

## SONOGRAPHIC EVALUATION OF THE PLANTAR FASCIA IN ASYMPTOMATIC SUBJECTS

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**Purpose:** To evaluate the appearance of the plantar fascia in asymptomatic subjects.

**Materials and methods:** Thirty-one asymptomatic subjects were examined by 2 musculoskeletal radiologists. The plantar fascia was evaluated for thickness, echogenicity, vascularity on power Doppler, rupture, fluid adjacent to the fascia, and calcifications.

**Results:** The study included 14 men and 17 women (age, 17-79 years; mean, 45 years). The mean thickness of the plantar fascia in men was 3.7 mm (range 2.5-7 mm), and in women 3.5 mm (range, 1.7-5.1 mm). The thickness was greater than 4 mm in 4 men (bilateral in 2). The mean thickness of fascias thicker than 4 mm in men was 5.4 mm (range, 4.3-7 mm). The thickness was greater than 4 mm in 5 women (bilateral in 4). The mean thickness of fascias thicker than 4 mm in women was 4.7 mm (range, 4.2-5.1 mm). There was no statistically significant difference between men and women and between both heels. Hypoechoogenicity was observed in 3 men (bilateral in 2), and in 5 women (bilateral in 6). Hypervascularity, rupture, fluid adjacent to the fascia, and calcifications were not observed.

**Conclusion:** A thickness greater than 4 mm and hypoechoogenicity, are common in the plantar fascia of asymptomatic subjects. Findings that were not seen in asymptomatic subjects include a thickness greater than 7 mm, hypervascularity on power Doppler, rupture, fluid adjacent to the fascia, and calcifications.

**Key-word:** Foot, US.

Plantar fasciitis is a low-grade inflammation of the plantar fascia and perifascial tissues. It is a common cause of heel pain and usually affects middle-aged women, as well as younger, predominantly male, runners (1). The condition is likely related to repeated strain, leading to microtears and inflammation. Imaging is commonly used to confirm the diagnosis, and exclude other causes of posterior heel pain (2).

Although MR imaging may be used to diagnose plantar fasciitis, many authors suggest ultrasound is an accurate, simple, and noninvasive technique to diagnose the condition. Previous investigators have reported that the most important diagnostic findings in plantar fasciitis are thickening and hypoechoogenicity, and occasionally fluid collections adjacent to the fascia. Wall et al. (3) suggest that a plantar fascia thickness greater than 4 mm is consistent with plantar fasciitis. This value has been used as a reference value in several studies (4-6).

To our knowledge, there are no data about the ultrasound appearance of the plantar fascia in asymptomatic subjects. Hence, it is not known if certain commonly used ultrasound criteria of plantar fasciitis might be seen in such a population. If so, this may entail the risk of attributing the patients' symptoms to

plantar fasciitis while other abnormalities may be overlooked and not further investigated. Therefore we decided to evaluate the plantar fascia in asymptomatic subjects with high resolution ultrasound.

### Materials and methods

Institutional Review Board approval for our study was obtained and consent from the asymptomatic subjects. They were interviewed to confirm they had not been symptomatic at the sole of the foot. Other exclusion criteria were a history of foot surgery, foot and ankle trauma, arthritis, gout, neuropathic foot disease, and diabetes mellitus. Both heels of the 31 asymptomatic subjects were scanned by one of two experienced musculoskeletal radiologists using a 12 MHz linear-array transducer on a state of the art system (Toshiba Applio XG, Tokyo, Japan). The examinations were performed with the subjects in prone position and the feet hanging freely over the edge of the examination table. Acoustic coupling gel, but no standoff-pad, was applied to the plantar surface of the foot. The focal zone was adjusted to the depth of the fascia. The central band of the plantar fascia was examined from its origin up to the metatarsal head region. The thickness was measured at

a reference point where the plantar fascia crossed the anterior aspect of the inferior border of the calcaneus. The measurement points are indicated in the figures by calipers (Figs. 1-3). The plantar fascia was evaluated for echogenicity. It was only considered hypoechoic if its echogenicity was markedly decreased with respect to the subcutaneous heel fat. The plantar fascia was also assessed for presence of calcification defined as markedly hyperechoic foci, with or without acoustic shadowing, vascularity with Doppler, tear, and fluid adjacent to the fascia. The saved images were reviewed by 2 investigators. Statistical analysis was performed using a t-test (independent samples) (IBM SPSS Statistics 20, Armonk, NY). The significance threshold was set at  $p = 0.05$ .

### Results

A total of 62 plantar fascias in 31 subjects (14 men, 17 women), aged from 17 to 79 years (mean age, 45 years) were evaluated (Fig. 1-3). The results are shown in Tables I and II. The mean thickness of the plantar fascia in men was 3.7 mm (range, 2.5-7 mm), and in women 3.5 mm (range, 1.7-5.1 mm). There was no statistically significant difference between the thickness of the fascia in men and women ( $p = 0.21$ ). There was no significant difference between the right and the left foot ( $p = 0.64$ ).

The thickness of the plantar fascia was greater than 4 mm in 4 men

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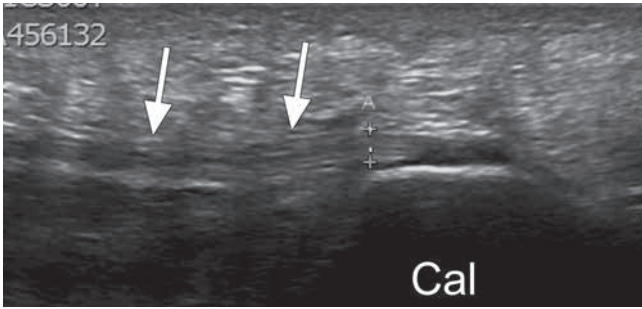


Fig. 1. — Asymptomatic 74-year-old woman. Right side. Thickness was 1.9 mm. The calcaneal insertion of the plantar fascia (arrows) is hyperechoic, and the middle portion is somewhat more hypoechoic compared to fat (this was not considered hypoechoic for analysis) (Cal, calcaneus).

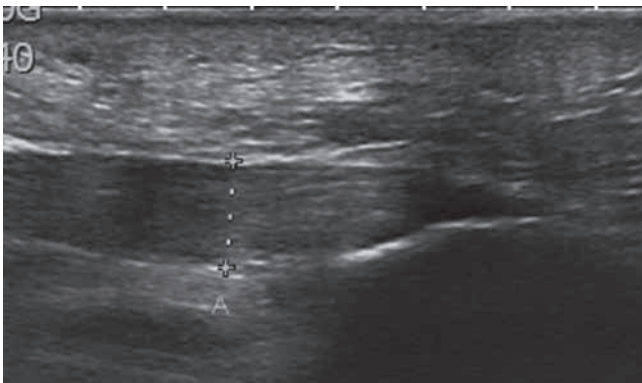


Fig. 3. — Right heel in asymptomatic 78-year-old man. Note markedly thickened (7 mm) and hypoechoic fascia (arrow) (Cal, calcaneus).

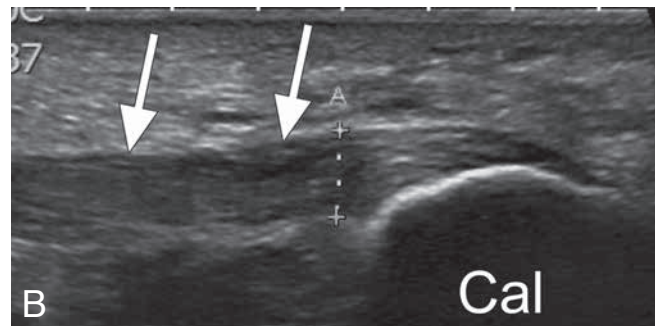
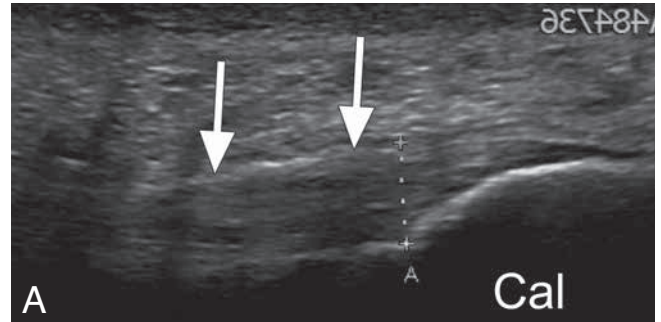


Fig. 2. — Asymptomatic 44-year-old woman. Right side (A) and left side (B).

Thickness of 5 mm is seen bilaterally. Both fascias (arrows) also appear hypoechoic relative to the subcutaneous fat plane. No vascularity is seen on power Doppler (box) (Cal, calcaneus).

(28.5%, bilateral in 2 volunteers). The mean thickness of fascia thicker than 4 mm in men was 5.4 mm (range, 4.3-7 mm). The thickness was greater than 4 mm in 5 women (29%, bilateral in 4 volunteers). The mean thickness of fascia thicker than 4 mm in women was 4.7 mm (range, 4.2-5.1 mm).

For our study, hypoechogenicity was considered present only if it was graded as 3 (very clearly hypoechoic). This was observed in 7 women

(42%, bilateral in 6) and 3 men (21.7%, bilateral in 2). The plantar fascia was both thicker than 4 mm and hypoechoic in 3 men (18%, bilateral in 2 men), and in 5 women (23%, bilateral in 4 women). All fascia that were thicker than 4 mm, were also hypoechoic. However some fascia in women were hypoechoic but not thicker than 4mm. Hypervascularity, rupture, fluid collections, and calcifications were not observed in any of the subjects.

**Discussion**

The plantar fascia is a fibrous aponeurosis, which inserts along the plantar aspect of the calcaneus. It has a central, medial, and lateral component and supports the longitudinal arch of the foot. Often the term plantar fascia is used to refer to the large central component, which inserts at the medial calcaneal tuberosity, and is considered most important in the setting of plantar fasciitis.

Table I. — Measured thickness in men and women (in mm). Mean and range, mean and range of thicknesses greater than 4 mm.

	Mean	Range	> 4 mm (mean)	> 4 mm (range)
Men	3.7	2.5-7	5.4	4.3-7
Women	3.5	1.7-5.1	4.7	4.2-5.1

Table II. — Number of volunteers with specific findings.

	> 4 mm hypoechoic both findings			hypervascularity fluid calcification tear			
Men	4	3	3	0	0	0	0
Women	5	7	5	0	0	0	0

The medial and lateral components overlie the intrinsic muscles.

The normal fascia is reported to be 2 to 4 mm thick and has a slightly echogenic fibrillar pattern at ultrasound (7).

With plantar fasciitis, usually the calcaneal insertion is involved, although occasionally the area of thickening can be localized at a distance from the calcaneal insertion. It is however, more typical for ruptures to be located distal to the calcaneal insertion. On ultrasound, commonly used criteria of plantar fasciitis are increased thickness (greater than 4 mm), and hypoechogenicity (9-11). Ultrasound has been shown to have good reproducibility for measurement of plantar fascia thickness and appreciation of hypoechogenicity (12, 13).

The typical presentation of plantar fasciitis is pain during the first few steps after rest or pain on arising in the morning. Pain is usually worse with exertion. On clinical exam, tenderness at the calcaneal origin may be evident (1, 9). Although plantar fasciitis may resolve after a few weeks, in some patients symptoms may become chronic. The best management of chronic plantar fasciitis is not entirely agreed upon and a variety of conservative approaches as well as more invasive treatments has been suggested (13-19).

Our study results, however, showed that a thickness greater than 4 mm could be observed in nearly 30% of asymptomatic subjects. We did not assess differences between men and women, due to the sample size. Hypoechogenicity of the plantar fascia, also a commonly used criterion of plantar fasciitis was seen in 21.7% of men, and 42% of women, in our study. The plantar fascia was both thicker than 4 mm and hypoechoic in 17.8% of men and 23.5% of women. Actually all fascias thicker than 4mm were also hypoechoic. Hence, the two most commonly used criteria of plantar fasciitis with ultrasound, are both seen together in asymptomatic subjects.

Although no histological studies are available of the plantar fascia in asymptomatic subjects we speculate that the observed hypoechogenicity may reflect a degenerative phenomenon.

When the plantar fascia was thickened and hypoechoic in asymptomatic subjects, this was often the case bilaterally. Hence, we recommend a comparison with the contralateral

side when performing an ultrasound study of the plantar fascia.

Hyperemia has been considered to be an important feature of acute plantar fasciitis in some studies. When evaluating hyperemia, care should be taken to exert as little pressure with the ultrasound probe as possible. Still because of heel thickness this may be difficult, and small vessels could potentially be compressed. None of our volunteers showed hyperemia.

Fluid adjacent to the plantar fascia and tear are less commonly demonstrated in plantar fasciitis. In our study none of the asymptomatic subjects had fluid adjacent to the plantar fascia or tear.

Our study has some limitations. First, the study population is relatively small. Second, there was no follow up of our study subjects and hence we cannot entirely exclude that subjects with increased fascia thickness or hypoechogenicity ultimately will not develop symptoms of plantar fasciitis. However we detected these abnormalities in about 25% of our study population. Third, with regard to the evaluation of echogenicity, we acknowledge this is a somewhat subjective feature that may be difficult to appreciate due to anisotropy and inhomogeneous penetration of thick plantar skin and subcutaneous tissues (20).

In summary, thickness greater than 4 mm and hypoechogenicity, and both findings, can be seen in the plantar fascia of asymptomatic subjects. We suggest prudence when attributing the patients' symptoms to plantar fasciitis only based on these ultrasound findings. This could entail the risk of missing another diagnosis. Often these findings are bilateral, and a comparison with the contralateral side may be helpful. Findings that were never observed in asymptomatic subjects, include a thickness greater than 7 mm, and we would suggest this as a new cut-off value. Hypervascularity, rupture, fluid collections adjacent to the fascia, and calcifications also were never observed in asymptomatic subjects.

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