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Pattern, Distribution, and MRI Characteristics of Modic Changes in Patients with Low Back Pain: A Prospective 3 Tesla MRI Study

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ABSTRACT

Background: Low back pain is a common musculoskeletal disorder. Modic changes are MRI signal alterations of vertebral endplates and adjacent bone marrow associated with intervertebral disc degeneration and low back pain. Type 1 Modic changes indicate inflammatory marrow edema and may be difficult to identify on conventional MRI sequences. Short Tau Inversion Recovery (STIR) imaging is highly sensitive to edema and may improve detection. This study evaluated the pattern, distribution, and MRI characteristics of Modic changes using 3 Tesla MRI.

Methods: A prospective cross-sectional study was conducted among 101 patients with low back pain demonstrating Modic changes on lumbar spine MRI at the Department of Radiodiagnosis and Medical Imaging, UCMS-Teaching Hospital, Nepal. Patients aged 34-81 years were enrolled. Modic changes were classified by type, vertebral level, and signal characteristics on T1-weighted, T2-weighted, and STIR sequences. Data were analyzed using descriptive statistics and chi-square tests.

Results: Modic Type 2 changes were the most common, occurring in 60 patients (59.4%), followed by Type 1 in 31 (30.7%) and Type 3 in 10 (9.9%). The L4-L5 and L5–S1 levels were the most frequently involved. MRI signal characteristics were consistent with the established Modic classification. STIR hyperintensity was observed exclusively in Type 1 changes, improving visualization of inflammatory marrow edema. A significant association was found between age group and Modic change type ($p < 0.001$), with Type 1 changes more common in younger patients and Types 2 and 3 increasing with age.

Conclusion: Type 2 Modic changes were the predominant pattern. STIR imaging improved detection of inflammatory Type 1 changes and may be a useful complementary sequence in routine lumbar spine MRI protocols.

Keywords: Modic Changes; STIR; Low Back Pain; Lumbar Spine; MRI.

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INTRODUCTION

Low back pain (LBP) is one of the most common musculoskeletal disorders worldwide and a leading cause of disability, affecting nearly 80% of individuals during their lifetime. Early identification of structural and inflammatory abnormalities is important for appropriate management and prevention of chronic disease progression. Among the imaging abnormalities associated with LBP, Modic changes (MCs) are significant MRI findings that reflect pathological alterations in the vertebral endplates and adjacent bone marrow.[1] Modic changes are classified into three types based on combined T1- and T2-weighted MRI signal characteristics. Type 1 changes demonstrate hypointense signal intensity on T1-weighted images and hyperintense signal intensity on T2-weighted images, corresponding to inflammatory marrow edema and vascular granulation tissue. Type 2 changes represent fatty marrow replacement, whereas Type 3 changes correspond to subchondral sclerosis.[2,3] Type 1 changes are particularly relevant because they are more strongly associated with active low back pain and inflammatory processes.[4] Magnetic resonance imaging plays a vital role in the evaluation of LBP.[5] Conventional T1- and T2-weighted sequences provide important anatomical and pathological information; however, subtle inflammatory marrow edema may not always be clearly visualized. Short Tau Inversion Recovery (STIR) imaging, owing to its fat suppression capability and high sensitivity to fluid, may improve visualization of inflammatory vertebral endplate changes.[6-9] The use of 3 Tesla MRI further enhances image quality and spatial resolution, facilitating improved assessment of vertebral marrow abnormalities. Although Modic changes have been well characterized internationally, no prospective study using 3 Tesla MRI has reported their pattern, distribution, and T1/T2/STIR characteristics in the Nepalese population. This study therefore provides region-specific data that may guide local imaging protocols. This study evaluated the pattern, distribution, and MRI characteristics of Modic changes on T1-, T2-, and STIR sequences using 3 Tesla MRI.

METHODS

This prospective study was conducted in the Department of Radiodiagnosis and Medical Imaging at Universal College of Medical Sciences and Teaching Hospital (UCMS-TH), Nepal, from March to August 2025. Ethical approval was obtained from the Institutional Review Committee of UCMS (Ref. No. UCMS/IRC/058/25). Written informed consent was obtained from all participants prior to enrollment. A total of 101 consecutive patients with low back pain demonstrating Modic changes on lumbar MRI were included in the study. Patients aged 30-85 years referred for MRI evaluation of low back pain were enrolled. Exclusion criteria included previous lumbar spine surgery, traumatic vertebral fractures, infectious or inflammatory spinal disorders, known spinal malignancy, and pregnancy. The sample size was calculated using Cochran's formula: $n = z^2pq / d^2$, where z = 1.96 (95% confidence level), p=0.36 (prevalence of Modic changes)[8], q=1 - p, and d = 0.1 (10% margin of error). This yielded an initial sample size of 89. To account for a potential 10% dropout or incomplete data, the sample size was increased by 10%, resulting in a target of approximately 98 patients. A total of 101 patients were enrolled to exceed this target. MRI examinations were performed using a 3 Tesla Siemens Magnetom Lumina scanner with a dedicated spine coil. The imaging protocol included sagittal T1-weighted, sagittal and axial T2-weighted, and sagittal STIR sequences. Modic changes were classified according to Modic's original classification as Type 1 (Hypointense signal on T1-weighted and hyperintense signal on T2-weighted images), Type 2 (Hyperintense on both T1 and T2 weighted images) and Type 3 (hypointense on both T1 and T2 weighted images). The type of Modic change, vertebral level involvement, and MRI signal characteristics on T1-, T2-, and STIR sequences were recorded. Statistical analysis was performed using SPSS version 20. Descriptive statistics were used to summarize demographic and imaging findings. Associations between Modic change types and age groups or vertebral levels

were analyzed using the chi-square test. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 101 patients with low back pain were included in this study. The baseline demographic characteristics, patterns of Modic changes, and vertebral level involvement are shown in Table 1. The mean age of the participants was 55.63±11.93 years (range: 30-85 years), with an almost equal gender distribution of 50 males (49.5%) and 51 females (50.5%). The majority of patients belonged to the 51-60 years age group (34.6%). Modic changes were predominantly Type 2, identified in 60 patients (59.4%), followed by Type 1 in 31 patients (30.7%) and Type 3 in 10 patients (9.9%). With respect to vertebral level involvement, the L4-L5 level was most commonly affected in 58 patients (57.43%), followed by L5-S1 in 36 patients (35.64%). Involvement of the upper lumbar levels was less frequent, with L3-L4 involved in 6 patients (5.94%) and L1-L2 in 1 patient (0.99%) (Table 1).

Table 2 shows that the MRI signal characteristics

Table 1. Baseline demographic characteristics and MRI findings of the study population

Variable	Frequency (n%)
Sex	
Male	50 (49.5%)
Female	51 (50.5%)
Mean age (years)	55.63 ± 11.93
Age Groups (Years)	
< 40	13 (12.9%)
41-50	20 (19.8%)
51-60	35 (34.6%)
61-70	21 (20.8%)
> 71	12 (11.9%)
Modic Changes Pattern	
Type 1	31 (30.7%)
Type 2	60 (59.5%)
Type 3	10 (9.9%)
Vertebral Level Involvement	
L1–L2	1 (0.99%)
L3–L4	6 (5.94%)
L4-L5	58 (57.43%)
L5–S1	36 (35.64%)

Table 2. MRI signal intensity patterns across T1-weighted, T2-weighted, and STIR sequences according to Modic change type

Modic Characteristics	T1-Weighted, n (%)		T2-Weighted n (%)		STIR n (%)	
	Hyperintense	Hypointense	Hyperintense	Hypointense	Hyperintense	Hypointense
Type 1, n=31	0 (0%)	31 (100%)	31 (100%)	0 (0%)	31 (100%)	0 (0%)
Type 2, n=60	60 (100%)	0 (0%)	60 (100%)	0 (0%)	0 (0%)	60 (100%)
Type 3, n=10	0 (0%)	10 (100%)	0 (0%)	10 (100%)	0 (0%)	10 (100%)

Table 3. Association between Modic change types, age groups, and vertebral levels

Variables	Modic Type 1 n (%)	Modic Type 2 n (%)	Modic Type 3 n (%)	p-value
Age Groups (Years)				
< 40	13 (100%)	0 (0%)	0 (0%)	<0.001
41-50	12 (60%)	8 (40%)	0 (0%)	
51-60	3 (8.6%)	32 (91.4%)	0 (0%)	
61-70	3 (14.3%)	12 (57.1%)	6 (28.6%)	
> 71	0 (0%)	8 (66.7%)	4 (33.3%)	
Vertebral Level Involvement				
L1–L2	0 (0%)	1 (100%)	0 (0%)	0.089
L3–L4	5 (83.3%)	1 (16.7%)	0 (0%)	
L4-L5	19 (32.8%)	33 (56.9%)	6 (10.3%)	
L5–S1	7 (19.4%)	25 (69.4%)	4 (11.1%)	

observed in our study were consistent with established Modic classification patterns. STIR hyperintensity was consistently observed in Type 1 changes, supporting its usefulness in detecting inflammatory vertebral marrow edema. A statistically significant association was observed between age group and Modic change type ($p < 0.001$), with Type 1 changes more common in younger patients, while Types 2 and 3 were more frequent in older age groups. The high proportion of Type 1 changes in the youngest age group (below 40 years) may reflect early inflammatory changes, though the small subgroup size (n=13) warrants cautious interpretation. No statistically significant association was observed between vertebral level involvement and Modic change type ($p = 0.089$) (Table 3).

DISCUSSION

This study evaluated the patterns and distribution of Modic changes in patients with low back pain at UCMS-TH in Nepal. Type 2 Modic changes were the predominant pattern observed (59.4%), followed by Type 1 (30.7%) and Type 3 changes (9.9%), with L4-L5 and L5-S1 levels (57.43% and 35.64%, respectively) most frequently involved, which correspond to regions of increased mechanical stress within the lumbar spine. These findings are consistent with previous studies conducted by Järvinen et al.[2] and Lv et al.[10] The MRI signal characteristics observed in this study were consistent with the established Modic classification described in previous literature.[2,4,10] STIR hyperintensity was identified exclusively in Type 1 changes, supporting the role of STIR imaging in improving visualization of inflammatory vertebral marrow edema. Although STIR does not replace conventional Modic classification, it improves confidence in identifying active inflammatory Type 1 changes. A significant association between age group and Modic change type ($p < 0.001$) was observed, with Type 1 changes predominating in younger patients and Types 2 and 3 increasing with age. These findings suggest an age-related difference in distribution of Modic types rather than direct progression. Similar observations were reported by Järvinen et al.[2], who demonstrated that Type 1 Modic changes are associated with active low back symptoms. The findings of this study support the complementary role of STIR imaging alongside conventional MRI sequences in evaluating inflammatory Modic changes in patients with low back pain. The use of 3 Tesla MRI provided improved image quality and better visualization of vertebral marrow signal alterations. This study has several limitations, including its single-center design, the absence of clinical pain severity correlation, and lack of longitudinal follow-up imaging to confirm temporal changes. Additionally, the extent of Modic changes was assessed qualitatively rather than quantitatively.

CONCLUSIONS

In this prospective 3 Tesla MRI study, Type 2 changes were the most common (59.4%), followed by Type 1 (30.7%) and Type 3 (9.9%). The L4–L5 level was predominantly involved (57.4%), and a significant association was found between Modic type and age ($p < 0.001$), suggesting an age-related difference in distribution of Modic types rather than direct progression. STIR imaging may be a useful complementary sequence to conventional T1- and T2-weighted imaging in routine lumbar spine MRI protocols, especially when inflammatory Modic Type 1 changes are suspected

Limitations

The study was conducted in a single teaching hospital; therefore, the findings may not be generalizable to other settings. In addition, the use of a non-probability convenience sampling technique may limit the representativeness of the sample

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