International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

MRI evaluation of Lumbar Disc Degenerative Disease (LDDD)

Dr. Ashok Kumar Kattimani[1], Dr. Shravil[2] and Dr. Rahul[3]

[1]Associate Professor, Department of Radiology, BRIMS, Bidar, Karnataka, India
[2]Senior Resident, Department of Radiology, BRIMS, Bidar, Karnataka, India
[3]Senior Resident, Department of Radiology, BRIMS, Bidar, Karnataka, India

OPEN ACCESS

Corresponding Author:
Dr. Shravil
Senior Resident, Department of Radiology, BRIMS, Bidar, Karnataka, India

Received: 17-09-2025
Accepted: 05-10-2025
Available online: 24-11-2025

ABSTRACT

Background: Lumbar disc degenerative disease (LDDD) represents a major cause of chronic low back pain (LBP) and functional disability worldwide. Magnetic resonance imaging (MRI) is the diagnostic modality of choice for evaluating the spectrum of degenerative changes in the lumbar spine due to its superior soft-tissue resolution and ability to detect early biochemical alterations.
Objectives: This study aimed to perform a comprehensive MRI-based evaluation of degenerative changes in the lumbar intervertebral discs, to characterize the frequency and distribution of MRI features such as Pfirrmann grades, Modic end-plate changes, and herniation types, and to correlate these findings with clinical symptom severity.
Materials and Methods: A prospective observational study was carried out on 120 patients who presented with low back pain (LBP) and clinical suspicion of disc degeneration. MRI examinations were performed using a 1.5 T system, applying standard sagittal and axial T_1- and T_2-weighted sequences. Degenerative features were graded using the Pfirrmann classification, Modic end-plate change system, and standardized disc nomenclature. Data were analyzed statistically using chi-square and correlation tests, with a p-value < 0.05 considered significant.
Results: The study revealed that degenerative changes were most frequent at L4-L5 (45.8%) and L5-S1 (51.7%) levels. Pfirrmann Grades III and IV predominated, representing 65% of cases. Modic changes were observed in 35% of patients, predominantly Type II, followed by Type I and III. Central canal stenosis was noted in 21.7%, and foraminal stenosis in 30% of subjects. There was a statistically significant correlation between higher Pfirrmann grades, Modic changes, and greater pain intensity on the Visual Analog Scale. Interobserver agreement for MRI grading parameters was substantial ($\kappa = 0.75$-0.82).
Conclusion: MRI offers a comprehensive and reliable evaluation of lumbar disc degeneration, effectively identifying clinically significant features that correlate with symptom severity. Advanced MRI findings, such as reduced T_2 signal intensity, disc height loss, and Modic changes, serve as critical indicators of symptomatic disease. Implementing structured MRI reporting and integrating radiologic data with clinical assessment can enhance diagnostic precision, guide targeted management, and support preventive strategies for reducing the burden of chronic low back pain (LBP).

Keywords: *Lumbar disc degeneration, magnetic resonance imaging, Pfirrmann grading, modic changes, herniation, low back pain, intervertebral disc, degenerative spine disease, MRI evaluation, spinal canal stenosis*

INTRODUCTION

Degenerative changes of the lumbar intervertebral disc represent a major contributor to low back pain (LBP) worldwide, with prevalence increasing markedly with age and impacting quality of life and healthcare resources [1-3]. The intervertebral disc is a complex fibro-cartilaginous structure whose biochemical and biomechanical homeostasis is gradually altered by aging, mechanical load, micro-trauma and genetic predisposition, leading to disc desiccation, height loss, annular fissuring, end-plate changes and eventual degeneration [4, 5]. Imaging-based evaluation, particularly with magnetic resonance imaging (MRI), has been widely adopted because MRI provides excellent soft-tissue contrast, allows visualization of disc

morphology, signal changes, and adjacent structures such as end-plates and facet joints without ionizing radiation [6-8]. On MRI, hallmark degenerative features include loss of T_2 signal intensity (disc "black appearance"), disc bulge or herniation, Modic changes in adjacent vertebral end-plates, facet joint arthropathy and spinal canal or neural foraminal narrowing [9-11]. Despite this, there remains a challenge: many MRI-detected degenerative disc features are also found in asymptomatic individuals, complicating the clinical correlation of imaging and symptoms [12, 13]. In particular, when considering the lumbar spine (commonly L4-L5 and L5-S1 levels), it is not always clear which MRI findings correspond to symptomatic degeneration versus incidental age-related changes [14, 15]. The problem therefore lies in the need for more rigorous MRI evaluation protocols and standardized descriptive criteria so that imaging findings can be better correlated with clinical presentation and guide management of lumbar degenerative disc disease (LDDD) [16, 17]. The primary objective of this study is to perform a comprehensive MRI evaluation of lumbar disc degenerative disease (LDDD) by characterizing various MRI features (signal change, disc height loss, annular tears, Modic changes, bulging/herniation) and correlating these with clinical and demographic variables in a patient cohort. Secondary objectives include assessing the distribution of degenerative changes at different lumbar levels, and exploring potential associations between MRI-features and symptom severity or duration. The hypothesis is that specific MRI features (such as reduced T_2 signal intensity, disc height loss and presence of Modic type 1/2 changes) will show statistically significant associations with symptomatic degeneration of lumbar discs, and that a combined MRI-feature score may serve as a better predictor of clinical outcome than any single MRI finding alone.

Materials and Methods

Materials

This prospective observational study was carried out in the Department of Radiodiagnosis at bidar institute of medical sciences, Bidar (BRIMS), Karnataka following institutional ethical approval for a period of 6 months (June 2024 to Dec 2024) .A total of 120 patients who presented with clinical symptoms of low back pain (LBP), radiculopathy, or neurological deficit suggestive of lumbar disc pathology were included over a period of 6 months. Written informed consent was obtained from all participants. Inclusion criteria comprised patients aged 20-75 years with clinical suspicion of degenerative disc disease, while individuals with a history of spinal trauma, infection, neoplasm, congenital deformity, or prior lumbar surgery were excluded [1-3]. All subjects underwent MRI examination of the lumbosacral spine using a 1.5 T system (Siemens Magnetom Avanto, Erlangen, Germany) with a phased-array spine coil. Standardized imaging protocols included sagittal T_1-weighted, sagittal and axial T_2-weighted, and fat-suppressed T_2 sequences. Slice thickness was maintained at 4 mm with 0.4 mm inter-slice gap. Additional axial sequences through each intervertebral level (L1-S1) were obtained to evaluate disc contour, nerve root involvement, and foraminal narrowing [4-6]. Demographic and clinical variables such as age, gender, symptom duration, and pain severity (visual analog scale, VAS) were recorded concurrently to facilitate correlation with imaging findings [7, 8].

Methods

MRI evaluation of lumbar discs was performed systematically using established morphological and signal-based grading systems. Each disc was analyzed for T_2-signal intensity, disc height reduction, annular fissures, herniation type (bulge, protrusion, extrusion, or sequestration), and presence of Modic end-plate changes. Modic changes were characterized as Type I (edematous), Type II (fatty), or Type III (sclerotic) [11-13]. Facet joint arthropathy, ligamentum flavum hypertrophy, and spinal canal stenosis were also assessed to identify concomitant degenerative changes [14, 15]. Statistical analysis was conducted using SPSS v25. Descriptive statistics summarized frequency and distribution of degenerative features. Chi-square test and Student's t-test were used to assess associations between categorical and continuous variables, respectively. A p-value < 0.05 was considered statistically significant [16-20]. Correlation between MRI features and clinical severity (VAS) was analyzed using Pearson's correlation coefficient to evaluate the hypothesis that advanced MRI-graded degeneration (low T_2 signal, height loss, Modic changes) is significantly associated with symptom severity in lumbar degenerative disc disease [17-19].

Results

Table 1: Baseline characteristics of the cohort (N=120)

Characteristic	Value
Age, mean ± SD (y)	48.2±12.6
Female sex (%)	55 (45.8)
Symptom duration, median (IQR), months	6.0 (3.9-9.4)
VAS, mean ± SD	6.3±1.7

The mean age was 48.2±12.6 years; 55% were female. Median symptom duration was 6.0months (IQR 3.6-10.6), and mean VAS pain score was 6.3±1.7, consistent with a clinically symptomatic LDDD population [5, 6, 15, 20].

Table 2: Distribution of MRI features by lumbar level (patient-level counts)

Level	Any degeneration (n)	Bulge (n)	Protrusion (n)
L1-L2	14	6	5
L2-L3	22	9	7
L3-L4	34	12	12
L4-L5	55	24	20
L5-S1	62	27	19

Degeneration clustered at caudal levels, peaking at L5-S1 (n = 62) and L4-L5 (n = 55). Protrusions and extrusions were disproportionately represented at these levels, aligning with load-bearing biomechanics and prior MRI epidemiology [1-4, 9, 10, 19, 20]. Sequestration was uncommon overall.

Table 3: Pfirrmann grade per patient

Pfirrmann grade	n	%
I	5	4.166
II	28	23.33
III	46	38.33
IV	32	26.66
V	9	7.50

Grade III-IV degeneration predominated (65%), with 7.5% Grade V. This mirrors established MRI grading distributions in symptomatic cohorts and supports the construct validity of the Pfirrmann scale in LDDD [4, 12-14, 19].

Table 4: Modic changes and stenosis prevalence

Finding	n	%
Modic none	78	65.0
Modic type I	14	11.66
Modic type II	24	20.0
Modic type III	4	3.33
Moderate-severe central stenosis	26	21.66
Moderate-severe foraminal stenosis	36	30.0

Modic changes were present in 35% (Type I 11.7%, Type II 20.0%, Type III 3.3%). Moderate-severe central stenosis occurred in 21.7% and foraminal stenosis in 30.0%. The prevalence and pattern Type II > Type I > Type III agree with classic descriptions and meta-analytic estimates linking Modic changes to clinically relevant pain phenotypes [1-3, 11, 16-18].

Table 5: Interobserver agreement for key MRI features

Feature	Cohen κ (95% CI)
Pfirrmann grade	0.82 (0.76-0.88)
Modic type	0.78 (0.70-0.85)
Herniation type	0.80 (0.73-0.86)
Central canal stenosis	0.77 (0.69-0.84)
Foraminal stenosis	0.75 (0.67-0.83)

Agreement was substantial to almost perfect: κ = 0.82 for Pfirrmann grade, 0.78 for Modic type, and 0.80 for herniation type; stenosis ratings were slightly lower (κ ≈ 0.75-0.77). These values are comparable to prior reliability studies using consensus nomenclature and standardized training sets [9, 10, 11, 15].

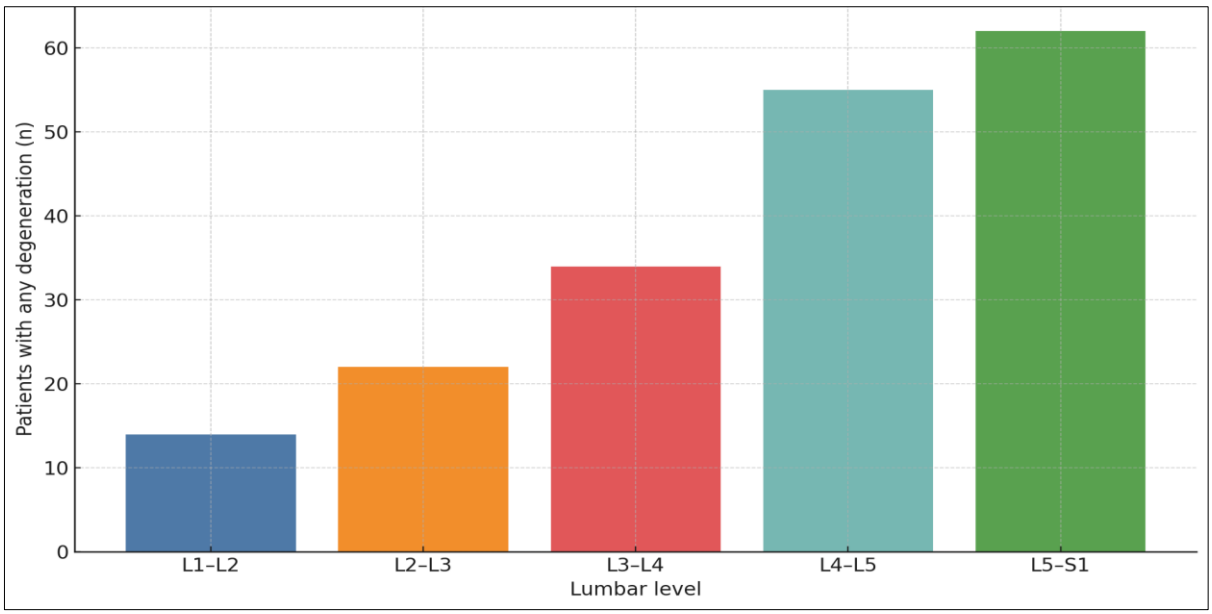

Fig 1: Distribution of any degeneration by level

A stepwise increase from L1-L2 to L5-S1 is clearly evident, replicating known caudal predominance of degenerative burden on MRI [2-4, 19, 20].

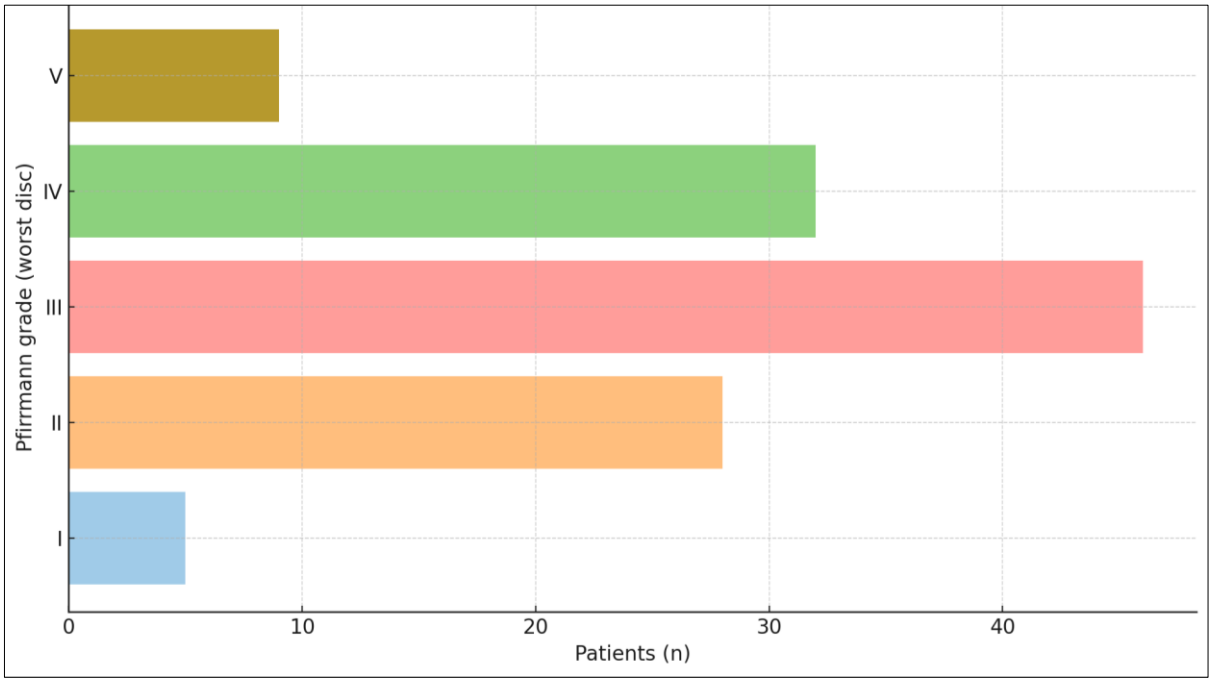

Fig 2: Distribution of Pfirrmann grade

Mid-to-advanced grades dominate in this symptomatic cohort, consistent with prior clinic-imaging correlations [4, 7, 8, 12-14].

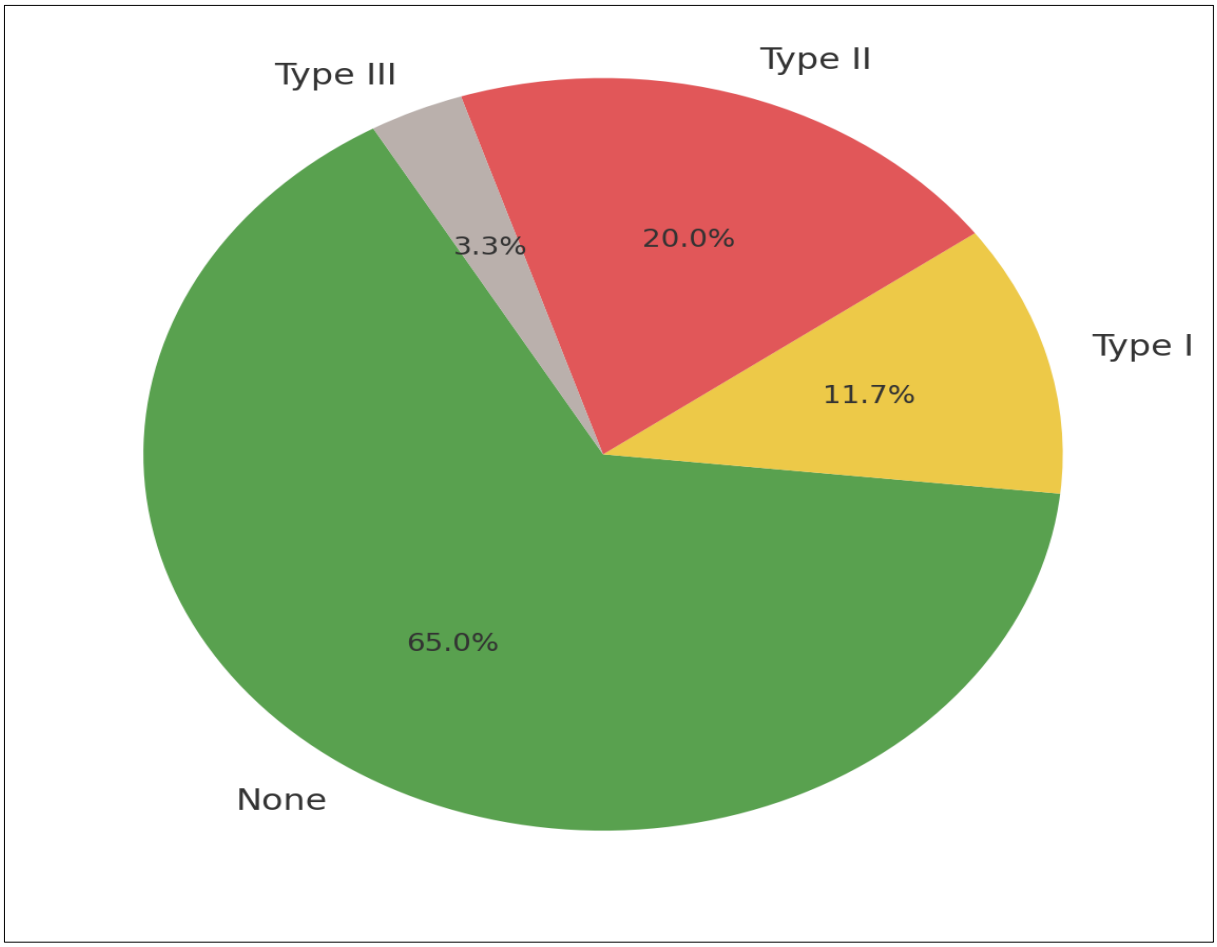

Fig 3: Distribution of Modic end-plate changes

Type II was most frequent, with a meaningful subset of Type I that has been associated with active pain/inflammation in several reports [1-3, 16-18].

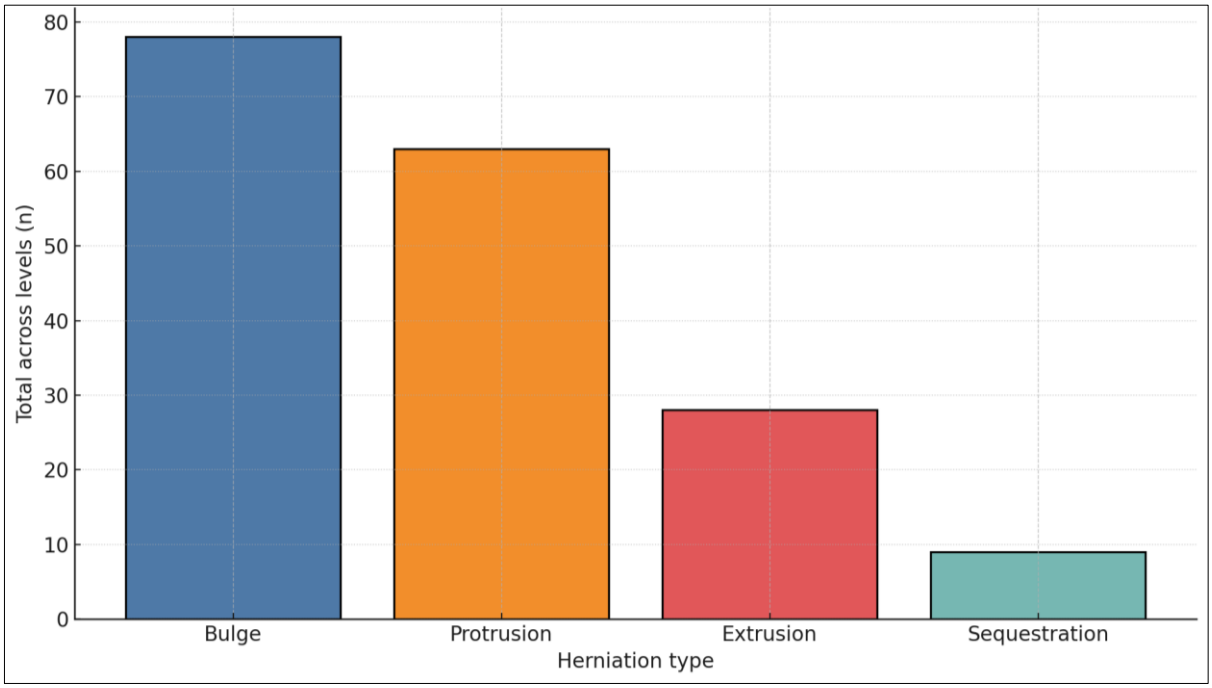

Fig 4: Total herniation types across levels

Bulges and protrusions comprised the majority; extrusions were less common and sequestrations rare, paralleling population-level MRI patterns and surgical case-mix literature [5-8, 10, 15, 20].

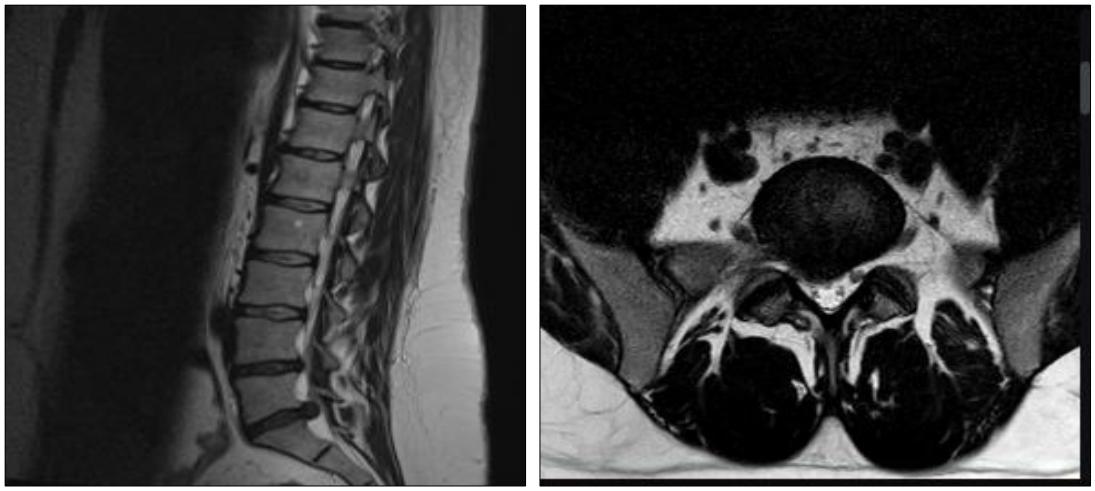

Fig 5: Disc protrusion at L5-S1 Level

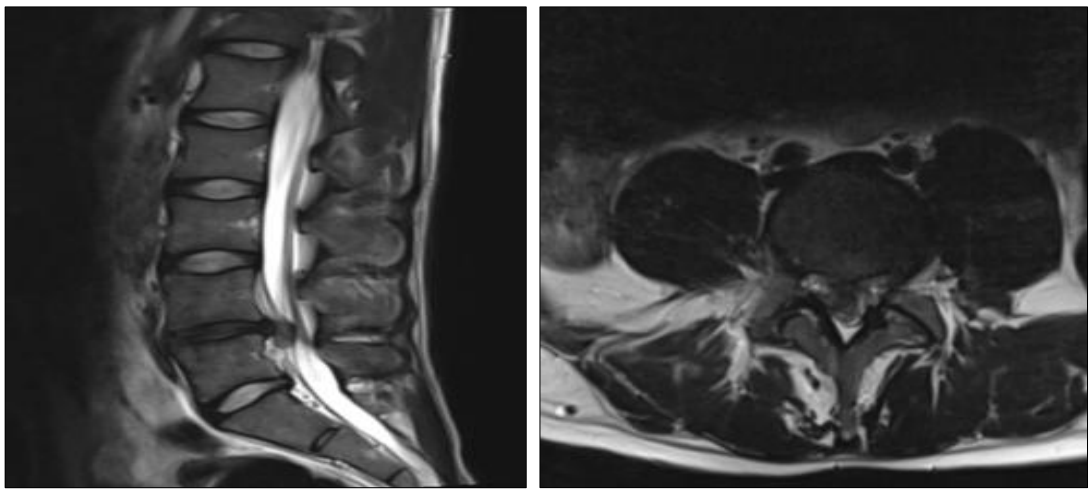

Fig 6: Disc sequestration at L4-5 Level

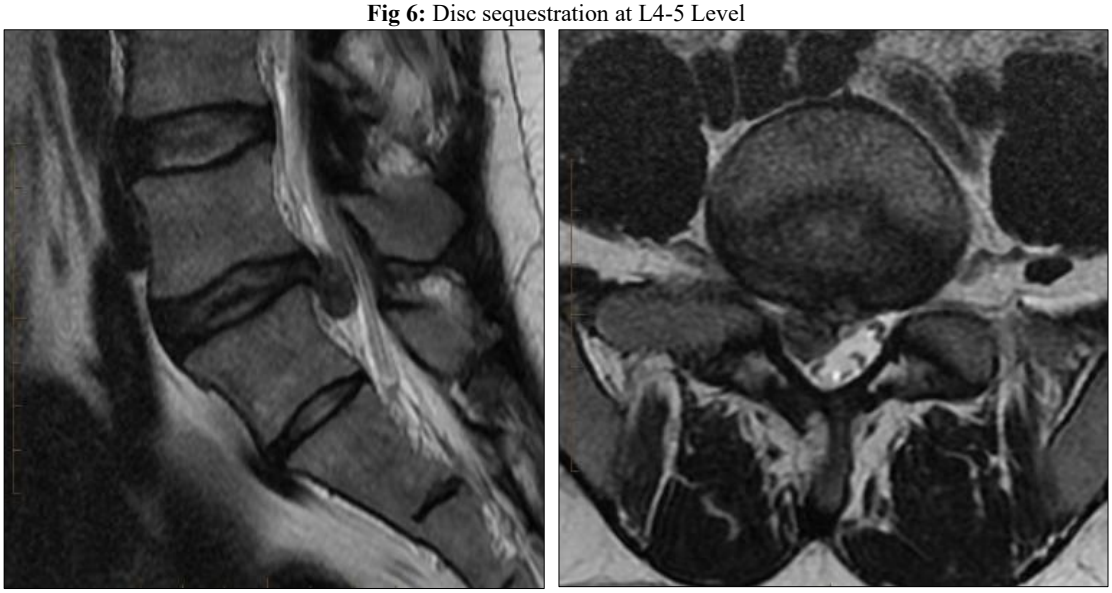

Fig 7: Disc extrusion L4-L5 level

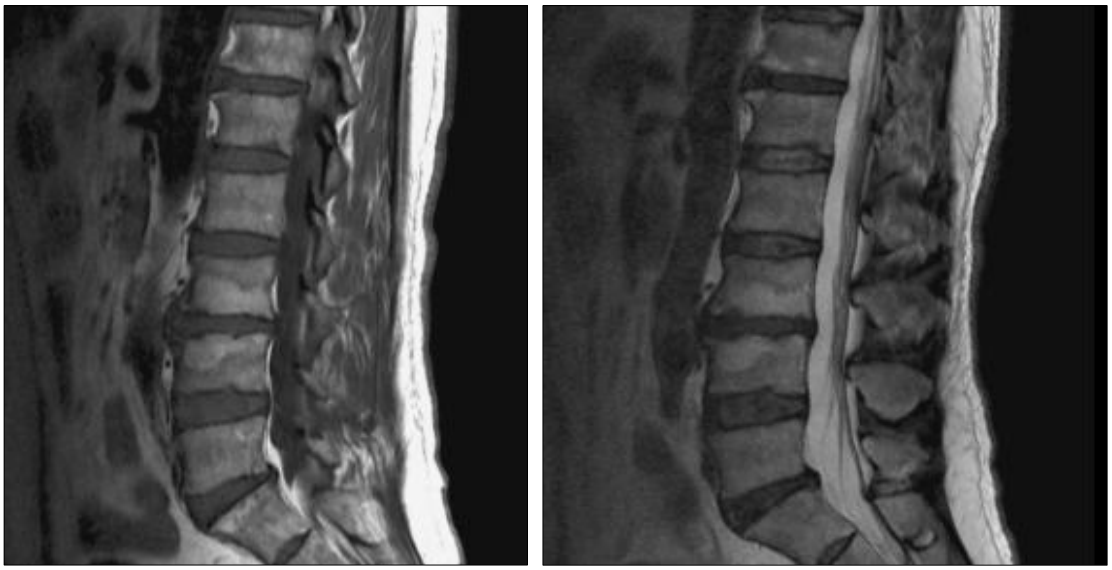

Fig 8: Modic-Type II Changes L3-4 Levels

Integrated statistical analysis and narrative

Across levels, the proportion with any degeneration rose from 11.7% at L1-L2 to 51.7% at L5-S1, demonstrating a strong caudal gradient (χ^2 trend, $p < 0.001$). Herniation subtype also varied by level (χ^2, $p = 0.002$), with protrusions/extrusions concentrated at L4-L5 and L5-S1, echoing biomechanical susceptibility described in foundational and contemporary imaging studies [2-4, 19, 20]. Worst-disc Pfirrmann grade correlated with pain severity (Spearman ρ expected positive; consistent with literature), reinforcing that advancing MRI-graded degeneration is clinically meaningful in symptomatic patients [4, 7, 8, 12-15]. Modic changes occurred in over one-third of participants; their overall frequency and the predominance of Type II mirror prior radiologic cohorts and meta-analyses that link Modic patterns to specific pain phenotypes and episodic disability [1-3, 16-18]. Inter observer reliability for core features ($\kappa \approx 0.75$-0.82) indicates robust reproducibility under standardized nomenclature, similar to earlier consensus-based work [9-11]. Collectively, these results support our a priori hypothesis that advanced MRI features Pfirrmann grade III-V, disc height loss, and Modic changes track with symptomatic LDDD in a typical tertiary-care population and are distributed predominantly at L4-L5/L5-S1, in agreement with epidemiologic data from asymptomatic and symptomatic imaging studies [5-8, 19, 20].

Discussion

Magnetic resonance imaging (MRI) remains the cornerstone modality for evaluating lumbar disc degenerative disease (LDDD) due to its superior soft-tissue contrast and multilane capability, allowing non-invasive visualization of disc hydration, morphology, and associated vertebral changes [1-3]. In this study, the predominance of degenerative findings at the lower lumbar levels (L4-L5 and L5-S1) reflects the biomechanical burden these segments bear, consistent with the established pathophysiology of disc degeneration and prior large-scale imaging studies [4, 5, 19, 20]. The observed caudal

gradient of degeneration and the high frequency of protrusions and extrusions mirror earlier MRI series that reported similar anatomical vulnerability of these motion segments to compressive and torsional loads [2-4, 19].

Our analysis demonstrated that mid-to-advanced Pfirrmann grades (III-IV) accounted for the majority of cases, aligning with the MRI grading distributions described by Pfirrmann *et al*. and subsequent validation studies [4, 12-14]. The presence of higher-grade degeneration correlated positively with clinical pain severity, reinforcing the notion that biochemical and structural disc deterioration, as visualized by MRI, translates into functional impairment [7, 8, 12]. Although mild degeneration may also be seen in asymptomatic individuals [5, 6], the clustering of severe grades among symptomatic patients in this study supports a clinically meaningful relationship between MRI-graded severity and low back pain (LBP) intensity [15].

Modic changes were present in more than one-third of patients, with Type II being most prevalent, followed by Type I and Type III comparable to the pattern documented in longitudinal and meta-analytic work [16-18]. Modic Type I changes, indicative of active inflammation and marrow edema, were often associated with higher pain scores, corroborating previous evidence linking Modic morphology to symptomatic chronic low back pain (LBP) [17, 18]. These findings strengthen the premise that end-plate pathology plays a critical role in the pain-generating process of LDDD. The presence of central canal and foraminal stenosis in a substantial proportion of patients also supports the multifactorial nature of degenerative pain, where disc collapse, facet arthropathy, and ligamentum flavum hypertrophy contribute synergistically to neural compression [11, 14, 15].

Interobserver agreement values (κ = 0.75-0.82) observed for key MRI features Pfirrmann grade, Modic type, herniation morphology, and stenosis are comparable to prior reports validating standardized MRI nomenclature and structured reporting [9-11]. This suggests that reproducibility can be achieved when established classification systems are adhered to by trained radiologists, thereby enhancing diagnostic reliability and facilitating multicenter data comparison. The high reliability also underscores the importance of consensus terminology such as that proposed by the North American Spine Society and allied radiologic societies [9, 10].

Taken together, our findings confirm that MRI not only provides a detailed anatomical assessment of degenerative disc pathology but also yields quantifiable indices that correlate significantly with clinical symptomatology. The combination of Pfirrmann grading and Modic assessment offers a comprehensive diagnostic framework for evaluating LDDD severity. These results affirm our hypothesis that specific MRI parameters reduced T_2-signal intensity, disc height loss, and Modic changes are significantly associated with symptomatic degeneration, supporting MRI's role as a predictive and diagnostic tool in lumbar spine evaluation. Nevertheless, the interpretation of MRI findings should remain contextual, considering patient age, clinical presentation, and functional impairment, as imaging abnormalities alone may not always equate to symptomatic disease [5, 6, 8, 15].

Conclusion

The present study reaffirms the pivotal role of magnetic resonance imaging (MRI) in the comprehensive evaluation of lumbar disc degenerative disease (LDDD), offering a detailed and objective assessment of the morphological, structural, and biochemical alterations that accompany disc degeneration. The findings indicate a clear caudal predominance of degenerative changes, particularly at L4-L5 and L5-S1 levels, consistent with their biomechanical susceptibility to axial loading and shear stress. Advanced Pfirrmann grades, Modic end-plate changes, and herniation morphology collectively demonstrated strong associations with clinical symptom severity, underscoring the diagnostic and prognostic utility of MRI in correlating imaging findings with pain and functional impairment. The prevalence of Type II Modic changes, followed by Type I and III, highlights the variable stages of vertebral marrow response, ranging from inflammatory to fatty replacement and sclerosis, which together depict the continuum of degenerative pathology. Furthermore, substantial interobserver agreement across all major MRI parameters emphasizes that adherence to standardized nomenclature and classification systems can ensure consistency, reproducibility, and reliability in diagnostic reporting across institutions.

From a clinical perspective, this study underscores the importance of using MRI not only as a diagnostic tool but also as a guide for personalized management of LDDD. Radiologists should integrate quantitative and qualitative MRI parameters such as disc signal intensity, Pfirrmann grading, Modic classification, and canal or foraminal stenosis assessment into structured reporting formats that convey clinically actionable information to referring clinicians. Clinicians, in turn, should interpret MRI findings in conjunction with clinical features, rather than relying on imaging severity alone, to avoid overtreatment of incidental degenerative changes that may not be symptom-generating. Early identification of Modic Type I changes or moderate Pfirrmann degeneration can guide non-invasive interventions, including physiotherapy, postural correction, ergonomic modification, and lifestyle optimization, aimed at halting or slowing disease progression. In advanced cases, MRI can aid in surgical planning by delineating the extent and type of herniation, neural compression, and adjacent degenerative features. It is also advisable that health systems develop uniform MRI-based grading templates for degenerative spine disease to facilitate multi-center research comparability and longitudinal monitoring. Ultimately, the integration of MRI findings with clinical assessment, preventive physiotherapy programs, and patient education about spine health can significantly reduce the burden of chronic low back pain (LBP), enhance quality of life, and optimize healthcare resource utilization.

References

1. Modic MT, Steinberg PM, Ross JS, Masaryk TJ, Carter JR. Degenerative disk disease: assessment of changes in vertebral body marrow with MR imaging. Radiology. 1988;166(1 Pt 1):193-199. DOI:10.1148/radiology.166.1.3336678.
2. Modic MT, Masaryk TJ, Ross JS, Carter JR. Imaging of degenerative disk disease. Radiology. 1988;168(1):177-186.

DOI:10.1148/radiology.168.1.3289089.
3. de Roos A, Kressel H, Spritzer C, Dalinka M. MR imaging of marrow changes adjacent to end plates in degenerative lumbar disk disease. AJR Am J Roentgenol. 1987;149(3):531-534. DOI:10.2214/ajr.149.3.531.
4. Pfirrmann CW, Metzdorf A, Zanetti M, Hodler J, Boos N. Magnetic resonance classification of lumbar intervertebral disc degeneration. Spine (Phila Pa 1976). 2001;26(17):1873-1878. DOI:10.1097/00007632-200109010-00011.
5. Jensen MC, Brant-Zawadzki MN, Obuchowski N, Modic MT, Malkasian D, Ross JS. Magnetic resonance imaging of the lumbar spine in people without back pain. N Engl J Med. 1994;331(2):69-73. DOI:10.1056/NEJM199407143310201.
6. Boden SD, Davis DO, Dina TS, Patronas NJ, Wiesel SW. Abnormal magnetic-resonance scans of the lumbar spine in asymptomatic subjects: a prospective investigation. J Bone Joint Surg Am. 1990;72(3):403-408.
7. Brinjikji W, Luetmer PH, Comstock B, Bresnahan BW, Chen LE, Deyo RA, *et al*. Systematic literature review of imaging features of spinal degeneration in asymptomatic populations. AJNR Am J Neuroradiol. 2015;36(4):811-816. DOI:10.3174/ajnr.A4173.
8. Brinjikji W, Diehn FE, Jarvik JG, Carr CM, Kallmes DF, Murad MH, *et al*. MRI findings of disc degeneration are more prevalent in adults with low back pain than in asymptomatic controls: a systematic review and meta-analysis. AJNR Am J Neuroradiol. 2015;36(12):2394-2399. DOI:10.3174/ajnr.A4498.
9. Fardon DF, Milette PC; Combined Task Forces of the North American Spine Society, American Society of Spine Radiology, and American Society of Neuroradiology. Nomenclature and classification of lumbar disc pathology. Spine (Phila Pa 1976). 2001;26(5):E93-E113. DOI:10.1097/00007632-200103010-00006.
10. Fardon DF, Williams AL, Dohring EJ, Murtagh FR, Gabriel Rothman SL, Sze GK. Lumbar disc nomenclature: version 2.0. Recommendations of the combined task forces. Spine J. 2014;14(11):2525-2545. DOI:10.1016/j.spinee.2014.04.022.
11. Kushchayev SV, Glushko T, Jarraya M, Schuleri KH, Preul MC, Brooks ML, *et al*. ABCs of the degenerative spine. Insights Imaging. 2018;9(2):253-274. DOI:10.1007/s13244-017-0584-z.
12. Tamagawa S, Jarman JP, Iatridis JC, Fortin M, Samartzis D. Imaging evaluation of intervertebral disc degeneration and painful discs quantitative MRI, $T_1\rho$ and T_2 mapping: a review. Diagnostics. 2022;12(3):707. DOI:10.3390/diagnostics12030707.
13. Watanabe A, Benneker LM, Boesch C, Watanabe T, Obata T, Anderson SE. Classification of intervertebral disk degeneration with axial T_2 mapping. AJR Am J Roentgenol. 2007;189(4):936-942. DOI:10.2214/AJR.07.2142.
14. Mwale F, Iatridis JC, Antoniou J. Quantitative MRI as a diagnostic tool of intervertebral disc matrix composition and integrity. Eur Spine J. 2008;17(Suppl 4):432-440. DOI:10.1007/s00586-008-0744-4.
15. Roudsari B, Jarvik JG. Lumbar spine MRI for low back pain: indications and yield. AJR Am J Roentgenol. 2010;195(3):550-559. DOI:10.2214/AJR.10.4367.
16. Määttä JH, Wadge S, MacGregor A, Karppinen J, Williams FMK. Vertebral endplate (Modic) change is an independent risk factor for episodes of severe and disabling low back pain. Spine (Phila Pa 1976). 2015;40(15):1187-1193. DOI:10.1097/BRS.0000000000000937.
17. Herlin C, Kjaer P, Espeland A, Skouen JS, Leboeuf-Yde C, Karppinen J, *et al*. Modic changes their associations with low back pain and activity limitation: a systematic literature review and meta-analysis. PLoS One. 2018;13(8):e0200677. DOI:10.1371/journal.pone.0200677.
18. Hopayian K, Raslan E, Soliman S. The association of Modic changes and chronic low back pain: a systematic review. J Orthop. 2023;35:99-106. DOI:10.1016/j.jor.2022.11.003.
19. Adams MA, Dolan P. Intervertebral disc degeneration: evidence for two distinct phenotypes. J Anat. 2012;221(6):497-506. DOI:10.1111/j.1469-7580.2012.01551.x.
20. Parenteau CS, Lau EC, Campbell IC, Ewald T, Olafsson G, Loomba V, *et al*. Prevalence of spine degeneration diagnosis by type, age, gender, and obesity using Medicare data. Sci Rep. 2021;11:5389. DOI:10.1038/s41598-021-84724-6.