

Clinical Research

Additional diagnostic value of digital radiology in plantar fasciitis diagnosis

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ABSTRAK

Latar belakang: Ultrasonografi (USG) adalah pemeriksaan standar baku emas untuk membedakan fascia plantaris yang normal dengan yang mengalami plantar fasciitis. Radiografi konvensional atau foto polos umumnya hanya digunakan untuk menyingkirkan diagnosis banding. Akhir-akhir ini, radiografi konvensional sudah banyak mengalami digitalisasi, sehingga pencitraan jaringan lunak oleh foto polos menjadi lebih baik. Namun, tidak diketahui apakah hasil evaluasi radiografi digital daerah kalkaneus, baik kualitatif maupun kuantitatif, memiliki nilai diagnostik serupa dengan temuan USG. Penelitian ini bertujuan untuk mengetahui nilai diagnostik temuan radiografi digital dan USG dalam mendiagnosis plantar fasciitis.

Metode: Studi ini menggunakan desain potong-lintang, dengan subjek pasien dewasa (>18 tahun) yang memiliki keluhan nyeri tumit bawah. Ketebalan plantar aponeurosis diukur dengan radiografi digital dan ultrasonografi. Masing-masing pengukuran dilakukan sebanyak tiga kali dan diambil nilai rerata. Fat stranding, entesofit kalkaneus dan mikrofraktur entesofit kalkaneus juga dievaluasi dalam radiografi digital. Hasil ketebalan plantar aponeurosis selanjutnya diklasifikasikan menjadi diagnosis plantar fasciitis.

Hasil: Tidak terdapat korelasi yang bermakna antara ketebalan plantar aponeurosis yang diukur menggunakan radiografi digital dan ultrasonografi ($r=0,069$, $p=0,688$). Tidak terdapat hubungan yang signifikan antara diagnosis plantar fasciitis dengan radiografi digital dan ultrasonografi menggunakan Fisher's exact test ($p=0,162$). Namun, radiografi digital memiliki sensitivitas yang tinggi dalam mendeteksi plantar fasciitis.

Kesimpulan: Radiografi digital berpotensi untuk digunakan sebagai modalitas diagnosis definitif untuk plantar fasciitis.

ABSTRACT

Background: Ultrasonography (USG) is regarded as the gold standard to differentiate normal plantar fascia and plantar fasciitis. Conventional radiography or plain X-ray is typically used to exclude differential diagnosis. Lately, conventional radiography has been digitalized and leads to better visualization of the soft tissue. However, it is not known whether digital radiography evaluation for calcaneus area, both qualitative and quantitative, has a similar diagnostic value as USG findings. Therefore, this study aimed to evaluate whether there is a strong correlation between digital radiographic and USG findings for diagnosing plantar fasciitis.

Methods: This is a cross sectional study examining adult patients (>18 years old) presenting with inferior heel pain. Plantar aponeurosis thickness was measured by digital radiography and ultrasonography; measurement was performed three times in each modality, and the average value was recorded. Fat stranding, presence of calcaneal enthesophyte, and microfracture were also evaluated in digital radiography. Measurement results were classified into plantar fasciitis diagnosis using the cut-off value 4 mm.

Results: There was no significant correlation between plantar aponeurosis thickness measured by digital radiography and by ultrasonography ($r=0.069$, $p=0.688$). There was no significant association between plantar fasciitis diagnosis by digital radiography and ultrasonography ($p=0.162$). However, digital radiography showed good sensitivity to detect plantar fasciitis using a cut-off value of >4 mm plantar fascia thickness.

Conclusion: Digital radiography might be used to aid definitive diagnosis for plantar fasciitis.

Keywords: calcaneus bone, digital radiography, plantar fasciitis, plantar aponeurosis, ultrasonography

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Plantar fasciitis is a common cause of inferior heel pain due to edema or inflammation in the plantar aponeurosis. Although the etiology has not been clearly identified, several things has been identified as risk factors, such as increasing age, obesity, biomechanic abnormality of the feet, and heavy physical activity.¹ Radiology plays an important role in diagnosing plantar fasciitis and in providing evaluation after treatment.² Conventional radiography is typically used to exclude differential diagnosis. Radiographic findings in plantar fasciitis include osteophyte formation in calcaneus bone although it is not specific. Ultrasonography (USG) is an effective tool, regarded as the gold standard, for differentiating normal plantar fascia and plantar fasciitis. High-frequency USG is used to evaluate edema or thickening of plantar fascia; thickness of more than 4 mm is a diagnostic feature for plantar fasciitis.^{3,4}

In the Department of Radiology of Cipto Mangunkusumo General Hospital, conventional radiography or plain X-ray has been digitalized to increase its image quality; it can visualize the soft tissue in a better quality.⁵ However, it is not known whether digital radiography evaluation for calcaneus area, both qualitative and quantitative, has a similar diagnostic value as USG findings. Therefore, this study aimed to evaluate whether digital radiographic correlates with ultrasonography (USG) findings in diagnosing plantar fasciitis.

METHODS

This is a cross-sectional study conducted at the Radiology Department of Cipto Mangunkusumo General Hospital from December 2014 to February 2015. This study has been approved by the Ethics Committee of the Faculty of Medicine, University of Indonesia (No. 80/UN2.F1/ETIK/2015). Subjects were recruited in consecutive sampling from plantar fasciitis patients who were referred to the Radiology Department of Cipto Mangunkusumo General Hospital. We included adult patients (>18 years old) presenting with inferior heel pain. Patients with open wound, mass, or infection in plantar surface of foot were excluded. Patients with history of surgery in plantar surface of foot, history of trauma, or fracture in the foot or ankle were also excluded.

Sample was plantar aponeurosis on the plantar side of the foot; since both feet were examined in this study, one patient could give 2 samples. Plantar fascia thickness was measured by two radiologists (MP, TS) for ultrasonography because the examination was very operator-dependent. The two operators were blinded; they did not know the digital radiography results and other operator's ultrasonography result. Digital radiography data were interpreted by other radiologist (TPS).

Patients underwent both digital radiography and USG examination on the same day; both feet were examined. Digital radiography used Siemens Multix Compact K/1175640X2187 machine, with exposure 40–50 kV and 4 mAs. Lateral projection was taken with subject lying on the lateral side of the examined foot, e.g. if the right foot was examined, the patient was asked to lie on his/her right side. The ankle was dorsiflexed, and digital radiography plate sized 18x24 cm was placed under the lateral malleolus. The fifth finger must be touching the radiography plate, and the ankle was on the centre of the plate. The other feet was placed in front of the plate and not be included in the film. The X-ray beam was centered on the calcaneus bone, which was about 2-3 cm below the medial malleolus. Lateral projection of both feet was taken to evaluate the calcaneus bone and the soft tissue surrounding it. A radiologist then evaluated the bone structure (normal/subluxation/dislocation), bone density (normal/porotic/sclerotic), osteophyte or enthesophyte formation particularly the enthesophyte in plantar side of calcaneus bone, fragmentation of osteophyte of enthesophyte, and edema or fat stranding in fat tissue surrounding the plantar fascia. In digital radiography, plantar fascia thickness was measured exactly on the inferior border of calcaneus bone where plantar aponeurosis inserted into calcaneus bone. Measurement was conducted three times, and then the average value was recorded.

USG was conducted using the Medison Accuvix V20 Prestige machine using linear transducer with 9–15 MHz frequency. Subject was lying in prone position, ankle dorsiflexed in 90 degrees. The operator examined from patient's right-hand side, and the plantar aponeurosis was visualized in sagittal projection to evaluate the echogenicity (hypoechoic/ hyperechoic), linearity or plantar aponeurosis fibers (parallel/not parallel), enthesophyte formation, musculoaponeurosis,

and rupture. Plantar aponeurosis thickness was measured in the anterior side of calcaneus bone's inferior border, where plantar aponeurosis was inserted into calcaneus bone (Figure 1). Measurement was performed three times by each examiner, and the average value was recorded.

Data were analyzed using SPSS version 20.0 to evaluate whether there was a correlation between plantar fascia thickness measured with digital radiography and USG as the gold standard. Sensitivity and specificity of digital radiography findings to diagnose plantar fasciitis were also tested.

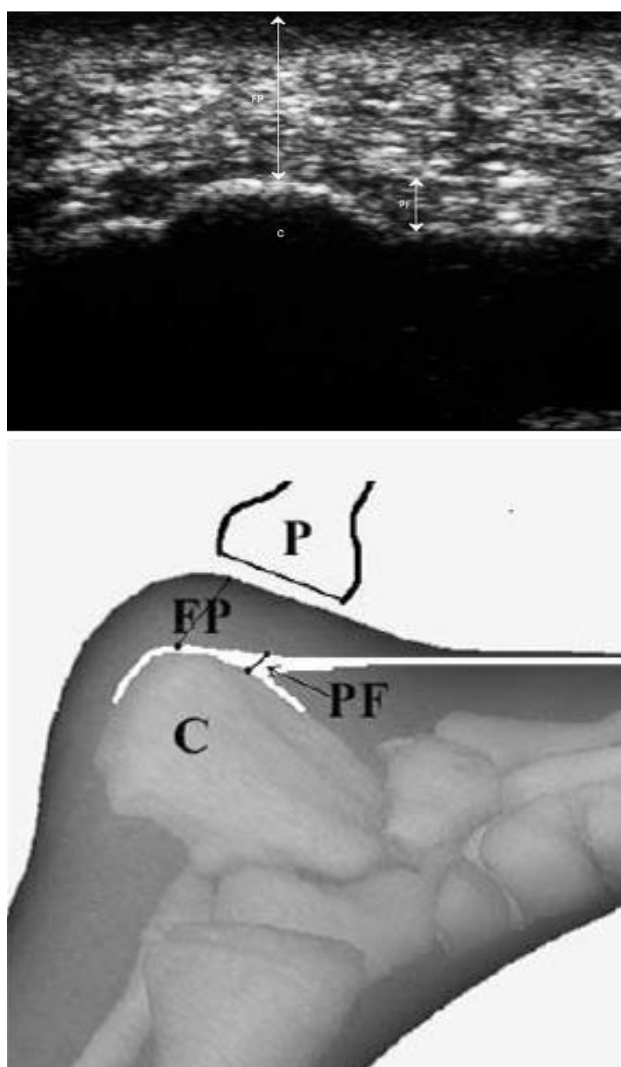


Figure 1. Plantar aponeurosis thickness measurement in USG, (a) longitudinal projection of calcaneus bone's inferior border, showing normal plantar aponeurosis fibers (short arrow), (b) diagram showing transducer position for plantar aponeurosis thickness measurement. (C= calcaneus bone, FP= fat pad, P= probe/ ultrasound transducer, PF= plantar fascia)

RESULTS

Patients

There were 18 subjects enrolled in this study. Basic characteristic of subjects can be seen in table 1.

Radiographic and ultrasonographic findings

Thirty six feet was examined, two from each patient. Mean plantar aponeurosis (PA) thickness in digital radiography was 6 mm, (3.5–9.8). PA >4 mm was found in 33 samples in digital radiography. Mean PA thickness in ultrasonography was 6 mm, (3.5–9.8). PA >4 mm was found in 34 samples in ultrasonography.

In digital radiography, fat stranding was found in 33 samples (91.6%), calcaneal enthesophyte in 32 samples (88.8%), and microfracture of calcaneal enthesophyte in 22 samples (61.1%) (Figure 2).

Correlation between digital radiographic and ultrasonographic measurement

There was no significant correlation between measurement using digital radiography and using ultrasonography with Pearson correlation test ($p=0.688$) (Figure 3). The measurement results was then classified using the cut-off 4 mm thickness, positive if the thickness was more than 4 mm and negative if less than 4 mm. There was no significant association between plantar fasciitis diagnosis using digital radiography and using ultrasonography ($p=0.162$) (Table 2).

There was no significant association between fat stranding found in digital radiography and plantar

Table 1. Patients' characteristics

Characteristics	n	%
Gender		
Male	1	5%
Female	17	95%
Age		
40–45 years old	1	5%
45–50 years old	2	10%
>50 years old	15	85%
Heel pain		
Right heel	2	11%
Left heel	5	27%
Right and left heel	11	62%

Table 2. Plantar fasciitis diagnosis using plantar fascia thickness (>4 mm) criteria by digital radiography measurement and ultrasonography measurement

	Plantar fasciitis based on ultrasonography		Total	
	Positive	Negative		
Plantar fasciitis based on digital radiography				
Positive	32 (97%)	1 (3%)	33	
Negative	2 (66.7%)	1 (33.3%)	3	p=0.162
Total	34	2	36	

Table 3. Fat stranding, calcaneal entesophyte, and microfracture found in digital radiography and plantar fasciitis found in ultrasonography

	Plantar fasciitis based on ultrasonography		Total	
	Positive	Negative		
Fat stranding				
Positive	32 (97%)	1 (3%)	33	
Negative	2 (66.7%)	1 (33.3%)	3	p=0.162
Total	34	2	36	
Entesophyte				
Positive	30 (93.8%)	2 (6.2%)	32	
Negative	4 (100%)	0 (0%)	4	p=1.000
Total	34	2	36	
Microfracture				
Positive	21 (95.5%)	1 (4.5%)	22	
Negative	13 (92.9%)	1 (7.1%)	14	p=1.000
Total	34	2	36	

fasciitis found in ultrasonography (p=0.162). Fat stranding was present in all plantar fasciitis cases diagnosed by digital radiography. There was no significant association between calcaneal entesophyte, as well as microfracture, found in digital radiography and plantar fasciitis found in ultrasonography (p=1.000) (Table 3).

DISCUSSION

Plantar fasciitis is an inflammation process, which can be diagnosed accurately using ultrasonography, with plantar fascia thickness cut-off value 4 mm. Other ultrasonography findings can also support the diagnosis, such as

hypoechoic plantar aponeurosis, fluid collection in the surrounding fat tissue, and pain elicited by compression maneuver. Lateral projection radiography of calcaneus bone is also widely used in plantar fasciitis, but its utilization is focused on calcaneal entesophyte or spur detection and excluding differential diagnoses. Levy et al⁶ proved that radiography was not beneficial in diagnosing plantar fasciitis. Osborne et al⁷ showed that plantar fascia thickness and fat pad abnormality found in calcaneus bone radiography (lateral projection) had 85% sensitivity and 95% specificity to diagnose plantar fasciitis.

Digital radiography of calcaneus bone using lateral projection could visualize plantar aponeurosis clearly, and its thickness could be measured. In this study, plantar aponeurosis measurement has been done three times, and the mean value was used for data analysis. However, this study did not find significant correlation between plantar aponeurosis measurement using digital radiography and using ultrasonography. Acutely inflamed plantar aponeurosis is often accompanied with surrounding fat tissue edema, which was also looked radio-opaque, known as “fat stranding”. The presence of fat stranding actually made plantar aponeurosis measurement more difficult; this was probably due to the inconsistency in radiographic measurement. Therefore, measurement of plantar aponeurosis thickness by digital radiography was inferior to ultrasonography.

When the plantar aponeurosis thickness was classified into less than 4 mm and more than 4 mm, digital radiography findings had no significant association with ultrasonography (p=0.162). However, statistical analysis showed good sensitivity and positive predictive value, both >80%, for plantar fasciitis diagnosis by digital radiography. The surrounding fat tissue edema (fat-stranding) could make plantar fascia thicker than it actually was when measured by digital radiography. As a result, normal plantar fascia thickness (<4 mm) appeared abnormal, and false positive could happen more frequently (lower specificity) in digital radiography. Conversely, a true abnormal plantar thickness (>4 mm) would be more highlighted by the surrounding edema, and therefore, false negative could rarely happen (higher sensitivity). In this study, all patients who actually had plantar fasciitis (diagnosed by ultrasonography) also had fat-stranding in digital radiography. This finding



Figure 2. Digital radiography of patient with A) fat stranding (arrow); B) calcaneal enthesophyte; C) calcaneal microfracture

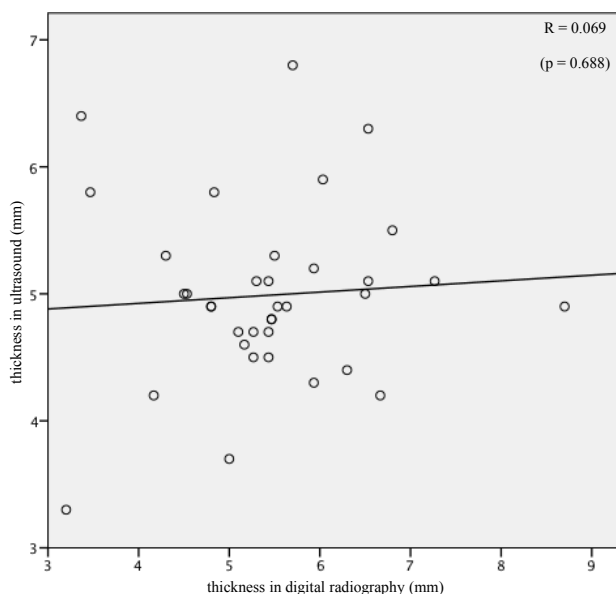


Figure 3. Scatter plot of plantar aponeurosis thickness measurement using digital radiography (X-axis) and using ultrasonography (Y-axis)

was consistent with the pathophysiology of plantar fasciitis, in which acutely inflamed plantar fascia was often accompanied by edema of the surrounding fat tissue. Thus, the presence of fat-stranding had good sensitivity in detecting an actual plantar fasciitis, as showed by Osborne et al⁷ This initial result and previous studies showed potential utilization for digital radiography to provide definitive diagnosis of plantar fasciitis. However, further study with larger sample size would be needed before we could recommend the use of digital radiography alone, without ultrasonography, to diagnose plantar fasciitis.

The presence of calcaneal enthesophyte or microfracture in digital radiography and plantar

fasciitis diagnosis in ultrasonography both showed insignificant association. There was a wide difference in significance value between association of enthesophyte in radiography – plantar fasciitis in ultrasonography, and fat stranding in radiography – plantar fasciitis in ultrasonography, suggesting that the presence of calcaneal enthesophyte or microfracture in digital radiography was truly not associated with plantar fasciitis, and conducting further study with larger sample size would not bring any difference in its statistical significance. This finding was also supported by Abreu et al⁸ which showed only 3% of calcaneal enthesophyte was located inside the plantar aponeurosis, while more than 90% was found outside plantar aponeurosis region. Therefore, plantar fasciitis was most likely not influenced by calcaneal enthesophyte.

Digital radiography could be potentially used to provide definitive diagnosis of plantar fasciitis, using plantar aponeurosis thickness cut-off value of 4 mm. However, this study had limitation: the small sample size. If further studies with larger sample size could confirm it, the plantar fasciitis diagnosis could be more efficient and cost-effective. By using digital radiography alone, examination time could be much shortened. It would also be more comfortable for patients because in ultrasonography examination, patients had to be lying in prone position, which was uncomfortable especially for obese patients. Additionally, digital radiography could also evaluate bony structure of the heel, which could not be evaluated in ultrasonography. Therefore, not only digital radiography could diagnose plantar fasciitis, but it could also evaluate or exclude other causes of heel pain, such as microfracture and heel spur.

In conclusion, digital radiography might be used to provide definitive diagnosis in plantar fasciitis cases, using plantar fascia thickness cut-off value 4 mm.

Conflicts of interest

The authors affirm no conflicts of interest in this study.

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