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# Sonographic Evaluation of Plantar Fasciitis and its Relation to Body Mass Index and Heel Pad Thickness

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## ABSTRACT

**Introduction:** Planter fasciitis is one of the most common causes of heel pain. The objective of this study is to study the sonographic appearance of plantar fascia in clinically suspected cases and to establish the correlation between plantar fasciitis, body mass index (BMI) and heel pad thickness (HPT).

**Methods:** In this case controlled analytical study, we sonographically evaluated 100 patients with clinical plantar fasciitis (unilateral: 90, bilateral: 10 with mean age 46.9yrs) and control group of 60 (120 heels) healthy volunteers with mean age 45.3yrs.

**Results:** Mean Plantar Fascia Thickness (PFT) and Heel Pad Thickness (HPT) are greater on the symptomatic side for patients with unilateral and bilateral PFs than on the asymptomatic with unilateral PFs, and also control subjects (PFT values are 4.41 ± 0.59, 4.63 ± 0.55, 2.83 ± 0.36, 2.62 ± 0.37 mm, and HPT values 17.64 ± 1.07, 17.28 ± 1.10, 16.91 ± 1.06, 16.73 ± 1.13 mm, respectively). ($p < 0.0001$). Mean BMI values of the case and control groups are 26.14 ± 1.9 and 24.42 ± 0.89 Kg/m$^2$, respectively ($p < 0.05$). We found hypoechogenicity of plantar fascia in 80 cases (72.7%), calcaneal spur in 69 cases (62.7%), biconvexity in 11 cases (10%) and perifascial fluid in 16 cases (14.5%) within the plantar fasciitis group (110 symptomatic heels).

**Conclusion:** Increased plantar fascia thickness, increased heel pad thickness and hypoechogenicity of plantar fascia are consistent sonographic findings in plantar fasciitis. Its occurrence has significant relation to high BMI.

***Keywords:*** *Aponeurosis; Body Mass Index; Calcaneus; Heel Spur*

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## INTRODUCTION

The plantar fascia is a strong multi-layered fibrous aponeurosis originating on the plantar surface of the posteromedial calcaneal tuberosity that provides static and dynamic support to the arch of the foot and assist with shock absorption during foot strike.[1,2]

Plantar fasciitis is a common pathological condition affecting the hind foot, and can often be a challenge for clinicians to successfully treat.[3,4] It is usually caused by bio-mechanical imbalance due to repeated strain resulting in tension along the fascia leading to micro tears and subsequent inflammation at its insertion.[1,5] Effective treatment requires an accurate diagnosis on the basis of the clinical findings with pathognomonic feature being the tenderness at the insertion site.[6,7,8]

A study by Nuran Sabir et al.[9] showed similar accuracy and effectiveness of sonogram in morphological assessment and diagnosis of plantar fasciitis as compared to MRI and is usually preferred because of its certain advantages over it like non-invasiveness, relatively inexpensive modality with excellent spatial resolution and well tolerated by patient. Real-time high-resolution ultrasonography has been proven to be a valuable technique for the diagnosis of plantar fasciitis.

Thickened plantar fascia is a well-established sonographic criteria for the diagnosis and has been previously reported in several studies.[10,11,12,13,14,15]

Studies were done in the past to evaluate the correlation between plantar fasciitis and body mass index (BMI) as well as heel pad thickness (HPT). However, they had recruited only small numbers of cases and often also lacked good comparison to well-controlled subjects.[11,14] HPT which plays an important role in shock absorption on ambulation, has not been sufficiently addressed in published studies. Little reference was directed as to whether HPT increased or became atrophic in plantar fasciitis.[16]

So, this study was done to evaluate both quantitative and qualitative sonographic parameters of plantar fascia in plantar fasciitis, to establish it's correlation with BMI and HPT in patients with a clinical diagnosis and to compare these findings with those of demographically-matched, asymptomatic control subjects.

## METHODS

This was a case controlled analytical study conducted in the Department of Radiology, Tribhuvan University Teaching Hospital, Kathmandu, Nepal from May 2017 to April 2018. The study was approved by ethical committee of the institution and informed consent were taken from all subjects. Study protocol included the use of high-resolution Ultrasound (10MHz) to evaluate the quantitative (plantar fascial thickness and associated heel pad thickness) as well as qualitative parameters (echogenicity, biconvexity, perifascial fluid collection, fascial rupture, fascia calcification, and presence of calcaneal spur) for 100 consecutive patients with clinical plantar fasciitis, presenting in the outpatient clinic of Orthopedics surgery department with heel pain. One hundred twenty feet of 60 healthy volunteers were also examined as control subjects.

Lateral X ray of the foot was obtained for all patients to confirm the presence/absence of subcalcaneal bony spur. Soft tissue and bones of the foot were also evaluated.

B-mode Ultrasound was performed in prone position with the feet hanging over the edge of the examination table to stretch the plantar fascia and better delineate its margins. Weight and height of every case and control subject were recorded and BMI was calculated by using the standard formula [BMI=Weight (in Kilogram)/(Height in meter)$^2$]. Data obtained were compiled and analyzed by standard statistical analytical tools using SPSS 11.5 Software.

## RESULTS

### Demographic distribution of study groups

Demographic features of all study subjects are demonstrated in Table 1. This shows that the occurrence of plantar fasciitis is more common in middle aged females (71 out of 100 patients in the age range between 40-50yrs). The healthy volunteers in the control group also has similar pattern of age and sex distribution, most common age range being 40-50yrs (mean 45.3yrs) with 73% of female participants.

***Table 1: Demographic features of all study subjects***

| Demographic Parameters | Healthy control group(n=60) | Patient with plantar fasciitis(n=100) | |
|---|---|---|---|
| | | Unilateral(n=90) | Bilateral(n=10) |
| Age(years) | Mean=45.38 Std. D =4.41 Minim=39 Max-im=65 | Mean=46.14 Std. D =8.75 Minim=28 Max-im=68 | Mean=47.70 Std. D =5.23 Minim=39 Maxim=56 |
| Sex(male : female) | M=16 (26.7%) F= 44 (73.3%) | M=26 (28.9%) F=64 (71.1%) | M=3(30%) F=7 (70%) |
| Height(cm) | Mean=164.05 Std. D =4.64 Minim=156 Max-im=173 | Mean=159.81 Std. D =5.65 Minim=147 Max-im=172 | Mean=163.40 Std. D =4.79 Minim=156 Max-im=171 |
| Weight(Kg) | Mean=65.70 Std. D =3.12 Minim=60 Max-im=75 | Mean=66.64 Std. D =6.49 Minim=54 Max-im=90 | Mean=71.40 Std. D =4.57 Minim=65 Maxim=78 |
| BMI(Kg/m2) | Mean=24.42 Std. D =0.89 Minim=22.39 Maxim=26.84 | Mean=26.08 Std. D =1.99 Minim=19.2 Maxim=33.1 | Mean=26.67 Std. D =0.88 Minim=24.50 Maxim=27.60 |

### Sonographic findings (Qualitative parameters) of plantar fascia

The qualitative parameters of Plantar fascia obtained sonographically include echogenicity, biconvexity, perifascial fluid, intra-fascial calcification and subcalcaneal spur (Table 2).

### Sonographic findings (Quantitative parameters) of plantar fascia and associtated heel pad thickness

Table 3. shows the quantitative sonographic findings which includes plantar fascia thickness (PFT) and heel pad thickness (HPT) within the study groups. In control group (16 men, 44 women), mean PFT is 2.62 ± 0.37mm (2.10-3.60mm), in unilateral plantar fasciitis group (26 men, 64 women), on symptomatic side, it is 4.63 ± 0.55mm (3.30-6.10mm) and on asymptomatic side 2.83 ± 0.36mm (2.20-3.90mm).In Patient with bilateral plantar fasciitis, mean PF thickness is 4.41 ± 0.59mm (3.30-5.30mm) The difference is statistically significant ($p < 0.0001$) between the plantar fasciitis and control groups. When we

compared the 90 unilateral heels with PFs to contralateral normal heel, mean PF thickness [4.63 ± 0.55mm (3.30-6.10mm)] in painful side to that of contralateral normal side [2.83 ± 0.36mm (2.20- 3.90mm)], the difference is also statistically significant (p <0.0001). PFT on the asymptomatic side of patients with unilateral plantar fasciitis is also significantly greater than that of control subjects (p~0.001). HPT on both sides for patients with bilateral and on the symptomatic side with unilateral plantar fasciitis being greater than on the asymptomatic side and also, than the control subjects (17.64 ± 1.07mm, 17.28 ± 1.10mm, 16.91 ± 1.06mm, 16.73 ± 1.13 mm, respectively) and these differences are statistically significant (P <0.0001) (Table 3).

***Table 2: Sonographic findings (Quantitative parameters) of plantar fascia and associated Heel pad thickness***

| Sonographic Findings (qualitative parameters) | Healthy control group [n=60(120 feet)] | Patient with unilateral plantar fasciitis (n=90) | | Patient with bilateral plantar fasciitis [n=10(20 feet)] |
|---|---|---|---|---|
| | | Symptomatic side(n=90) | Asymptomatic side(n=90) | |
| Hypoechogenicity | 3 (2.5%) | 65 (72.20%) | 0 | 15 (75%) |
| Biconvexity | 0 | 8 (8.9%) | 0 | 3 (15%) |
| Perifascial edema | 0 | 10 (11.10%) | 0 | 6 (30%) |
| Intrafascial calcification | 0 | 0 | 0 | 0 |
| Fascial rupture | 0 | 0 | 0 | 0 |
| Subcalcaneal spur | 12 (10%) | 57 (63.30%) | 8 (8.9%) | 12 (60%) |

***Table 3: Quantitative sonographic findings which includes plantar fascia thickness (PFT) and heel pad thickness (HPT) within the study groups***

| Sonographic Findings | Healthy control group [n=60(120 feet)] | Patient with unilateral plantar fasciitis(n=90) | | Patient with bilateral plantar fasciitis[n=10 (20 feet)] |
|---|---|---|---|---|
| | | Symptomatic side (n=90) | Asymptomatic side(n=90) | |
| Plantar fascial thickness (mm) | Mean=2.62<br>Std. D =0.37<br>Minim=2.10<br>Maxim=3.60 | Mean=4.63<br>Std. D =0.55<br>Minim=3.30<br>Maxim=6.10 | Mean=2.83<br>Std. D =0.36<br>Minim=2.20<br>Maxim=3.90 | Mean=4.41<br>Std. D =0.59<br>Minim=3.30<br>Maxim=5.30 |
| Heel Pad Thickness (mm) | Mean=16.73 Std. D =1.13<br>Minim=13.80<br>Maxim=19.10 | Mean=17.28<br>Std. D =1.10<br>Minim=15.10<br>Maxim=19.70 | Mean=16.91<br>Std. D =1.06<br>Minim=14.90<br>Maxim=19.20 | Mean=17.64<br>Std. D =1.07<br>Minim=14.90<br>Maxim=19.10 |

P <0.001 between the above 4 groups by one way ANOVA test.

## BODY MASS INDEX (BMI)

Table 4. gives the BMI data calculated as the ratio of body weight in kilogram to (height in metre)$^2$. The BMI for the patients with heel pain is higher than that of the control group. Mean BMI values of the case and control groups are 26.14 ± 1.9 (19.2-33.1) and 24.42 ± 0.89 (22.39-26.84), respectively. The difference is statistically significant ($p < 0.05$) (Table 8).

Linear relationship was observed between the BMI and Plantar fascia thickness (PFT) (figure 1) within the study groups. It was found that the higher the BMI value, the greater was the PFT ($p < 0.05$) (Table 4).

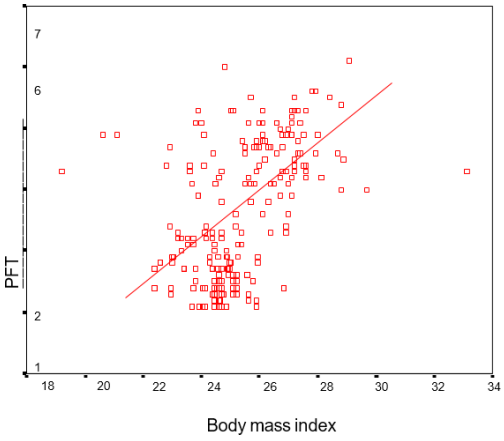


***Figure 1:*** *Linear scattered graph showing linear relationship between PFT (y-axis) and BMI (x-axis).*

***Table 4: Body mass index (correlation between case and control)***

| | Clinical diagnosis | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| BMI | Case | 100 | 26.1410 | 1.91871 | .19187 |
| | Control | 60 | 24.4211 | .89577 | .11564 |

# DISCUSSION

The plantar fascia, arising from the calcaneal tuberosity, extending to the forefoot and spanning the longitudinal arch, is the most important structure for dynamic arch support.[17,18]

According to Barrett SJ et al.[6] Plantar Fasciitis occurs in both sexes but is more common in women. We too found that the incidence is more common in the middle aged females, 71 out of 100 patients in the age range between 40-50yrs.

This study results indicate that the mean PFT in the patients with plantar fasciitis is greater than that of control group and contralateral normal foot in unilateral case. Mean difference is 2.01mm in unilateral and 1.79mm in bilateral plantar fasciitis group respectively. Similarly, mean difference of PFT between PFs and asymptomatic foot within the unilateral fasciitis group is 1.80mm.

In several studies, plantar fascia standard thickness shows different values for normal individuals. Mean PF thickness was reported 3.3mm (2.4-4.3mm) in the report of Gibbon W et al.[14] 2.6mm (1.6-3.8mm) in the study of Cardinal et al.[11] 3.4mm for females and 3.6mm for males by Wall et al.[15] Measurements in this study are lower than others reported and similar to those shown by Cardinal et al.[11] Cause of this difference may be attributed to lack of standardization of measurement point at longitudinal plain.

The difference in PFT was found to be statistically significant ($p < 0.0001$) between the plantar fasciitis and control groups. When we compared the 90 unilateral heels with PFs to contralateral normal heel i.e. mean PFT [4.63 ± 0.55mm (3.30-6.10mm)] in painful side to that of contralateral normal side [2.83 ± 0.36mm (2.20-3.90mm)], the difference was found to be statistically significant ($p < 0.0001$).

According to the study of Wall et al.[5] a PF thickness more than 4mm if associated with inflammatory changes would be consistent

with PFs.[15] Tsai WC et al.[16] also chose thickness of 4mm as a cut-off point to distinguish normal fascia from inflammatory fascia. In their study, the sensitivity of ultrasound in detecting plantar fasciitis was 91.9% (113/123), specificity was 90.5% (133/147), as they found fascia thickness less than 4.1mm in 10 symptomatic heels.

In our study, we too found the mean PFT >4mm in plantar fasciitis groups, the values being 4.63 ± 0.55mm (3.30-6.10mm) on symptomatic side of unilateral and 4.41 ± 0.59mm (3.30-5.30mm) in bilateral groups respectively. However, in 11 out of 110 symptomatic heels, the PFT is < 4mm.

In Gibbon W et al.[14] study plantar aponeurosis demonstrated sonographic features of tendonitis in 78%, perifascial fluid in 4% and intra-tendinous calcification in 3% of the patients. Similarly, Huseyin Ozdemir et al.[19] showed hypoechogenicity in 41%, biconvexity in 5.1% and perifascial fluid in 2.5% of plantar fasciitis.

Our study demonstrated hypoechogenicity in 72.20%, perifascial edema/fluid (11.10%), biconvexity in 8.9% cases of unilateral plantar fasciitis. Similarly, bilateral cases showed hypoechogenicity, perifascial edema and biconvexity in 75%, 30% and 15% respectively. However, fascial rupture and intra-fascial calcification are absent in both unilateral and bilateral cases.

Body weight has been implicated as a factor in plantar heel pain. Our results are consistent with other studies which reported a relationship between BMI and PFs occurrence.[19,20] The body mass index (BMI) is significantly higher in the patient compared to the control group suggesting that overweight may be a factor predisposing to heel pain by exerting excessive stress on the plantar fascia. Linear relationship was observed between BMI and PFT within the study groups as we found greater PFT with higher BMI value.

Mean heel pad thickness (HPT) was also found to be significantly greater in symptomatic heels than normal heels as observed in many other studies. Amis et al.[21] have reported a significantly increased HPT in patients with plantar fasciitis. Similarly, Prichasuk S.[22] also found that the heel-pad thickness and the compressibility index (resistance to compression) were greater in the patient groups.

## CONCLUSION

Ultrasonography (US) is an important tool for the evaluation of Plantar fasciitis, because of its easy availability, quick performance, high sensitivity of diagnosis, low-cost and free of radiation. Increased plantar fascia thickness and hypoechogenicity are consistent sonographic findings in patients with plantar fasciitis. There is significant correlation observed between occurrence of plantar fasciitis and BMI. Similarly, statistically significant differences ($p < 0.05$) are observed regarding heel pad thicknesses among the study groups, the values being greater in the patient with plantar fasciitis as compared to the control group

## CONFLICT OF INTEREST

None

## SOURCES OF FUNDING

None

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