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Correlation of High-Resolution Ultrasonography and Conventional Radiography in the Evaluation of Heel Pain at Kenyatta National Hospital

Suhaila Salim Abeid, Gladys Nthambi Mwango, Callen Kwamboka Onyambu

Department of Diagnostic Imaging and Radiation Medicine, School of Medicine, College of Health Sciences, University of Nairobi, Nairobi, Kenya
Email: drsuhailasalim@gmail.com, Gladys.mwango@uonbi.ac.ke, konyambu@yahoo

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Abstract

Background: The recent improvements in ultrasound technology coupled with wide availability, safety, portability, cost-effectiveness, non-ionizing with high spatial resolution renders it the initial choice of imaging for the evaluation of most musculoskeletal diseases. Ultrasound is a particularly useful tool to quickly and accurately localize and characterize pathologies of the sole. Heel pain is a common presenting complaint and affects a wide range of the adult population. Plantar fasciitis is the commonest cause in primary care settings. It presents with heel pain, discomfort, and disability limiting day-to-day weight-bearing activities. Although clinical history and examination give useful information, imaging allows further assessment of the plantar fascia and helps to determine the differentials. **Purpose of the Study:** This study was designed to quantify, characterize and correlate the ultrasonographic and radiographic findings in the diagnosis of plantar fascia disorders in patients presenting with heel pain at Kenyatta National Hospital. **Materials and Methods:** A prospective descriptive study was conducted over a period of seven months from May 2021 to November 2021 at the Radiology Departments of the University of Nairobi and Kenyatta National Hospital. A total of 59 patients with heel pain were recruited for the study. Both sonographic assessment and plain radiography assessment of the heel were done, and results recorded in the data collection form. Statistical analysis was done with SPSS version 22. **Results:** Normal findings were recorded in 8 patients (13.6%) with abnormal findings seen in 51 patients accounting for 86.4%. The abnormal findings were twice more common in females (40) than in men (19) with a mean age of 42.3 (SD 12.4) years. Only 9 (15.3%) patients were catego-

rized as having healthy weight, while the rest of the patients ranged from overweight 21 (35.6%) to obese 29 (49.2%). The most prevalent pathology was plantar fasciitis in 45 (76.3%) followed by plantar fascia tears 6 (10.2%). Abnormal plantar fascia thickness (67%) and echogenicity (71.6%) were the most sonographic findings encountered. The sensitivity, specificity, PPV, NPV and diagnostic accuracy of heel ultrasound compared to plain radiography were 97.5%, 60.2%, 69.5%, 97.2% and 78.6% for abnormal plantar fascia thickness, 87.6%, 100%, 100%, 75.5% and 85.9% for calcaneal spurs and 100%, 64.4%, 80.2%, 100% and 85.4% for cortical irregularities, respectively. **Conclusion:** Heel sonography achieved good diagnostic accuracy when compared to plain radiography in the diagnosis of plantar fascia disorders and it might be considered as an initial imaging modality to confirm clinically suspected plantar fasciitis.

Subject Areas

Diagnostics, Radiology & Medical Imaging

Keywords

Plantar Fasciitis, Heel Pad Thickness, Sonography, Radiography, Heel Pain

1. Introduction

Ultrasound is a real-time, non-ionizing modality that is readily available, portable, rapid, and less expensive to conduct [1]. Its application to musculoskeletal (MSK) conditions continues to expand and has become the basic initial methodology of imaging for the greater part of MSK conditions [2].

With innovative advances such as greater spatial resolution and dynamic imaging abilities, ultrasound can be considered a vital diagnostic alternative to MRI. Other advantages from a clinician's perspective include; assessment of a region situated on the opposite side for comparison as well as direct interaction with the patient allowing for immediate correlation with the patients' symptomatology [3].

Ultrasound (US) is an excellent imaging modality to determine the nature of a lesion or mass differentiating solid from cystic structures within soft tissues. The flexibility of probe placement permits multiple view analysis of a structure [2].

Contrary to other superior modalities, US does not present constraints as a result of metal artifacts. Colour and power Doppler also provide physiologic information on a particular structure [3]. However, its greatest disadvantage is the inability to evaluate the internal structure of tissue types with high acoustic impedance [4].

A high-resolution linear transducer is judged proportionate to MRI for a range of soft tissue abnormalities including muscles, tendons, ligaments, fascia, and bursae [3]. Reportedly, a 200 μm resolution is provided by the use of a 15 MHz probe, exceeding that of routine MRI. The technology advances have posi-

tively impacted the utilization of MSK-US thus improving the degree of objectivity behind soft tissue clinical diagnoses [5].

Plantar fasciitis is inflammation of the plantar fascia. It is considered the commonest cause of plantar heel pain (PHP) [6]. It occurs as a result of repetitive use or excessive load on the fascia, typically seen in active or sedentary adults. Although considered the most common diagnosis in patients with PHP, in the long run affecting 1 in 10 persons, a range of disorders can as well affect the plantar fascia. If the cause of heel pain is misdiagnosed or not diagnosed early enough, it may lead to long-term pain and discomfort for the patient, significantly hindering routine activities.

Although proper history taking and physical examination can give important information to capably diagnose plantar fascia disorders, diagnostic imaging plays a vital role in achieving the correct diagnosis, prompting appropriate treatment, and determining the prognosis [7].

The primary line of imaging for patients in our set up presenting with heel pain more often involves plain radiographs which have been recognized to not have a direct relationship to a diagnosis of plantar fascia disorder being a soft tissue pathology [8].

Ultrasonography is presently being progressively utilized in assessing the PF, more so in patients with a clinical diagnosis of plantar fasciitis. Owing to its higher spatial resolution, it has the ability to appreciate minor anatomical details better than MRI, however, MRI remains superior in contrast resolution [9]. It provides information such as the thickness, echogenicity, presence of ruptures, calcifications, fluid collections, and bony spurs. A properly conducted MSK-US works as a definitive imaging modality and dismisses the necessity for a further MRI examination. Contrary to MRI, no contraindications are reported to sonography [7].

In addition, colour Doppler ultrasound can identify hyperaemia in the plantar fascia, near its proximal insertion and in the perifascial soft tissue. Hyperaemia is a well-known feature in plantar fasciitis due to neurovascular growth and may contribute to pain. Similarly, in the case of infectious fasciitis, the PF is hyperaemic on Doppler evaluation. Colour Doppler therefore aids in ruling out the rest of the plantar fascia disorders as fibromas, xanthomas and tears show no vascular flow. Ultrasound and colour Doppler option can also be used for serial follow-ups as well as for treatment guidance [4].

An article by Ahmed R. *et al.*, 2016 on the effectiveness of US as an effective tool in PF concluded that the several advantages of US, *i.e.* non-ionizing, non-invasive, portable, and a dynamic imaging technique with fewer contraindications, ranks it superior as a diagnostic modality in the diagnosis of PF [7].

A study by Draghi *et al.*, 2017 on imaging findings of plantar fascia disorders concluded that ultrasound be deemed the first imaging modality to evaluate plantar fascia disorders on account of being cheap, quick, dynamic with a greater spatial resolution [10].

In 2018, Lulu He *et al.*, in the comparison study on MRI findings after MSK-US to reduce redundant imaging, concluded that ultrasound examinations seldom missed major key imaging findings and suggested that a well-performed MSK-US examination can serve as a conclusive modality lessening the need for another examination such as an MRI [4].

Wu *et al.*, 2019 established that the ultrasound measurements of plantar fascial thickness have a high degree of confidence comparable to cross-sectional modalities such as CT and MRI proving its accuracy [11].

Other common plantar fascia lesions to be considered as differentials include; plantar fibromatosis, plantar fascia tears, xanthomas, plantar infections, and foreign body reactions [10].

2. Methods

Study Design

This study was a descriptive cross-sectional study.

Study Area

This study was conducted at Kenyatta National Hospital (KNH).

Study Population

Patients attending KNH and the Department of Diagnostic Imaging and Radiation Medicine, the University of Nairobi with a referral for a heel radiograph or heel ultrasound and fit the inclusion criteria were included in the study following informed consent.

Scanning procedure

The patient was made to lie in a prone position. The symptomatic foot dorsiflexed to form 90 degrees with the distal leg and placed to hang over the edge of the table. The transducer was placed over the plantar aspect of the foot. Long-axis ultrasound scans for the symptomatic heel was performed with medial inclination to target the attachment of the plantar fascia to the calcaneal tubercle, to better appreciate the longitudinally placed fibrillar structure, sweeping across the entire width of the origin. The standard measuring point was where the fascia crossed the anterior-most aspect of the inferior border of the calcaneus, the point where it leaves the calcaneal tuberosity. Coupling gel was applied with the pre-sets and focus adjusted appropriately for superficial MSK examination. The gains were adjusted for good penetration of the thick skin of the heel [12]. No advantage was seen with transverse scanning in the evaluation of PF [13].

3. Results

Fifty nine patients who met the inclusion criteria were scanned at the Department of Diagnostic Imaging and Radiation Medicine, University of Nairobi. Eighty eight heel ultrasounds were performed with heel radiographs of the same reviewed thereafter. Data collection was done between May 2021 and November 2021.

3.1. Demographics and Patient Characteristics

The mean age of patients examined was 42.3 (SD 12.4) years and the median age

was 42.0 (IQR 32.5 - 52.5) years. Two patients (3.4%) were under 20 years, while 3 patients (5.9%) were above 60 years.

There were more female patients, 40 accounting for 67.8% than male patients, 19 representing 32.2% of all patients, where the ratio for male to female was 1:2.1.

Only 9 (15.3%) patients were categorized as having healthy weight, while the rest of the patients ranged from overweight 21 (35.6%) to obese 24 (40.7%) and the remaining 5 (8.5%) patients being severely obese as shown in Figure 1.

The most common clinical presentation was heel pain in all 59 patients (100%). Twenty nine (49.2%) were bilateral and 30 (50.8%) unilateral. Of the unilateral 17 (56.7%) were on the right and 13 (43.3%) on the left resulting in the total number of symptomatic heels to 88.

The average duration of symptoms was 1 - 10 months in 34 patients, 1 year in 14 patients, 2 years in 8 patients and 3 years in 3 patients.

Out of the 59 patients, no patient had a positive previous history of trauma but 13 (22.0%) had history of comorbid conditions. The most common comorbid condition was hypertension found in 8 (13.6%) patients. Of the 13 patients with comorbid conditions, 1 (1.7%) had diabetes mellitus and 4 (6.8%) had both hypertension and diabetes mellitus.

3.2. Ultrasound Findings

Only 8 patients (13.6%) of the study population did not have any plantar fascia pathology detected by ultrasound despite having a clinical complaint of plantar heel pain, with the remaining 51 (86.4%) being abnormal.

The most common pathology encountered was plantar fasciitis in 45 (76.3%) patients, of which 16 (27.1%) cases were bilateral and 29 (47.4%) cases unilateral, left 16 (27.1%) more affected than the right 13 (22.0%) followed by plantar fascia tears seen in 6 (10.1%) patients, 4 (6.8%) cases on the right and 2(3.3%) on the left. There were no cases of plantar foreign body, plantar xanthomas or plantar fibromas seen in our period of study.

A total of 88 feet were examined by ultrasound for heel pathology and the findings are shown in Table 1.

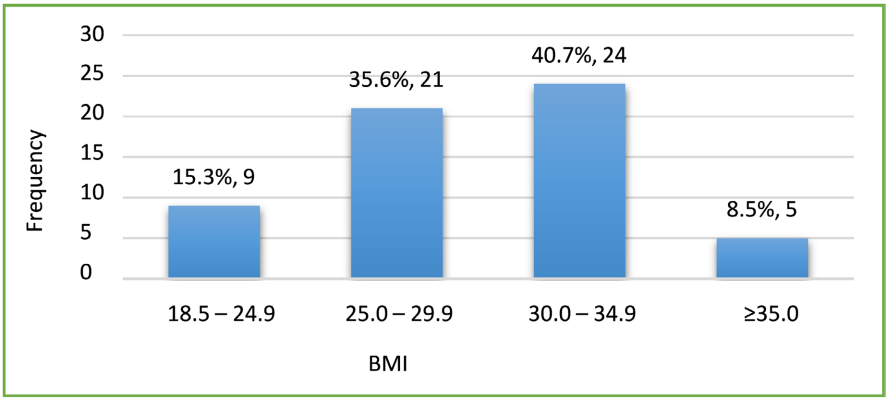

Figure 1. BMI distribution of the patients.

Table 1. Ultrasound findings.

	Normal, *n* (%)	**Abnormal,** *n* (%)
PF thickness	29 (32.9)	59 (67.0)
PF echogenicity	25 (28.4)	63 (71.6)
PF vascularity	53 (60.2)	35 (39.7)
	Present, *n* (%)	**Absent,** *n* (%)
Calcaneal spur	53 (60.2)	35 (39.7)
Calcifications		88 (100.0)
Perifascial edema	58 (65.9)	30 (34.0)
Foreign body		88 (100.0)
Mass lesion		88 (100.0)
Cortical irregularities	65 (73.9)	23 (26.1)

3.3. Plantar Fasciitis

Plantar fasciitis accounted for 76.3% of the pathologies seen in patients with a mean age of 45. The male to female ratio was 1:2. The most common sonographic finding in the diagnosis of plantar fasciitis was an abnormal plantar fascia thickness with a mean of 5.9 mm in males and 5.6 mm in females seen in 59 (67%) of the total scanned symptomatic heels. Right heels scanned accounting for 28 (31.8%) and the left 31 (35.2). Second, is the finding of diffuse plantar fascia hypo-echogenicity seen in 57 (64.7%) symptomatic heels, 26 (29.5%) on the right and 31 (35.2%) on the left (Table 2).

There was a statistical significant association between plantar fasciitis with age and BMI as assessed by the independent sample t-test (p value = < 0.001 and 0.018 respectively). However, the association was not significant between gender and plantar fasciitis as assessed by Pearson chi-square test (p value = 0.914).

3.4. Plantar Fascia Tear

It was the second commonest pathology seen in 6 patients accounting for 10.2% in a younger age group with a mean of 33. The male to female ratio was 1:5 characterized by abnormal thickening and partial disruption of the plantar fascia fibers with focal hypoechoic changes (Table 3).

No statistical significant association between plantar fascia tears with age and BMI (p value = 0.058 and 0.526 respectively) as assessed by the independent sample t-test, and the association was also not significant between gender and plantar fascia tears (p value = 0.653) as assessed by Pearson chi-square test.

3.5. Plain Radiograph Findings

The radiographs of the total 88 symptomatic feet examined by ultrasound were reviewed and the findings are shown in Table 4.

Table 2. Association between Plantar fasciitis with Age, BMI and gender.

		Plantar fasciitis		
		Yes, (n = 44)	**No,** (n = 15)	**p-value**
Age, *mean* ± *SD*		45.7 ± 11.5	32.3 ± 9.4	**<0.001**
BMI, *mean* ± *SD*		30.3 ± 3.9	27.4 ± 4.1	**0.018**
Gender, n (%)	Male	14 (31.8)	5 (33.3)	0.914
	Female	30 (68.2)	10 (66.7)	

Table 3. Association between Plantar fascia tears with Age, BMI and gender.

		Plantar fasciitis		
		Yes, (n = 7)	**No,** (n = 52)	**p-value**
Age, *mean* ± *SD*		33.2 ± 7.4	43.3 ± 12.5	0.058
BMI, *mean* ± *SD*		28.6 ± 2.1	29.7 ± 4.3	0.526
Gender, n (%)	Male	1 (16.7)	18 (34.0)	0.653
	Female	5 (83.3)	35 (66.0)	

Table 4. Heel radiograph findings.

		Normal, n (%)	**Abnormal,** n (%)
Plantar fascia thickness		46 (52.2)	42 (47.7)
		Present, n (%)	**Absent,** n (%)
Calcaneal spur		61 (69.3)	27 (30.7)
Calcifications		23 (26.1)	65 (73.9)
Perifascial edema			88 (100.0)
Foreign body			88(100.0)
Mass lesion		52 (59.0)	36 (40.9)
Cortical irregularities	Achilles enthesopathy	3 (5.1)	56 (94.9)

Only 42 (47.7%) of plantar fascia thickness were abnormal, contrary to heel ultrasound where a higher number of 59 (67%) of the symptomatic heels were abnormal. Similarly, cortical irregularities were seen in slightly fewer patients 52 (59%) compared to the 65 (73.9%) seen in ultrasound examination. Only 23 (26.1%) patients had soft tissue swelling. However 61 (69.3%) bony spurs were detected with a less number 53 (60.2%) seen with ultrasound and a total of 3 patients had other findings of achilles enthesopathy.

No findings of calcifications, mass/nodules or foreign body detected on both modalities.

3.6. Diagnostic Accuracy of Ultrasound

The standard of practice imaging modality was plain radiography, of which the study was to determine the sensitivity, specificity, PPV, NPV and the diagnostic accuracy of ultrasound against the standard.

The sensitivity, specificity, PPV, NPV and diagnostic accuracy of heel ultrasound compared to plain radiography was 97.5%, 60.2%, 69.5%, 97.2% and 78.6% for abnormal plantar fascia thickness, 87.6%, 100%, 100%, 75.5% and 85.9% for calcaneal spurs and 100%, 64.4%, 80.2%, 100% and 85.4% for cortical irregularities, respectively as summarized in Table 5 and Table 6.

Representative figures are illustrated in Figures 2-6.

Table 5. PF thickness.

		Plain Radiograph						
		Abnormal	Normal	Sen.	Spe.	DA	PPV	NPV
	US							
PF thickness right	Abnormal	19	9	95.0%	65.4%	78.3%	67.9%	94.4%
	Normal	1	17					
PF thickness left	Abnormal	22	9	100.0%	55.0%	78.6%	71.0%	100.0%
	Normal	0	11					

Table 6. Calcaneal spurs.

		Plain Radiograph						
		Present	Absent	Sen.	Spe.	DA	PPV	NPV
	US							
Spurs right	Present	27	0	96.4%	100.0%	88.5%	100.0%	94.7%
	Absent	1	18					
Spurs left	Present	26	0	78.8%	100.0%	83.3%	100.0%	56.3%
	Absent	7	9					

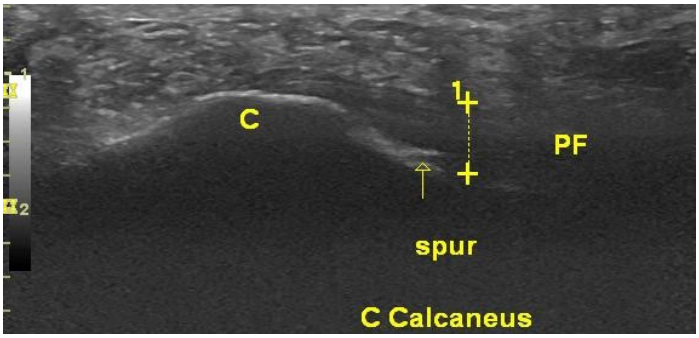

Figure 2. Sample case from study showing abnormally thickened, diffusely hypoechoic plantar fascia that measured 4.9 mm with presence of a calcaneal spur.

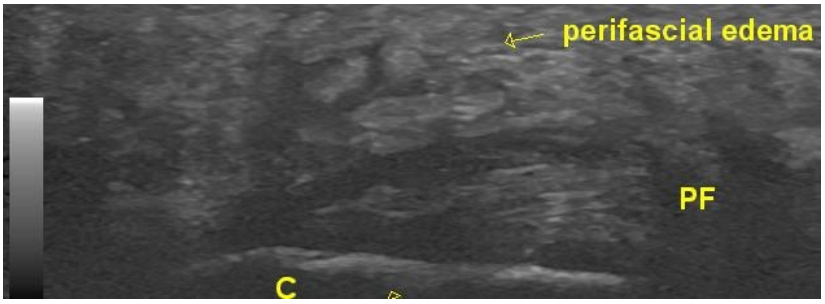

Figure 3. Demonstration of perifascial edema. Note the thickened hypoechoic plantar fascia that measured 5.5 mm.

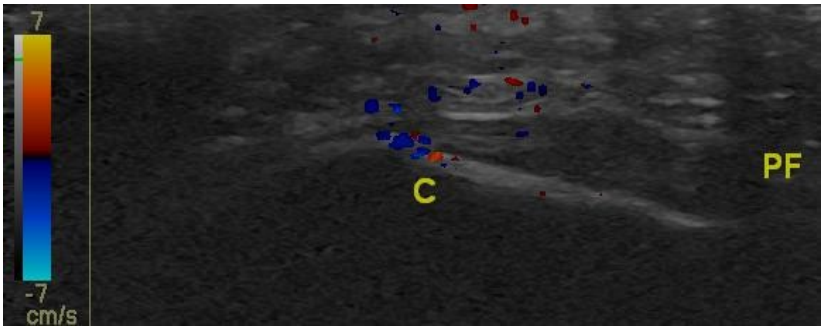

Figure 4. Colour Doppler showing increased vascularity at the proximal end of an abnormally thickened hypoechoic plantar fascia.

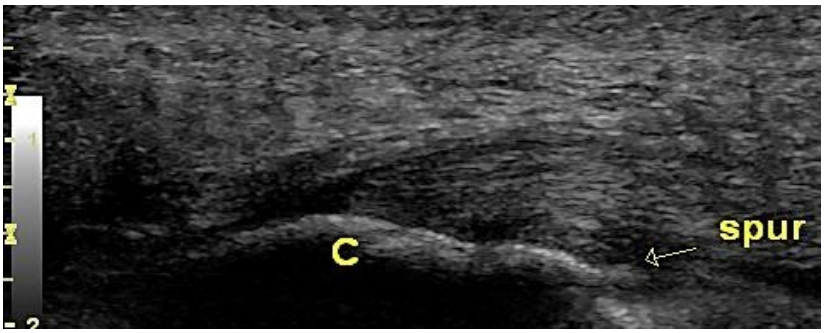

Figure 5. Shows a thickened plantar fascia with normal echogenic fibrillary pattern but with a focal areas of hypoechogenicity, one subjacent to a calcaneal spur (arrow).

Figure 6. Bilateral heel with right sided calcaneal spur. Normal plantar fascia thickness bilaterally.

4. Discussion

The ultrasound examinations were performed in 19 (32.2%) male and 40 (67.8%) female patients. Female patients were more affected which has also been observed in studies by Riddle *et al.* (2010, Al-Azhar University) [14] and M. Afrikat *et al.* (2003, Gaziosmanpasa University-Turkey) [15] which showed that heel pain was more prevalent in women than men.

The mean age of the patients was 42.3 years and comparable to that described by Draghi F *et al.*, 2017 [10] and M. Afrikat *et al.* [15] in their studies who reported mean ages of 44 and 47. The authors postulated that this finding was related to the fact that the condition is primarily a degenerative process and was associated with standing upright and weight bearing. It was commonly seen in active working adults [16].

Fifty-nine patients (100%) presented with heel pain as their only primary complaint. This concurred with several articles stating that the commonest cause of heel pain is plantar fasciitis. Majority, 34 patients (57.6%) had symptoms between one month and one year followed by 25 patients (42.4%) with symptoms for more than a year.

Only 9 (15.3%) patients were categorized as having healthy weight, while the rest of the patients 50 (84.8%) ranged from overweight to obese. Similarly, a higher body mass index BMI > 27 in patients with plantar fasciitis was proved to be the only significant clinical association by Van Leeuwen KDB *et al.* (2015, Tasmania University-Australia) [17].

The most prevalent pathology identified was plantar fasciitis in 61 (76.3%) of the 88 feet. The average plantar fascial thickness in the 88 feet with plantar fasciitis was a mean of 5.9 mm in males and 5.6 mm in females. Forty-seven of the 175 feet scanned were negative for plantar fasciitis. The mean plantar fascial thickness of the 21 feet negative for plantar fasciitis had a mean of 3 mm in males and 3.7 mm in females. Similar findings were reported by Argerakis NG *et al.*, 2015 who found an average plantar fascia thickness of 6 mm in patients with plantar fasciitis and the mean of the negative for plantar fasciitis as 3.5 mm [18].

Fifty seven of the 88 feet with plantar fasciitis (64.7%) also demonstrated concomitant diffuse hypo-echogenicity of the plantar fascia agreeing with the results of a study by E Cardinal *et al.*, 2012 who reported diffuse hypoechogenicity of the plantar fascia in 84% symptomatic heels in patients with plantar fasciitis [13].

However, despite plantar fascia hyperemia being considered to be an important feature of acute plantar fasciitis, only 35 (39.7%) of symptomatic heels demonstrated hyper-vascularity. Similar findings were reported in a study by McMillan AM *et al.*, 2013 who found hyperemia of the plantar fascia present in only 8 of 30 participants with plantar fasciitis and concluded that Doppler ultrasound is often normal with plantar fasciitis but various degrees of hyperaemia may be demonstrated [19]. They postulated that the lack of hyperaemia could be because of different heel thickness among patients and small vessels that could also potentially be compressed during scanning.

Plantar fascia tears were demonstrated in 6 (10.2%) patients with the main sonographic finding of partial disruption of the plantar fascia fibres with focal hypoechoic changes accounting for 4 (4.5%) on the right and 2 (2.3%) on the left of the total hypo-echogenicities seen in symptomatic heels.

Plantar calcaneal spurs and plantar fasciitis and tears frequently co-existed. 53 (60.2%) were present on the 88 symptomatic heels scanned as seen in a study by Hylton B. Menz *et al.*, 2018 where plantar calcaneal spurs and fascial thickening frequently coexisted (60%), while plantar calcaneal spurs in the absence of fascial thickening were uncommon (4%) [20]. Johal's study demonstrated a significant association between plantar fasciitis and calcaneal spur formation where a significant higher prevalence of calcaneal spurs were in the cases than the comparison group (89% versus 32%) [21]. Gibbon *et al.*, however, detected a lower rate in bony spurs in 24% in a larger population than ours with idiopathic plantar fasciitis [22]. Further research is warranted to assess the association and whether it is causal.

Other prevalent features assessed by the ultrasound were presence of perifascial edema present in 58 (65.9%) of 88 heels comparable with Abdel-wahab *et al.*, 2008 study that reported a sonographic diagnostic accuracy of 60.8% for edema around the plantar fascia in patients with plantar fasciitis.

Additionally calcaneal cortical irregularities were also seen in 65 (73.9%) of the symptomatic heels [23].

Correlating with plain radiographic findings as a reference standard in this study since it is the primary line of imaging for patients in our set up presenting with heel pain, sonography showed 97.5% sensitivity, 60.2% specificity and an overall diagnostic accuracy of 78.6% in assessing abnormal plantar fascia thickness. Less abnormal plantar fascia numbers were detected by radiographs compared with ultrasound, taking into consideration that plain radiographs gives limited data in terms of the delicate soft tissue involvement and therefore does not have a direct relationship to a diagnosis of plantar fascia disorder being a soft tissue pathology. These findings were consistent with those seen in a study by Osborne *et al.*, 2006 who reported a sensitivity of 85% and specificity of 95% for plantar fasciitis and concluded that the key radiological features were not spurs but rather changes in the soft tissues [24].

Sonography revealed higher sensitivity and specificity, 87.6% and 100%, respectively in detecting calcaneal spurs in patients with heel pain with an overall diagnostic accuracy of 85.9% contrary to a study by Abdel Wahab *et al.*, reported that the lowest diagnostic accuracy of ultrasound was in detection of associated calcaneal spur (56.5%).

Additionally, the sensitivity of ultrasound in the detection of cortical irregularities was 100% with a specificity of 64.4% and a diagnostic accuracy of 85.4%. These are changes in the cortex of the calcaneus at the attachment of the plantar fascia that have been correlated with plantar fasciitis mainly using lateral heel radiography. Despite ultrasound having a limitation of evaluating bony structures, this study found that 65 (73.8%) of the symptomatic heels had cortical ir-

regularities. This was a higher prevalence than those detected on plain radiography 52 (59%) and could be explained by the ability to sweep the ultrasonic beam across the area of interest severally that enables the detection of subtle contour irregularities [10].

No mass nodules, foreign body or calcifications were identified in both modalities, this may be due to low number of patient up attributed to the pandemic and a short duration of study.

5. Conclusion

The study has swown that ultrasound can detect plantar fascia pathologies in patients presenting with heel pain and therefore may be useful as a first line imaging modality in resource poor settings where sonography is readily available and cost effective. A high BMI was consistently associated with heel pain and plantar fascia disorders.

Recommendations

This study recommends that a larger number of patients to be expanded to further elaborate on the heel ultrasound findings and verify the results within the Kenyan population. A dedicated footprint ultrasound transducer for musculoskeletal ultrasound would be ideal for future examinations. Radiologists should also be encouraged to take up musculoskeletal sonography as a subspecialty. Clinicians should be empowered with knowledge on the usefulness of musculoskeletal ultrasound in assessing heel pathologies.

Conflicts of Interest

The authors declare no conflicts of interest.

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