

Comparison of Pain Intensity and Neuropathic Characteristics in Single-Level L4-L5 and L5-S1 Lumbar Disc Herniations

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Abstract

Introduction: Lumbar disc herniation is a common clinical condition in which pain severity and characteristics may differ according to the anatomical level involved. This study aimed to compare pain intensity and neuropathic pain features between patients with single-level L4-L5 and L5-S1 disc herniations. **Methods:** This cross-sectional observational study included 72 patients aged 18–80 years with MRI-confirmed single-level L4-L5 (n=46) or L5-S1 (n=26) herniations. Demographic and clinical data were recorded. Pain intensity was measured using the Visual Analog Scale (VAS) for current, most severe, and average pain. Neuropathic pain components were assessed with the PainDETECT questionnaire. Statistical analyses included independent-samples t-tests, Mann-Whitney U tests, and chi-square tests. **Results:** Mean age and sex distribution were similar between groups ($p>0.05$). VAS scores for current, most severe, and average pain did not significantly differ between L4-L5 and L5-S1 groups ($p>0.05$). However, a higher proportion of patients with L4-L5 herniation had PainDETECT scores ≥ 19 , indicating probable neuropathic pain, compared with the L5-S1 group (63.0% vs. 26.9%, $p=0.015$). Radiating leg pain was also more common in the L4-L5 group (95.7% vs. 80.8%, $p=0.042$). **Conclusions:** While pain intensity was similar across groups, patients with L4-L5 herniations exhibited neuropathic pain features and radicular symptoms more frequently than those with L5-S1 herniations. These findings suggest that the anatomical level of disc herniation may influence pain quality, which could guide more tailored pain management strategies.

Keywords: lumbar disc herniation, neuropathic pain, radicular pain, lumbar spine

1. Introduction

Lumbar disc herniation (LDH) is a common degenerative spinal pathology characterized by the displacement of the nucleus pulposus through a disrupted annulus fibrosus^{1,2}. This condition often leads to mechanical compression of the nerve root and the activation of inflammatory cascades, resulting in pain and neurological symptoms^{3,4}. The most frequently affected levels are L4-L5 and L5-S1, where herniation typically manifests with low back pain, sciatica, paresthesia, and restricted mobility^{5,6}.

Pain associated with LDH may arise from both nociceptive and neuropathic mechanisms. While nociceptive pain results from tissue injury, neuropathic pain originates from direct damage

or dysfunction of the somatosensory nervous system⁷. In LDH, these mechanisms frequently coexist, leading to a mixed pain pattern that complicates both diagnosis and management⁸.

Neuropathic pain in LDH can be attributed to three primary pathophysiological processes: activation of local nociceptors in the degenerated disc (local neuropathic pain), direct mechanical compression of the nerve root (mechanical neuropathic radicular pain), and the effect of pro-inflammatory mediators released from the herniated disc on neural tissues (inflammatory neuropathic radicular pain)^{9,10}. These components may influence both the quality and intensity of perceived pain¹¹.

In recent years, self-report tools such as the PainDETECT questionnaire have been widely used to identify neuropathic components in chronic low back pain^{12,13}. However, there is a limited body of literature examining how the specific level of disc herniation—particularly L4-L5 versus L5-S1—might differentially affect pain characteristics, especially with respect to neuropathic features¹².

Pain in lumbar disc herniation is multifactorial and influenced by disc morphology, location, size, degenerative status, and individual anatomical characteristics. Within this complex framework, the present study aims to explore whether the anatomical level of single-level lumbar disc herniation (L4-L5 vs. L5-S1) is associated with differences in neuropathic pain characteristics, rather than suggesting a direct causal relationship between disc level and pain intensity.

2. Materials and Methods

This cross-sectional observational study was conducted between February and July 2024 at the Physical Medicine and Rehabilitation and Neurosurgery outpatient clinics of SBÜ Ümraniye Training and Research Hospital. A total of 72 volunteer patients aged between 18 and 80 years who presented with low back and/or leg pain and were diagnosed with single-level lumbar disc herniation at either the L4-L5 or L5-S1 level based on lumbar magnetic resonance imaging (MRI) were included in the study. The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Ümraniye Training and Research Hospital Ethics Committee on January 11, 2024 (Approval No: E54132726-000-234078410). Written informed consent was obtained from all participants.

This study was designed as an exploratory cross-sectional observational study. Due to the limited availability of previous studies directly comparing neuropathic pain characteristics between single-level L4-L5 and L5-S1 lumbar disc herniations using the PainDETECT questionnaire, a formal a priori power analysis was not performed. Therefore, all consecutive patients who met the inclusion criteria during the study period were included in the study.

Patients were eligible if they had a confirmed diagnosis of L4-L5 or L5-S1 disc herniation and demonstrated cognitive competence sufficient to complete the self-report instruments. Patients with multilevel disc herniation, polyneuropathy due to diabetes or other systemic conditions, a history of lumbar spine or lower extremity surgery, central or peripheral nervous system disorders (including but not limited to carpal tunnel syndrome, sciatic neuropathy, multiple sclerosis, or postherpetic neuralgia), vascular disease of the lower extremities, malignancy, pregnancy, or current breastfeeding were excluded from the study.

All participants underwent a detailed physical and neurological examination performed by the same experienced physical medicine and rehabilitation specialist. Pain intensity and characteristics were assessed using the Visual Analog Scale (VAS) and the PainDETECT questionnaire¹⁴, which has been validated in Turkish for the assessment of neuropathic pain components. The VAS was applied to measure current pain, the most severe pain, and the average pain experienced over the past week. PainDETECT was used to evaluate the likelihood of neuropathic pain, and all assessments were conducted through face-to-face interviews under direct supervision.

2.1. Statistical Analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 16.0 (SPSS Inc., Chicago, IL, USA). The distribution of continuous variables was

assessed using the Kolmogorov–Smirnov test. Normally distributed continuous variables were presented as mean $\pm$ standard deviation (SD), and group comparisons were conducted using the independent samples t-test. Non-normally distributed data were expressed as median (minimum–maximum) and compared using the Mann–Whitney U test. Categorical variables were expressed as frequencies and percentages, and analyzed using the Chi-square (χ^2) test. A p-value of less than 0.05 was considered statistically significant.

3. Results

A total of 72 patients with single-level lumbar disc herniation were included in the study. Among them, 46 patients had L4-L5 level herniation (Group 1) and 26 had L5-S1 level herniation (Group 2). The mean age was 47.8 ± 11.7 years in Group 1 and 42.8 ± 11.3 years in Group 2. The proportion of female patients was higher in both groups: 71.7% in Group 1 and 76.9% in Group 2. There was no statistically significant difference between the groups in terms of age or sex distribution ($p > 0.05$) (Table 1).

Table 1. Demographic and clinical features of the patients by herniation level.

Variable	L4-L5 (n = 46)	L5-S1 (n = 26)	p-value*
Age (mean $\pm$ SD)	47.8 ± 11.7	42.8 ± 11.3	>0.05
Female (%)	71.7%	76.9%	>0.05
Current VAS (mean)	5.67	5.38	0.804
Most severe VAS (mean)	8.09	7.65	>0.05
Average VAS (mean)	6.15	6.04	>0.05
PainDETECT score (mean $\pm$ SD)	18.91 ± 6.2	17.00 ± 7.1	0.288
Leg pain (%)	95.7%	80.8%	0.042

*Statistically significant at $p < 0.05$. Independent samples t-test for continuous variables with normal distribution; Mann–Whitney U test for non-parametric data; Chi-square test for categorical variables.

Pain intensity and type were assessed using the Visual Analog Scale (VAS) and PainDETECT questionnaire. VAS scores for current pain, most severe pain, and average pain over the past week showed no statistically significant difference between groups ($p > 0.05$ for all comparisons). Mean VAS scores were 5.67 (current), 8.09 (most severe), and 6.15 (average) in Group 1, and 5.38, 7.65, and 6.04, respectively, in Group 2.

The mean PainDETECT score was 18.91 ± 6.2 in the L4-L5 group and 17.00 ± 7.1 in the L5-S1 group, with no statistically significant difference ($p = 0.288$). However, when PainDETECT scores were categorized, a marked difference emerged. In the L4-L5 group, 63.0% ($n = 29$) of patients had scores ≥ 19 , indicating a high likelihood of neuropathic pain, while this proportion was 26.9% ($n = 7$) in the L5-S1 group. Conversely, low neuropathic pain probability (≤ 12) was observed in 10.9% ($n = 5$) of Group 1 and in 30.8% ($n = 8$) of Group 2 patients. This distribution was statistically significant ($\chi^2 = 8.36$, $p = 0.015$) (Table 2).

The presence of radiating leg pain was reported in 95.7% of Group 1 and 80.8% of Group 2 patients. This difference also reached statistical significance ($p = 0.042$), suggesting more frequent radicular involvement in L4-L5 herniations.

Table 2. Distribution of PainDETECT categories by disc herniation level.

PainDETECT Category	L4-L5 (n = 46)	L5-S1 (n = 26)
High (≥ 19)	29 (63.0%)	7 (26.9%)
Uncertain (13–18)	12 (26.1%)	11 (42.3%)
Low (≤ 12)	5 (10.9%)	8 (30.8%)

4. Discussion

This study aimed to assess whether the anatomical level of lumbar disc herniation (L4-L5 vs. L5-S1) is associated with differences in pain severity and neuropathic pain characteristics. Although there were no statistically significant differences in current, average, or most severe pain intensity as measured by the Visual Analog Scale (VAS), the distribution of PainDETECT scores suggested a substantially higher prevalence of neuropathic pain in patients with L4-L5 disc herniation^{12,14,15,16}.

The observed predominance of neuropathic pain in the L4-L5 group may be attributed to anatomical and biomechanical factors. The L4-L5 spinal segment, located at the lumbosacral junction, is subject to increased biomechanical stress due to its greater range of motion and load-bearing role^{1,2,4,17}. These features may predispose the L5 nerve root to compression or irritation from disc pathology at this level. Since the L5 nerve root supplies a broader region of the lower extremity, including motor and sensory innervation to the dorsum of the foot and lateral thigh, its involvement can contribute to more prominent neuropathic symptoms such as burning, electric shock sensations, and paresthesias^{3,5,18}. These findings are consistent with previous studies indicating a stronger association between L5 nerve root compression and radicular neuropathic pain profiles^{1,8,19}.

Additionally, the significantly higher rate of radiating leg pain in the L4-L5 group further supports the hypothesis of more extensive nerve root involvement. This suggests that the anatomical level of herniation may influence not only the clinical distribution of pain but also its underlying neurophysiological features^{7,10,20}. In contrast, L5-S1 herniations tend to affect the S1 nerve root, which innervates the posterior leg and sole of the foot. It is possible that patients perceive S1-related symptoms as less severe or less neuropathic in nature due to differences in cortical representation or symptom localization, although further research is warranted to elucidate these mechanisms^{4,6,21}.

The lack of significant differences in VAS scores between groups emphasizes the complexity of pain assessment in lumbar disc herniation. Pain intensity alone may not accurately reflect the presence or extent of neuropathic involvement. Tools like PainDETECT, which evaluate qualitative features of pain, can provide more detailed insight into pain mechanisms and are essential for identifying patients who may benefit from targeted neuropathic pain treatments such as gabapentinoids or serotonin–norepinephrine reuptake inhibitors^{12,14,22}.

It should be emphasized that the anatomical level of disc herniation represents only one component within a complex interaction of structural, biomechanical, and neurophysiological factors contributing to pain perception. Disc morphology, degree of nerve root compression, disc degeneration, and individual anatomical variations likely play a dominant role in determining pain intensity and radicular symptoms. Therefore, the findings of this study should be interpreted as reflecting an association between disc level and neuropathic pain features within a multifactorial context, rather than implying a direct or exclusive causal relationship.

Our results underscore the need for a multidimensional approach in evaluating pain in patients with lumbar disc herniation. Incorporating neuropathic pain assessment tools into routine clinical practice may aid in more precise phenotyping of patients and inform individualized treatment strategies^{7,8,23}. Furthermore, identifying the disc herniation level as a potential contributing factor to pain type can assist clinicians in prognostic counseling and therapeutic decision-making^{1,3,24}. Future prospective studies with larger sample sizes, electrophysiological evaluations, and longitudinal follow-up may provide further insights into the relationship between herniation level and neuropathic pain development. Such studies could also help clarify whether the observed differences translate into varied responses to specific treatment modalities^{2,10,25}.

The strength of this study lies in its inclusion of patients with MRI-confirmed single-level lumbar disc herniation, which allowed for a relatively homogeneous study population. The use of standardized and validated assessment tools, such as the Visual Analog Scale (VAS) and the PainDETECT questionnaire, as well as evaluations performed by the same physician, contributed to methodological consistency.

Nevertheless, several limitations should be acknowledged. First, the cross-sectional design precludes causal inferences regarding the relationship between disc herniation level and pain

characteristics. Second, pain assessment was based on self-reported measures without electrophysiological confirmation, which may have introduced reporting bias. Third, the relatively small sample size—particularly in the L5–S1 group—and the absence of an a priori power analysis may limit the statistical power and generalizability of the findings.

In addition, disc herniation morphology (e.g., central, paracentral, foraminal, or extraforaminal) was not systematically classified, and age-related variations in disc composition and degenerative status were not controlled for. These factors may influence pain intensity and neuropathic pain features and should be considered when interpreting the results. Future studies incorporating detailed radiological subclassification, age-stratified analyses, and prospective designs are warranted to further clarify these relationships.

5. Conclusion

This study demonstrates that while overall pain severity does not significantly differ between L4–L5 and L5–S1 disc herniations, the neuropathic characteristics of pain appear more frequently in L4–L5 cases. The higher proportion of patients with a high PainDETECT score and radiating leg pain in the L4–L5 group suggests that disc level may influence the qualitative aspects of pain more than its intensity. These findings underscore the need for clinicians to assess pain characteristics in addition to severity, as this may guide more targeted and individualized treatment approaches in lumbar disc herniation within a multifactorial clinical context.

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