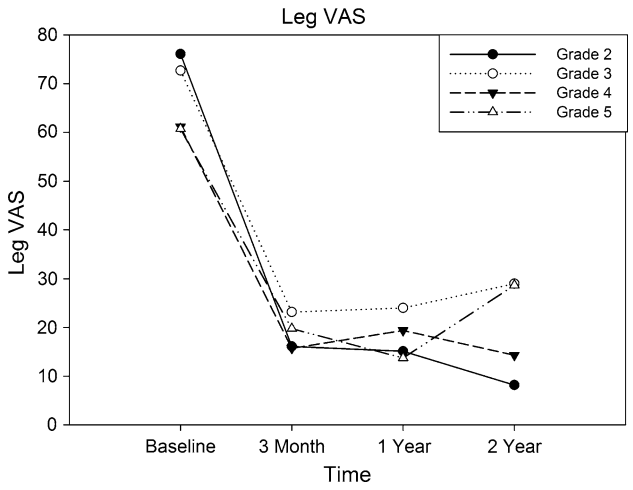

Fig. 3 Change in Leg VAS over time

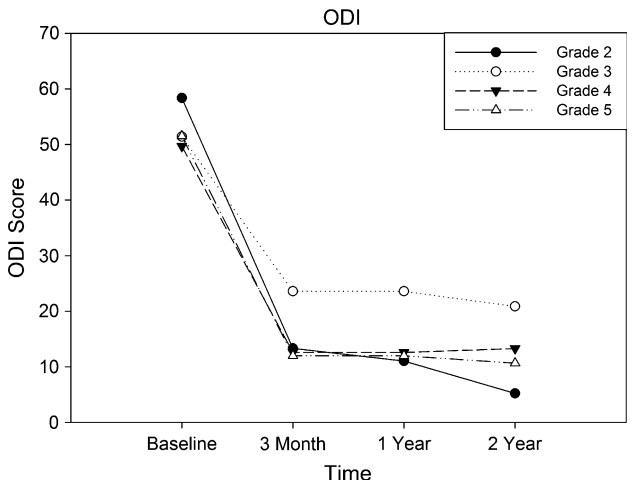

Fig. 4 Change in ODI over time

preoperative adjacent level Pfirrmann grades and VAS back pain at 2 years postoperatively.

From the current data, no correlation was found between the Pfirrmann grade of adjacent level degeneration and postoperative outcomes following lumbar discectomy up to 1 year after surgery. While there was a small difference in back pain noted at 2 years, this finding is confounded by poor follow-up at this time point. Considering these data, our hypothesis that adjacent level degeneration would influence surgical outcomes is not strongly supported.

This is not an entirely surprising finding. The relationship between disc degeneration and low back pain remains poorly understood. The classic study by Boden et al. [2] clearly demonstrates that varying grades of disc degeneration can present in patients with no active or past history of low back pain. The equivocal results between surgical and nonoperative treatment of discogenic low back pain further prove our lack of understanding of this relationship [16, 17]. Likewise, it has been well established [18] that the radiographic incidence of adjacent level degeneration following fusion far surpasses the incidence of symptomatic adjacent level disease. Considering these data and our current findings, patients can be advised that it is unlikely that surgical outcomes, namely specifically low back pain improvement, will be influenced by degeneration of adjacent levels.

Similarly, the relationship between disc herniations and low back pain is not entirely clear. Though discectomy is classically considered a "leg pain operation," previous studies have reported improvement in back pain following discectomy [12, 19]. A subgroup analysis of SPORT demonstrated that discectomy improved back pain compared to nonoperatively treated patients at 2-year follow-up [20]. In an earlier study, Toyone et al. [19] found that back pain improved following lumbar discectomy. Though it can improve, others have found that back pain following discectomy is quite common [13]. These seemingly contradictory findings suggest that (1) lumbar disc herniation, though a common cause of radiculopathy, can also cause low back pain that might be relieved by discectomy and that (2) there are likely many other concomitant causes of low back pain in this population, as indicated by the incomplete relief of back pain in the vast majority of patients.

One of the potential concomitant causes of continued low back pain is adjacent level degeneration, the focus of the current investigation. While research on the affect of adjacent level degeneration on surgical outcomes has been inconclusive, patients have increasing access to their imaging reports through medical record portals and as such frequently inquire about the integrity of the "rest of their spine," namely how the other non-herniated discs might affect them in the future. In some cases, degeneration is more significant at levels other than the operative level, raising patient concern regarding surgical outcomes. From the current study, however, patients can be reasonably reassured that adjacent level degeneration does not seem to strongly influence discectomy outcomes.

Additionally, our data suggest that an increase in back pain after surgery is unlikely to affect function. Our data show an increase in back VAS (Fig. 2) for patients with an adjacent level bearing a pre-operative Pfirrmann grade of 3 at the 2-year mark; however, this is not accompanied by an increase in ODI (Fig. 4). It is possible that discs with this grade are in a 'transitional' state and the increase in back VAS was caused by the rapid degeneration of the adjacent disc. While it is impossible to confirm subsequent degeneration without postoperative MRIs, the absence of a sharp increase in ODI score for this follow-up duration suggests that back pain, caused by degenerated discs or otherwise, does not affect a patients post–post operative function.

While the strengths of this study include prospective data collection, a multi-surgeon/center patient pool, independent

radiographic evaluation by a single grader un-involved with the index procedures, and the use of validated outcomes measurements for both functional and pain scores, several limitations should be acknowledged. First, there was likely underpowering of the number of patients with each degeneration grade, though we found little difference between groups. This suggests that a large sample size would be necessary to achieve adequate power to detect small differences in outcome, should one exist. Another limitation was the retrospective nature of the study, though the data was gathered prospectively. Finally, 2-year follow-up was achieved in only about half the patients, weakening any conclusions about findings at this time point.

Conclusions

While previous studies have focused on a host of other factors, our analysis is the first to investigate the relationship between adjacent level degeneration and clinical outcomes following lumbar discectomy. Our data add to the volume of previous work that weakens the link between the severity of radiographic findings and degree (or presence) of symptoms in a patient. When MRI reports describe multi-level degeneration concomitant with a symptomatic disc herniation scheduled to be surgically treated, patients can be reassured that current evidence does not suggest a deleterious effect on postoperative outcomes.

Additionally, our findings suggest that an increase in post-operative back pain is not accompanied by a loss of function as measured by the ODI.

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