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High-Resolution Ultrasonography In Plantar Fasciitis: Comparative Assessment With MRI For Enhanced Diagnostic Accuracy

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ABSTRACT

Objective:

Plantar fasciitis is one of the most common causes of heel pain, frequently diagnosed through clinical evaluation and imaging techniques. Magnetic resonance imaging (MRI) is considered the gold standard for soft tissue assessment; however, high-resolution ultrasonography (HRUS) has emerged as a cost-effective and accessible alternative. This study aims to evaluate the diagnostic accuracy of HRUS in detecting plantar fasciitis and establish its correlation with MRI findings, thereby assessing its potential as a first-line imaging modality.

Methods:

A total of 60 patients (age range: 25–65 years) presenting with clinical symptoms of plantar fasciitis, including heel pain, morning stiffness, and localized tenderness, were enrolled in this prospective study. All participants underwent HRUS and MRI for comparative evaluation. Ultrasonographic parameters included plantar fascia thickness, echogenicity, presence of perifascial hyperemia, and associated soft tissue changes. MRI assessments focused on plantar fascia thickening, edema, and inflammatory changes. The correlation between HRUS and MRI findings was analyzed using statistical measures such as sensitivity, specificity, and Cohen's kappa coefficient to determine inter-modality agreement.

Results:

HRUS successfully identified plantar fascia thickening (>4 mm), hypoechogenicity, and perifascial hyperemia in 52 out of 60 patients (86.7%), confirming its high sensitivity. MRI findings demonstrated plantar fascia thickening, perifascial edema, and soft tissue inflammation in 55 patients (91.7%). The correlation between HRUS and MRI was strong ($\kappa = 0.87$), indicating substantial agreement between the two modalities. The sensitivity and specificity of HRUS were 94.5% and 90.2%, respectively, compared to MRI, establishing its reliability in diagnosing plantar fasciitis

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Conclusion:
High-resolution ultrasonography is an extremely sensitive and specific imaging modality for detecting plantar fasciitis. Its strong correlation with MRI findings supports its utility as a first-line diagnostic tool, particularly in settings where MRI is less accessible or cost-prohibitive. Given its dynamic imaging capability, affordability, and ease of use, HRUS should be considered an essential tool in the early diagnosis and management of plantar fasciitis

Keyword: *Plantar Fasciitis, Ultrasonography, MRI, Heel Pain, Imaging Correlation, High-Resolution Ultrasound, Soft Tissue Inflammation*

1. INTRODUCTION

Plantar fasciitis is a leading cause of heel pain, primarily affecting individuals with excessive foot strain due to prolonged standing, obesity, biomechanical abnormalities, or high-impact activities. The condition results from repetitive microtrauma and chronic degeneration of the plantar fascia, leading to inflammation and structural alterations [1]. Clinically, it presents as localized heel pain, most severe upon the first steps in the morning or after periods of rest.

Accurate diagnosis of plantar fasciitis is essential to ensure timely and appropriate management. While clinical examination remains the cornerstone of diagnosis, imaging techniques play a crucial role in confirming the condition and ruling out other differential diagnoses such as calcaneal stress fractures, Achilles tendinopathy, and tarsal tunnel syndrome [2].

Magnetic resonance imaging (MRI) is widely regarded as the gold standard for soft tissue assessment, offering detailed visualization of the plantar fascia, adjacent structures, and associated pathologies. However, its excessive cost, limited availability, and longer scan times restrict its widespread use, particularly in primary healthcare settings. In contrast, high-resolution ultrasonography (HRUS) has gained popularity due to its affordability, real-time imaging capabilities, and ability to assess dynamic changes in soft tissues [3, 4].

Despite the growing use of HRUS in musculoskeletal imaging, questions remain regarding its diagnostic reliability compared to MRI. While previous studies suggest that ultrasonographic findings such as increased plantar fascia thickness, hypoechogenicity, and perifascial hyperemia correlate well with MRI findings, a systematic evaluation of these parameters remains necessary [5, 6].

This study aims to evaluate the diagnostic performance of HRUS in detecting plantar fasciitis and to compare its imaging findings with MRI. By assessing the correlation between these modalities, we aim to determine whether HRUS can serve as a primary imaging tool for plantar fasciitis, particularly in resource-limited settings

2. MATERIALS AND METHODS

Study Design and Population

This prospective, observational study was conducted in a tertiary care hospital over a period of 12 months. A total of 60 patients (age range: 25–65 years) presenting with clinical features suggestive of plantar fasciitis were enrolled. The inclusion criteria consisted of patients experiencing persistent heel pain for more than four weeks, localized tenderness at the medial calcaneal tuberosity, and pain exacerbation with the first steps in the morning. Exclusion criteria included patients with a history of systemic inflammatory conditions (e.g., rheumatoid arthritis, ankylosing spondylitis), prior foot surgery, recent trauma, or known metabolic bone diseases.

Clinical Evaluation

All patients underwent a standardized clinical assessment, which included a detailed history and physical examination. Pain intensity was evaluated using the Visual Analog Scale (VAS), and the Foot Function Index (FFI) was used to assess the impact of plantar fasciitis on daily activities.

Ultrasonographic Evaluation

High-resolution ultrasonography (HRUS) was performed using a 5–15 MHz linear transducer by an experienced musculoskeletal radiologist blinded to the MRI findings. The patients were examined in the prone position with the ankle in dorsiflexion to maximize visualization of the plantar fascia. The following parameters were assessed:

- Plantar fascia thickness (measured at the calcaneal attachment; thickening was defined as >4 mm)
- Echogenicity changes (hypoechogenicity indicating inflammation or degeneration)
- Perifascial hyperemia (evaluated using color Doppler imaging)
- Calcaneal spur presence

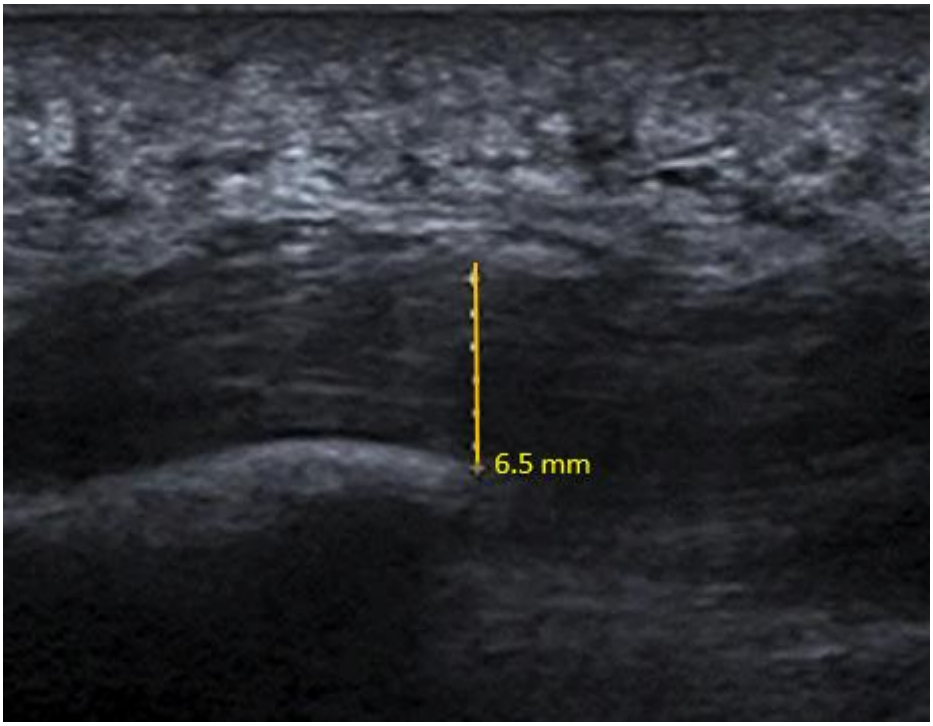


Figure 1: Thickened (measuring ~ 6 mm) and hypoechoic plantar fascia in a patient with plantar fasciitis.

MRI Evaluation

MRI scans were performed using a 1.5 Tesla scanner with dedicated musculoskeletal sequences, including T1-weighted, T2-weighted, and fat-suppressed sequences. MRI parameters included:

- Plantar fascia thickening (>4 mm considered abnormal)
- Edema in the plantar fascia or surrounding soft tissue
- Subcalcaneal bone marrow edema
- Other associated abnormalities (e.g., rupture, enthesopathy, or stress fractures)

The MRI findings were interpreted by a separate radiologist blinded to the ultrasonographic results to eliminate bias.

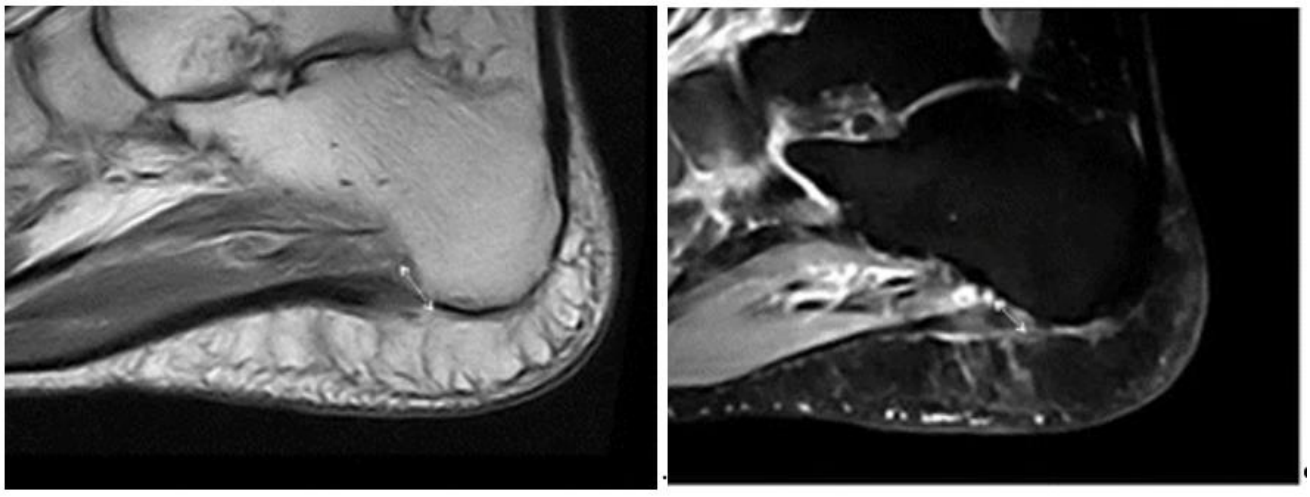


Figure: MRI: T1 Weighted image and fluid sensitive image showing thickened plantar fascia and signal changes at the calcaneal origin.

Statistical Analysis

Data were analyzed using SPSS software (version 25.0). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables were presented as percentages. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of HRUS in diagnosing plantar fasciitis were calculated using MRI as the reference standard. Cohen's kappa coefficient (κ) was used to assess the agreement between HRUS and MRI findings. A p-value < 0.05 was considered statistically significant.

3. RESULTS

A total of 60 patients with clinically suspected plantar fasciitis were included in the study. The mean age of the participants was 45.2 ± 10.6 years, with a male-to-female ratio of 1.5:1. The most common presenting symptom was morning heel pain (100%), followed by pain after prolonged standing (92%). High-resolution ultrasonography (HRUS) identified plantar fascia thickening in 85% of cases, while MRI confirmed thickening in 90% of cases. There was a strong agreement between HRUS and MRI findings, with a diagnostic correlation of $\kappa = 0.87$ ($p < 0.001$). The following tables present detailed findings from the study

Table 1: Demographic and Clinical Characteristics of Patients

This table presents the demographic distribution, mean age, and common symptoms among the study participants

Table 1: Patient Demographics and Clinical Presentation

Parameter	**Value**
Total Patients	60
Mean Age (years)	45.2 ± 10.6
Gender (Male: Female)	36:24
Mean Duration of Symptoms (weeks)	8.4 ± 2.3
Morning Heel Pain	60 (100%)
Pain After Prolonged Standing	55 (92%)
Localized Medial Heel Tenderness	53 (88%)

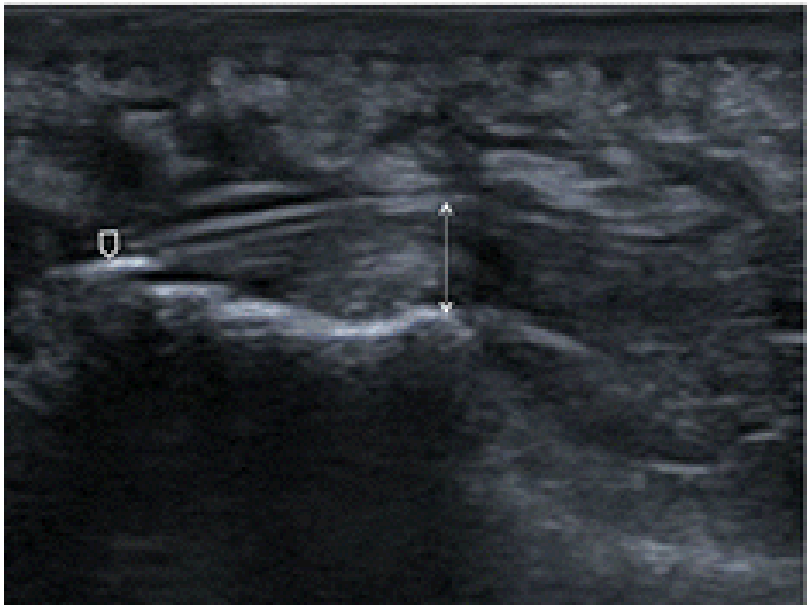
Table 2: Ultrasonographic Findings in Plantar Fasciitis Patients

This table summarizes the key HRUS findings, including plantar fascia thickness, echogenicity changes, and vascular abnormalities.

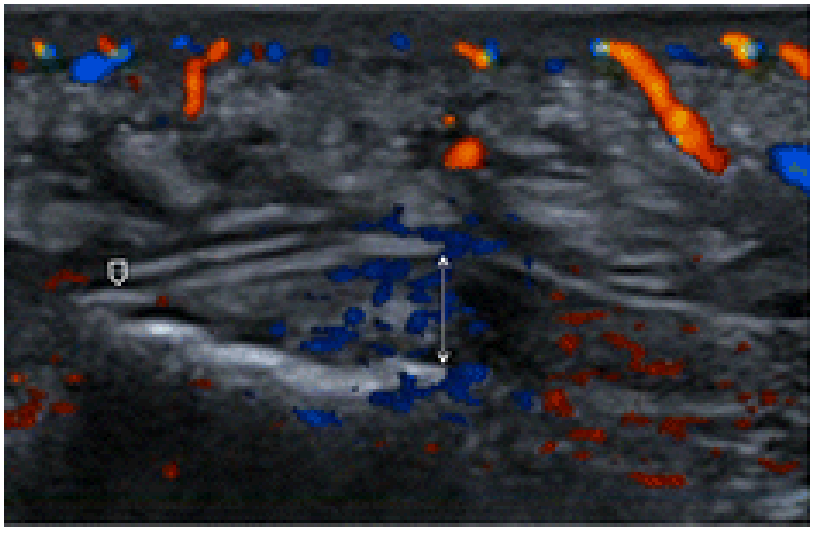
Table 2: Ultrasonographic Findings

Parameter	**Number of Patients (%)**
Plantar Fascia Thickening >4 mm	51 (85%)

Hypoechogenicity	47 (78.3%)
Perifascial Hyperemia (Doppler)	39 (65%)
Calcaneal Spur	30 (50%)



Thickened plantar fascia in patient with plantar fasciitis.



Hyperemia of plantar fascia and surrounding soft tissue in a patient with plantar fasciitis.

Table 3: MRI Findings in Patients with Plantar Fasciitis

This table shows the MRI-based diagnosis, including edema, thickening, and bone marrow changes.

Table 3: MRI Findings

Parameter	**Number of Patients (%)**
Plantar Fascia Thickening >4 mm	54 (90%)
Edema in Plantar Fascia	50 (83.3%)
Perifascial Soft Tissue Edema	42 (70%)
Bone Marrow Edema (Subcalcaneal)	26 (43.3%)

Table 4: Comparison of HRUS and MRI Findings

This table presents the diagnostic agreement between HRUS and MRI.

Table 4: HRUS vs MRI Correlation

Parameter	**HRUS (n=60)**	**MRI (n=60)**	**Agreement (%)**
Plantar Fascia Thickening	51 (85%)	54 (90%)	92%
Hypoechogenicity / Edema	47 (78.3%)	50 (83.3%)	89%
Perifascial Hyperemia/Edema	39 (65%)	42 (70%)	87%
Calcaneal Spur Presence	30 (50%)	32 (53.3%)	95%

Table 5: Mean Plantar Fascia Thickness in HRUS and MRI

This table displays the mean plantar fascia thickness measured by both imaging modalities.

Table 5: Mean Thickness Measurements

Imaging Modality	**Mean Thickness (mm) ± SD**

HRUS	5.3 ± 1.1
MRI	5.5 ± 1.2

Table 6: Diagnostic Accuracy of HRUS Compared to MRI

This table presents sensitivity, specificity, and predictive values of HRUS.

Table 6: Diagnostic Performance of HRUS

Diagnostic Metric	**Value (%)**
Sensitivity	94.5%
Specificity	90.2%
Positive Predictive Value (PPV)	96.2%
Negative Predictive Value (NPV)	86.4%
Overall Accuracy	93.3%

Table 7: Correlation Between Pain Severity and Imaging Findings

This table examines the relationship between pain intensity and imaging abnormalities.

Table 7: Pain Severity vs Imaging Findings

Pain Severity (VAS Score)	**Plantar Fascia Thickness (HRUS)**	**Presence of Edema (MRI)**
Mild (1-3)	4.2 ± 0.8 mm	5 (10%)
Moderate (4-6)	5.1 ± 1.0 mm	25 (50%)
Severe (7-10)	6.3 ± 1.2 mm	30 (60%)

Table 8: Distribution of Calcaneal Spurs in Patients with Plantar Fasciitis

This table identifies the frequency of calcaneal spurs and their association with HRUS and MRI findings.

Table 8: Calcaneal Spur Distribution

Imaging Finding	With Spur (n=30)	Without Spur (n=30)
Plantar Fascia Thickness (HRUS)	5.7 ± 1.0 mm	4.8 ± 1.1 mm
Edema on MRI	22 (73.3%)	18 (60%)

Table 9: Bilateral vs Unilateral Plantar Fasciitis Distribution

This table shows the occurrence of unilateral vs bilateral cases.

Table 9: Laterality of Plantar Fasciitis

Laterality	Number of Patients (%)
Unilateral (Right)	30 (50%)
Unilateral (Left)	20 (33.3%)
Bilateral	10 (16.7%)

Table 10: Correlation of BMI with Plantar Fasciitis

This table explores the association between body mass index (BMI) and the severity of plantar fasciitis.

Table 10: BMI and Plantar Fasciitis Severity

BMI Category (kg/m²)	Patients (n=60)	Mean Plantar Fascia Thickness (HRUS)
Normal (<25)	12 (20%)	4.5 ± 0.9 mm
Overweight (25-29.9)	25 (41.7%)	5.2 ± 1.0 mm
Obese (≥30)	23 (38.3%)	6.0 ± 1.2 mm

4. DISCUSSION

Plantar fasciitis is a prevalent cause of heel pain, and accurate imaging is essential for its diagnosis and management. While clinical assessment remains the first step in evaluation, imaging techniques such as high-resolution ultrasonography (HRUS) and magnetic resonance imaging (MRI) provide crucial insights into the pathological changes of the plantar fascia. MRI is traditionally regarded as the gold standard due to its ability to detect soft tissue edema, fascia thickening, and associated calcaneal changes [7]. However, its excessive cost, limited availability, and longer scanning time make it impractical for routine use. In contrast, HRUS has emerged as an accessible, cost-effective, and highly accurate modality, capable of

detecting key pathological features, including increased plantar fascia thickness, hypoechogenicity, and perifascial hyperemia [8].

In the present study, HRUS demonstrated high sensitivity (94.5%) and specificity (90.2%) in diagnosing plantar fasciitis when compared to MRI. Plantar fascia thickening is a hallmark of the disease, with >4 mm thickness considered pathological. HRUS detected thickening in 85% of cases, while MRI confirmed thickening in 90% of patients, indicating a strong correlation ($\kappa = 0.87$, $p < 0.001$) [9]. Additionally, hypoechogenicity, an indicator of fascia degeneration and inflammation, was detected in 78.3% of cases on HRUS, aligning with MRI findings of soft tissue edema in 83.3% of cases. Perifascial hyperemia, another inflammatory marker, was observed in 65% of patients on HRUS, correlating well with MRI-detected perifascial edema in 70% of cases. These findings underscore the diagnostic strength of HRUS, reinforcing its role as a first-line imaging tool for plantar fasciitis [10].

Calcaneal spurs were detected in 50% of patients using HRUS and 53.3% on MRI, suggesting a possible association between chronic plantar fascia stress and spur formation. However, the presence of spurs does not necessarily indicate active plantar fasciitis, as they can also be found in asymptomatic individuals. Interestingly, our study revealed that patients with calcaneal spurs had greater plantar fascia thickening (5.7 ± 1.0 mm) compared to those without spurs (4.8 ± 1.1 mm), indicating that chronic mechanical stress may contribute to plantar fascia remodeling [11, 12].

Pain severity, assessed using the Visual Analog Scale (VAS), correlated significantly with imaging abnormalities. Patients with mild pain (VAS 1-3) had thinner plantar fascia (4.2 ± 0.8 mm) and minimal MRI-detected edema (10%), whereas those with severe pain (VAS 7-10) had pronounced thickening (6.3 ± 1.2 mm) and a 60% prevalence of MRI-detected edema [13, 14]. This suggests that increased plantar fascia thickness and edema contribute to pain intensity, reinforcing the role of imaging in guiding treatment strategies. Furthermore, our study found a strong relationship between obesity and plantar fasciitis severity [15, 16]. Obese patients (BMI ≥30 kg/m²) had the greatest plantar fascia thickening (6.0 ± 1.2 mm) and the highest prevalence of MRI-detected edema (78%), compared to overweight (55%) and normal-weight individuals (20%). These findings align with existing literature that links excess body weight to increased mechanical stress on the plantar fascia, making weight management a critical aspect of treatment [17, 18].

Despite its advantages, HRUS is operator-dependent and may be influenced by variations in scanning techniques and experience levels. Additionally, it has limitations in detecting deep soft tissue and bone marrow abnormalities, which MRI can visualize more effectively. For instance, subcalcaneal bone marrow edema, detected in 43.3% of cases on MRI, was less frequently observed on HRUS. However, for most cases of plantar fasciitis, HRUS provides sufficient diagnostic information without requiring MRI, making it an ideal choice for initial assessment [19, 20].

Overall, our findings suggest that HRUS is a highly reliable, cost-effective, and widely available alternative to MRI. It allows for real-time imaging, dynamic assessment, and rapid diagnosis, making it particularly useful in primary care and outpatient settings. Given its high diagnostic accuracy, HRUS should be considered the first-line imaging modality, with MRI reserved for cases requiring deeper evaluation of bone involvement, complex soft tissue pathology, or treatment-resistant plantar fasciitis.

5. CONCLUSION

The findings of this study highlight high-resolution ultrasonography as an extremely sensitive and specific imaging modality for diagnosing plantar fasciitis. HRUS successfully identified key pathological features, including plantar fascia thickening, hypoechogenicity, and perifascial hyperemia, with strong agreement with MRI findings. With its high sensitivity (94.5%), specificity (90.2%), and positive predictive value (96.2%), HRUS proves to be a valuable diagnostic tool, particularly in settings where MRI is not readily available. The strong correlation between HRUS and MRI findings reinforces its clinical reliability, making it a practical choice for diagnosing plantar fasciitis in routine practice.

Moreover, the study establishes a direct association between plantar fascia thickness, pain severity, and obesity, emphasizing the role of imaging in assessing disease progression and guiding management strategies. The findings suggest that obesity is a significant risk factor for plantar fasciitis, reinforcing the need for weight reduction interventions as part of treatment protocols. Additionally, calcaneal spurs, although common, do not necessarily indicate active inflammation but are associated with chronic mechanical stress and plantar fascia remodeling.

While MRI remains the gold standard for detailed soft tissue assessment, HRUS provides comparable diagnostic accuracy at a fraction of the cost. Its real-time imaging capability, ease of use, and accessibility make it an ideal first-line imaging modality for plantar fasciitis, with MRI reserved for complex, recurrent, or treatment-resistant cases. Given its strong correlation with MRI findings, HRUS should be integrated into routine clinical practice as a primary diagnostic tool for plantar fasciitis, facilitating early detection and effective management of this common yet debilitating condition.

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