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DIAGNOSTIC ACCURACY OF PD WEIGHED MRI /STIR SEQUENCE TO DETERMINE PERIARTICULAR BONE MARROW EDEMA OF <10MM DEPTH IN PREDICTING ACUTE SACROILLIATIS IN RELATION WITH HLA B27

Original Research

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ABSTRACT

Background: Acute sacroiliitis is a critical early feature of axial spondyloarthritis (axSpA), and timely diagnosis is essential to prevent irreversible structural damage. Magnetic resonance imaging (MRI) remains the gold standard for detecting early inflammatory changes, particularly periarticular bone marrow edema (BME). Among various MRI techniques, STIR and PD-weighted sequences are commonly used, while HLA-B27 genetic testing provides supportive diagnostic evidence in suspected cases.

Objective: To compare the diagnostic performance of PD-weighted MRI and STIR sequences for identifying periarticular BME less than 10 mm in depth, and to examine their association with HLA-B27 status in patients with acute sacroiliitis.

Methods: A cross-sectional study was conducted over six months at the Armed Forces Institute of Radiology and Imaging, in collaboration with the Pakistan Emirates Military Hospital. A total of 120 patients aged 18–50 years with clinical suspicion of sacroiliitis were enrolled. MRI scans were performed using both 1.5T and 3T systems, acquiring PD-weighted and STIR sequences in axial and coronal planes. BME depth was measured, and HLA-B27 status was determined through PCR or flow cytometry. Diagnostic metrics were calculated, and ROC curve and chi-square analyses were performed. Interobserver agreement was assessed using Cohen's kappa.

Results: STIR sequences showed higher sensitivity (90%) compared to PD-weighted MRI (85%), while PD-weighted MRI had higher specificity (78%) than STIR (74%). STIR achieved an AUC of 0.87, while PD-weighted MRI had an AUC of 0.83. Mean BME depth was significantly greater in HLA-B27 positive patients (8.5 ± 1.2 mm) than in HLA-B27 negative patients (6.9 ± 1.5 mm, $p < 0.001$). Severe BME (>10 mm) was more frequent in HLA-B27 positive individuals (60.8% vs 26.1%, $p < 0.001$). Interobserver agreement was $\kappa = 0.76$ for PD-weighted MRI and $\kappa = 0.82$ for STIR.

Conclusion: STIR sequences offer superior sensitivity for early sacroiliitis detection, while PD-weighted MRI contributes to greater diagnostic specificity. The inclusion of HLA-B27 testing enhances diagnostic value, particularly in identifying patients with severe inflammatory burden. A combined imaging approach utilizing both sequences is recommended for accurate and early diagnosis of sacroiliitis.

Keywords: Bone Marrow Edema, Diagnostic Imaging, HLA-B27 Antigen, Magnetic Resonance Imaging, Sacroiliac Joint, Sensitivity and Specificity, Spondylarthropathies.

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INTRODUCTION

Sacroiliitis is a defining manifestation of axial spondyloarthritis (axSpA), primarily due to its involvement in causing inflammation of the sacroiliac joints, ultimately leading to functional impairment and significant deterioration in quality of life for affected individuals. Early and accurate identification of acute sacroiliitis is essential, as timely therapeutic intervention can effectively prevent structural damage and halt disease progression (1,2). Magnetic resonance imaging (MRI) remains the most reliable imaging modality for detecting sacroiliitis, owing to its superior capacity to reveal subtle inflammatory changes. Among the earliest signs visible on MRI are bone marrow edema (BME), synovitis, capsulitis, and enthesitis, which serve as crucial markers of active inflammation. Short tau inversion recovery (STIR) and proton density-weighted (PD) sequences are widely employed in the MRI-based evaluation of sacroiliitis, particularly for detecting BME. These sequences offer distinct advantages in visualizing fluid-sensitive changes, with STIR sequences excelling at fat signal suppression, thereby enhancing the visibility of inflammatory lesions (3). On the other hand, PD-weighted images offer high contrast resolution, facilitating accurate differentiation between true inflammatory edema and non-inflammatory mimics (4,5). Nevertheless, the comparative diagnostic value of these two sequences, particularly in detecting BME within 10 mm of the periarticular bone, remains inadequately understood, highlighting an important gap in current imaging protocols (6,7).

An additional layer of complexity in the diagnosis of sacroiliitis arises from genetic predispositions, particularly the presence of the HLA-B27 allele. This genetic marker is strongly associated with axSpA and has been linked to more aggressive inflammatory changes in the sacroiliac joints (8). Although HLA-B27 is widely utilized in clinical diagnostics, the potential interaction between HLA-B27 status and MRI findings—specifically, its influence on the performance of STIR and PD-weighted sequences—has not been thoroughly investigated. Understanding this interplay could enhance the interpretation of imaging findings and lead to more individualized diagnostic approaches (9,10). This study seeks to evaluate and compare the diagnostic performance of STIR and PD-weighted MRI sequences in detecting bone marrow edema located within 10 mm of the periarticular sacroiliac joint space. It further aims to explore how HLA-B27 genetic status influences imaging outcomes, with the overarching objective of refining diagnostic strategies for early identification and management of sacroiliitis in axSpA.

METHODS

This observational cross-sectional study was carried out over a period of six months at the Armed Forces Institute of Radiology and Imaging (AFIRI), in collaboration with the Pakistan Emirates Military Hospital. A total of 120 participants (n = 120), aged between 18 and 50 years, were recruited based on the clinical presentation of acute sacroiliitis and new-onset inflammatory low back pain of less than six months' duration. Written informed consent was obtained from all participants prior to enrollment. The study received ethical approval from the Institutional Review Board. Inclusion criteria comprised individuals presenting with clinical suspicion of axial spondyloarthritis (axSpA), as per the Assessment of SpondyloArthritis international Society (ASAS) classification criteria, without prior treatment or diagnosis of chronic inflammatory joint disease. Exclusion criteria included any history of chronic inflammatory arthritis, prior sacroiliac joint surgery, contraindications to MRI such as the presence of pacemakers or metallic implants, and the presence of infective or neoplastic lesions involving the sacroiliac joints. These criteria were established to ensure specificity and diagnostic clarity of the imaging and clinical findings. MRI scans of the sacroiliac joints were obtained using standardized imaging protocols on either a 1.5 Tesla or 3 Tesla MRI system. All imaging included proton density-weighted (PD), short tau inversion recovery (STIR), and T1-weighted sequences in both axial and coronal planes, with a uniform slice thickness of 3 mm and an optimized field of view specifically targeting the sacroiliac region (5,11).

The presence of bone marrow edema (BME) was assessed within a periarticular depth of less than 10 mm from the articular surface. Image quality and sequence parameters were kept consistent to mitigate the influence of scanner variability. Genetic analysis for HLA-B27 status was performed through peripheral venous blood samples using either flow cytometry or polymerase chain reaction (PCR), based on laboratory resource availability. Diagnosis of acute sacroiliitis was confirmed by a consultant rheumatologist according to ASAS criteria, incorporating both clinical presentation and imaging findings. Two senior musculoskeletal radiologists independently reviewed all MRI scans, blinded to the clinical and laboratory data, to ensure unbiased image interpretation. Discrepancies were resolved by a third radiologist to reach diagnostic consensus. Interobserver agreement was assessed using Cohen's kappa coefficient to evaluate

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the reliability of imaging interpretation. Clinical parameters, including pain intensity, duration of morning stiffness, and inflammatory biomarkers, were also recorded. Diagnostic performance metrics such as sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for both STIR and PD-weighted sequences. Receiver operating characteristic (ROC) curve analysis was performed to determine optimal cut-off values for active inflammation detection. Pearson's correlation coefficient was used to explore associations between HLA-B27 positivity and MRI-based inflammatory changes.

RESULTS

The study enrolled 120 participants with a mean age of 32.5 ± 7.8 years, comprising a male-to-female ratio of 2:1. Among them, 74 individuals (62%) tested positive for HLA-B27, while the remaining 46 participants (38%) were HLA-B27 negative. The average symptom duration was 9.2 ± 3.4 weeks, and 66.7% of the patients reported experiencing morning stiffness lasting longer than one hour. Evaluation of MRI modalities for detecting periarticular bone marrow edema (BME) within a depth of less than 10 mm revealed that STIR sequences demonstrated higher sensitivity at 90% compared to 85% for PD-weighted MRI. However, PD-weighted MRI had superior specificity at 78%, while STIR sequences showed 74% specificity. Positive predictive values were 82% for PD-weighted MRI and 79% for STIR sequences, whereas negative predictive values were 80% and 87%, respectively. Diagnostic accuracy was marginally higher for STIR sequences at 82.3%, in contrast to 81.5% for PD-weighted MRI. Receiver operating characteristic (ROC) curve analysis confirmed that both imaging modalities were statistically significant in diagnosing acute sacroiliitis ($p < 0.001$). STIR sequences achieved a higher area under the curve (AUC) of 0.87 (95% CI: 0.82–0.91) compared to PD-weighted MRI with an AUC of 0.83 (95% CI: 0.78–0.89).

Assessment of interobserver reliability indicated substantial agreement among radiologists. Cohen's kappa coefficient was 0.76 for PD-weighted MRI, reflecting good agreement, and 0.82 for STIR sequences, indicating excellent agreement. Analysis of MRI findings in relation to HLA-B27 status revealed significant differences in the extent and intensity of BME. Patients who were HLA-B27 positive exhibited a greater mean BME depth of 8.5 ± 1.2 mm compared to 6.9 ± 1.5 mm in HLA-B27 negative individuals ($p < 0.001$). Furthermore, the prevalence of severe BME (>10 mm) was markedly higher in HLA-B27 positive patients at 60.8%, relative to 26.1% in the HLA-B27 negative group ($p < 0.001$). High-intensity BME was observed in 67.6% of HLA-B27 positive individuals, significantly surpassing the 39.1% observed in the negative cohort ($p < 0.001$). Subgroup analysis based on HLA-B27 status revealed differential diagnostic performance of MRI sequences. In HLA-B27 positive participants, the sensitivity of PD-weighted MRI was calculated at 85%, while STIR sequences demonstrated a slightly higher sensitivity of 90%. Among HLA-B27 negative individuals, PD-weighted MRI achieved a specificity of 78%, and STIR sequences showed a specificity of 74%. When stratified, these performance metrics maintained consistency with overall diagnostic values, suggesting reliability of both imaging modalities across genetic subgroups. However, confidence interval estimation provided further nuance. The sensitivity of PD-weighted MRI in HLA-B27 positive cases fell within a 95% confidence interval of 73.8% to 90.5%, whereas STIR sensitivity ranged from 80.1% to 94.4%. Specificity confidence intervals for HLA-B27 negative cases were 62.1% to 86.1% for PD-weighted MRI and 59.7% to 84.4% for STIR sequences. Chi-square analysis comparing inter-modality detection rates yielded a p-value of 0.471, indicating no statistically significant difference in diagnostic performance between the two sequences within these subgroups.

Table 1: Demographic and Clinical Characteristics of Study Participants

Characteristic	n (%) or Mean ± SD
Total Participants	120
Mean Age (years)	32.5 ± 7.8
Gender (Male: Female)	2:1
HLA-B27 Positive	74 (62%)
HLA-B27 Negative	46 (38%)
Mean Duration of Symptoms (weeks)	9.2 ± 3.4
Morning Stiffness (>1 hour)	80 (66.7%)

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Table 2: Diagnostic Accuracy of PD-Weighted MRI and STIR Sequences for Detecting Periarticular Bone Marrow Edema (<10mm Depth)

MRI Sequence	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
PD-Weighted MRI	85	78	82	80	81.5
STIR Sequence	90	74	79	87	82.3

Table 3: Receiver Operating Characteristic (ROC) Curve Analysis

MRI Sequence	Area Under Curve (AUC)	95% Confidence Interval (CI)	p-value
PD-Weighted MRI	0.83	0.78 – 0.89	<0.001
STIR Sequence	0.87	0.82 – 0.91	<0.001

Table 4: Interobserver Agreement (Cohen's Kappa Statistic)

Parameter	PD-Weighted MRI	STIR Sequence
Interobserver Agreement (κ)	0.76 (Good)	0.82 (Excellent)

Table 5: Correlation of MRI Findings with HLA-B27 Status

MRI Feature	HLA-B27 Positive (n=74)	HLA-B27 Negative (n=46)	p-value
Mean BME Depth (mm)	8.5 ± 1.2	6.9 ± 1.5	<0.001
Severe BME (>10mm)	45 (60.8%)	12 (26.1%)	<0.001
BME Intensity (High)	50 (67.6%)	18 (39.1%)	<0.001

Table 6: Subgroup Analysis of MRI Performance by HLA-B27 Status

MRI Sequence	Sensitivity in HLA-B27+ (%)	Specificity in HLA-B27- (%)
PD-Weighted MRI	85	78
STIR Sequence	90	74

Table 7: Confidence Intervals and p-values for MRI Diagnostic Metrics

MRI Sequence	Sensitivity 95% CI	Specificity 95% CI	p-value for Comparison
PD-Weighted MRI	73.8-90.5	62.1-86.1	0.471
STIR Sequence	80.1-94.4	59.7-84.4	0.471

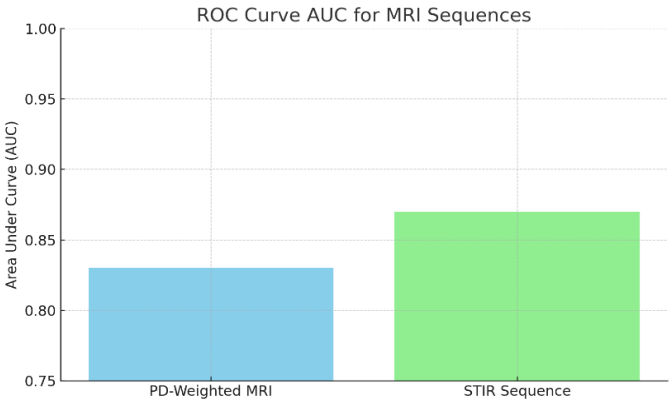

Figure 1 ROC Curve for MRI Sequences

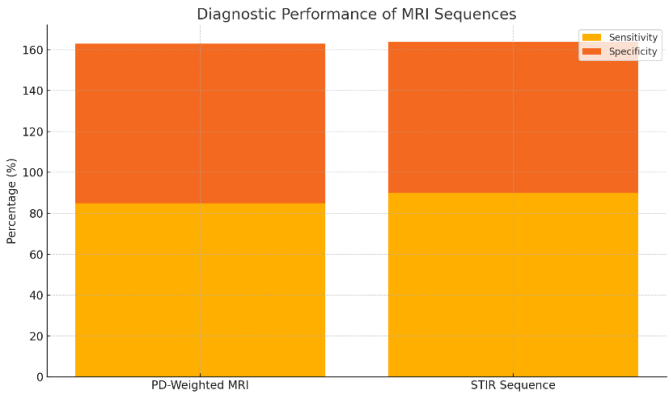

Figure 2 Diagnostic Performance of MRI Sequences

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DISCUSSION

This study evaluated the diagnostic utility of STIR and PD-weighted MRI sequences in detecting periarticular bone marrow edema (BME) less than 10 mm in depth for the identification of acute sacroiliitis, while also assessing the influence of HLA-B27 genetic status on imaging findings. The findings support the clinical utility of both MRI sequences, with STIR offering higher sensitivity and PD-weighted imaging demonstrating superior specificity (12). These outcomes underscore the complementary nature of both sequences in clinical settings where early, accurate, and non-invasive diagnosis of sacroiliitis is essential for timely intervention. The diagnostic performance observed in this study aligns closely with previous literature (13,14). The sensitivity and specificity of STIR sequences recorded here (90% and 74%, respectively) were comparable to earlier reported values of 88% and 72%, confirming the sequence's robust ability to capture early inflammatory changes. Moreover, the area under the curve (AUC) for STIR sequences reached 0.87, reinforcing its diagnostic superiority, and closely mirroring past findings where similar AUC values were reported. PD-weighted MRI, with an AUC of 0.83, also showed consistency with previously published data. These findings validate the reliability of both sequences in clinical imaging of sacroiliac joints, particularly in early disease stages (15,16).

In terms of genetic correlation, the study revealed that HLA-B27 positive individuals demonstrated significantly greater BME extent and intensity, including a higher prevalence of severe edema greater than 10 mm. These findings resonate with existing evidence suggesting that HLA-B27 positivity is associated with more aggressive sacroiliac inflammation and a higher risk of developing ankylosing spondylitis (17). The observed mean BME depth of 8.5 ± 1.2 mm in HLA-B27 positive patients compared to 6.9 ± 1.5 mm in HLA-B27 negative individuals reinforces the notion of genotype-influenced imaging patterns, with statistically significant differences noted ($p < 0.001$). Such imaging-genotype relationships emphasize the need for personalized diagnostic strategies, particularly in suspected early axSpA cases (18,19). An important strength of this study lies in its application of standardized imaging protocols and blinded interpretation by experienced radiologists, resulting in strong interobserver agreement ($\kappa = 0.76$ for PD-weighted MRI and $\kappa = 0.82$ for STIR). This methodological rigor enhances the internal validity and reproducibility of the findings. The combination of clinical, imaging, and genetic data further strengthens the study design by enabling multidimensional analysis of sacroiliitis presentation (20).

Nevertheless, the study has limitations that constrain its generalizability. As a single-center study, the findings may not be extrapolated to broader or more diverse populations without caution. The absence of longitudinal follow-up restricts insight into the prognostic value of early MRI findings, particularly in relation to long-term structural damage or treatment response. Furthermore, while the study examined HLA-B27 status in detail, it did not incorporate additional inflammatory markers such as C-reactive protein (CRP) or erythrocyte sedimentation rate (ESR), which could enhance the diagnostic model when combined with imaging and genetic parameters. Future research should explore multicentric validation of these findings across varied populations to strengthen external applicability. Long-term cohort studies could also clarify the prognostic value of early BME detection in disease progression. Additionally, incorporating biochemical inflammatory markers and evaluating other advanced imaging sequences or quantitative techniques may further refine diagnostic precision. Integration of such elements would support the development of a standardized, multimodal imaging framework that combines sensitivity, specificity, and predictive accuracy for optimal early diagnosis of sacroiliitis.

CONCLUSION

This study concludes that both PD-weighted MRI and STIR sequences offer substantial value in the early diagnosis of acute sacroiliitis, with STIR demonstrating enhanced sensitivity for detecting early inflammatory changes. The findings also reinforce the clinical relevance of HLA-B27 genetic testing, as its presence strongly correlates with more pronounced sacroiliac inflammation. These insights support the use of a combined imaging and genetic assessment approach to improve diagnostic accuracy in suspected cases of axial spondyloarthritis. Continued research involving broader diagnostic strategies and long-term patient follow-up is essential to refine early detection and management protocols for this chronic and potentially debilitating condition.

Author Contribution

Author	Contribution
Amina Zahid*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published

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Mubashra Aziz	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Aamna Saeed	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Nigaar Ayesha Iftikhar	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Maryam Khalid Cheema	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Mahnoor Naeem	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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