MRI Assessment of Lumbar Intervertebral Disc Degeneration and its Association with Modic Changes

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ABSTRACT

Introduction: Low Back Pain is a very common disability affecting millions of people worldwide. Magnetic Resonance Imaging is the preferred tool of investigation in these patients in which commonly encountered findings include lumbar disc degeneration and endplate changes. However, there are few studies exploring a potential relationship between these two findings. **Aims:** To evaluate whether endplate changes, as described by Modic, are associated with the Pfirrmann grades of disc degeneration. **Methods:** Magnetic Resonance Imaging scans of the lumbar spine were performed on a consecutive group of 200 patients experiencing low back pain. Disc degeneration was assessed using the Pfirrmann grading system, while endplate changes were categorized according to Modic types. This comprehensive evaluation aimed to identify the relationships between disc degeneration and Modic changes in this patient population. **Results:** The most commonly affected age groups were those between 40 and 60 years, with a higher prevalence in females. Among 200 patients with disc degeneration, 74 (37%) exhibited Modic changes. The most common type of disc degeneration was Pfirrmann grade III and most common type of Modic change was type II. Non-Modic, Type 1 and Type 2 changes showed significant differences in Pfirrmann grade (p < 0.01). **Conclusion:** Significant correlation was observed between endplate changes and intervertebral disc degeneration, as demonstrated by imaging findings. This relationship indicates that as disc degeneration worsens, the association between the Pfirrmann and Modic classifications becomes statistically stronger.

Keywords: Disc degeneration, Endplate, Magnetic Resonance Imaging, Modic, Spine

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INTRODUCTION

Low back pain (LBP) is one of the primary contributors of diminished health-related quality of life and disability affecting approximately 619 million people globally.[1,2] People from any age group and gender can present with the symptoms of low back pain but its prevalence increases with age and is seen more commonly in females. By the time girls reach 18 and boys reach 20, half of them have already encountered at least one episode of back pain.[3] While multiple factors contribute to LBP, disc degeneration (DD) stands out as a notable risk factor.[4-7] Other degenerative changes in the spine seen with advancing age include High Intensity Zone (HIZ) lesions, disc herniation and endplate changes such as Schmorl's node and Modic changes (MC).[8-11] Grade of disc degeneration was first described by Pfirrmann in 2001 based on Magnetic Resonance Imaging (MRI) criteria to assess disc morphology, including signal intensity, disc height and differentiation between nucleus and annulus.[12] This classification demonstrates effective utility in distinguishing various levels of disc degeneration.[13] There seems to be a strong connection between disc degeneration and Modic changes.[14] Modic changes (MC) are subchondral vertebral marrow lesions first described by Assheur et al[15] and further classified by Roos and Modic et al.[16-18] The objective of this study is to enhance comprehension regarding the different stages of lumbar disc degeneration and its correlation with established Modic changes.

METHODS

This cross-sectional, population-based study was performed on consecutive patients with low back pain sent for MRI Lumbar spine from April 2024 to September 2024 in the Department of Radiology, Nepalgunj Medical College. The study consisted of 200 patients. Institutional review committee approval and written informed consent were obtained. The patients were selected based on the following inclusion and exclusion criteria.

Inclusion criteria

Consecutive adult patients sent for MRI of lumbar spine having lumbar disc degeneration with/ without Modic changes.

Exclusion criteria

1. Patients presented with trauma.

2. Previous history of spinal surgery.

3. Patients with suspicion of infection, malignancy.

4. Patient refusing to give consent.

Imaging assessment

The MRI examination was performed using General Electronics (GE) 1.5 Tesla MRI of model Signa Creator (Illinois, USA). Standard imaging sequences included sagittal T1 and T2-weighted turbo spin-echo (TSE), and axial T2 TSE of lumbar segmental levels from L1-S1. Imaging parameters for sagittal T1: Repetition time (TR)- 700 ms (milliseconds), Echo time (TE)- 10 ms, matrix- 352x224; for sagittal T2: TR- 3000 ms, TE- 100 ms, matrix- 384x256. Field of view was 35x35 mm and slice thickness was 5 mm for sagittal T1 and T2 and 4 mm for axial T2. Lumbar disc degeneration for each level was assessed and classified according to Pfirrmann grading. Similarly, Modic changes was evaluated and classified according to type.

For determining grade of lumbar disc degeneration:

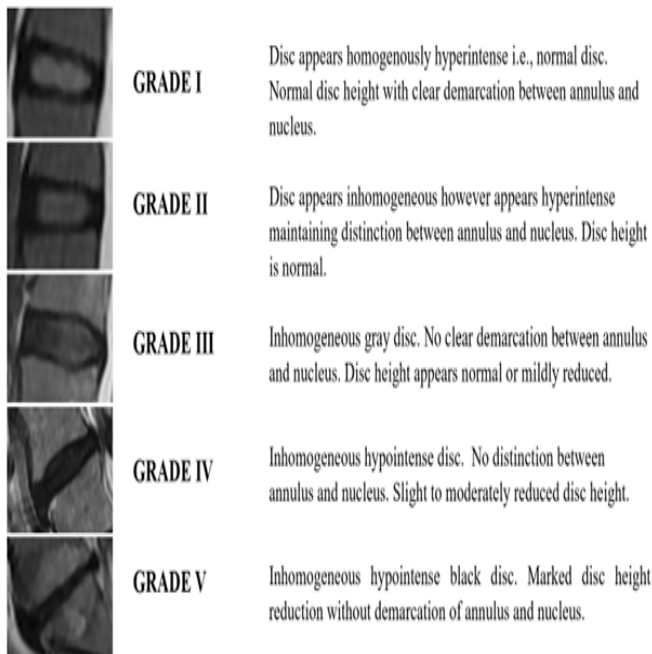There are five grades of lumbar disc degeneration as described by Pfirrmann. (Figure 1)

Figure I: Grades of lumbar disc degeneration

For determining different Modic Types:

Modic described three different types of vertebral endplate changes. (Figure 2)
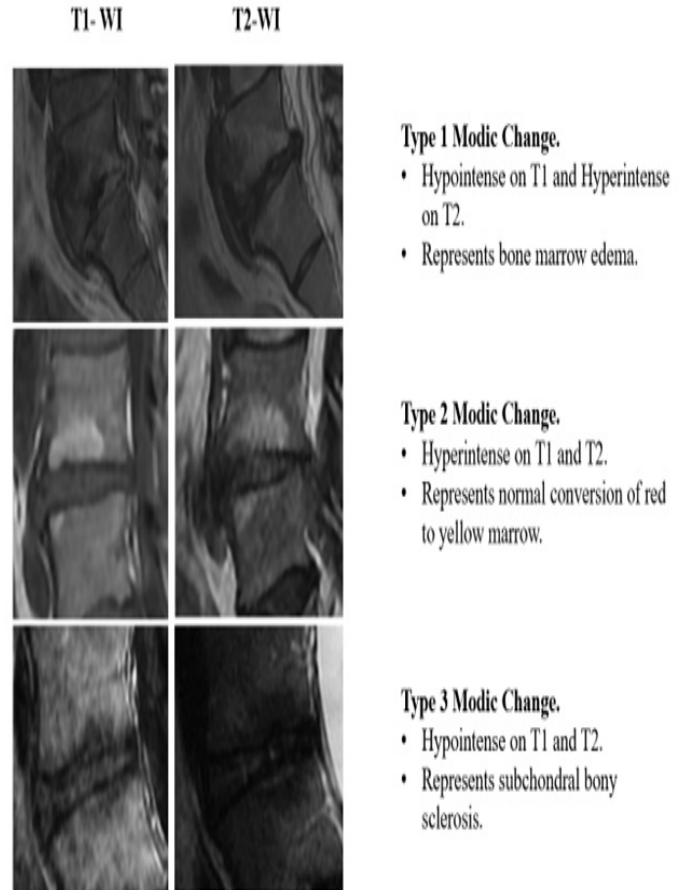

Figure 2: T1 weighted image (T1- WI) and T2 weighted image (T2-WI) showing different types of Modic Changes

Considerations:

1. As disc degeneration and Modic changes is less pronounced at L1-L2 and L2-L3, the assessment focused on levels L3-L4, L4-L5, and L5-S1. Additionally, in cases where degeneration was present at multiple levels, the grading was determined based on the more affected level.

2. In instances of mixed types of Modic changes, the type that holds greater clinical significance was mentioned, following the order of Modic I, Modic II and Modic III.

Statistical analysis

The results were tabulated in Microsoft Excel. The statistical analysis was done using IBM Statistical Package for the Social Sciences (SPSS) version 26 (Armonk, New York). Descriptive and frequencies statistics were carried out to all variables of interest as necessary. Comparison between the sexes was done using Mann-Whitney tests and for different age groups

Kruskal-Wallis tests was used. Existence of relation between Pfirrmann and Modic measurements was verified using Spearman correlations and a threshold for statistical significance was established at $p \leq 0.05$.

RESULTS

Patient Demographics

A total of 200 patients who met the inclusion and exclusion criteria were enrolled in the study which included 108 females (54%) and 92 males (46%). The age of the patients ranged from 20 years to 80 years with mean age of 45.56 ± 14.13 years. Age was divided into three groups; less than 40 years, 40 to 60 years and more than 60 years. (Table I)

Variable	N	%
Sex		
Male	92	46
Female	108	54
Age Group		
<40 years	74	37
40 to 60 years	87	43.5
>60 years	39	19.5
Total	200	100

Table I: Description of sex and age group of the patients evaluated

Lumbar Disc Degeneration and Modic changes

Most common type of disc degeneration observed was grade III (37%), followed by grade IV (31.5%), II (15.5%), I (8.5%) and V (7.5%). Modic changes were detected in 74 individuals, representing 37% of the cohort. Modic 2 was the most frequently observed type (73%), followed by Modic 1 (27%); Modic 3 was not identified in any of the cases examined. The relationship between different grades of disc degeneration and Modic changes is illustrated in Table II.

	I	II	III	IV	V	Total
Non-Modic	17	31	40	38	0	126
Type 1 Modic	0	0	11	6	3	20
Type 2 Modic	0	0	23	19	12	54
Type 3 Modic	0	0	0	0	0	0
Total	17	31	74	63	15	200

Table II: Relationship between Modic changes and the severity of vertebral disc degeneration assessed by Pfirrmann grading

In Non-Modic patients that constituted 63 % of the study, the average Pfirrmann grade was 2.78 ± 1.02. Pfirrmann grade of 3.6 ± 0.75 was seen in type 1 Modic patients and in Modic type 2 changes Pfirrmann grade was 3.79 ± 0.76. Non-Modic, Type 1 and Type 2 changes showed significant differences in Pfirrmann grade ($p < 0.01$). The Pfirrmann grade demonstrated a statistically significant rise across all assessed discs as age groups advanced.

While Modic changes were more frequently observed among males in our study, no statistically significant difference was detected. Similarly, type 2 Modic changes were more prevalent in older age groups, whereas type 1 Modic changes were observed across all age groups.

DISCUSSION

Low back pain (LBP) is among the leading causes of disability globally, particularly affecting older adults. MRI is the preferred diagnostic tool for assessing patients with low back pain, as it is highly effective at identifying degenerative changes in the spine. Many earlier studies, including those by Jensen et al[19] and Kokkonen et al,[20] have established the connection between Modic changes and disc degeneration. However, only a few studies have investigated the relationship between Pfirrmann grading of lumbar disc degeneration and the types of Modic endplate changes.

In our study, 74 patients (37%) exhibited associated endplate changes, with Modic type 2 being the most prevalent (73%), a finding previously encountered by Modic et al.[16, 17] These endplate changes were typically observed at the L4-L5 and L5-S1 levels. This can be attributed to the greater mobility of the L4-L5 level, which may lead to more significant disc degeneration compared to other intervertebral segments.[21, 22] Several past studies, including one by Yu LP et al[23] reported Pfirrmann grade IV as the most prevalent grade. However, in our analysis of disc degeneration grading, grade III was the most common, found in 37% of cases, followed by grade IV at 31.5% and grade V at 7.5%. Notably, there were no cases of grade I or II discs identified. When the two classifications were compared, the data revealed a strong correlation, indicating that higher Pfirrmann grades are associated with more significant Modic changes ($p < 0.05$). Patients with Modic type 1 changes had a mean Pfirrmann grade of 3.6, while those with Modic type 2 changes had a Pfirrmann grade of 3.79. These findings are in line with other studies by Yu LP 23 and Rodrigues, L.M.R. et al.[24]

LIMITATIONS

As with other studies, this research has several limitations. First, the sample size is limited, which impacts the overall incidence of Modic changes. Second, the study focuses solely on the original Pfirrmann grading and does not consider the newly modified Pfirrmann grade. Finally, including additional clinical parameters, such as pain scores, would have provided a more comprehensive analysis.

CONCLUSION

Our study highlights a clear link between intervertebral disc degeneration and changes in endplates as seen on MRI. It suggests that early detection of these changes could allow for timely

intervention to prevent further disc degeneration. More advanced disc degeneration is associated with greater endplate alterations, emphasizing the relationship between these two processes in maintaining spinal health.

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