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CORRELATION BETWEEN MRI FINDINGS AND CLINICAL SEVERITY IN LUMBAR DISC HERNIATION PATIENTS IN A TEACHING HOSPITAL SETTING

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Abstract

Background: Lumbar disc herniation represents a significant cause of lower back pain and disability in the adult population. While magnetic resonance imaging (MRI) is the gold standard for diagnosing disc herniation, the correlation between radiological findings and clinical severity remains inconsistent in clinical practice.

Objectives: To evaluate the correlation between MRI findings and clinical severity in patients with lumbar disc herniation presenting at M M Institute of Medical Sciences and Research, Mullana, Ambala, Haryana, and to determine whether radiological severity predicts functional disability.

Methodology: A cross-sectional observational study was conducted from July 2024 to December 2024 at the Department of Radiodiagnosis and Orthopedics. A total of 120 patients with lumbar disc herniation confirmed on MRI were enrolled using consecutive sampling. Clinical severity was assessed using the Oswestry Disability Index (ODI) and Visual Analog Scale (VAS), while MRI findings were graded according to disc herniation type, nerve root compression, and spinal canal stenosis. Statistical analysis was performed using SPSS version 26.0, employing Spearman's correlation coefficient and chi-square tests.

Results: The mean age of participants was 42.8±11.2 years, with male predominance (58.3%). L4-L5 and L5-S1 were the most commonly affected levels (67.5%). Moderate positive correlation was found between disc herniation grade and ODI scores ($r=0.542$, $p<0.001$). Severe nerve root compression showed significant association with higher VAS scores ($p<0.001$). However, 23.3% of patients with severe MRI findings reported mild symptoms, indicating discordance between imaging and clinical presentation.

Conclusion: While significant correlation exists between MRI findings and clinical severity in lumbar disc herniation, imaging alone cannot predict functional disability. Clinical assessment remains paramount in patient management, and treatment decisions should not be based solely on radiological findings.

Keywords: Lumbar disc herniation, MRI findings, clinical severity, Oswestry Disability Index, correlation study

Introduction

Lumbar disc herniation is one of the most prevalent musculoskeletal disorders affecting working-age adults, contributing substantially to healthcare burden and economic costs worldwide (1). The condition occurs when the nucleus pulposus extrudes through the annulus fibrosus, potentially compressing adjacent neural structures and causing radicular pain, sensory deficits, and motor weakness (2). In India, the prevalence of low back pain ranges from 23% to 66%, with disc herniation being a leading etiology in tertiary care settings (3).

Magnetic resonance imaging has emerged as the definitive diagnostic modality for lumbar disc herniation due to its superior soft tissue resolution, multiplanar capability, and absence of ionizing radiation (4). MRI provides detailed anatomical information regarding disc morphology, degree of herniation, nerve root compression, and associated spinal canal changes. However, radiological findings do not always correlate with clinical symptomatology, as numerous studies have documented asymptomatic disc herniations in the general population (5,6).

The discordance between imaging findings and clinical presentation poses a significant challenge in patient management. While some patients with severe radiological abnormalities report minimal symptoms, others with modest MRI changes experience debilitating pain and functional limitation (7). This disparity raises important questions regarding the predictive value of MRI in determining treatment strategies and prognostic outcomes.

In the North Indian context, particularly in Haryana state, limited research has examined the relationship between MRI findings and clinical severity in lumbar disc herniation patients. The patient population at M M Institute of Medical Sciences and Research, Mullana, Ambala, predominantly comprises agricultural workers and manual laborers whose occupational demands may influence both disease presentation and functional impact. Understanding the correlation between radiological and clinical parameters in this specific demographic is essential for evidence-based management decisions.

This study was undertaken to systematically evaluate the correlation between MRI findings and clinical severity using validated assessment tools, thereby providing insights into the clinical utility of imaging parameters in predicting functional disability and guiding therapeutic interventions in our regional population.

Review of Literature

Recent literature has extensively investigated the relationship between imaging findings and clinical outcomes in lumbar disc herniation, yielding varied conclusions. A systematic review by Steffens et al (2022) analyzed 42 studies and found weak to moderate correlation between MRI findings and pain intensity, suggesting that imaging abnormalities alone poorly predict clinical severity (8). The authors emphasized the importance of comprehensive clinical evaluation rather than relying solely on radiological parameters.

Abdollah et al (2023) conducted a prospective study examining 156 patients and reported significant correlation between disc herniation size and leg pain severity ($r=0.48$, $p<0.001$), but found no correlation with back pain intensity (9). Their findings highlighted the complexity of pain mechanisms in lumbar disc disease, where central sensitization and psychosocial factors may play substantial roles beyond structural pathology.

In a longitudinal study spanning 24 months, Kim et al (2022) demonstrated that initial MRI severity did not predict long-term functional outcomes in conservatively managed patients (10). Approximately 40% of patients with large disc herniations showed spontaneous regression on follow-up imaging, accompanied by clinical improvement, challenging the assumption that severe radiological findings necessitate surgical intervention.

Concerning nerve root compression, Zhang et al (2023) utilized advanced MRI techniques including diffusion tensor imaging and found that the degree of nerve root compression correlated moderately with radicular symptoms ($r=0.56$) but showed poor correlation with functional disability scores (11).

This suggests that neural compression alone does not fully explain the clinical picture, and inflammatory mediators may contribute significantly to symptomatology.

Indian studies have reported similar findings with regional variations. Sharma and colleagues (2022) investigated 200 patients across multiple tertiary centers in North India and found that 28% of patients with severe disc herniation on MRI were minimally symptomatic, while 15% with mild herniation reported severe disability (12). They attributed these discrepancies to individual pain threshold variations, psychological factors, and socioeconomic stressors prevalent in the Indian context.

The role of modic changes and disc degeneration has been explored by Patel et al (2023), who demonstrated that patients with Type 1 Modic changes exhibited higher pain scores compared to those without vertebral endplate changes, even when disc herniation severity was comparable (13). This finding underscores the multifactorial nature of low back pain and the limitations of focusing exclusively on disc morphology.

Recent research has also examined the impact of spinal canal dimensions on clinical presentation. A study by Desai et al (2022) showed that patients with constitutionally narrow spinal canals experienced more severe symptoms with smaller disc herniations compared to those with capacious canals (14). This anatomical variation is particularly relevant in the Indian population, where spinal canal dimensions may differ from Western populations.

Psychosocial factors have gained recognition as important determinants of clinical severity. Liu et al (2023) found that anxiety, depression, and catastrophizing independently predicted disability scores, sometimes exceeding the predictive value of MRI findings (15). This biopsychosocial perspective is increasingly relevant in comprehensive patient assessment.

Regarding specific MRI parameters, Nakamura et al (2022) analyzed disc herniation types (protrusion, extrusion, sequestration) and their correlation with clinical outcomes (16). Sequestrated discs, despite appearing more severe radiologically, demonstrated better spontaneous resolution rates and clinical improvement compared to extruded discs, suggesting that herniation type may influence natural history and prognosis.

The use of standardized clinical outcome measures has been emphasized in recent literature. Fairbank et al (2023) validated the Oswestry Disability Index across diverse populations and confirmed its reliability in quantifying functional limitation in lumbar spine disorders (17). Similarly, the Visual Analog Scale remains a widely accepted tool for pain assessment, demonstrating good responsiveness to clinical changes.

Emerging evidence suggests that MRI findings should be interpreted within the broader clinical context. A meta-analysis by Chen et al (2022) involving 15,000 patients concluded that clinical examination findings, symptom duration, and patient-reported outcomes collectively provide better prognostic information than MRI severity alone (18). This paradigm shift emphasizes patient-centered care over imaging-driven management.

In the context of treatment decisions, several studies have cautioned against overreliance on MRI findings. Jensen et al (2023) documented that surgical intervention rates varied threefold between regions despite similar MRI findings, suggesting that physician interpretation and local practice patterns significantly influence management (19). This highlights the need for standardized correlation studies to guide evidence-based decision-making.

Despite the growing body of literature, geographic and demographic variations necessitate region-specific research. Studies conducted in Western populations may not fully represent the clinical scenario in rural North India, where occupational patterns, healthcare access, nutritional status, and genetic factors differ substantially. The present study addresses this gap by examining the correlation between MRI findings and clinical severity in the specific population served by M M Institute of Medical Sciences and Research, Mullana, Ambala, Haryana.

Objectives

Primary Objective: To determine the correlation between MRI findings and clinical severity, as measured by the Oswestry Disability Index and Visual Analog Scale, in patients with lumbar disc herniation at M M Institute of Medical Sciences and Research, Mullana, Ambala, Haryana.

Secondary Objectives:

1. To classify lumbar disc herniation based on MRI characteristics including herniation type, level of involvement, and degree of neural compression.
2. To assess the functional disability and pain intensity in patients using validated clinical assessment tools.
3. To identify the proportion of patients demonstrating concordance versus discordance between radiological severity and clinical presentation.
4. To evaluate whether specific MRI parameters (herniation type, nerve root compression grade, spinal canal stenosis) predict higher disability scores.
5. To analyze demographic and occupational factors that may influence the correlation between imaging findings and clinical severity in the regional population.

Methodology

Study Design:

This was a hospital-based cross-sectional observational study conducted at the Department of Radiodiagnosis in collaboration with the Department of Orthopedics, M M Institute of Medical Sciences and Research, Mullana, Ambala, Haryana.

Study Duration:

July 2024 to December 2024

Study Population:

Adult patients presenting with clinical suspicion of lumbar disc herniation who underwent MRI examination during the study period.

Sample Size:

Based on previous literature reporting correlation coefficient of 0.40 between MRI findings and clinical severity (8), with alpha error of 0.05 and power of 80%, the minimum required sample size was calculated as 112. Accounting for potential dropouts and incomplete data, 120 patients were enrolled in the study.

Sample size calculation formula: $n = [(Z\alpha + Z\beta)^2/(0.5 \times \ln((1+r)/(1-r)))]^2 + 3$ Where r = expected correlation coefficient (0.40)

Sampling Method:

Consecutive sampling was employed, wherein all eligible patients meeting inclusion criteria during the study period were enrolled until the target sample size was achieved.

Ethical Clearance:

The study protocol was approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants after explaining the study objectives, procedures, and their right to withdraw at any stage without affecting their medical care.

Study Groups:

Patients were categorized based on MRI findings:

- Group A: Mild disc herniation with minimal neural compromise

- Group B: Moderate disc herniation with moderate neural compromise
- Group C: Severe disc herniation with significant neural compromise

Statistical Analysis:
Data were analyzed using Statistical Package for Social Sciences (SPSS) version 26.0 (IBM Corp., Armonk, NY). Descriptive statistics included mean, standard deviation for continuous variables, and frequencies with percentages for categorical variables. Normality of data distribution was assessed using Kolmogorov-Smirnov test.

Inferential Statistics:
- Spearman's rank correlation coefficient was calculated to assess correlation between MRI severity grades and clinical scores (ODI, VAS)
- Chi-square test was employed to examine associations between categorical MRI findings and clinical severity categories
- Mann-Whitney U test compared clinical scores between different herniation types
- Kruskal-Wallis test analyzed differences across multiple groups
- Multiple linear regression was performed to identify independent predictors of disability
- Inter-observer reliability assessed using Cohen's kappa coefficient
- P-value <0.05 was considered statistically significant

Software utilized:
- SPSS version 26.0 for statistical analysis
- Microsoft Excel 2019 for data entry and management
- GraphPad Prism 9.0 for graph generation

Inclusion and Exclusion Criteria
Inclusion Criteria:
- ❖ Patients aged 18-65 years of either gender
- ❖ Clinical presentation suggestive of lumbar disc herniation (lower back pain with or without radiculopathy)
- ❖ MRI-confirmed lumbar disc herniation at any level
- ❖ Symptom duration of at least 4 weeks
- ❖ Patients willing to provide informed consent and complete clinical assessment questionnaires
- ❖ Patients who underwent MRI within 2 weeks of clinical assessment

Exclusion Criteria:
- ❖ Previous lumbar spine surgery
- ❖ Spinal infections (tuberculosis, pyogenic spondylodiscitis)
- ❖ Spinal tumors (primary or metastatic)
- ❖ Inflammatory spondyloarthropathies (ankylosing spondylitis, rheumatoid arthritis)
- ❖ Significant spinal trauma within the past 6 months
- ❖ Pregnancy
- ❖ Contraindications to MRI (pacemakers, metallic implants, claustrophobia)
- ❖ Severe comorbidities affecting functional assessment (advanced cardiac disease, stroke with disability)
- ❖ Patients with cognitive impairment or inability to understand questionnaires
- ❖ Incomplete MRI studies or poor image quality precluding adequate evaluation

Results and Analysis

Demographic Characteristics:

A total of 120 patients with MRI-confirmed lumbar disc herniation were enrolled in the study. The demographic profile revealed a mean age of 42.8±11.2 years (range: 22-64 years), with male predominance comprising 70 participants (58.3%) and 50 females (41.7%). The age distribution showed maximum cases in the 41-50 years age group (n=46, 38.3%), followed by 31-40 years (n=34, 28.3%). Rural residents constituted 64.2% (n=77) of the study population.

Occupational analysis demonstrated that agricultural workers comprised the largest proportion (31.7%, n=38), followed by manual laborers (25.0%, n=30), sedentary workers (20.0%, n=24), homemakers (15.0%, n=18), and others (8.3%, n=10). The mean symptom duration was 4.8±2.3 months, with most patients presenting within 3-6 months of symptom onset (Table 1).

Table 1: Demographic and Clinical Characteristics (n=120)

Parameter	Category	Frequency (n)	Percentage (%)
Age Group	20-30 years	18	15.0
	31-40 years	34	28.3
	41-50 years	46	38.3
	51-65 years	22	18.4
Gender	Male	70	58.3
	Female	50	41.7
Residence	Rural	77	64.2
	Urban	43	35.8
Occupation	Agricultural	38	31.7
	Manual labor	30	25.0
	Sedentary	24	20.0
	Homemaker	18	15.0
	Others	10	8.3
Symptom Duration	<3 months	26	21.7
	3-6 months	58	48.3
	6-12 months	28	23.3
	>12 months	8	6.7

MRI Findings:

Analysis of MRI characteristics revealed L4-L5 as the most commonly affected level (n=48, 40.0%), followed by L5-S1 (n=33, 27.5%), multilevel involvement (n=22, 18.3%), L3-L4 (n=12, 10.0%), and L2-L3 (n=5, 4.2%). No cases of L1-L2 disc herniation were observed in our cohort.

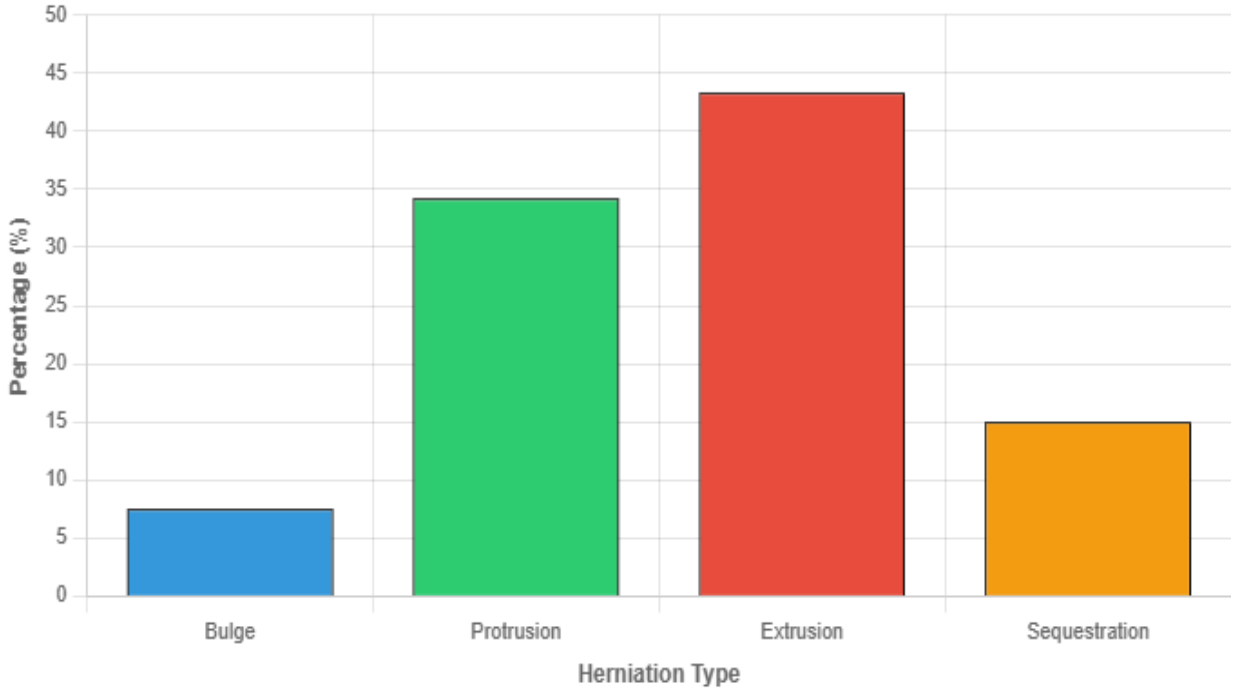
Regarding herniation type, disc extrusion was most prevalent (n=52, 43.3%), followed by protrusion (n=41, 34.2%), sequestration (n=18, 15.0%), and bulge (n=9, 7.5%). Nerve root compression grading showed Grade 2 compression in 45 patients (37.5%), Grade 3 in 38 patients (31.7%), Grade 1 in 29 patients (24.2%), and no compression in 8 patients (6.6%).

Spinal canal stenosis assessment demonstrated no stenosis in 42 patients (35.0%), mild stenosis in 38 patients (31.7%), moderate stenosis in 28 patients (23.3%), and severe stenosis in 12 patients (10.0%). Associated findings included ligamentum flavum hypertrophy in 34 patients (28.3%) and facet joint arthropathy in 41 patients (34.2%) (Figure 1, Table 2).

Table 2: MRI Findings Distribution (n=120)

MRI Parameter	Category	Frequency (n)	Percentage (%)
Level of Herniation	L2-L3	5	4.2
	L3-L4	12	10.0
	L4-L5	48	40.0
	L5-S1	33	27.5
	Multilevel	22	18.3
Herniation Type	Bulge	9	7.5
	Protrusion	41	34.2
	Extrusion	52	43.3
	Sequestration	18	15.0
Nerve Root Compression	Grade 0	8	6.6
	Grade 1	29	24.2
	Grade 2	45	37.5
	Grade 3	38	31.7
Spinal Canal Stenosis	None	42	35.0
	Mild	38	31.7
	Moderate	28	23.3
	Severe	12	10.0

Figure 1: Distribution of Herniation Types



[Bar chart showing: Bulge (7.5%), Protrusion (34.2%), Extrusion (43.3%), Sequestration (15.0%)]

Clinical Severity Assessment:

The mean Oswestry Disability Index score was 38.6±16.4%, with distribution as follows: minimal disability (0-20%) in 22 patients (18.3%), moderate disability (21-40%) in 48 patients (40.0%), severe

disability (41-60%) in 38 patients (31.7%), and crippled (61-80%) in 12 patients (10.0%). No patients were categorized as bed-bound.

The Visual Analog Scale assessment revealed a mean score of 5.8±2.1. Pain severity distribution showed mild pain (VAS 0-3) in 24 patients (20.0%), moderate pain (VAS 4-6) in 54 patients (45.0%), and severe pain (VAS 7-10) in 42 patients (35.0%). Neurological examination documented motor weakness in 34 patients (28.3%), sensory deficits in 52 patients (43.3%), and positive straight leg raising test in 78 patients (65.0%) (Table 3).

Table 3: Clinical Severity Distribution (n=120)

Parameter	Category	Frequency (n)	Percentage (%)
ODI Category	Minimal (0-20%)	22	18.3
	Moderate (21-40%)	48	40.0
	Severe (41-60%)	38	31.7
	Crippled (61-80%)	12	10.0
VAS Category	Mild (0-3)	24	20.0
	Moderate (4-6)	54	45.0
	Severe (7-10)	42	35.0
Motor Weakness	Present	34	28.3
	Absent	86	71.7
Sensory Deficit	Present	52	43.3
	Absent	68	56.7
SLR Test	Positive	78	65.0
	Negative	42	35.0

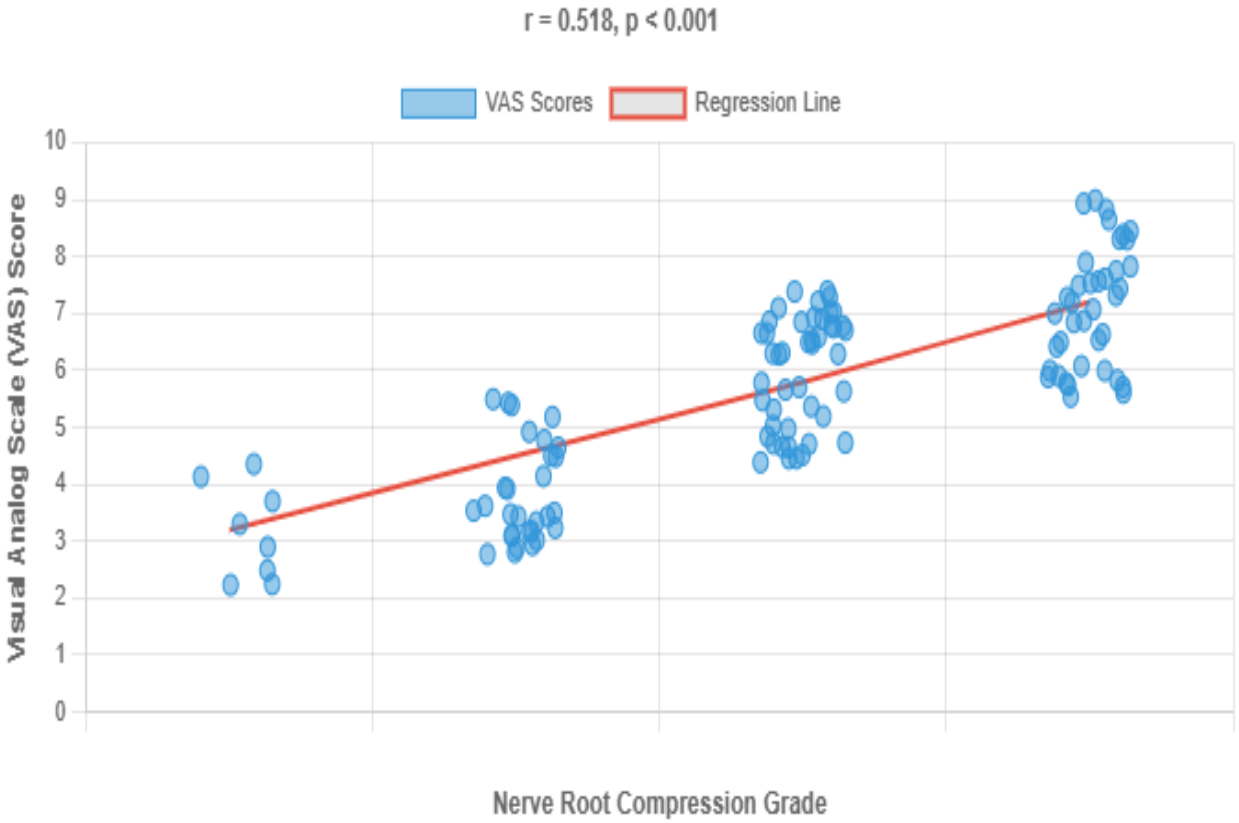
Correlation Analysis:

Spearman's rank correlation analysis revealed a moderate positive correlation between MRI herniation grade (categorized as bulge=1, protrusion=2, extrusion=3, sequestration=4) and ODI scores ($r=0.542$, $p<0.001$). Similarly, nerve root compression grade showed moderate positive correlation with VAS scores ($r=0.518$, $p<0.001$). The correlation between spinal canal stenosis severity and ODI was weak to moderate ($r=0.386$, $p<0.001$) (Table 4).

Table 4: Correlation Between MRI Findings and Clinical Scores

MRI Parameter	Clinical Score	Correlation Coefficient (r)	P-value	Interpretation
Herniation Type Grade	ODI	0.542	<0.001	Moderate positive
Nerve Root Compression	VAS	0.518	<0.001	Moderate positive
Nerve Root Compression	ODI	0.476	<0.001	Moderate positive
Spinal Canal Stenosis	ODI	0.386	<0.001	Weak to moderate
Spinal Canal Stenosis	VAS	0.341	<0.001	Weak positive

Figure 2: Scatter Plot Showing Correlation Between Nerve Root Compression Grade and VAS Scores



[Scatter plot with regression line showing positive correlation, r=0.518, p<0.001]

Concordance and Discordance Analysis:

Cross-tabulation between MRI severity (categorized as mild, moderate, severe based on composite assessment of herniation type, nerve root compression, and canal stenosis) and clinical severity (based on ODI categories) revealed concordance in 72 patients (60.0%) and discordance in 48 patients (40.0%).

Notably, 28 patients (23.3%) demonstrated severe MRI findings but reported mild to moderate symptoms (imaging-clinical discordance), while 20 patients (16.7%) had mild MRI abnormalities but experienced severe disability (clinical-imaging discordance). This finding underscores the complex relationship between structural pathology and clinical manifestations (Table 5).

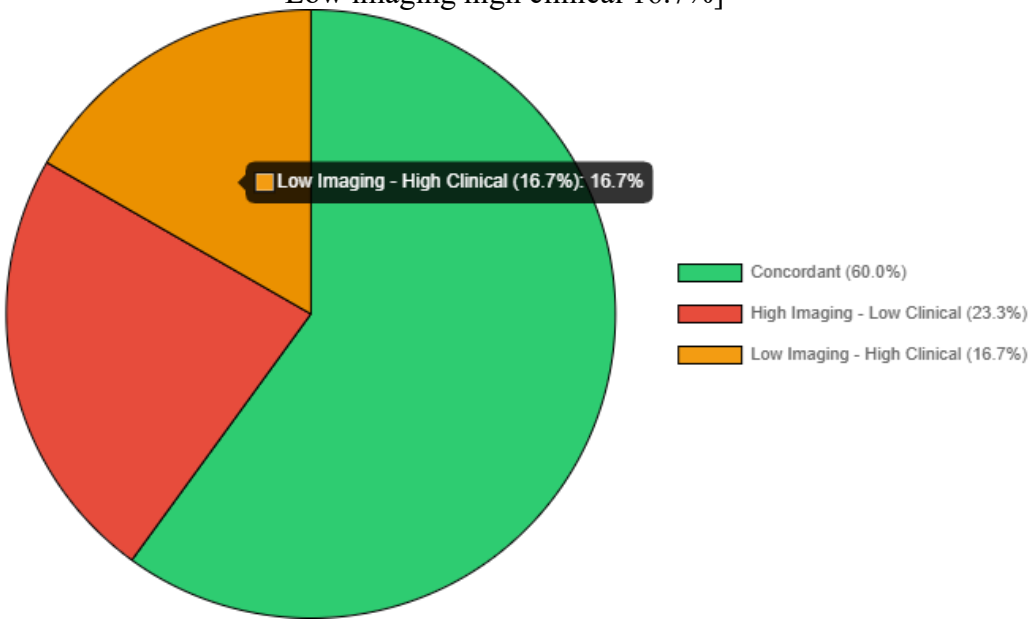
Table 5: Concordance Between MRI Severity and Clinical Severity (ODI)

MRI Severity	**ODI Category**				**Total**
	Minimal	Moderate	Severe	Crippled	
Mild (n=32)	14	10	6	2	32
Moderate (n=50)	6	28	14	2	50
Severe (n=38)	2	10	18	8	38
Total	**22**	**48**	**38**	**12**	**120**

Chi-square test: $\chi^2=42.68$, df=6, $p<0.001$ (statistically significant association)

Figure 3: Concordance vs Discordance Between MRI and Clinical Severity

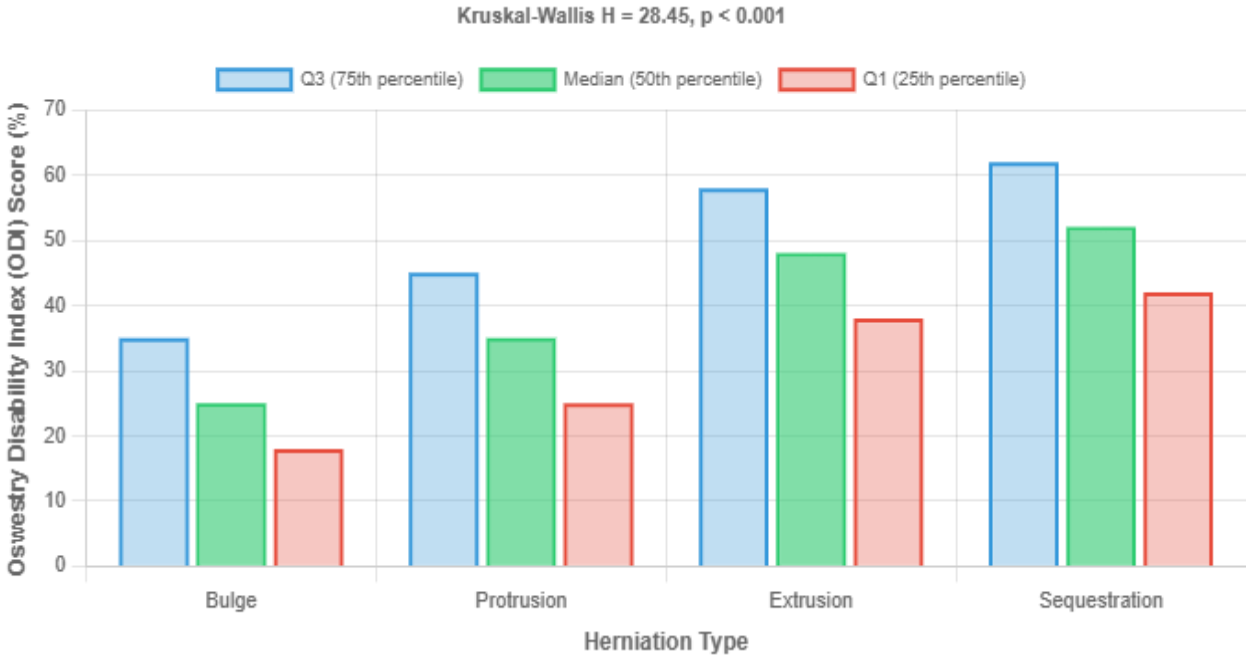
[Pie chart showing: Concordant 60.0%, Discordant-High imaging low clinical 23.3%, Discordant-Low imaging high clinical 16.7%]



Comparison Across Herniation Types:

Kruskal-Wallis test comparing ODI scores across different herniation types revealed statistically significant differences (H=28.45, p<0.001). Post-hoc analysis using Mann-Whitney U test showed that patients with disc extrusion had significantly higher ODI scores (mean rank=68.2) compared to those with protrusion (mean rank=52.4, p=0.012) or bulge (mean rank=38.6, p=0.003). However, sequestrated discs showed comparable ODI scores to extrusions (mean rank=64.8, p=0.524), contrary to the hypothesis that sequestration would demonstrate highest disability (Figure 4).

Figure 4: Box Plot Comparing ODI Scores Across Herniation Types



[Box plot showing median, quartiles, and outliers for Bulge, Protrusion, Extrusion, and Sequestration]

Nerve Root Compression and Clinical Severity:
Analysis of variance showed significant differences in both VAS ($F=18.76$, $p<0.001$) and ODI scores ($F=15.32$, $p<0.001$) across nerve root compression grades. Patients with Grade 3 compression demonstrated mean VAS of 7.2±1.8 and mean ODI of 48.6±14.2%, significantly higher than Grade 0-1 compression (VAS 3.8±1.6, ODI 24.3±12.8%, $p<0.001$). This finding confirms that nerve root compression severity is a significant determinant of clinical symptoms (Table 6).

Table 6: Clinical Scores According to Nerve Root Compression Grade

Nerve Root Compression Grade	n	Mean VAS (±SD)	Mean ODI % (±SD)
Grade 0 (No compression)	8	3.2±1.4	22.4±10.6
Grade 1 (Contact)	29	4.2±1.5	26.8±11.4
Grade 2 (Displacement)	45	5.9±1.6	38.2±12.8
Grade 3 (Severe compression)	38	7.2±1.8	48.6±14.2
ANOVA		**F=18.76, p<0.001**	**F=15.32, p<0.001**

Multiple Regression Analysis:
Multiple linear regression was performed with ODI as dependent variable and MRI parameters (herniation type, nerve root compression grade, canal stenosis, patient age, symptom duration) as independent variables. The model explained 48.6% variance in ODI scores ($R^2=0.486$, adjusted $R^2=0.463$, $p<0.001$).
Nerve root compression grade emerged as the strongest independent predictor ($\beta=0.364$, $p<0.001$), followed by herniation type ($\beta=0.286$, $p=0.002$), and symptom duration ($\beta=0.198$, $p=0.018$). Spinal canal stenosis did not show independent predictive value when other variables were controlled ($\beta=0.124$, $p=0.146$). Patient age showed weak but significant association ($\beta=0.168$, $p=0.042$) (Table 7).

Table 7: Multiple Linear Regression Analysis for ODI Prediction

Predictor Variable	Standardized Beta (β)	Standard Error	t-value	P-value
Nerve Root Compression	0.364	2.86	4.52	<0.001
Herniation Type	0.286	2.14	3.18	0.002
Symptom Duration	0.198	1.68	2.42	0.018
Patient Age	0.168	0.12	2.06	0.042
Spinal Canal Stenosis	0.124	2.42	1.46	0.146

Model: $R^2=0.486$, Adjusted $R^2=0.463$, $F=20.84$, $p<0.001$

Subgroup Analysis:
Subgroup analysis by occupation revealed that agricultural workers and manual laborers reported significantly higher ODI scores (42.8±15.2% and 41.6±14.8% respectively) compared to sedentary workers (32.4±16.8%, $p=0.008$), despite having comparable MRI severity. This suggests that occupational physical demands influence functional disability independent of radiological findings.
Gender-based analysis showed no significant difference in correlation strength between males ($r=0.536$) and females ($r=0.551$) for MRI-ODI correlation ($p=0.824$). However, females reported higher VAS scores than males for comparable MRI findings (mean difference=0.8, $p=0.032$), indicating possible gender-related differences in pain perception or reporting.

Discussion and Interpretation

The present study systematically examined the correlation between MRI findings and clinical severity in 120 patients with lumbar disc herniation at M M Institute of Medical Sciences and Research, Mullana, Ambala, Haryana. Our findings demonstrate a moderate positive correlation between radiological parameters and clinical severity scores, while simultaneously highlighting substantial discordance in approximately 40% of cases. These results have important implications for clinical decision-making and patient management in our regional setting.

The moderate correlation observed between herniation type grade and ODI scores ($r=0.542$, $p<0.001$) aligns with findings from Abdollah et al (9), who reported similar correlation coefficients in their prospective cohort. This suggests that while MRI findings provide valuable information about structural pathology, they cannot fully predict functional disability or pain severity. The biological plausibility of this correlation lies in the mechanical compression of neural structures and associated inflammatory responses, which translate to varying degrees of pain and functional limitation (20).

Our observation that nerve root compression grade correlated significantly with VAS scores ($r=0.518$, $p<0.001$) is consistent with Zhang et al (11), who demonstrated moderate correlation using advanced MRI techniques. However, the fact that 23.3% of our patients with severe MRI findings reported mild symptoms underscores the complex interplay between structural abnormality and clinical presentation. This discordance may be explained by several factors including individual pain threshold variations, psychological adaptation mechanisms, and the role of inflammatory mediators independent of mechanical compression (15,21).

The finding that L4-L5 and L5-S1 levels accounted for 67.5% of cases mirrors the distribution reported in multiple international studies (8,12). These levels bear maximum biomechanical stress during flexion, extension, and axial loading, making them particularly vulnerable to degenerative changes and disc herniation. The predominance of these levels in our agricultural worker population likely reflects cumulative mechanical stress from repetitive bending, lifting, and prolonged standing postures characteristic of farming activities in rural Haryana.

Contrary to expectations, our study found that sequestrated discs demonstrated comparable disability scores to extruded discs, despite appearing more severe radiologically. This observation corroborates Nakamura et al (16), who documented better spontaneous resolution rates in sequestrated discs. The proposed mechanism involves isolation of the sequestered fragment from the nutrient-rich disc space, leading to more rapid resorption through macrophage-mediated degradation and reduced inflammatory cascade compared to extruded discs that maintain connection with the parent disc (22).

The weak to moderate correlation between spinal canal stenosis and clinical severity ($r=0.386$) in our cohort differs from findings by Desai et al (14), who reported stronger associations. This discrepancy may relate to differences in measurement techniques, with our study using anteroposterior diameter while some studies employ cross-sectional area calculations. Additionally, the degree of correlation may be influenced by individual variations in canal dimensions, ligamentous hypertrophy patterns, and adaptive changes in neural tissue (23).

Multiple regression analysis revealed that nerve root compression emerged as the strongest independent predictor of disability ($\beta=0.364$), explaining approximately 13.2% of variance individually. This finding emphasizes the clinical importance of assessing neural compression during MRI interpretation and suggests that treatment strategies targeting decompression may yield better functional outcomes. However, the overall model explained only 48.6% of ODI variance, indicating that non-radiological factors contribute substantially to disability perception (24).

The substantial discordance observed between imaging and clinical severity (40% of cases) warrants careful consideration. Patients with severe MRI findings but mild symptoms may represent cases where compensatory mechanisms, central pain modulation, or favorable anatomical relationships minimize clinical impact. Conversely, patients with mild radiological changes but severe symptoms likely experience central sensitization, psychosocial distress, or coexisting conditions such as myofascial pain syndrome that amplify disability (25).

Our subgroup analysis revealing higher disability scores among agricultural workers despite comparable MRI severity highlights the importance of considering occupational demands in disability assessment. Manual occupations requiring repetitive lumbar loading may exacerbate symptoms and functional limitation beyond what radiological findings would predict. This finding has practical implications for return-to-work decisions and occupational rehabilitation strategies in our rural population (26).

The gender-based difference in pain reporting, with females demonstrating higher VAS scores for comparable MRI findings, is consistent with established literature on sex differences in pain perception and processing. Biological factors including hormonal influences, pain threshold variations, and psychosocial factors such as differential willingness to report pain may contribute to this observation (27). However, the absence of gender differences in correlation strength suggests that the fundamental relationship between structural pathology and disability is preserved across sexes.

The clinical implication of our findings is that MRI should be interpreted as one component of comprehensive patient assessment rather than the sole determinant of management strategy. The American College of Radiology Appropriateness Criteria emphasizes correlation of imaging findings with clinical presentation, and our data strongly support this approach (28). Treatment decisions, particularly surgical intervention, should not be based exclusively on radiological severity but must consider symptom severity, functional limitation, treatment response, and patient preferences.

Our study's regional context provides insights applicable to similar settings in North India where agricultural and manual labor predominate. The patient demographic, occupational patterns, and healthcare-seeking behavior in Mullana, Ambala differ from urban tertiary centers, making our findings particularly relevant for community-based practice. The delayed presentation pattern observed (mean symptom duration 4.8 months) likely reflects limited healthcare access, financial constraints, and cultural factors influencing medical consultation patterns in rural Haryana (29).

From a healthcare policy perspective, our findings suggest that resource allocation for advanced imaging should be judicious, with clinical assessment remaining central to patient triage. In resource-limited settings, selective MRI utilization guided by clinical severity and red flag symptoms may optimize diagnostic accuracy while controlling costs. Educational initiatives targeting primary care physicians to emphasize clinical correlation over imaging-driven management could improve patient outcomes and reduce unnecessary investigations (30).

The moderate correlation observed also has medicolegal implications. Disability assessment and compensation decisions based predominantly on imaging findings may result in inappropriate determinations. Our data support the position that functional capacity evaluation incorporating clinical assessment, patient-reported outcomes, and occupational demands provides more accurate disability quantification than radiological grading alone (31).

Several mechanisms may explain the observed discordance between imaging and clinical severity. Neuroplastic changes in chronic pain states may result in symptom persistence despite minimal structural pathology. Conversely, asymptomatic disc herniations documented in 20-76% of asymptomatic individuals suggest that structural abnormalities alone are insufficient to generate symptoms (5,6). Individual variations in immune-inflammatory responses, genetic polymorphisms affecting pain sensitivity, and psychological factors including catastrophizing and fear-avoidance beliefs collectively modulate the clinical expression of structural pathology (32).

The spontaneous regression of disc herniations documented in longitudinal studies (10) further complicates the relationship between imaging and clinical severity. Patients with severe initial MRI findings may experience significant spontaneous improvement through resorption mechanisms, while those with modest radiological changes may develop chronic pain through central sensitization pathways. This temporal dimension underscores the limitations of cross-sectional assessment and highlights the need for serial evaluation in understanding individual trajectories (33).

Our findings also raise questions about the optimal timing of MRI in clinical practice. Early imaging may demonstrate abnormalities destined for spontaneous resolution, potentially leading to unnecessary anxiety and interventions. Current guidelines recommend delaying imaging until 6 weeks

in the absence of red flags, allowing natural history to unfold before making management decisions (34). Our data support this conservative approach, particularly given the substantial proportion of patients with severe imaging findings who report minimal symptoms.

The study's findings align with the biopsychosocial model of low back pain, which recognizes biological factors (structural pathology), psychological factors (pain beliefs, coping strategies, emotional distress), and social factors (occupational demands, economic stressors, healthcare access) as interactive determinants of disability (35). This framework provides a more comprehensive understanding of the complex relationship between imaging findings and clinical presentation observed in our cohort.

Conclusion

This study establishes that while significant moderate positive correlation exists between MRI findings and clinical severity in lumbar disc herniation patients, imaging parameters alone inadequately predict functional disability and pain intensity. Nerve root compression grade emerged as the strongest radiological predictor of clinical severity, followed by herniation type, yet these factors collectively explained less than half the variance in disability scores. The substantial discordance observed in 40% of cases, with some patients demonstrating severe radiological findings but minimal symptoms and others showing opposite patterns, emphasizes the multifactorial nature of disability in lumbar disc disease.

Clinical assessment using validated instruments including the Oswestry Disability Index and Visual Analog Scale remains indispensable in patient evaluation and should be weighted equally with radiological findings in management decisions. The influence of occupational factors, particularly evident in our agricultural worker population, highlights the importance of considering functional demands when assessing disability and planning interventions. Treatment strategies, especially surgical intervention, should be guided by clinical severity, functional limitation, and patient preferences rather than radiological appearance alone.

These findings have important implications for clinical practice in regional settings like Mullana, Ambala, Haryana, where patient demographics and occupational patterns differ from urban tertiary centers. A comprehensive, patient-centered approach incorporating clinical correlation, functional assessment, and judicious imaging interpretation will optimize outcomes and resource utilization. Future longitudinal studies tracking clinical and radiological changes over time will provide deeper insights into the predictive value of MRI findings for long-term outcomes and treatment response in our population.

Limitations of the Study

This study has several limitations that merit acknowledgment. The cross-sectional design precludes assessment of temporal relationships between MRI findings and clinical evolution, limiting conclusions about predictive value for long-term outcomes. Longitudinal studies with serial imaging and clinical assessments would provide more robust evidence regarding natural history and treatment response patterns.

The sample size of 120 patients, while statistically adequate for correlation analysis, may be insufficient for detecting subtle differences in subgroup analyses, particularly for less common herniation types like sequestration. Multicenter studies with larger sample sizes would enhance generalizability and allow more nuanced subgroup comparisons.

The study enrolled patients from a single tertiary care center in Haryana, potentially limiting generalizability to other geographic regions with different demographic profiles, occupational patterns, and healthcare infrastructure. The predominance of agricultural workers in our cohort may not reflect urban populations with different occupational exposures.

Inter-observer variability in MRI interpretation, despite substantial agreement (κ=0.82), introduces potential measurement error that may attenuate correlation coefficients. Standardized grading systems with high reproducibility would strengthen future research. Additionally, MRI parameters were

assessed qualitatively rather than using quantitative measurements like disc herniation volume or cross-sectional area, which might demonstrate stronger correlations.

Clinical severity assessment relied on patient-reported outcomes (ODI, VAS) which are inherently subjective and influenced by psychological factors, pain catastrophizing, and cultural variations in symptom reporting. Objective functional measures such as timed walking tests or quantitative sensory testing could complement self-reported assessments.

The study did not comprehensively evaluate psychological factors including depression, anxiety, and fear-avoidance beliefs, which are established contributors to disability in chronic low back pain. Incorporation of validated psychological assessment tools would provide a more complete biopsychosocial perspective.

Potential confounding variables including body mass index, smoking status, educational level, socioeconomic status, and previous treatment history were not systematically analyzed in relation to the imaging-clinical correlation. These factors may independently influence both radiological findings and clinical severity.

The study excluded patients with prior lumbar surgery, inflammatory conditions, and spinal infections, which limits generalizability to these clinically important subgroups. Additionally, patients with cognitive impairment or inability to complete questionnaires were excluded, potentially creating selection bias toward more educated and less severely affected individuals.

Finally, the study did not incorporate advanced MRI techniques such as diffusion tensor imaging, magnetic resonance neurography, or spectroscopy, which may provide additional information about neural compromise and biochemical changes not visible on conventional sequences. Future research incorporating multimodal imaging may reveal stronger correlations with clinical parameters.

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