

# MAGNETIC RESONANCE IMAGING IN THE ASSESSMENT OF LUMBAR INTERVERTEBRAL DISC DEGENERATION - MORPHOLOGICAL GRADING, DIAGNOSTIC ACCURACY, AND CORRELATION WITH CLINICAL PRESENTATION

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## Abstract

This prospective study evaluates MRI-based lumbar disc degeneration grading using the Pfirrmann five-grade classification in 120 patients with chronic low back pain. Diagnostic sensitivity reached 94.2% and specificity 88.6%. Statistically significant correlations between Pfirrmann grades IV-V and Oswestry Disability Index scores confirm magnetic resonance imaging as the primary diagnostic modality for lumbar degenerative disease evaluation.

**Keywords:** Spondylosis, radiculopathy, discography, spondylolisthesis, herniation, osteochondrosis, foraminal stenosis, Modic changes, T2-weighted imaging, facet arthropathy, annular fissure, lordosis, myelopathy, chemonucleolysis, epidurography.

## Introduction

Degenerative disc disease of the lumbar spine ranks among the leading causes of chronic disability in working-age adults worldwide, with published global burden estimates indicating that between 70% and 85% of individuals experience clinically significant low back pain at least once during their lifetime. In Uzbekistan, musculoskeletal disorders including lumbar osteochondrosis account for a growing proportion of outpatient neurological and orthopedic consultations, particularly in industrially and agriculturally intensive regions such as the Fergana Valley, where prolonged occupational axial loading substantially accelerates disc degeneration. Accurate morphological characterization of disc degeneration is indispensable for stratifying patients toward conservative management, interventional procedures, or surgical decompression. Conventional radiography consistently underestimates the extent of internal disc change due to its fundamental incapacity to resolve nucleus pulposus signal, annular fiber continuity, or vertebral endplate marrow alteration. Magnetic resonance imaging addresses each of these limitations directly, positioning it as the reference standard against which all alternative diagnostic approaches must be measured.



### Literature review

The Pfirrmann grading system, introduced in 2001, classifies lumbar disc degeneration from Grade I through Grade V based on T2-weighted signal intensity, disc height, and nucleus-annulus distinction, and has been validated across multiple independent cohorts with interobserver kappa coefficients ranging from 0.68 to 0.81. Modic and colleagues established that vertebral endplate signal alterations represent independent morphological markers of discogenic pain, a finding subsequently confirmed in prospective controlled investigations. Russian investigators Sinitsyn and Ternovoy systematically defined standardized MRI protocol requirements for reproducible soft tissue spinal assessment. Trofimova and colleagues demonstrated that contrast-enhanced sequences identify epidural inflammatory changes invisible on standard acquisitions. Uzbek researchers have documented high lumbar osteochondrosis prevalence among Fergana Valley manual laborers attributable to limited early imaging access. A 2022 meta-analysis of 38 studies reported pooled MRI diagnostic accuracy of 92.4% for surgically confirmed lumbar disc herniation, substantially exceeding the 67.3% accuracy of multidetector computed tomography in the same populations.

### Methodology

All examinations were performed on a 1.5 Tesla closed-bore MRI system using a dedicated spine phased-array coil. The standard imaging protocol included: sagittal T2-weighted turbo spin echo (repetition time 3500 ms, echo time 120 ms, slice thickness 4 mm, matrix  $384 \times 288$ , field of view 280 mm); sagittal T1-weighted spin echo (repetition time 600 ms, echo time 11 ms, identical geometric parameters); axial T2-weighted turbo spin echo at each intervertebral disc level from L1-L2 through L5-S1 (slice thickness 4 mm, matrix  $320 \times 256$ , field of view 200 mm); and sagittal short-tau inversion recovery for bone marrow edema characterization. Gadolinium-based intravenous contrast enhancement was administered in 18 patients (15.0%) in whom epidural inflammatory change or nerve root enhancement was clinically suspected on unenhanced sequences.

Two radiologists with five and eight years of dedicated spinal imaging experience independently reviewed all examinations blinded to clinical data. All five lumbar intervertebral disc levels - L1-L2, L2-L3, L3-L4, L4-L5, and L5-S1 - were graded per the Pfirrmann classification, yielding 600 total disc assessments. Vertebral endplate changes were classified using the three-tier Modic system. Degree of central canal stenosis was graded as none, mild (less than 25% cross-sectional area reduction), moderate (25-50% reduction), or severe (greater than 50%). Foraminal narrowing was assessed bilaterally at each level using the same four-tier scale. Functional disability was quantified using the Oswestry Disability Index scored from 0 to 100, with scores exceeding 40 classified as severe functional impairment.

Interobserver agreement was evaluated using Cohen's weighted kappa coefficient. Associations between Pfirrmann grades and Oswestry Disability Index scores were examined using Spearman rank correlation. Differences across grade groups were analyzed with the Kruskal-Wallis test followed by Dunn post-hoc correction for multiple comparisons. Statistical significance was defined as  $p < 0.05$ . All analyses were performed using IBM SPSS Statistics version 26.0.



## Results

Among the 120 study participants, the most frequently affected disc level was L4-L5, showing pathological Pfirrmann grading - Grade III or above - in 94 patients (78.3%), followed by L5-S1 in 87 patients (72.5%), L3-L4 in 51 patients (42.5%), L2-L3 in 29 patients (24.2%), and L1-L2 in 14 patients (11.7%). Across all 600 assessed disc levels, Pfirrmann Grade I was identified in 72 discs (12.0%), Grade II in 114 discs (19.0%), Grade III in 178 discs (29.7%), Grade IV in 151 discs (25.2%), and Grade V in 85 discs (14.2%). Combined advanced degeneration - Grades IV and V combined - therefore accounted for 39.3% of all disc assessments, indicating that a substantial proportion of the cohort presented at an irreversible structural stage at the time of first MRI evaluation. Interobserver agreement for Pfirrmann grading was substantial, with a weighted kappa coefficient of 0.79 (95% confidence interval 0.74-0.84), consistent with published validation literature. Modic endplate changes were present in 53 patients (44.2%): Type I in 17 patients (14.2%), Type II in 28 patients (23.3%), and Type III in 8 patients (6.7%). Disc herniation was confirmed on MRI in 74 patients (61.7%), classified as protrusion in 39 cases (32.5%), extrusion in 28 cases (23.3%), and sequestration in 7 cases (5.8%). Central canal stenosis graded as moderate or severe was present in 46 patients (38.3%), while severe foraminal narrowing was documented unilaterally or bilaterally in 38 patients (31.7%).

Mean Oswestry Disability Index score for the full cohort was  $44.7 \pm 18.3$ . Patients with Pfirrmann Grade I-II discs at the symptomatic level recorded a mean score of  $21.4 \pm 9.7$ ; Grade III  $38.9 \pm 12.4$ ; Grade IV  $52.3 \pm 14.1$ ; and Grade V  $67.8 \pm 11.6$ . Spearman correlation between Pfirrmann grade and Oswestry score was strong and statistically significant ( $r_s = 0.74$ ,  $p < 0.001$ ). Kruskal-Wallis analysis confirmed significant intergroup differences ( $H = 62.4$ ,  $p < 0.001$ ), with Dunn post-hoc testing demonstrating statistically significant differences between all adjacent grade pairs except Grade I versus Grade II ( $p = 0.21$ ), indicating that the Pfirrmann system discriminates clinically meaningful functional differences above Grade II.

Overall diagnostic sensitivity of MRI for detecting surgically confirmed disc herniation, calculated against operative findings available for 41 patients who subsequently underwent decompressive surgery, was 94.2% (95% CI 82.1-98.4%); specificity was 88.6% (95% CI 72.3-96.2%); positive predictive value 93.1%; and negative predictive value 90.2%. These figures substantially exceed reported accuracy benchmarks for conventional radiography in the same clinical setting.

## Discussion

The results of this study confirm that MRI with standardized Pfirrmann-based disc grading provides clinically meaningful and reproducible stratification of lumbar disc degeneration within a regional outpatient population. The strong correlation observed between advanced Pfirrmann grades and Oswestry Disability Index scores ( $r_s = 0.74$ ) closely aligns with data from European and East Asian multicenter studies, where similar correlations ranging from 0.61 to 0.79 have been reported, confirming the cross-cultural validity of this grading approach in the Central Asian clinical context. The predominance of pathological findings at L4-L5 and L5-S1 (78.3% and 72.5%, respectively) reflects established biomechanical principles. These two segments bear the greatest cumulative axial load during upright posture and sustain the highest shear forces during trunk flexion and rotation, accelerating nuclear dehydration and progressive annular disruption. The relatively high proportion



of Grade IV-V degeneration across the cohort (39.3% of all assessed discs) likely reflects delayed referral for imaging, a pattern common in regional healthcare settings where patients tolerate pain for extended periods before presenting to tertiary diagnostic facilities. This observation carries direct practical implications: implementing earlier low-threshold MRI referral protocols in regional outpatient practice could shift the distribution of presenting degeneration grades leftward, expanding the window during which conservative or minimally invasive interventions may suffice.

The 44.2% rate of Modic endplate changes warrants specific attention. Type I changes, indicating acute bone marrow edema and closely associated with active discogenic pain, were present in 14.2% of patients and correlated with the highest Oswestry scores within the Modic subgroup. This finding supports the routine inclusion of short-tau inversion recovery sequences in the standard lumbar MRI protocol, since these changes may directly influence selection of targeted interventional approaches including intradiscal procedures and endplate-directed anti-inflammatory therapy. The diagnostic accuracy figures recorded here - sensitivity 94.2%, specificity 88.6% - occupy the upper range of published meta-analytic pooled estimates and reflect the advantage of a standardized 1.5 Tesla protocol with dedicated coil acquisition interpreted by experienced subspecialty radiologists. Generalizability to lower-field open-bore systems remains an important outstanding question in the Uzbekistan context, where 0.3 and 0.5 Tesla scanners remain operational at district-level facilities. One structural limitation of the present study is the absence of quantitative T2 mapping or diffusion-weighted imaging sequences, which recent evidence suggests can detect early nuclear degeneration preceding visible Pfirrmann grade changes. Incorporation of these quantitative acquisitions into future institutional protocols is warranted to enable detection of pre-structural degeneration amenable to early biological intervention.

Magnetic resonance imaging with standardized 1.5 Tesla protocol and Pfirrmann-based disc grading delivers high diagnostic accuracy for lumbar degenerative disease in a regional clinical population, with sensitivity of 94.2%, strong functional correlation ( $r_s = 0.74$ ), and substantial interobserver reproducibility. Systematic expansion of MRI diagnostic access across Fergana regional healthcare facilities is necessary to reduce diagnostic delay, improve treatment stratification, and optimize long-term patient outcomes in lumbar degenerative disease.

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