Clinical Impact of Disc Degeneration, Modic Changes, and Paraspinal Muscle Atrophy: A Cross-Sectional Observational Study

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ABSTRACT

Objective: This study set out to explore how lumbar disc degeneration, Modic changes, and atrophy of the paraspinal muscles—detected using MRI—are connected to pain intensity and functional disability in individuals with low back pain (LBP).

Materials and Methods: Fifty-two adults (18 years or older) who had been experiencing LBP for at least three months and had MRI scans of the lumbar spine were included. Pain and disability levels were measured using the Visual Analog Scale (VAS) and the Oswestry Disability Index (ODI). MRI scans were analyzed for structural changes: disc degeneration was assessed with the Pfirrmann grading system, Modic changes were classified into types 1 through 3, and multifidus muscle atrophy was graded from 0 (normal) to 4 (severe). Statistical analysis included correlation and group comparisons.

Results: Disc degeneration was most frequently observed at the L4–L5 segment (77%), while paraspinal muscle atrophy was most common at the L5–S1 level (39%). Degeneration at the L3–L4 level was strongly associated with both VAS and ODI scores ($p<0.01$). Atrophy of the multifidus muscle at L5–S1 had the strongest link with ODI scores ($\rho=0.586$; $p<0.001$). Modic type 2 changes were common at both L4–L5 and L5–S1 and were significantly related to higher VAS scores. No significant differences were found between men and women. However, patients aged 50 and older had notably higher pain and disability scores, as well as more pronounced degenerative changes on MRI ($p<0.05$).

Conclusion: Lumbar disc degeneration, Modic changes, and atrophy of the paraspinal muscles are key structural markers associated with increased pain and functional impairment in patients with LBP. MRI analysis by specific spinal

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segments may improve diagnostic accuracy and help guide more personalized treatment strategies.

Keywords: low back pain, disc degeneration, modic changes, muscle atrophy, MRI, VAS, ODI

Disk Dejenerasyonu, Modic Değişiklikleri ve Kas Atrofisinin Klinik Yansımaları: Gözlemsel Bir Çalışma

ÖZET

Amaç: Bu çalışma, lomber disk dejenerasyonu, Modic değişiklikleri ve paraspinal kasların atrofi durumunun—MRI kullanılarak tespit edilen—bel ağrısı şiddeti ve fonksiyonel yetersizlik ile ilişkisini araştırmayı amaçladı.

Gereç ve Yöntem: En az üç aydır bel ağrısı yaşayan ve lomber omurga MRI görüntülemesi bulunan 52 yetişkin çalışmaya dahil edildi. Ağrı ve yetersizlik düzeyleri Vizüel Analog Skala (VAS) ve Oswestry Engellilik Endeksi (OEE) ile değerlendirildi. MRI taramaları yapısal değişiklikler açısından incelendi: disk dejenerasyonu Pfirrmann derecelendirme sistemi ile, Modic değişiklikleri tip 1'den tip 3'e kadar sınıflandırıldı, multifidus kas atrofisi ise 0 (normal) ile 4 (şiddetli) arasında derecelendirildi. İstatistiksel analizde korelasyon ve grup karşılaştırmaları yapıldı.

Bulgular: Disk dejenerasyonu en sık L4–L5 segmentinde (%77) gözlendi, paraspinal kas atrofisi ise en yaygın L5–S1 seviyesinde (%39) bulundu. L3–L4 düzeyindeki dejenerasyon hem VAS hem de OEE skorları ile güçlü bir ilişki gösterdi ($p<0.01$). L5–S1'deki multifidus kas atrofisi, OEE skorlarıyla en güçlü ilişkiyi ortaya koydu ($\rho=0.586$; $p<0.001$). Modic tip 2 değişiklikleri hem L4–L5 hem de L5–S1'de yaygındı ve daha yüksek VAS skorlarıyla anlamlı şekilde ilişkiliydi. Elli yaş ve üzerindeki hastalarda ağrı ve yetersizlik skorları belirgin derecede daha yüksek, MRI'da ise dejeneratif değişiklikler daha belirgin bulundu ($p<0.05$).

Sonuç: Lomber disk dejenerasyonu, Modic değişiklikleri ve paraspinal kas atrofisi; bel ağrısı olan hastalarda artmış ağrı ve fonksiyonel bozukluk ile ilişkili önemli yapısal belirteçlerdir. Omurga segmentlerine özel MRI analizi, tanısal doğruluğu artırabilir ve daha kişiselleştirilmiş tedavi stratejilerinin yönlendirilmesine yardımcı olabilir.

Anahtar Kelimeler: bel ağrısı, disk dejenerasyonu, modic değişiklikleri, kas atrofisi, MRI, VAS, OEE.

INTRODUCTION

Low back pain (LBP) is among the most common musculoskeletal conditions globally, affecting up to 80% of people at some point in their lives. When chronic, it can significantly reduce quality of life, increase healthcare utilization, and lead to major productivity losses. Because of its widespread impact, researchers have continued to explore the structural changes that might explain this pain.

Degenerative changes in the lumbar spine—such as disc degeneration, Modic changes at the vertebral endplates, facet joint arthritis, muscle atrophy around the spine, and narrowing of the nerve pathways—are often involved in the development of LBP. MRI is the most accurate imaging tool to detect these abnormalities. Yet, there's still a lack of clear correlation between what is seen on MRI and the symptoms patients report. Some individuals with severe degeneration may have little to no pain, while others with only mild changes may experience debilitating symptoms. The intensity of pain and degree of disability in LBP are typically measured using validated tools like the Visual Analog Scale (VAS) and the Oswestry Disability Index (ODI) [Fairbank & Pynsent, 2000].

In recent years, research has highlighted the importance of MRI-based indicators in understanding chronic LBP. Numerous studies have linked disc degeneration with both reduced function and increased pain [Cheng et al.,2023; Kim et al.,2020]. Similarly, loss of muscle mass and fat infiltration in the multifidus—a key stabilizing muscle of the spine—are now known to contribute to instability and disability, particularly in older adults [Fortin & Macedo,2023; Shi et al.,2022]. Modic changes, especially types 1 and 2, have been associated with inflammation and pain at the endplates of the vertebrae [Modic et al.,1988; Zehra et al.,2019]. Despite this knowledge, few studies have assessed these three degenerative features together or examined how their effects vary across different levels of the spine. Additionally, newer imaging techniques like fat mapping and radiomics are being developed, but their relevance to patient outcomes is still being explored [Ziegelmayer et al.,2025; Sconfienza et al.,2024].

To bridge this gap, our study investigated how lumbar disc degeneration, Modic changes, and paraspinal muscle atrophy seen on MRI relate to pain and disability in patients with LBP. We also looked at how these associations differ based on age and sex.

MATERIAL AND METHOD

The study protocol was reviewed and approved by the Clinical Research Ethics Committee of Istanbul Medipol University (Protocol Code: E-10840098-

202.3.02-5565, decision number:1023). Written informed consent to participate in the study was obtained from all individuals. All stages of the study were conducted in accordance with the ethical principles of the Declaration of Helsinki.

Study Design and Participants

This was a cross-sectional analytical study conducted at Medipol Acıbadem District Hospital. A total of 52 patients who visited the outpatient clinic with complaints of LBP were included after clinical evaluation and lumbar MRI. All participants gave informed consent. To be eligible, individuals had to be at least 18 years old, have experienced LBP for three months or more, and have a complete lumbar MRI available. Exclusion criteria included a history of lumbar spine surgery, spinal trauma, infection, cancer, or any inflammatory spinal conditions.

Clinical Assessment

Pain intensity was measured using the VAS, which ranges from 0 (no pain) to 10 (worst possible pain). Functional disability was evaluated with the ODI, a questionnaire designed to assess how LBP affects daily activities. The ODI consists of 10 items, each scored from 0 to 5, with the total expressed as a percentage. Based on these scores, disability levels were classified as:

- Minimal (0–20%)
- Moderate (21–40%)
- Severe (41–60%)
- Very Severe (61–80%)
- Crippled (81–100%) [Fairbank & Pynsent, 2000]

Radiological Evaluation

MRI scans of the lumbar spine were performed using a 1.5 Tesla machine. Both sagittal T1- and T2-weighted images were reviewed. Imaging assessments were focused on three key spinal levels: L3–L4, L4–L5, and L5–S1.

The following degenerative changes were evaluated:

- **Disc Degeneration:** Rated using the Pfirrmann classification (Grade 1 = normal to Grade 5 = severe degeneration).
- **Modic Changes:** Categorized as Type 1 (inflammatory), Type 2 (fatty), or Type 3 (sclerotic) based on vertebral endplate and bone marrow signals [Modic et al.,1988].
- **Facet Joint Degeneration:** Scored from 0 (normal) to 3 (severe), based on narrowing of joint space, hypertrophy, and presence of bone spurs.
- **Paraspinal Muscle Atrophy:** Assessed by examining the multifidus muscle's size and degree of fatty infiltration. Graded from 0 (normal) to 4 (severe

atrophy) [Fortin& Macedo,2013].

- **Neural Foraminal Narrowing:** Graded from 0 to 3 using sagittal images, based on loss of perineural fat and any nerve root compression, according to the method described by Lee et al. [Lee et al.,2013].

All MRI readings were performed by an experienced musculoskeletal radiologist (10 years' experience) who was blinded to the patients' clinical information.

Statistical Analysis

Data analysis was performed using IBM SPSS Statistics, version 23.0. Continuous variables were presented as mean ± standard deviation or median (range), while categorical variables were reported as frequency and percentage. The Kolmogorov-Smirnov and Shapiro-Wilk tests were used to assess normal distribution.

- For comparisons between two groups: the independent samples t-test was used for normally distributed data, and the Mann-Whitney U test for non-parametric data.
- For comparisons among more than two groups: the Kruskal-Wallis test was applied.
- For categorical variables: Chi-square or Fisher's exact test was used as appropriate.
- Correlations between variables were assessed using the Spearman correlation coefficient.

A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 52 patients were included in the analysis. The mean age was 45.7 ± 10.3 years (range: 28–66), with 30 females (58%) and 22 males (42%). The mean VAS score was 6.87 ± 1.0 and the mean ODI score was 76.4 ± 11.1 (Table 1).

Table 1. Demographic and Clinical Characteristics of Participants

Variable	Value
Number of participants	52
Age (mean ± SD)	45.7 ± 10.3 years (range: 28–66)
Gender	Female: 30 (58%), Male: 22 (42%)
VAS score (mean ± SD)	6.87 ± 1.0 (range: 5–9)
ODI score (mean ± SD)	76.4 ± 11.1 (range: 52–94)

VAS: Visual Analog Scale; ODI: Oswestry Disability Index; SD: Standard Deviation. Data are presented as mean ± SD and minimum–maximum values.

MRI findings revealed degenerative changes in multiple lumbar segments. The most common observation was grade 4 disc degeneration, particularly at the L4–L5 level (77%), followed by the L5–S1 level (48%). At L3–L4, degeneration was less severe but still notable: grade 3 in 38% and grade 4 in 58% of cases. Modic type 2 changes were most frequently observed at L5–S1 (19%) and L4–L5 (11%), while type 1 changes were rare (<2%).

Facet joint degeneration was most commonly mild (grade 1) and predominantly seen at the L3–L4 level (67%). Paraspinal muscle atrophy, especially in the multifidus, was most frequently detected at the L5–S1 level (39%) and L4–L5 level (42%), mostly at grade 1 severity. Neural foraminal narrowing was observed most frequently at L4–L5 (73%) and L5–S1 (61%), with the majority of cases classified as grade 1 (Table 2).

Table 2. Distribution of Radiological Findings by Vertebral Level

Finding	L3–L4 (%)	L4–L5 (%)	L5–S1 (%)
Disc Degeneration			
Grade 2	2	–	8
Grade 3	38	21	36
Grade 4	58	77	48
Grade 5	2	2	8
Modic Changes			
None	92	85	79
Type 1	–	4	2
Type 2	8	11	19
Facet Degeneration			
Grade 0	14	13	11
Grade 1	67	52	48
Grade 2	17	29	31
Grade 3	2	6	10
Muscle Atrophy			
Grade 0	56	35	11
Grade 1	36	42	39
Grade 2	2	17	33
Grade 3	4	2	11
Grade 4	2	4	6

Neural Foraminal Narrowing			
Grade 0	13	2	29
Grade 1	85	73	61
Grade 2	2	19	8
Grade 3	–	6	2

MRI: Magnetic Resonance Imaging; Modic: Vertebral endplate signal change; Grade: Severity level. Data are presented as frequency (%).

Sex-based Comparisons

There were no statistically significant differences between male and female patients in terms of VAS and ODI scores ($p > 0.05$). Similarly, no significant sex-based differences were found in the distribution of radiological findings, including disc degeneration, Modic changes, facet degeneration, muscle atrophy, or foraminal narrowing (Table 3).

Table 3. Comparison of Clinical and Radiological Findings by Sex and Age

Part A: By Sex

Variable	**Female (n=30)**	**Male (n=22)**	**p-value**
VAS (mean ± SD)	6.97 ± 1.03	6.73 ± 0.98	0.404
ODI (mean ± SD)	77.2 ± 12.11	75.32 ± 9.79	0.552
Modic L5–S1 (Type 2)	7 (23%)	3 (13%)	0.443

Part B: By Age Group (<50 vs ≥50)

Variable	**<50 years (n=29)**	**≥50 years (n=23)**	**p-value**
VAS (mean ± SD)	6.7 ± 0.98	7.3 ± 1.03	0.005
ODI (mean ± SD)	70.8 ± 10.5	83.4 ± 7.3	0.033
L3–L4 Disc Degeneration (G4)	11 (38%)	19 (83%)	0.004
L5–S1 Muscle Atrophy (≥G2)	7 (24%)	26 (76%)	0.008

VAS: Visual Analog Scale; ODI: Oswestry Disability Index; SD: Standard Deviation. Statistical tests used: independent samples t-test, Mann-Whitney U, and Chi-square. $p<0.05$ considered statistically significant.

Age-based Comparisons

When patients were divided into two groups (<50 and ≥50 years), those aged ≥50 had significantly higher VAS ($p = 0.005$) and ODI scores ($p = 0.033$). In this group, L3–L4 disc degeneration, Modic type 2 changes, muscle atrophy, and facet degeneration were significantly more common. A significant association between age and L3–L4 foraminal narrowing was also found ($p = 0.024$).

When patients were categorized into four age groups (<39, 40–49, 50–59, ≥60 years), both VAS ($p = 0.012$) and ODI ($p < 0.001$) scores showed a progressive increase with age. Segmental degenerative changes—particularly L3–L4 disc degeneration, L5–S1 muscle atrophy, and facet joint degeneration—were most prevalent in the ≥60 age group (Table 3).

Correlation Analyses

Significant positive correlations were observed between VAS and:

- **Age** ($\rho = 0.395$, $p = 0.004$)
- **ODI** ($\rho = 0.551$, $p < 0.001$)
- **L3–L4 disc degeneration** ($\rho = 0.419$, $p = 0.002$)
- **L4–L5 Modic changes** ($\rho = 0.437$, $p = 0.001$)

ODI scores were most strongly correlated with:

- **L3–L4 disc degeneration** ($\rho = 0.612$, $p < 0.001$)
- **L5–S1 muscle atrophy** ($\rho = 0.586$, $p < 0.001$)

Other correlations, such as those with foraminal narrowing, were weaker and not statistically significant (Table 4).

Table 4. Correlation Between Clinical Scores and Radiological Findings

Variable	VAS (ρ / p-value)	ODI (ρ / p-value)
Age	0.395 / 0.004	0.547 / <0.001
L3–L4 Disc Degeneration	0.419 / 0.002	0.612 / <0.001
L4–L5 Modic Change	0.437 / 0.001	0.381 / 0.005
L5–S1 Muscle Atrophy	0.289 / 0.038	0.586 / <0.001
L5–S1 Foraminal Narrowing	0.289 / 0.038	0.246 / 0.079

VAS: Visual Analog Scale; ODI: Oswestry Disability Index. Statistical test used: Spearman correlation. p<0.05 considered statistically significant.

DISCUSSION

This study explored how structural changes in the lumbar spine, visible on MRI, relate to pain severity (VAS) and functional impairment (ODI) in people with chronic LBP. The analysis showed that key imaging findings—especially disc degeneration, Modic changes, and paraspinal muscle atrophy—were significantly linked to worse pain and disability scores.

The most common degenerative finding was grade 4 disc degeneration, most often seen at the L4–L5 and L5–S1 levels. Notably, degeneration at the L3–L4 level also had a strong connection to both pain and disability. This highlights the

clinical importance of upper lumbar segments, which are sometimes overlooked in routine assessments. These results echo previous research, including studies by Kim et al. [2020] and Cheng et al. [2023], who found disc degeneration to be a central contributor to disc-related pain and declining function.

Modic type 2 changes were frequently observed at the L4–L5 and L5–S1 levels and were associated with increased pain scores. This finding supports earlier studies suggesting that Modic changes, particularly types 1 and 2, may play an active role in chronic pain by promoting inflammation and fatty changes in the vertebral endplates [Kamal et al.,2024,Zehra et al.,2019]. These changes should not be dismissed as incidental—they may have direct clinical significance.

Among all factors examined, atrophy of the multifidus muscle—especially at the L5–S1 level—had the strongest correlation with disability. This reinforces the growing recognition that muscle health, particularly in stabilizing spinal muscles like the multifidus, is crucial for maintaining function. These findings are in line with prior reports that link muscle wasting and fatty infiltration to both instability and increased disability [Chen et al.,2024; Shi et al.,2022].

Facet joint degeneration was seen more frequently in older adults, especially those aged 60 and above. While the link between facet joint degeneration and clinical scores wasn't as strong, its coexistence with other spinal changes suggests it contributes to the broader degenerative process [Habibi et al.,2022; Määttä et al.,2016].

Age was clearly a factor—patients aged 50 and older had more advanced structural changes and higher pain and disability scores. This trend supports the well-established idea that spinal degeneration progresses with age. Määttä et al. [Määttä et al.,2016] found similar results, showing that degenerative MRI changes predict long-term decline in function.

Interestingly, there were no significant differences in imaging or clinical scores between male and female patients. Although some previous studies have suggested gender differences in how spinal degeneration or pain is experienced, our findings may reflect cultural reporting habits or sample size limitations.

A key strength of this study is its segment-specific analysis, which allowed for a deeper look at how each lumbar level contributes to symptoms. The strong relationship between L3–L4 degeneration and clinical outcomes suggests that focusing only on the lower spine may overlook important pathology. Analyzing Modic changes, muscle atrophy, and disc damage together gives a more complete

picture of what's driving a patient's pain and disability.

However, the study does have limitations. The relatively small sample size and cross-sectional design mean we can't conclude cause and effect. Also, the grading systems used for MRI features are semi-quantitative and subject to some interpretation. Future research should use objective, quantitative imaging tools and follow patients over time to better understand how these changes impact outcomes.

CONCLUSION

This study shows that key degenerative changes seen on lumbar MRI—particularly disc degeneration, Modic changes, and paraspinal muscle atrophy—are closely linked to the intensity of pain and level of disability in patients with chronic LBP. These associations were especially notable at the L3–L4 and L5–S1 spinal levels. Age was a major factor influencing both imaging and clinical findings, while sex was not. Segment-by-segment MRI evaluation can offer valuable insights into the source of symptoms and may guide more precise treatment strategies. To build on these results, future studies with larger groups and more advanced imaging tools are needed to better understand the long-term significance of these structural changes.

Ethical approval: The study protocol was reviewed and approved by the Clinical Research Ethics Committee of Istanbul Medipol University (Protocol Code: E-10840098-202.3.02-5565, decision number:1023).

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