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ORIGINAL ARTICLE

Role of Ultrasonography and Magnetic Resonance Imaging in Assessment of Plantar Fasciitis

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ABSTRACT

Background: plantar fasciitis is the most common cause of inferior heel pain. Sonography should be the initial imaging modality for straight forward confirmation of clinically suspected plantar fasciitis. MRI may be reserved for cases where a more diagnosis of plantar fasciitis is not satisfactory to explain the clinical presentation and when complex pathology is suspected. the aim of the study is to assess the role of MRI in assessment of plantar fasciitis. **Methods**: This study was carried out at Radio diagnosis Department, Zagazig University Hospitals; the study was carried on 18 patients and 18 asymptomatic volunteers were used as a control group. Ultrasonography and MRI were done to all patients. **Results:** The plantar fascia was thickened in symptomatic feet. The thickness of the plantar fascia in symptomatic feet was (2.9 – 8.4 mm; 6.01± 1.4) measured by ultrasound which was significantly thicker than in the control group (1.90 – 3.70 mm; 3.09±0.8), P < 0.05. Other sonographic signs used for the diagnosis of plantar fasciitis in the study were compared to MRI findings. The diagnostic accuracy was 83.3 for plantar fascia thickening, 83.3% for intra-fascial abnormal signal, 77.8% for soft tissue edema, and the lowest diagnostic accuracy of ultrasound was in detection of associated calcaneal spur (38.9%). The findings were tabulated and discussed in relation to other literature. **Conclusion:** sonographic diagnosis of plantar fasciitis is a useful tool with an acceptable diagnostic accuracy comparable to MRI. Sonography should be the initial imaging modality. MRI may be reserved when complex pathology is suspected.

Keywords: MRI, Plantar fasciitis, Ultrasound.

INTRODUCTION

The term "fasciitis" is defined as "inflammation of the fascia"; however, this definition is now thought to be incorrect due to the absence of inflammatory cells within the plantar fascia. Histological changes of plantar fascia in this disease are suggestive of fasciosis (degenerative process) rather than fasciitis (inflammatory process) [1], but fasciitis remains the accepted disease description [2].

Plantar fascia (PF) has also been defined as painful heel syndrome, chronic plantar heel pain, heel spur syndrome, runner's heel and calcaneal periostitis [3]. Heel pain is a prevalent complaint in the foot and ankle practice. PF is the most prevalent cause of heel pain [4] and is also the most common plantar fascia injury [5]. It tends to occur more frequently in females, middle-aged, army recruits, athletes, and the obese [6]. Approximately10 % of individuals have plantar fasciitis at some point during their life time [7]. The peak incidence occurring at 40-60 years of age [8]. It is not influenced by age or gender [9].

Each year, pain caused by plantar fasciitis is responsible for 1-2 million visits to the medical office [6].

METHODS

Type of the study: prospective case control study

Patients: From November 2017 to December 2018, 18 patients with symptoms suggestive of plantar fasciitis with ages range from 26 years- to 58 years with mean age group ± SD (40.3±6.9) were referred from Rheumatology and Orthopedic departments to Radio-diagnosis department; Zagazig University Hospitals, after obtaining institutional board review from our hospital. Eighteen asymptomatic volunteers were held in the study as a control group to provide a baseline to the normal appearance of the plantar fascia their ages range from 25 years- to 55years with mean age group ± SD (36.7±4.5).

Written informed consent was obtained from all participants and the study was approved by the research ethical committee of Faculty of Medicine, Zagazig University. The work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

All patients were subjected to:

I- Full history taking and thorough clinical examination including: -

1) Name, age, sex and occupation.
2) Symptoms and signs including: heel pain that was worst at the beginning of the day, tenderness along the medial calcaneal tuberosity, localized swelling along the medial calcaneal tuberosity, foot stiffness, and limping.

II- Imaging study: -

Ultrasonography and magnetic resonance imaging were done to all patients and control group.

Technique

1) Ultrasonography: - sonographic examinations were performed with GE p7 scanner using a 3-12 MHz linear transducer. Patients lay supine with their feet were supported on the table and with their ankles dorsiflexed to 90°.
2) Magnetic resonance imaging: - all patients were examined by MRI using a limited protocol specially designed for the study, MRI of the foot was performed on a 1.5T Philips Gyroscan Achieva (Best, The Netherlands) closed configuration whole body scanner using an extremity coil. Patients were positioned in supine position with their foot first and were instructed not to move during the examination. Extremity surface coil was placed over the foot surface.

MRI protocol

a) Sagittal T1 weighted images (TR 500-650 msec, TE 20 msec, slice thickness 2.5 mm, gap 0.3 mm, FOV= 170 mm and NSA =2).
b) Sagittal T2 fat saturation images: (TR 4900 msec, TE 100 msec, slice thickness 3 mm, gap 0.3 mm, FOV= 170 mm and NSA =1).
c) Sagittal stir images (TR 4000- 5000 msec, TE 100 msec, TI 130 msec, slice thickness 3 mm, gap 0.3 mm, FOV= 170 mm and NSA =1).
d) Coronal stir images (TR 4000- 5000 msec, TE 100 msec, TI 130 msec, slice thickness 3 mm, gap 0.3 mm, FOV= 170 mm and NSA =1).

Image interpretation:

Sonograms and MR images were evaluated independently by 2 different radiologists in a blinded fashion. Magnetic resonance images were interpreted by an experienced musculoskeletal radiologist with more than ten-year experience. Sonography was performed by the candidate (a 4-year radiology resident). Furthermore, before the study, the candidate was taught how to perform the sonographic examination of the plantar fascia.

A) Ultrasonography**:**

Thickness of the plantar fascia was measured in the sagittal plane. The diagnosis of plantar fasciitis was established when the plantar fascia thickness was more than 4 mm with reduced echogenicity. Other associated findings of plantar fasciitis as perifascial edema or bony calcaneal spurs were reported.

B) Magnetic Resonance Imaging:

Thickness of the plantar fascia was measured in the sagittal plane. Fascial thickening exceeding 4 mm as well as signal intensity changes

manifested as hyper-intense signal in T2 fat sat and STIR images and/or intermediate signal in T1WI were reported and considered as diagnostic signs of plantar fasciitis.

Other features of plantar fasciitis such as edema in the adjacent soft tissues, underlying calcaneal bone marrow edema and bony calcaneal spurs were also reported.

Statistical Analysis

The findings of imaging studies were evaluated and correlated to clinical results. Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy intervals were calculated.

RESULTS

Our study included 18 cases complaining of heel pain, diagnosed as having plantar fasciitis according to their clinical presentation (case group) as well as 18 (control group). The ages of case group ranged from (26 to 58 years) with the mean age was (40.3±6.8) years, their mean body weight was (88.9±20.7) ranged from (65 to 120) Kg and (55.6%) of them were females. In the case group (77.8%) had US thickening and (83.3%) MRI thickening, intra-fascial abnormal signal were in (50.0%) of cases by US and (55.6%) by MRI, soft tissue edema were in (50.0%) of cases by US and (72.2%) by MRI, underlying calcaneal BM edema were in (33.3%) of cases by MRI and wasn't detected by US and calcaneal spur in (16.7%) of cases by US and (77.8%) by MRI.

Tables (1) show that: By considering MRI as a reference (gold standard), the statistical diagnostic accuracy of ultrasound for abnormal focal thickening is (83.3%), for intra-fascial abnormal signal is (83.3%), for soft tissue edema is (77.8 %), for underlying bone marrow edema is (66.7 %), and for bony calcaneal spurs is (38.9 %).

Table (2), the overall accuracy of ultrasound in detection of thickness of plantar fascia comparing with MRI was 88.4%.

Table 1. The diagnostic ability of ultrasound in detection of diagnostic signs Comparing with MRI:

Variable	Sensitivity	Specificity	PVP	PVN	Accuracy
PF thickening	86.7%	66.7%	92.8%	50.0%	83.3%
Intra-fascial abnormal signal	80.0%	87.5%	88.9%	77.8%	83.3`%
Soft tissue edema	95.5%	80.0%	44.4`%	55.6%	77.8%
Underlying calcaneal BM edema	0.00%	100.0%	0.00%	66.7%	66.7%
Calcaneal spur	21.4%	100.0%	100.0%	26.7%	38.9%

Table 2. The overall diagnostic validity of ultrasound in diagnosis of plantar fasciitis comparing with MRI:

Variable	MRI				
	Sensitivity	Specificity	PVP	PVN	Accuracy
ultrasound	86.9%	70.0%	95.2%	50.0%	88.4%

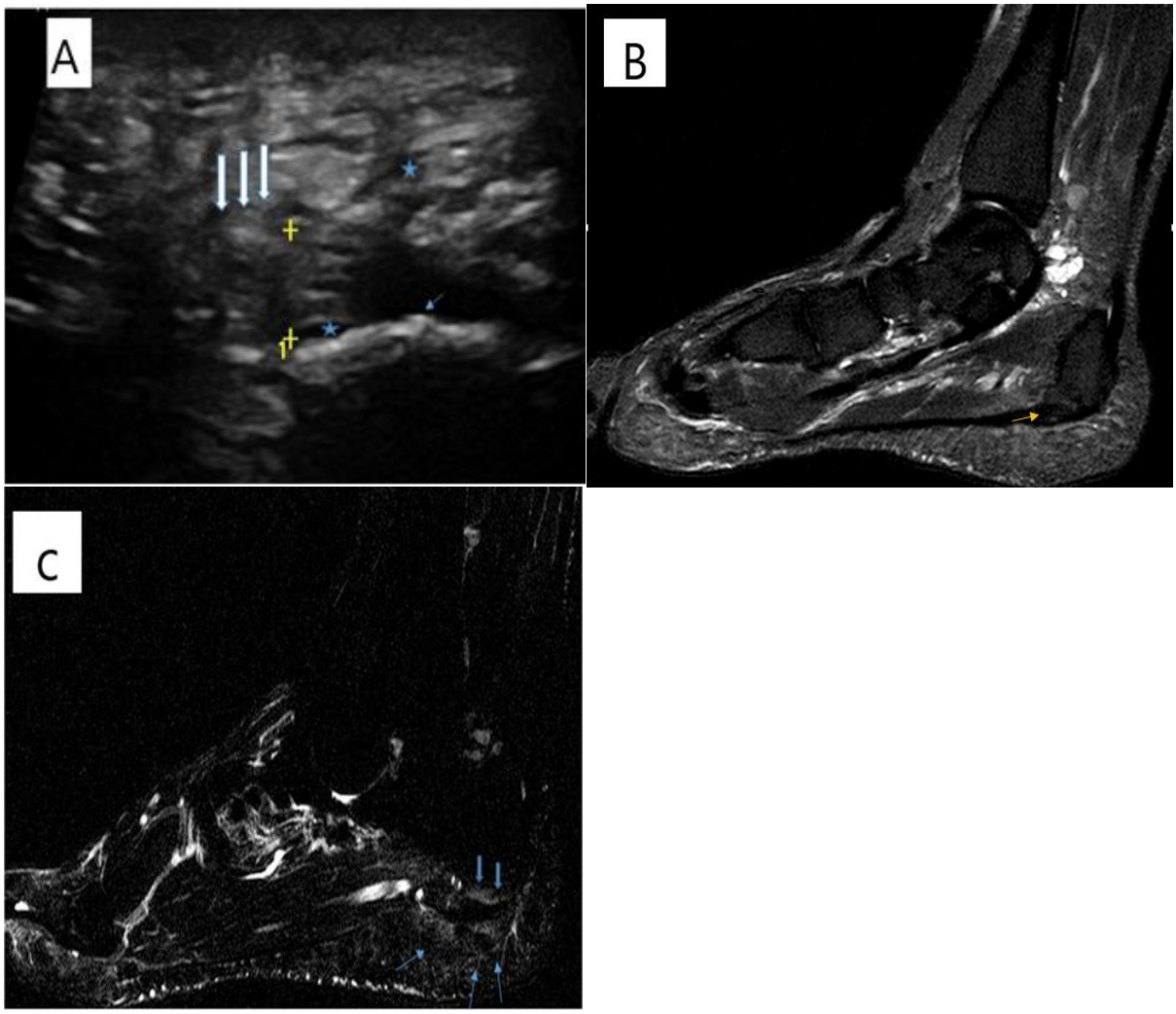

Figure 1. 50-year-old female patient with right plantar fasciitis.
(A) Sagittal ultrasonography of the right heel revealed prominently thickened inhomogenously hypo-echoic plantar fascia at its calcaneal origin measuring (7.5 mm) (cursors), with loss of edge sharpness of the fascia (thick arrows). Associated subcutaneous edema, localized fluid collection (star) and bony calcaneal spur (thin arrows) were also noted by ultrasonography. **(B)** Sagittal STIR MR image showing abnormal increased intra-substance signal intensity of thickened plantar fascia. **(C)** Sagittal T2 fat saturation MR image show hyper-intense peri-fascial soft tissue edema (thin arrows). The abnormal

high marrow signal intensity at the calcaneal insertion reflecting underlying bone marrow edema was also noted (thick arrow).

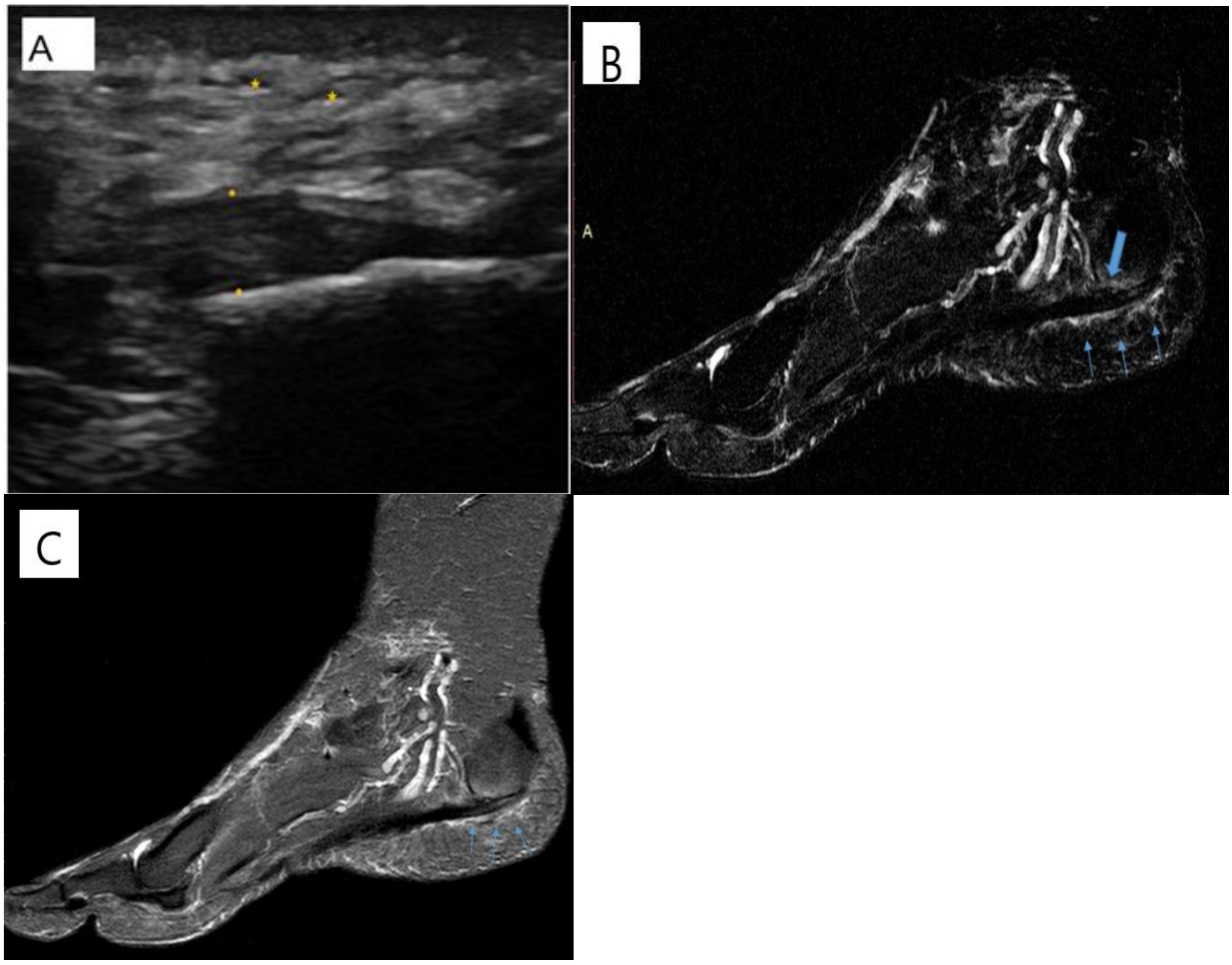

Figure 2. 39-year-old female patient with right plantar fasciitis.
(A) Sagittal ultrasonography of the left heel revealed thickened plantar fascia at its calcaneal origin measuring (7 mm) (cursors), associated subcutaneous edema (star). **(B)** Sagittal T2 fat saturation MR image show abnormal increased intra-substance signal intensity of thickened plantar fascia. Hyper-intense peri-fascial soft tissue edema (thin arrows). The abnormal high marrow signal intensity at the calcaneal insertion reflecting underlying bone marrow edema was also noted (thick arrow). **(C)** Sagittal STIR MR image showing abnormal increased intra-substance signal intensity of thickened plantar fascia with hyper-intense peri-fascial soft tissue edema (thin arrows).

DISCUSSION

Classically the diagnosis of plantar fasciitis was based on the history and physical examination of the patient, it is described as morning pain on the undersurface of the heel that relieves walking and rises with extended physic al activity [10]. However, several disorders mimic the appearance of plantar fasciitis [11][12]. Different
imaging methods have therefore been used over the past years to confirm the diagnosis of plantar fasciitis, including plain radiography, magnetic resonance imaging and high-resolution ultrasound [13]. Direct imaging of the plantar fascia was possible with MRI and US [14].

Blankenbaker and Smet, [15] reported that the plantar fascia is best scanned in the longitudinal axis.

In the current research, the thickness of the plantar fascia in the control group was by ultrasound (1.9 – 3.7 mm; 3.09±0.8) and by MRI (1.40 – 4.1 mm; 3.07± 1.02).

However, the plantar fascia was significantly th icker in patients with plantar fasciitis,

measuring (2.9 – 8.4 mm; 6.01± 1.4) by ultrasound and (3.5– 8.0 mm; 6.5± 1.8) by MRI.

The documented standard plantar fascia measurements varied; the mean value was (3.62 ± 0.68 mm) as recorded by Afrikat et al. [16]. The mean value of Abdel-Wahab et al. [17] was (1.7 ± 0.06) and the mean value of Cardinal et al. [12] was (2.6 mm ± 0.48).Reported values of fascia thickness in plantar fasciitis also varied; Blankenbaker and Smet [15] reported a mean value of 5.2 mm, Gibbon et al. [18] 4.68 mm, Berkowitz et al. [11] 7.4 mm, Cardinal et al. [12] 5.2 mm and Abdel-Wahab et al.[17] 4.9 mm. These differences may be related to the small number of patients in each study.

In our research the MR imaging characteristics of plantar fasciitis were: fascial thickening exceeding 4 mm with signal intensity changes of the plantar fascia manifested as hyper-intense signal in T2 fat saturation and STIR images &/or intermediate signal in T1WI. Many previous studies also used these criteria as diagnostic parameters in plantar fasciitis [21],[22],[23],[24].

Other MR imaging findings that indicate plantar fasciitis included edema of the adjacent fat pad and underlying soft tissues and limited marrow edema within the medial calcaneal tuberosity [22],[24],[25].

By ultrasonography, plantar fasciitis was considered evident when the plantar fascia thickness was greater than 4 mm. These criteria were also used as diagnostic parameters in many previous researches in plantar fasciitis [12],[15],[16],[26],[27],[28].

The hypoechoic ultrasonographic changes of the plantar fascia were common findings in our research (50.0%). These results followed Cardinal et al [12], Akfirat et al [16], Sabir et al [27], Tsai et al [29] and Abdel-Wahab et al [17] in 68.3% of cases, Tsai et al [29] recorded hypoechoic fascia, Abdel-Wahab et al [17] reported it in 69.5% of cases, and Cardinal et al [12] reported it in 84% of cases.

The statistical diagnostic accuracy of ultrasound is 83.3%. Abdel-Wahab et al [17] reported accuracy of ultrasound in diagnosing plantar facial thickening of 73. 9%.

Perifascial edema and/or edema in the adjacent soft tissues of the symptomatic heels were detected by ultrasonography in nine patients (50.0%) and by MRI in thirteen patients (72.2%). The statistical diagnostic accuracy of ultrasound for the identification of peri-fascial edema was 77.8 %.

Peri-fascial edema as reported by Abdel-Wahab et al [17] was detected by ultrasound in 60.1% of the patients, which was in agreement with our results.

On the other hand, peri-facsial edema as reported by Gibbon and Long [26] was detected by ultrasound in 5% of the cases. These finding were not in accordance with our results.

According to the results of the study, the diagnosis of plantar fasciitis by ultrasonography was established when the plantar fascia thickness was more than 4 mm. According to the statistical analysis 13 cases (72.2%) gave positive findings in both ultrasound and MRI (true positive). One (5.5%) of the cases gave positive sonographic findings, which were not detected by MRI (false positive). Two (11.0%) of the cases gave positive findings by MRI that were not detected by ultrasound (false negative). Two cases (11.0%) gave negative results by both ultrasound and MRI despite the clinical diagnosis of plantar fasciitis (true negative). Therefore, ultrasound proved to have 86.9% sensitivity and 70% specificity in the diagnosis of plantar fasciitis, with overall diagnostic accuracy of 88.4%.

Sabir et al [27] reported positive findings of plantar fasciitis by both ultrasonography and MRI (true positive) in 37.93% of the cases. This did not agree with our results in which the true positive cases reached 72.2%. Negative findings by ultrasound and MRI were reported by Sabir et al [27] in 45.5% of the cases,

however in the current study in only 11% of the cases. This may be attributed to the proper selection of cases in the current study, in which the clinical presentation typically matches the classical pain of plantar fasciitis, thus minimizing the incidence of true negative cases and increasing the incidence of positive cases by MRI for better comparison with the sonographic findings. Advanced machines used in the current study also gave better results in the diagnosis of plantar fasciitis compared to the older machines used in Sabir et al [27].

Sabir et al [27] reported positive sonographic findings in 7.58% of the cases, whereas MRI gave negative results (false positive). However, in the current study false positive results were detected in 5.5% of the cases only. This may be due to the advanced ultrasound devices used in the current study.

Sabir et al [27] reported positive MRI findings in 8.96% of the cases, whereas sonography revealed negative findings (False negative), which relatively agreed with our results that revealed false negative results in 11%.

Sabir et al [27] and Abdel-Wahab et al [17] compared ultrasound and MRI with respect to their accuracy and validity in the detection of plantar fasciitis. Ultrasound sensitivity and specificity were reported to be 80.9% and 85.7%, respectively, in Sabir et al [27]. In the current study, sensitivity was higher reaching 86.9% and specificity was as low as 70%, The statistical diagnostic accuracy of ultrasound was also reported to be 69.5% in the study carried out by Abdel-Wahab et al [17]. However, in the current study it was reported to reach 88.4%. Those differences may be due to the different number of cases in each study.

Our research therefore agreed with Tsai et al [29] that increased thickness and hypoechoic plantar fascia are a sonographic finding in patients with plantar fasciitis. These objective measurements can provide the physician with adequate data to verify an initial diagnosis of plantar fasciitis and evaluate individual treatment regimens. It also agreed and with Afrikat et al [16]. that ultrasonography is the first step for plantar fasciitis, because it is easy, quick, available, high sensitivity of diagnosis, cheap and free radiation, and with Cardinal et al [12] that ultrasound may be a valuable noninvasive technique for the diagnosis of plantar fasciitis.

We also agreed with Sabir et al [27] that ultrasonography is a successful instrument in the diagnosis of plantar fasciitis. The high spatial resolution of sonography for superficial structures, ease of patient manipulation, and real-time ability to correlate findings directly to patient symptoms provide advantages over MRI in the evaluation of patients with plantar fasciitis. Sonography is non-invasive, less costly, easily accessible, simpler, and quicker than other imaging modalities. All of these suggest that sonography can confirm or exclude plantar fasciitis.

CONCLUSION

sonographic diagnosis of plantar fasciitis is a useful tool with an acceptable diagnostic accuracy comparable to MRI. Sonography should be the initial imaging modality for direct confirmation of clinically suspected plantar fasciitis. MRI may be reserved for cases where ordinary diagnosis of plantar fasciitis is not satisfactory to explain the clinical presentation and when complicated pathology is suspected.

Conflict of Interest: Nothing to declare.
Financial Disclosures: Nothing to declare.

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