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# Does the Size or Location of Lumbar Disc Herniation Predict the Need for Operative Treatment?

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## Abstract

**Study Design:** Retrospective cohort study.

**Objective:** The goal of this study was to determine whether the absolute size (mm$^2$), relative size (% canal compromise), or location of a single-level, lumbar disc herniation (LDH) on axial and sagittal cuts of magnetic resonance imaging (MRI) were predictive of eventual surgical intervention.

**Methods:** MRIs of 89 patients were reviewed, and patients were split into groups based on type of management received (34 nonoperative vs 55 microdiscectomy). Radiographic characteristics—including size of disc herniation (mm$^2$), size of spinal canal (mm$^2$), location of herniation on axial (central, paracentral, foraminal) and sagittal (disc level, suprapedicle, pedicle, infrapedicle) planes, and type of herniation (bulge, protrusion, extrusion, sequestration)—were measured by 2 independent, orthopedic spine fellows and compared between groups via univariate and multivariate analyses.

**Results:** The operative group showed a significantly higher percentage of canal compromise (39.5% vs 31.1%, $P = .001$) compared to the nonoperative group. Multiple logistic regression analysis showed higher odds of eventual operative intervention for a disc protrusion (odds ratio [OR] 6.30 [1.99, 19.86], $P = .002$) or disc extrusion (OR 11.5 [1.63, 81.2], $P = .014$) for Rater 1 and a higher odds of eventual surgical management for a paracentral location for both Rater 1 and Rater 2 (OR = 3.39 [1.25, 9.22], $P = .017$, and OR = 5.46 [1.77, 16.8], $P = .003$, respectively).

**Conclusions:** Disc herniations in a paracentral location were more likely to undergo operative treatment than those more centrally located, on axial MRI views.

### Keywords
lumbar disc herniation, LDH, size, location, bulge, protrusion, extrusion, sequestration, MRI

## Introduction

Lumbar disc herniation (LDH) is a highly prevalent condition in the United States and a common cause of disability in the adult population. While LDHs can occur in all ages, the highest prevalence is among patients between 30 and 50 years of age, with a male-to-female ratio of 2:1.[1] Approximately 95% of all herniated discs in this age group occur in the lower lumbar spine between L4-S1, whereas those observed in older patients typically occur

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above L4.[1] Nonoperative treatment is successful in a large number of patients, with only a small proportion eventually require surgical treatment.[2] However, given the high prevalence of this disease, lumbar microdiscectomy is one of the most commonly performed spine surgeries performed in the United States with an estimated occurrence of up to 480 000 annual cases.[3]

Early degenerative changes in the lumbar spine that compromise the structural integrity of the annulus fibrosus may allow the herniation of nucleus pulposus material into the spinal canal. This herniated material commonly impinges on the traversing nerve root in the central or paracentral aspect of the canal. Less often, the herniated disc may impinge on the exiting nerve root in the foraminal or extraforaminal areas of the affected disc. While the pathomechanics of this process are fairly straightforward, the location and size of the herniation may affect clinical outcomes. Magnetic resonance imaging (MRI) is the most sensitive imaging modality used to diagnose and assess a disc herniation.[4] However, interpretation of MRI is largely subjective and few studies to date have attempted to elucidate the relationship between disc herniation morphology and corresponding clinical symptoms.[5-8] Specifically, it is still unclear which MRI characteristics may be predictive of successful nonoperative treatment. Saal et al noted that large extrusions and sequestrations resorb faster and, thus, may be favorable factors for determining the success of nonoperative treatment; however, the authors also noted that the size, canal position, and spinal level of a LDH may be important factors to consider.[2]

Several prospective studies analyzing conservative versus operative treatment for LDH have found that patients can at least expect improved short-term pain relief with surgery.[9-11] Even when comparing long-term differences, the Spine Patient Outcomes Research Trial (SPORT) and the Maine Lumbar Spine Study (MLSS) both found that patients selected for surgery had meaningful clinical differences at 8- and 10-year mark, respectively.[10,12] Furthermore, a subanalysis of the SPORT trial, which evaluated disc morphology based on central versus lateral herniations and disc protrusions versus sequestrations/extrusions, was inconclusive in determining whether morphology was predictive of surgery.[13] Therefore, the aim of this study was to categorize disc herniation morphology based on the type, size, and location, and determine whether these characteristics were predictive of eventual surgical intervention.

## Materials and Methods

After institutional review board approval was obtained, patients with a diagnosis of LDH treated at a single center academic institution between 2015 and 2018 were retrospectively identified. Patients under the age of 18 years or those with unavailable MRI findings in the institution's Picture Archiving and Communications System (PACS) were excluded from the analysis. Patient charts were reviewed and the cohort was divided into 2 groups based on whether each patient underwent continued nonoperative treatment or microdiscectomy for treatment of a single-level LDH. For patients in the operative group, the total time between the first clinic visit and the operative intervention was noted.

Individual MRIs was reviewed using the institution's PACS system: Sectra Workstation IDS7 18.2 (Sectra AB). Disc morphology characteristics that were reviewed include affected lumbar level, type of herniation, size of herniation, and location of herniation on axial and sagittal views. The latter 3 measurements taken were based on definitions set forth by the combined task forces of the North American Spine Society, American Society of Spine Radiology, and American Society for Neuroradiology Lumbar Disc Nomenclature 2.0.[14] For type of herniation, a disc bulge (symmetric or asymmetric) was defined by the presence of soft tissue extending beyond the ring apophyses throughout the circumference of the disc. A disc protrusion was present if the greatest distance between the edges of the disc material outside of the disc space was less than the distance between the edges of the base of the herniation. A disc extrusion was present when any one distance between the edges of the disc beyond the disc space was greater than the distance between the edges at the base of the herniated material. Sequestration was noted when the herniated material lost continuity with the disc space. In order to consistently identify the size of the disc herniation, the authors utilized PACS to find the axial view demonstrating the largest identifiable area of pathology. Once this view was found, the region of interest (ROI) tool was utilized to estimate the cross-sectional area ($mm^2$). ROI of the disc herniation (ROI-Disc; Figure 1) and the ROI of the spinal canal (ROI-canal; Figure 2) were both ascertained. The boundaries of the spinal canal were designated as follows: Posterior vertebral wall–anterior border; ligamentum flavum–posterior border; and projected medial walls of the pedicle–lateral border. These characteristics were individually graded by 2 orthopedic spine fellows (Rater 1 and Rater 2). The percent of canal involvement was calculated as follows: (ROI-Disc/ROI-Canal) $\times$ 100%. The definitions for location were also based on the aforementioned lumbar disc nomenclature.[14] To determine the location of herniation in the axial plane, the view with the largest identifiable area of soft tissue herniated was considered. The spinal canal was divided into 4 equal quarters using an intrafacet line extending through the most medial aspect of the superior articular facet (lateral boundaries) and a middle line extending from the center of the disc anteriorly through spinous process posteriorly (medial boundaries; Figure 3). If the disc herniation extended into the medial 2 quarters, it was graded as a central disc herniation, whereas extension into the lateral 2 quarters was graded as a paracentral disc herniation. If the herniation extended laterally past the intrafacet line, a foraminal disc herniation was documented. For the purposes of this study, extraforaminal disc herniations were grouped into the same category as foraminal disc herniations. ROI-Disc, but not ROI-Canal, was calculated for foraminal herniations. Finally, the area of disc herniation on the sagittal cut was also calculated based on the largest observable area of soft tissue herniated. Figure 4 depicts the 4 zones of disc herniation as described in the lumbar disc nomenclature guidelines: disc level, suprapedicle, pedicle, and infrapedicle level.[14]

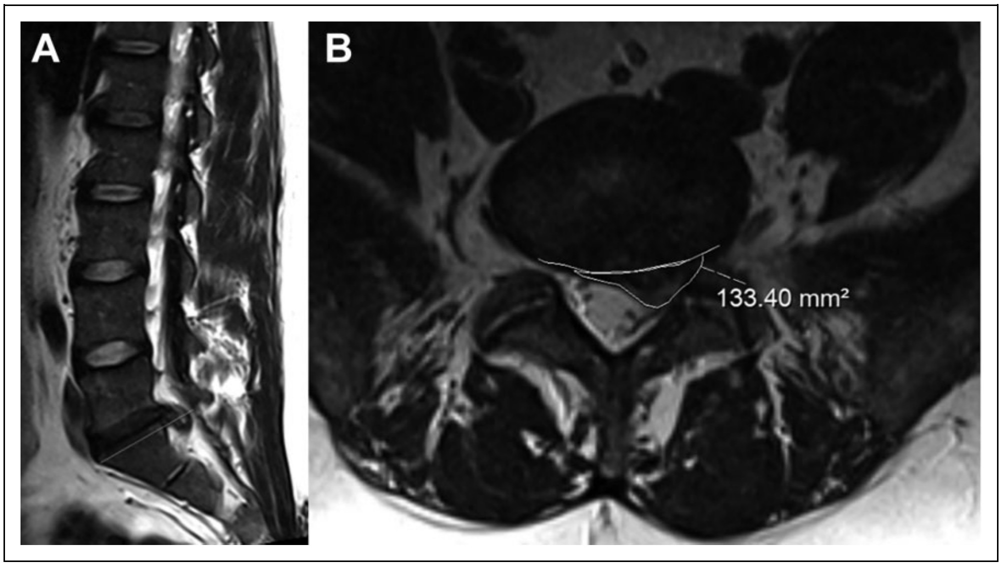


**Figure 1.** (a) Sagittal T2 MRI showing the axial level of measurement an L5-S1 disc herniation. (b) The representative T2 axial cut is shown here, with ROI-Disc outlined.

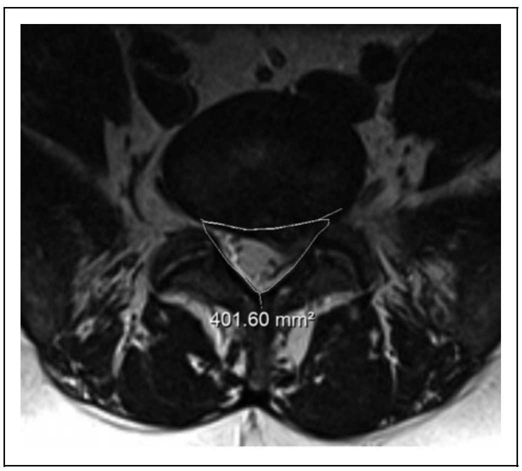


**Figure 2.** Figure showing the outline of the spinal canal formed by the posterior vertebral wall, ligamentum flavum, and projected medial borders of the pedicle.

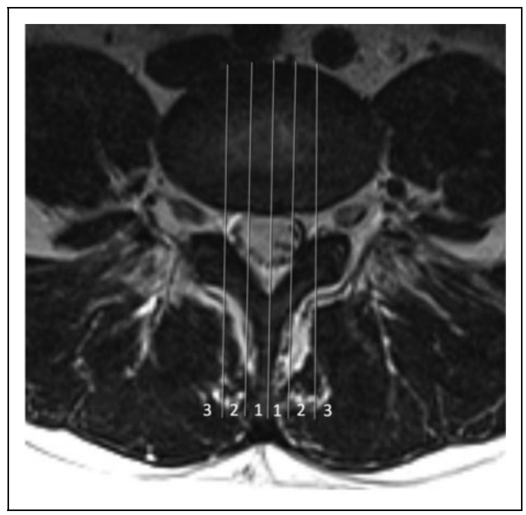


**Figure 3.** Measurement of location of disc herniation was assessed on the axial cut. Zone 1 indicates a central herniation, zone 2 indicates a paracentral herniation, and zone 3 indicates a foraminal/extraforaminal disc herniation.

### *Statistical Methods*

Continuous data between groups was compared via Student's *t* test, while categorical data was compared using either Pearson $\chi^2$ analysis or a Fisher's exact test. Interobserver reliability comparing measurements between Rater 1 and Rater 2 was performed by the calculating Fleiss κ statistic, denoted by κ.[15] Strength of agreement was interpreted using the Landis and Koch grading system (<0.0: "poor agreement"; 0.01-0.20: "slight agreement"; 0.21-0.40: "fair agreement"; 0.41-0.60: "moderate agreement"; 0.61-0.80: "substantial agreement"; 0.81-1.00: "almost perfect agreement").[16] Multiple logistic regression analysis controlling for age, sex, and disc level was performed to determine the odds of eventually undergoing surgical intervention for each disc morphology characteristic. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 24 (IBM Corporation). A *P* value of less than .05 for each test was considered to be statistically significant.

## Results

After excluding patients that did not meet inclusion and exclusion criteria for the study, a total of 89 patients were identified and included in the final analysis. Of these, 34 patients were treated nonoperatively and 55 patients were treated with microdiscectomy. The average age in the nonoperative group (49.6 years [45.3, 53.9]) was similar to that observed in the microdiscectomy group (50.0 years [45.8, 54.3]; $P = .888$). There were no differences between groups in terms of sex ($P = .306$) or duration of symptoms ($P = .859$). Patients in the microdiscectomy group underwent surgery at an average of 2.28 months after initial presentation to the treating surgeon. The majority of patients had disc herniations at L4-5 and L5-S1, with a higher proportion of patients having disc herniations at L5-S1 in the microdiscectomy group (L5-S1, 45.5%, vs L4-5, 35.3%). Conversely, while the nonoperative group also had a majority of disc herniations between L4-5 and L5-S1, there was a higher number of observed cases at L4-5 (L4-5, 52.9%, vs L5-S1, 35.3%). There was no significant difference between operative and nonoperative groups in terms of the frequency of disc herniation observed at each level ($P = .491$). When assessing type of disc herniation, Rater 1 identified a significant difference between groups with a higher proportion of microdiscectomy patients demonstrating a disc protrusion ($P = .003$); however, there was no difference in this outcome for Rater 2 ($P = .358$). Overall interobserver reliability for this disc morphology characteristic indicated "moderate agreement" ($\kappa = 0.590$). Results of all baseline characteristics are shown in Table 1.

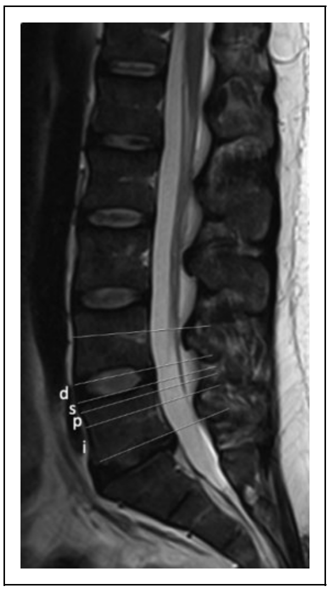


**Figure 4.** Measurement of the disc herniation on the sagittal cut. Extent of the herniation was determined into the furthest zone: d = disc level, s = suprapedicle, p = pedicle, i = infrapedicle.

There were no significant differences between the nonoperative and microdiscectomy groups in terms of ROI-Canal (362.4 $mm^2$ vs 339.8 $mm^2$, $P = .378$) or ROI-Disc size (108.9 $mm^2$ vs 131.0 $mm^2$, $P = .285$). Interobserver reliability for ROI-Canal demonstrated "almost-perfect agreement" ($\kappa = 0.824$) and "substantial agreement" for ROI-Disc ($\kappa = 0.780$). Percent of canal involvement was significantly lower in the nonoperative group compared to the microdiscectomy group (31.1% vs 39.5%, $P = .001$). When measuring the location of the herniation on the axial cut, both raters found a significantly higher proportion of central herniations in the nonoperative group and a higher proportion of paracentral herniations in the microdiscectomy group (Rater 1: $P = .016$ and Rater 2: $P = .005$) with substantial interobserver reliability ($\kappa = 0.710$). Comparing the level of herniation on the sagittal cut, Rater 1 found a lower proportion of disc-level herniations in the microdiscectomy group ($P = .044$), whereas Rater 2 did not find a difference between groups ($P = .215$). Interobserver reliability for this measure demonstrated "moderate agreement" ($\kappa = 0.512$). Measurements of disc herniation size and location are shown in Table 2.

Multiple logistic regression analysis showed that an increasing percentage of canal involvement was indicative of increased odds of eventual surgical management (odds ratio [OR] 1.08 [1.02, 1.14], $P = .007$). For Rater 1, type of herniation was a significant predictor of surgical

**Table 1.** Baseline Characteristics.

| | Nonoperative treatment, n = 34 | | Microdiscectomy, n = 55 | | P |
|---|---|---|---|---|---|
| Age (years) | 49.6 [45.3, 53.9] | | 50.0 [45.8, 54.3] | | .888 |
| Sex | | | | | .306 |
| Female | 18 (52.9%) | | 23 (41.8%) | | |
| Male | 16 (47.1%) | | 32 (58.2%) | | |
| Disc level | | | | | .491 |
| L1-2 | 2 (5.9%) | | 1 (1.8%) | | |
| L2-3 | 1 (2.9%) | | 1 (1.8%) | | |
| L3-4 | 1 (2.9%) | | 5 (9.1%) | | |
| L4-5 | 18 (52.9%) | | 23 (41.8%) | | |
| L5-S1 | 12 (35.3%) | | 25 (45.5%) | | |
| Type of herniation | Rater 1 | Rater 2 | Rater 1 | Rater 2 | |
| Bulge | 18 (52.9%) | 14 (41.2%) | 9 (16.4%) | 15 (27.3%) | $P^1 = .003$* |
| Protrusion | 13 (38.2%) | 15 (44.1%) | 35 (63.6%) | 24 (43.6%) | $P^2 = .358$ |
| Extrusion | 2 (5.9%) | 4 (11.8%) | 9 (16.4%) | 14 (25.5%) | $\kappa = 0.590$ |
| Sequestration | 1 (2.9%) | 1 (2.9%) | 2 (3.6%) | 2 (3.6%) | |
| Duration of symptoms | | | | | .859 |
| <6 months | 13 (38.2%) | | 20 (36.4%) | | |
| >6 months | 21 (61.8%) | | 35 (63.6%) | | |
| Time to surgery (months) | — | | 2.28 [1.59, 2.98] | | — |

**Table 2.** Disc Herniation Size and Location.

| | Nonoperative treatment, n = 34 | | Microdiscectomy, n =55 | | |
|---|---|---|---|---|---|
| ROI-Canal (mm$^2$) | 362.4 [323.9, 400.9] | | 339.8 [312.7, 367.0] | | $P = .378$; $\kappa = 0.824$ |
| ROI-Disc (mm$^2$) | 108.9 [91.9, 125.9] | | 131.0 [118.9, 143.1] | | $P = .285$; $\kappa = 0.780$ |
| % of Canal | 31.1 [27.1, 35.1] | | 39.5 [36.5, 42.6] | | $P = .001$* |
| Level of herniation on axial cut | Rater 1 | Rater 2 | Rater 1 | Rater 2 | |
| Central | 19 (55.9%) | 16 (47.1%) | 19 (34.5%) | 13 (23.6%) | $P^1 = .016$* |
| Paracentral | 10 (29.4%) | 9 (26.5%) | 33 (60.0%) | 34 (61.8%) | $p^2 = .005$* |
| Foraminal | 5 (14.7%) | 9 (26.5%) | 3 (5.5%) | 8 (14.5%) | $\kappa = 0.710$ |
| Level of herniation on sagittal cut | | | | | |
| Disc | 25 (73.5%) | 31 (91.2%) | 25 (45.5%) | 41 (74.5%) | $P^1 = .044$* |
| Suprapedicle | 7 (20.6%) | 2 (5.9%) | 18 (32.7%) | 9 (16.4%) | $P^2 = .215$ |
| Pedicle | 0 | 0 | 5 (9.1%) | 3 (5.5%) | $\kappa = 0.512$ |
| Infrapedicle | 2 (5.9%) | 1 (2.9%) | 7 (12.7%) | 2 (3.6%) | |

*Indicates statistical significance ($p < 0.05$).

**Table 3.** Multiple Logistic Regression: Odds of Undergoing Surgery, Controlling for Age, Sex, and Disc Level.

| | β-Coeff | OR | P | | | |
|---|---|---|---|---|---|---|
| ROI-Canal (mm$^2$) | −0.005 | 0.99 [0.98, 1.01] | .111 | | | |
| ROI-Disc (mm$^2$) | 0.011 | 1.01 [0.99, 1.02] | .085 | | | |
| % of Canal | 0.074 | 1.08 [1.02, 1.14] | .007* | | | |
| | Rater 1 | | | Rater 2 | | |
| | β-Coeff | OR | P | β-Coeff | OR | P |
| Type of herniation | | | .008* | | | .509 |
| Bulge | — | — | — | — | — | — |
| Protrusion | 1.841 | 6.30 [1.99, 19.86] | .002* | 0.345 | 1.41 [0.51, 3.89] | .504 |
| Extrusion | 2.442 | 11.5 [1.63, 81.2] | .014* | 1.087 | 2.97 [0.73, 12.1] | .129 |
| Sequestration | 1.709 | 5.52 [0.41, 75.4] | .200 | 0.218 | 1.24 [0.08, 18.3] | .874 |
| Level of herniation on axial cut | | | .022* | | | .004* |
| Central | — | — | — | — | — | — |
| Paracentral | 1.220 | 3.39 [1.25, 9.22] | .017* | 1.697 | 5.46 [1.77, 16.8] | .003* |
| Foraminal | −0.686 | 0.50 [0.09, 2.73] | .427 | −0.193 | 0.82 [0.21, 3.30] | .785 |
| Level of herniation on sagittal cut | | | .354 | | | .465 |
| Disc | — | — | — | — | — | — |
| Suprapedicle | 0.812 | 2.25 [0.77, 6.59] | .138 | 1.376 | 3.96 [0.73, 21.4] | .110 |
| Pedicle | 38.5 | — | .999 | 39.6 | — | .999 |
| Infrapedicle | 1.113 | 3.05 [0.54, 17.3] | .209 | 0.052 | 1.05 [0.08, 13.6] | .968 |

Abbreviation: OR, odds ratio.
*Indicates statistical significance ($p < 0.05$).

intervention ($P = .008$) with higher odds for disc protrusion (OR = 6.3 [1.99, 19.86], $P = .002$) and disc extrusion (OR = 11.5 [1.53, 81.2], $P = .014$) compared to disc bulge. For both Rater 1 and Rater 2, paracentral location on the axial cut was a significant predictor of surgical management (Rater 1, OR = 3.39 [1.25, 9.22], $P = .017$; Rater 2, OR = 5.46 [1.77, 16.8], $P = .003$). However, the level of herniation on the sagittal cut was not a significant predictor for either rater. Results from the multivariate analysis can be located in Table 3.

## Discussion

Nonsurgical care is successful for a majority of patients presenting with acute LDH and the decision for operative treatment is only made after the patient has failed to experience sufficient relief of symptoms with nonoperative treatment. However, determining which patients are prone to fail conservative care is more difficult. Even with the development of nomenclature schemes to accurately describe LDH, there can still be significant variation within each class. Only a few studies to date have examined whether LDH characteristics can be used to predict failure of conservative therapy; as such, the purpose of this study was to determine whether disc herniation type, size, or location in axial or sagittal MRI planes were predictive of the eventual need for operative treatment.[5-7]

The findings from this study suggest that while disc herniation size and spinal canal size did not significantly differ between groups, the percentage of canal involvement was significantly higher in patients who eventually required operative treatment ($P = .001$). Even after adjusting for baseline demographics and disc herniation level, the percentage of canal involvement was a small, but significant, predictor of eventually requiring microdiscectomy (OR = 1.08, $P = .007$). ROI-Canal was smaller and disc herniation size was larger in the microdiscectomy group, whereas this ratio was reversed in the nonoperative group. This reversal in ratio is an important characteristic, as it explains why the microdiscectomy group demonstrated a higher percentage of canal involvement. In addition, the interobserver reliability was found to be in "almost perfect agreement" for ROI-Canal ($\kappa = 0.824$) and in "substantial agreement" for ROI-Disc ($\kappa = 0.780$) measurements. Only 3 other studies quantified the relationship between the cross-sectional area of a disc herniation and the eventual need for surgery in LDH patients.[5,6,8] Carlisle et al analyzed 44 patients who underwent nonoperative treatment and 44 patients who underwent microdiscectomy for LDH, and found that the disc herniation size was larger and the spinal canal size was smaller in the surgery group.[6] Again, by definition, this implies that the average percent canal compromise was significantly larger in the surgery group. In a prospective, observational study, Carragee and Kim found that patients with a smaller disc to canal ratio had improved outcomes in the nonoperative group, whereas those with larger absolute disc areas and smaller canal areas (larger disc to canal ratio) had improved outcomes in the operative group.[5] The findings from these 2 studies are similar to and in support of the findings observed in the present study. However, the current study also found that percent of canal involvement was also a significant predictor of eventual operative treatment.

The location of herniation in the axial plane was also significantly difference between the 2 groups in this study. Both Rater 1 and Rater 2 found that the microdiscectomy group exhibited a higher proportion of paracentral disc herniations, while the nonoperative group presented with a higher proportion of central disc herniations ($P = .016$ and $P = .005$, for Rater 1 and 2, respectively). Additionally, paracentral herniations were found to have a 3.39 times and 5.46 times (for Rater 1 and Rater 2, respectively) higher odds of eventually requiring operative treatment with microdiscectomy. This makes intuitive sense, since the posterior longitudinal ligament provides a mechanical barrier against most central disc herniations, leaving a weak point just lateral to it at the paracentral location. In addition, a herniation at the paracentral location causes direct impingement on the traversing nerve root, causing neurologic symptoms. Similar to this study, Mysliwiec et al created a classification scheme for the extent of disc herniation in the axial plane by measuring depth and width, and found that patients in an operative cohort were more likely to have herniations extending up to the superior articular process and located in a paracentral region.[7] In a subanalysis of the SPORT Trial, Pearson et al found that patients with central herniations demonstrated greater improvements in low back pain compared to those with lateral disc herniations; however, this study grouped paracentral, foraminal, and extraforaminal herniations into an overarching "lateral" category.[13]

In the present study, when assessing the level of herniation in the sagittal plane, only Rater 1 found that the operative group had a significantly lower proportion of disc-level herniations ($P = .044$), whereas Rater 2 did not. Furthermore, there was less reliability in these measurements between raters ($\kappa = 0.512$). The results of this study were not robust enough to determine which LDH location on the sagittal plane can be used to reliably predict failure of conservative therapy in this cohort of patients. To our knowledge, however, while some studies have inferred herniation level by noting disc sequestrations, no other study has attempted to classify the extent of herniation in the sagittal plane. As such, the present findings may be used as a reference point for future, prospective studies that should attempt to further delineate this relationship.

Other studies examining LDH morphology have not quantified herniation size or location between treatment groups as predictors of success or failure of conservative care. In perhaps the only study to develop a predictive model, Hao et al retrospectively evaluated 1127 patients with LDH and developed a 6-part grading system combining clinical symptom severity, location of herniation in the axial plane, and patient outcomes.[17] The authors recommended patients falling in the lower 3 grades undergo conservative treatment, whereas patients in the higher 3 grades undergo operative treatment.[17] However, this grading system was developed using both computed tomography and MRI scans, and incorporated subjective clinical measures.[17] Takada et al followed 42 patients treated nonoperatively with serial MRIs and calculated canal-hernia mass ratio.[18] While the authors found that a reduction in this ratio correlated with symptomatic improvement after 3 months, the study did not include patients who eventually required surgical management which limits the generalizability of the findings.[18]

## Strengths

There are several strengths to this study. Disc herniation and spinal canal size were quantified, as were location of the herniation in axial and sagittal planes. Prior studies have only evaluated 1 or 2 of these parameters, but not all of them simultaneously. Additionally, there was "substantial agreement" to "almost perfect agreement" for 3 out of the 5 measures calculated, indicating strong reliability in these MRI parameters. Finally, a multiple logistic regression model was used to predict which disc morphology characteristics were indicative of the need for operative treatment.

## Limitations

There are several limitations of the present analysis including the retrospective nature of the study. Inherent to this study design is the potential for reporting or selection bias. For example, patients in the study were identified over a 5-year time span, and a few of the patients initially identified in the nonoperative group may have crossed into the surgical group after the end of data collection. Furthermore, the issue of bias between each rater must be addressed. Each rater separately identified the axial or sagittal view of interest on MRI based on experience and at their own discretion; as such, there was no consistent method employed to determine which exact imaging slice would be best for each measurement. Consequently, interobserver reliability was the only calculation used to assess the reliability of each set of measurements. Finally, patient outcomes were not analyzed in this study; therefore, accurate assessments cannot be made regarding objective measurements of improvement in either group.

## Conclusion

In this study, a higher percent of canal involvement and the presence of a paracentral disc herniation in the axial plane were predictors of undergoing operative treatment for LDH. LDH characteristics observed in the sagittal plane were less robust and reliable and would benefit from further, prospective studies with larger sample sizes. These findings suggest that individual anatomic differences may be suggestive of success with initial nonoperative treatment for LDH. While this is one of the only studies to quantify both the size and location of disc herniation, a large, randomized prospective study is needed to accurately determine predictive factors for surgical intervention.

### Declaration of Conflicting Interests

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### Ethical Approval

This study was approved by the Institutional Review Board at the Thomas Jefferson University Hospital. Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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