CHAPTER **5**

PLANTAR FASCIITIS (FASCIOSIS) TREATMENT OUTCOMES STUDY: Plantar Fascia Thickness Measured by Ultrasound and Correlated with Patient Self Reported Improvement

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INTRODUCTION

Plantar fasciitis (PF) is the most common cause of heel pain and accounts for 15% of all foot disorders,[1] with approximately 2 million Americans seeking treatment for it every year.[2] PF typically results from repetitive trauma or excessive load on the fascia,[3] disproportionately affecting middle-aged women and younger, predominantly male runners.[4] Although the term fasciitis denotes inflammation, histological studies by Lemont and colleagues have shown noninflammatory changes within the fascia, with evidence of "fiber fragmentation in association with myxoid degeneration."[5] For this reason, they suggested that PF be more appropriately termed plantar fasciosis.

The role of imaging in the management of PF is essential in making the correct diagnosis and differentiating from other causes of heel pain.[6] Imaging may also be of value in the follow up of patients with PF, especially athletes, in order to time appropriate recommencement of physical activity.[7] Ultrasonography (US) has been well recognized as an effective imaging diagnostic tool for PF,[1,4,7-12] with the advantages of being noninvasive, well tolerated by patients, cost effective, free of radiation, and able to provide perfect spatial resolution for superficial structures.[4,7,11] Furthermore, several authors have reported the thickening of the plantar fascia together with hypoechoic changes as characteristic features of PF when imaged by US.[7,12-15]

Given the thickening of the plantar fascia as a commonly observed finding with US in patients with PF, the present authors postulate that there should be a decrease in the plantar fascia thickness as the patients improve in their symptoms with treatment. Previous studies had tested this hypothesis and reported a decrease in the mean thickness of the plantar fascia on US after being treated with corticosteroid injection,[10,13] however, they were done in a limited number of patients. The purposes of this prospective study are: 1) To compare the plantar fascia thickness using US between a control group and a group of PF patients that are of statistically significant number; 2) To analyze the difference in the plantar fascia thickness using US in the study group before and after treatment: 3) To observe patients grade their pain levels at three specific time periods (morning-noon-evening) during the day and correlate their symptomatic improvement with plantar fascia thickness reduction as measured by US.

MATERIALS AND METHODS

This prospective study involved 30 patients with plantar fascia pain at the heel and instep who were recruited with their consent from the senior author's private practice. Diagnosis was based on clinical history and physical examination in accordance with the diagnostic guidelines of Leach et al.[16] Exclusion criteria included direct trauma, systemic inflammatory disease, connective tissue disease, lumbar spine disc herniation, patients with suspected history of secondary pain gain and those that would not or could not return for evaluation weekly for at least 2 consecutive weeks. Patients with overt tarsal tunnel syndrome were excluded; however, focal medial calcaneal neuritic pain was included. Thirty-three control subjects were examined. The control group consisted of consenting patients who were seen at the senior author's private practice for nonheel-related pain. The plantar fascia of 28 patients' feet were assayed via US bilaterally (n = 56) and 5 patients' plantar fascia were assayed unilaterally for a grand total of 61 feet. Age, weight, sex, and height measurements were recorded for both the study and control group.

Ultrasound protocol. The senior author utilized a diagnostic ultrasound machine with a 4 cm wide transducer head and 8 MHz probe (Sonoline Sienna, Siemens; Berlin, Germany) on consenting patients from his practice before and after treatment. Patients were sitting with their feet over the edge of the table and allowed to see the examination results. The examination consisted of applying ultrasonic gel to the transducer and the patients' skin. The foot was allowed

to relax in a semi-flexed position, and the plantar fascia was traced by hand from the arch into the heel to discern the borders. Imaging of the plantar fascia consisted of real time scanning and obtaining the longitudinal sonograms. The thickness of the plantar fascia was measured at the thickest portion from the base of the medial calcaneal tubercle where a bright echogenic line was easily visible. A perpendicular measurement was then taken to the top of the plantar fascia image where the most inferior border of the plantar fascia was discernable from fat (Figure 1).

All 30 patients in the study group underwent ultrasound examination of the heel before any treatment was rendered, and had their plantar fascia thickness measured. The results were compared with those of the control group. Each patient in the study group was evaluated weekly for at least 2 consecutive weeks, with the treatment period varying from 2 weeks to 3 months (mean follow up 4.29 weeks, range 2-12 weeks). Treatment modalities also varied from patient to patient, although all patients took nonsteroidal anti-inflammatory drugs prior to being seen by the senior author. All patients received either higher arch over-the-counter inserts with biomechanical posting for valgus, varus, arch or instep augmentation, heel posting, or custom orthotics. These treatments were augmented occasionally with injections of local anesthesia, with or without steroid supplementation, or physical therapy.

All 30 patients were followed until the patients judged their own symptoms to be pain free, minimal pain, or reached maximum medical improvement, at which time they were subjected to a repeat US examination of the heel. In addition, each of the 30 patients was asked to rate their pain level according to the Faces Pain Rating Scale (Figure 2). The subjective pain assessment was requested to be done in the AM, noon, and PM, both before and after treatment.

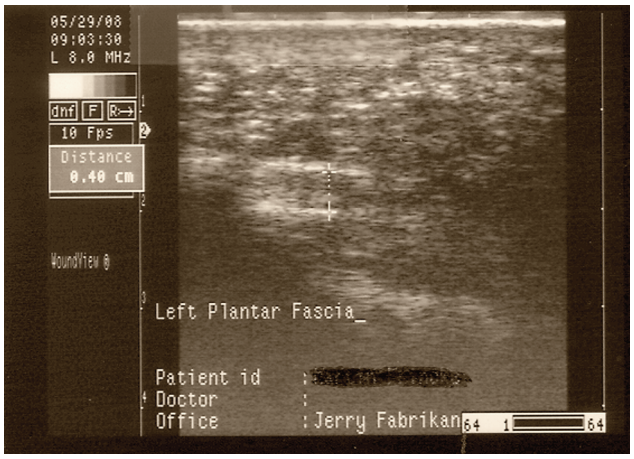

Figure 1. The thickness of the plantar fascia was measured at the thickest portion from the base of the medial calcaneal tubercle where a bright echogenic line was easily visible. A perpendicular measurement was then taken to the top of the plantar fascia image.

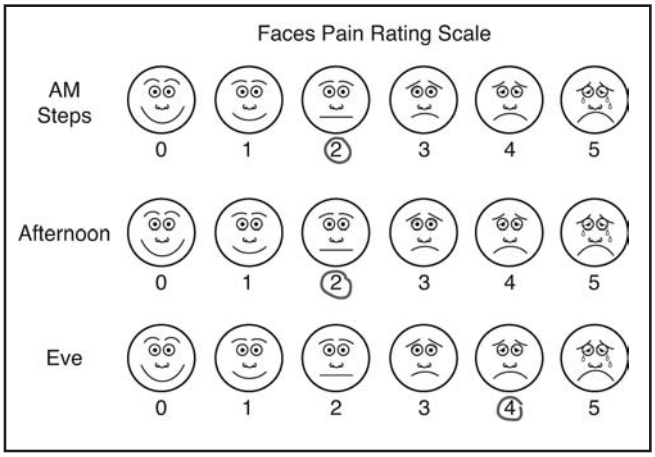

Figure 2. Faces Pain Rating Scale.

RESULTS

The sex distribution between the control and the study group was shown to be evenly matched ($X^2 = 0.009$, $P = 0.923$) (Table 1). The control group was comparable with the study group in terms of height and age ($P > 0.05$). The difference in body mass index (BMI) between the two groups was notable with higher BMI displayed by the study group, however, it did not reach the level of statistical significance (BMI Control M = 28.32; BMI Study M = 32.06; $P = 0.054$) (Table 2).

The two groups showed significant difference in weight (Control M = 180.55 lb; Study M = 207.20 lb; t = -2.190; $P < 0.05$) (Table 2). The males in the study group were significantly heavier than their counterparts in the control group (Control M = 185.92 lb; Study M = 233.29 lb; t = -2.935; $P < 0.05$). The female members in the control and the study groups were comparable in weight (Control M = 176.76 lb; Study M = 184.38 lb; t = -0.475; $P = 0.638$).

The study group was further analyzed by way of the Pearson correlation analysis to reveal a significant positive correlation between the plantar fascia thickness and BMI (r = 0.545, $P = 0.003$). There was no difference in BMI between men and women in the study group (BMI male M= 33.578; BMI female M= 30.917, t = 1.192; $P = 0.251$).

The difference in the thickness of the plantar fascia between the control group and the pre-treatment study group was analyzed. All 30 patients in the study group reported unilaterally symptomatic feet. The 12 symptomatic right feet in the study group were compared with 29 right feet in the control group, and the 18 symptomatic left feet in the study group were compared with 32 left feet in the

Table 1

SEX DISTRIBUTION OF BOTH GROUPS

	GROUP				TOTAL	
	PATIENT		CONTROL			
GENDER	Numbers of Patients	%	Numbers of Patients	%	Numbers of Patients	%
FEMALE	16	53.3	18	54.5	34	54.0
MALE	14	46.7	15	45.5	29	46.0
TOTAL	30	100.0	33	100.0	59	100.0

** Chi-Square X^2 = .009, p = .923 – this is for gender / treatment vs control – no difference.*

Table 2

COMPARISON OF TREATMENT AND CONTROL GROUP ON DEMOGRAPHIC INFORMATION

	GROUP	N	M	T	*P*
AGE	Treatment	30	57.14	-0.372	0.712
	Control	31	58.55		
WEIGHT	Treatment	30	207.20	2.190	0.033
	Control	29	180.55		
HEIGHT (IN INCHES)	Treatment	28	67.14	0.305	0.761
	Control	28	66.82	0.305	0.761
BMI	Treatment	28	32.06	1.969	0.054
	Control	28	28.32		

control group. The study group showed a significantly thicker plantar fascia when compared with the control group, in both the right and left feet (Right foot thickness control M = 0.325 cm; Right foot thickness study M = 0.633 cm; t = -12.313; $P < 0.001$; Left foot thickness control M = 0.313; Left foot thickness study M = 0.614; t = -10.569; $P < 0.001$) (Table 5).

The difference in the plantar fascia thickness in the study group before and after treatment was analyzed. The mean ± SD plantar fascia thickness before treatment was 0.621 ± 0.113 cm and after treatment was 0.418 ± 0.096 cm. The paired t-test revealed a significant decrease in plantar fascia thickness post treatment (t = 12.105, $P < 0.001$) (Table 6). Using pre- and post-fascia thickness of the treatment subjects for power analysis, this study had moderate power (Cronbach's alpha = 0.762).

The pain scores assessed by the Faces Pain Rating Scale before and after treatment were analyzed through the Wilcoxon's Signed Ranks Test, a test comparing two groups of ordinal data, which revealed significantly less pain post treatment (Pre-post AM pain: z = -4.819, $P < 0.001$; Pre-post noon pain: z = -4.779, $P < 0.001$; Pre-post PM pain: z = -4.848, $P < 0.001$) (Table 7). The pain scores recorded in AM, noon and PM before treatment were analyzed for any significant differences by the Friedman Test, a test comparing the ordinal data from a one-sample repeated measures design, which revealed significantly more pain in PM than at noon (X^2 2[2] = 14.535, $P < 0.001$). No statistically significant difference was found among the pain scores taken after treatment (X^2 2[2] = 1.564, $P = 0.458$) (Table 8).

Finally, we performed Spearman rho correlational analysis, a method of seeking relationship between continuous versus ordinal variables, to measure dependence between thickness reduction in plantar fascia and reduction in reported level of pain before and after symptomatic resolution. There was no statistically significant correlation ($P = 0.177$, $P = 0.348$), although both variables were associated findings in all 30 patients in the study group.

DISCUSSION

The US measured normal thickness of the plantar fascia reported in the literature varies in its ranges. The mean plantar fascia thickness was reported to be 2.6 mm (1.6-3.8 mm) by Cardinal et al, 3.3 mm (2.4-4.3 mm) by Gibbon and Long, 2.2 mm for the contralateral normal heel, and 2.5 mm for the control group by Ozdemir et al, and 3.4 mm for women and 3.6 mm for men by Wall et al.[9,7,11,15] It is generally accepted that plantar fascia thickness of more than 4 mm would be abnormal, and consistent with PF.[4,15]

In the present study, the mean ± SD plantar fascia thickness of the subjects in the asymptomatic control group was 0.325 ± 0.047 cm for the right feet, and 0.313 ± 0.052 cm for the left feet (Table 3). The mean ± SD plantar fascia thickness of the subjects in the symptomatic study group was 0.633 + 0.115 cm for the right feet, and 0.614 ± 0.115 cm for the left feet (Table 4), all of which findings were consistent with the reported ranges in the literature for the normal and abnormal plantar fascia thickness. Also consistent with the published data[7,12-15] was that the symptomatic group demonstrated a significantly thicker plantar fascia than the control group (Table 5). Local hypoechogenicity at the calcaneal insertion site of the plantar fascia, loss of definition at the interface between the plantar fascia and the surrounding tissue layers, as well as peri-insertional edema were additional US findings.[8,14,17]

Ozdemir et al stated that BMI measurements were significantly different between the plantar fasciitis (28 kg/m^2) and the control groups (25 kg/m^2).[11] In our study, the study group displayed a higher BMI than the control group, with the difference in BMI falling barely short of statistical significance (BMI Control M = 28.32; BMI Study M = 32.06, P = 0.054) (Table 2). Judging from the narrow margin by which the level of statistical

Table 3

PLANTAR FASCIA OF THE CONTROL GROUP

	NUMBER OF PATIENTS	MINIMUM THICKNESS (CM)	MAXIMUM THICKNESS (CM)	MEAN VALUES (CM)
Asymptomatic right	29	0.220	0.440	0.325
Asymptomatic left	32	0.200	0.380	0.313

Table 4

PLANTAR FASCIA OF THE STUDY GROUP

	NUMBER OF PATIENTS	MINIMUM THICKNESS (CM)	MAXIMUM THICKNESS (CM)	MEAN VALUES (CM)
Symptomatic right	12	0.490	0.950	0.633
Symptomatic left	18	0.490	0.830	0.313

Table 5

PLANTAR FASCIA THICKNESS (CONTROL VS. STUDY)

	M	NUMBER OF PATIENTS	t	*P*
Control Asymptomatic Right	0.325	29	-12.313	< 0.001
Study Symptomatic Right	0.633	12		
Control Asymptomatic Left	0.313	32	-10.569	< 0.001
Study Symptomatic Left	0.614	18		

significance was missed, and the fact that the two groups showed a statistically significant difference in weight that is a variable related to BMI, it is likely that the difference would have been statistically significant had the sample sizes been larger. Additionally, the study group was proven to be significantly heavier than the control group due to the male members in the study group being much heavier than their counterparts in the control group. The female members in the control and the study groups were comparable in weight.

Huerta et al reported moderate correlation between BMI and plantar fascia thickness.[18] In the present investigation, we confirm their findings by reporting a significant positive correlation between the plantar fascia thickness and BMI of the study group (r = .545, *P* = 0.003).

The results from the present study were in agreement with the hypothesis of a significant decrease in the plantar fascia thickness associated with symptomatic improvement in the patient group with PF (Table 6). All 30 patients demonstrated statistically significant decrease in the plantar fascia thickness post symptomatic resolution. Our purpose was to compare the thickness of the plantar fascia on US before and after relief of pain, not to necessarily assess the efficacy of a particular treatment modality of PF, as in the studies by Kamel et al and Kane et al with corticosteroid injections.[10,13] To achieve our goal of getting the symptomatic patient group to the state of pain relief before visualizing their plantar fascia on US, we did

Table 6

PLANTAR FASCIA THICKNESS PRE/POST TREATMENT

	M (cm)	SD (cm)	t	*P*
Pre-Treatment	0.621	0.113	12.105	< 0.001
Post-Treatment	0.418	0.096		

Table 7

WILCOXON'S SIGNED RANKS TEST FOR DIFFERENCES IN PRE- AND POST-TREATMENT PAIN SCORES

	n	z	*P*
Pre- to Post-treatment AM Pain	30	-4.819	< 0.001
Pre- to Post-treatment Noon Pain	30	-4.779	<0.001
Pre- to Post-treatment PM Pain	30	4.848	< 0.001

Table 8

FRIEDMAN TEST COMPARING PRE- AND POST-TREATMENT PAIN BY TIME OF DAY

	MEAN RANK	df	X^2	*P*
Pre-treatment AM Pain	2.12	2	14.543	< 0.001
Pre-treatment Noon Pain	1.55			
Pre-treatment PM Pain	2.33			
Post-treatment AM Pain	2.12	2	1.564	0.458
Post-treatment Noon Pain	1.90			
Post-treatment PM Pain	1.98			

not limit them to one specific type of treatment, but rather subjected them to combination of therapies to maximize the effect. All 30 patients enrolled in the study were followed until the patients judged their own symptoms to be pain free, minimal pain, or reached maximum medical improvement, with the end result of statistically significant decrease in pain level after treatment (Table 7).

Clinical presentation of PF is generally reported to be gradual onset of pain in the inferior heel, worse when taking the first few steps in the morning or after a period of inactivity.[16,19] The patient with PF tends to feel better with gradually increased activity but worsens in pain towards the end of the day with increased duration of weight-bearing activity.[16] To date, however, there is no study published to test the validity of these reports, which remain largely based on clinical observations. In the present study, we asked the symptomatic group to rate their pain level on the Faces Pain Rating Scale at 3 times in the day, in the AM, noon and PM, both before and after treatment. Pain scores taken after treatment did not show any statistically significant difference from AM to noon to PM; since scores were taken after PF symptoms had been resolved, no fluctuation in the pain level reportedly typical of PF was assessed (Table 8, bottom half). However, pain scores taken before treatment revealed a significantly increased level of pain in the PM.

Our results confirmed most pain in the PM, followed by AM and the least pain at noon, with only the difference in the pain level between PM and noon being statistically significant (Table 8, top half). To reiterate, the AM pain was not significantly different from either noon or PM pain. This finding suggests that repeated mechanical trauma causing microtears in the plantar fascia during the day with increased weight-bearing activity, i.e., the PM pain, may be the more prevalent factor in pain than AM post static dyskinesia, although there is no statistically significant difference found between the two.

Although it has been amply demonstrated that a significant decrease in the patients' grading of their symptomatic complaints after treatment is associated with a decrease in their plantar fascia thickness, we could not find statistical correlation between these two variables. Using a Spearman rho correlational analysis, there was no statistically significant correlation between the reduction in the absolute thickness of the plantar fascia and reduction in reported level of pain. In other words, while the amount of plantar fascia thinning did not equate to a predictable mathematical relationship with the reduction in pain levels, all 30 patients enrolled in the study group still experienced symptomatic improvement. Subjective assessment of pain, with variance in pain threshold from patient to patient, as well as variance in the time span between the initial and final US measurement of plantar fascia thickness, may be the large contributing factors in the absence of systematic relationship between the two variables. Also, variance in the duration of PF symptoms until first seeking medical help could be another important factor. In 1995, Fabrikant and Ly found that the longer the patient experienced PF symptoms or delayed seeking treatment for symptoms, the less likely they would respond to conservative therapy.[20]

Concerning the diagnosis of plantar fasciitis versus plantar fasciosis, there are further questions to be posed with respect to the disease process, especially given the varying lengths of treatment required to resolve the individual symptoms in this study. If one subscribes to the notion that plantar fasciitis is a temporary thickening due to softening of the plantar fascia from fluid infiltrates as viewed in US, then he or she could reasonably expect to see a significant decrease in plantar fascia thickness accompanying symptomatic improvement. This view would then lead to the obvious notion that a true fasciosis, which is a non-inflammatory thickening of the fascia as a result of degenerative changes, would not respond as readily to rest and, correspondingly, would not decrease as much in thickness as a more truly inflamed, fluid influenced tissue. One could then consolidate these hypotheses as follows: that plantar fasciitis/fasciosis disease process actually constitutes a continuum. Perhaps heel pain may begin as a traction and/or pressure plantar fasciitis with softening and thickening early onward, where it responds to injections and biomechanical rest afforded by orthotics in the form of stretch and pressure limitation of the plantar fascia. At an indeterminate future date, as a result of long term chronic stretch and focal pressure on the fluid enhanced plantar fascia, the plantar fascia develops fiber fragmentation and myxoid degeneration, and morphs into plantar fasciosis, similar to the Achilles tendinosis.

CONCLUSION

This prospective study confirmed: reports from previous investigations that the plantar fascia thickness in symptomatic patients is significantly thicker on US than that in non-symptomatic ones; that the plantar fascia thickness diminishes on US with successful treatment; that clinical treatment with injection and biomechanical correction has a salutary effect on plantar fascia thickness that is measurable; that patient reports of improvement in their own symptomatic complaints were associated with a reduction in plantar fascia thickness as measured by US, although there was no statistically significant correlation; and that plantar fascia tenderness is truly at its worst towards the end of the day. Office based

ultrasound can help diagnose and confirm plantar fasciitis/fasciosis through the measurement of the plantar fascia thickness, as well as the typical visual presentation of symptomatic plantar fascia. As a non-invasive, cost effective and radiation-free diagnostic modality, US should be considered and implemented early in the diagnosis and treatment of plantar fasciitis/fasciosis.

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