The Correlation Between Plantar Fascia Thickness and Symptoms of Plantar Fasciitis

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Background: The purpose of this study was to determine whether changes in plantar fascia thickness are a reliable gauge of efficacy of treatment protocols for plantar fasciitis.

Methods: Thirty-nine feet (30 patients) with plantar fasciitis received an ultrasound examination to measure the thickness of the medial band of the plantar fascia. Each patient assessed his or her pain using the visual analogue scale. Following various treatments, a second ultrasound examination was performed and the thickness of the plantar fascia was again measured and subjective pain level assessed.

Results: Twenty-nine feet (74.4%) showed a decrease in plantar fascia thickness and a decrease in pain. One foot (2.6%) experienced an increase in fascia thickness and reported an increase in pain. Four feet (10.3%) had an increase in thickness of the plantar fascia and reported no change in pain level. Three feet had minor increases in fascia thickness but reported a decrease in pain (7.7%). One foot (2.6%) had no change in fascia thickness but a decrease in pain and one foot (2.6%) had a decrease in the plantar fascia but no change in pain level. The average reduction in fascia thickness was 0.82 mm ± 1.04 mm, correlating with an average improvement in pain of 3.64 ± 2.7 ($P < 0.005$).

Conclusions: This study provides evidence that changing thickness of the plantar fascia is a valid objective measurement to assess effectiveness of new or existing treatment protocols. (J Am Podiatr Med Assoc 101(5): 385-389, 2011)

Ultrasound is often used in podiatric practice to evaluate plantar fascia pathology. It is the most widely reported imaging modality utilized for this condition.[1] Many studies have been performed that have evaluated the thickness of the plantar fascia before and after a given treatment regimen to prove that treatment's efficacy.[2-5] These studies have assumed that an intimate relationship exists between the plantar fascia thickness and the patient's pain level. While this correlation is assumed to exist, the precise relationship between the plantar fascia thickness and pain level is not well established in the literature. The purpose of this study was to determine whether a statistically significant correlation exists across a given sample population, irrespective of treatment regimen. This would help determine the validity of studies that use changes in plantar fascia thickness as a gauge of efficacy of their treatment protocols for plantar fasciitis.

Plantar fasciitis is the most common cause for heel pain, and is estimated to affect 10% of the general population.[2] In the United States, 2 million people seek treatment for this condition each year.[6] Typical symptoms include pain with the first few steps in the morning or after rest, and pain with increased physical exercise, or both.[2] Often the diagnosis can be made by clinical examination alone; however, imaging modalities including ultrasound and magnetic resonance imaging (MRI) can aid in diagnosis and rule out other causes of heel pain (Table 1). Although MRI is a useful modality to diagnose plantar fasciitis, because of its expensive and time-consuming nature, it is not feasible to use serial MRIs to follow a patient's progress with a given treatment regimen.

Associations of plantar fasciitis with obesity, body mass index (BMI) >30 kg/m^2, middle age, changes in activity level, prolonged standing, pes planus, pes cavus, and equinus have been de-

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Table 1. Differential Diagnosis for Heel Pain

Musculoskeletal	Calcaneal epiphysitis
	Stress fracture
	Osteomyelitis
	Inflammatory arthropathies
	Subtalar arthritis
	Posterior tibial tendonitis
Nervous System	Lumbar spine disorders
	Neuropathies
	Tarsal tunnel syndrome
	Entrapment of the plantar nerves in the foot
Disorders	Osteomalacia
	Paget's disease
	Sickle cell disease
Soft tissue	Tumors
	Fat pad atrophy
	Heel pad contusion
	Retrocalcaneal bursitis
	Plantar fascial rupture

scribed.[3, 7-10] Radiographs may show the formation of a spur at the calcaneal tuberosity, but this may have no direct relationship to heel pain.[11] Plantar fasciitis often responds to a broad range of conservative therapies, and there is no single universally accepted way of treating this condition.[6]

Ultrasonography is a useful tool for diagnosing plantar fasciitis. The thickness of the fascial band can be measured at its insertion into the calcaneal tuberosity, which is also the origin of the flexor digitorum brevis, abductor digiti minimi, and abductor hallucis.[12] Surrounding bursa, tears, calcifications, and ruptures can be readily identified.[13, 14] Ultrasound examination is noninvasive and painless; it allows dynamic imaging with good spatial resolution and is cost effective.[14, 15] Increased thickness of the plantar fascia can be detected sonographically and is associated with plantar fasciitis.[13, 14, 16] According to Hammer et al,[3] ultrasonographic studies presented significant differences in the mean thickness of plantar fascia between symptomatic and asymptomatic patients. Sonographic guidance is frequently used for heel injections and improves the accuracy, thus improving efficacy and preserving the mechanical properties of the heel pad.[17, 18]

Materials and Methods

Thirty patients (39 feet) with a clinical diagnosis of plantar fasciitis were evaluated. Their diagnosis was based on clinical history and physical examination. One common symptom included pain at the insertion of the plantar fascia into the medial plantar tuberosity of the calcaneus. Pain was reported to be most intense with the first few steps in the morning, after ambulation or increased activity, or both. To qualify for participation in the study all patients gave verbal consent. Approval for research was given and moderated by the Ethics Committee at the Foot and Ankle Associates of Illinois. Twenty-one patients had unilateral fasciitis and nine had bilateral. There were three female and 27 male patients, and their ages ranged from 41 to 82 (mean, 44.8) years. Average weight was 216.7 pounds (range, 139.8 to 320 pounds), and the mean BMI was 31.13 kg/m^2 (range, 23.53 to 47.35 kg/m^2).

The patient's subjective pain was measured with a visual analog scale (VAS) from 0 to 10, with 0 representing no pain, and 10 representing the worst pain in the patient's experience. Each foot was then evaluated sonographically with a linear 7.5 MHz transducer. The transducer was placed in the sagittal plane on the medial band of the plantar fascia at its insertion into the medial calcaneal tuberosity. The plantar fascia was assessed for echogenic appearance and thickness changes along its length. No tears in the fascia or plantar fibromas were noted. The thickness of the medial band of the plantar fascia was measured from the tip of the plantar medial tuberosity of the calcaneus to the superficial aspect of the plantar fascia as seen in Figure 1. The same technician (S.M.) was used each time to keep the measurements consistent. The patients were treated with a variety of conservative modalities including rest, icing, ultrasound-guided corticosteroid injections, padding, shoe modifica-

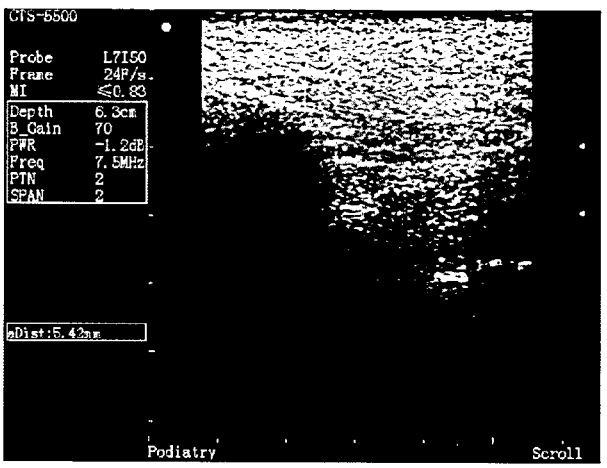

Figure 1. Ultrasound measuring the medial band of the plantar fascia in the sagittal plane.

tions, over-the-counter arch supports, and stretching. Patients were then asked to return in 3 weeks to reassess their pain and have their plantar fascia measured again. The average follow-up period was 19.33 days ± 9.8 days. The change in thickness was then compared with the subjective reduction in symptoms.

Results

The average thickness of the medial band of the plantar fascia for the total population was 5.71 mm ± 1.33 mm on initial examination. The average thickness for the medial plantar fascia on follow-up examination was 4.89 mm ± 1.19 mm. The mean thickness of the plantar fascia on initial and follow-up visits was compared with their subjective pain assessment (Table 2). Paired *t* tests were used to compare means between pre- and post-treatment VAS pain rating and fascia thickness. *P* values of less than 0.05 were considered statistically significant. The average change in fascia thickness was a reduction of 0.82 mm ± 1.04 mm that correlated with an average improvement in pain of 3.64 ± 2.63 ($P < .005$). Twenty-nine feet (74.4%) showed a decrease in plantar fascia thickness and a decrease in patients' symptoms of heel pain. Four feet (10.3%) had an increased plantar fascia thickness and no change in pain. Three feet (7.7%) had minor increases in fascia thickness but decreased pain. One foot (2.6%) experienced an increase in fascia thickness and an increase in pain. Another foot (2.6%) had a decrease in plantar fascia thickness and no change in pain, and another foot (2.6%) had no change in fascia thickness but a decrease in pain. Figure 2 is scatter plot that shows a trendline demonstrating the correlation between the change in plantar fascia thickness and the subjective change in patients' pain level on the VAS.

Discussion

The standard "normal" or asymptomatic thickness reported for the plantar fascia is 2.3 to 4.3 mm, averaging 3.4 mm over 11 studies summarized in Table 3.[3, 12-15, 19-24] Generally, it is accepted that a thickness of greater than 4 mm would be consistent with plantar fasciitis.[1, 14] For the purposes of this study, a mean plantar fascia thickness of 3.4 was considered the control. Thus, a 3.4 mm fascia thickness was assumed to have a VAS rating of 0. All of the patients in this study with symptomatic plantar fasciitis had a plantar fascia thickness greater than 3.4 mm.

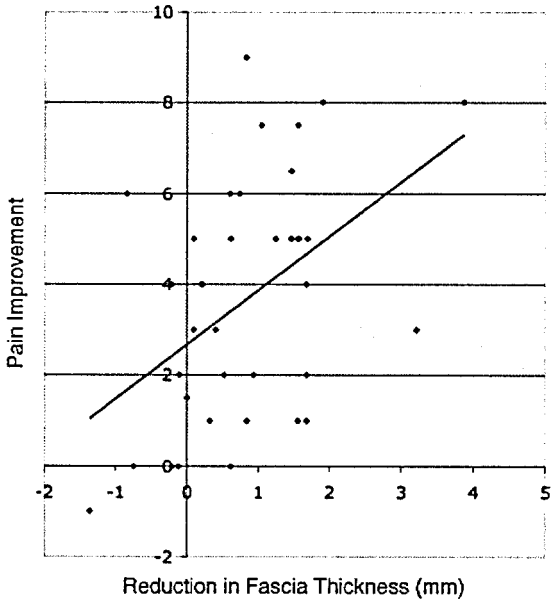

Figure 2. Scatter plot with trendline comparing change in fascia thickness with improvement of pain as rated on the visual analog scale for each of the 39 feet.

This study found a statistically significant relationship between the change in plantar fascia thickness and the change in pain level (using the VAS) after treatment. In 29 (74.4%) of the 39 feet, a reduction in symptoms correlated strongly with a reduction in plantar fascia thickness. One foot (2.6%) showed an increase in plantar fascia thickness and an increase in pain. Thus, 30 (77%) of the 39 feet exhibited decreased or increased plantar fascia thickness, which correlated with a respective decrease or increase in pain level on the VAS.

Table 2. Thickness of Plantar Fascia and VAS Pain Level on Initial and on Follow-up Examination

	Thickness of Plantar Fascia (mm)	Pain Level at Initial Visit (VAS)	Thickness at Follow-up Visit (mm)	Pain Level at Follow-up Visit (VAS)
Average	5.71	6.47	4.89	2.88
Standard Deviation	1.3	2.4	1.2	2.7

Table 3. Literature Comparison of the Mean Thickness of Symptomatic and Asymptomatic Plantar Fascia

	Mean Age (years)	No. of Patients	No. of Feet	Mean Thickness of Plantar Fascia (mm)
Patients with Symptomatic Plantar Fasciitis				
Present study	44.8	30	39	5.71
Wall et al[14]	49.2	19	38	5.6
Cardinal et al[13]	45	17	19	5.2
Vohra et al[21]	47.6	109	211	5.4
Kane et al[20]	58	23	28	5.7
Tsai et al[19]	48.4	14	14	6.5
Kamel and Kotob[15]	Not reported	20	20	5.8
Gene et al[22]	Not reported	30	47	6.3
Hammer et al[3]	51.6	22	22	5.2
Akfirat et al[12]	Not reported	23	25	4.8
Sabir et al[23]	Not reported	77	145	4.9
Walther et al[24]	Not reported	20	20	6.1
Patients with Asymptomatic Plantar Fascia				
Wall et al[14]	45.5	20	40	3.6
Cardinal et al[13]	Not reported	Not reported	30	2.9
Vohra et al[21]	49.6	16	32	2.7
Kane et al[20]	58	18	18	3.8
Tsai et al[19]	48.4	14	14	4
Kamel and Kotob[15]	Not reported	20	20	2.3
Gene et al[22]	Not reported	30	30	3.6
Hammer et al[3]	51.6	22	22	4.3
Akfirat et al[12]	Not reported	15	15	3.4
Sabir et al[23]	Not reported	77	77	3.2
Walther et al[24]	Not reported	20	20	3.8

Four feet (10.3%) had an increase in plantar fascia thickness but reported no change in pain level and, one foot (2.6%) had a decrease in plantar fascia thickness but no change in pain level. It is possible that subtle changes in fascia thickness may not be sufficient for some patients to report a change in pain level. It is interesting to note that no patients had an increase in pain and a decrease in plantar fascia thickness.

The three feet (7.7%) that experienced minor increases in plantar fascia thickness and a decrease in pain, and the one foot (2.6%) that had no change in plantar fascia thickness but a decrease in pain may have resulted from evaluator error, such as measuring the fascia in a different region than the previous measurement. A larger sample population may help reduce the significance of these outliers.

It should be noted that the sample population in this study was skewed toward middle-aged males.

Conclusion

As mentioned above, numerous other studies have found that plantar fascia thicknesses have reduced and VAS values improved with various treatments including low-level laser therapy, steroid injections, extracorporeal shockwave therapy, nonsteroidal anti-inflammatory drugs, and botulinum toxin type A injections.[2-6, 15, 22, 25] Using a variety of treatment regimens, this study provides evidence that supports the hypothesis that a reduction in plantar fascia thickness correlates closely with a reduction in pain level. However, further study with a larger patient population and a wider demographic would provide more substantial evidence of this relationship.

While performing serial ultrasounds on a patient with plantar fasciitis who is improving may be considered arbitrary, it can be useful to obtain an *objective* measure in evaluating the effectiveness of new or existing treatment regimens. As the body of

evidence grows regarding the relationship between the plantar fascia thickness and pain levels, it is not unreasonable to assume that fascia thickness alone without the accompanying VAS scores may soon be enough evidence to prove the efficacy of a given treatment regimen. Ultrasound also then becomes more useful in directing the practitioner to consider differential or concomitant diagnoses or in identifying malingering patients.

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Conflict of Interest: None reported.

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