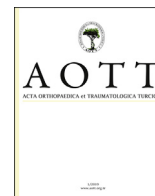


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## The thickness of heel fat-pad in patients with plantar fasciitis

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## ABSTRACT

**Objective:** The aim of this study was to investigate the thickness of heel fat pad (THP) and to detect the relationship between the plantar fasciitis (PF) and age, occupation, BMI, longitudinal arch, the thickness of heel fat-pad in the patients with PF.

**Methods:** A total of 50 patients (29 women and 21 men; mean age: 46.5 years (range: 22–70)) that were diagnosed with PF were included to this study. Patients' affected side were compared with the healthy opposite side with the angle of medial arch (AMA) and first metatarsophalangeal angle (FMTPA) on the foot radiograms, and THP and thickness of first metatarsal fat pad (TFMFP) using ultrasonography (USG) of both feet.

**Results:** The mean AMAs of feet with pain and without pain were 122.56° and 120.60°, respectively. The mean FMTPAs of feet with pain and without pain were 14.72° and 14.40°, respectively. The mean THPs of feet with pain at the point of the medial calcaneal tubercle and the mean TFMFPs of the feet with pain at the point of the first metatarsal head were 19.45 mm and 6.75 mm, respectively. The mean THPs of feet without pain at the point of the medial calcaneal tubercle and the mean TFMFPs of the feet without pain at the point of the first metatarsal head were 19.94 mm and 6.75 mm, respectively. It was observed that the mean AMA in the heels with pain was significantly higher than that of the heel without pain ( $p < 0.05$ ) and the mean THP in the heels with pain was significantly thinner than that of the heel without pain ( $p < 0.05$ ).

**Conclusion:** The results indicate that USG is an accurate and reliable imaging technique for the measurement of THP in the diagnosis of plantar fasciitis and the heel pad was thinner in the painful heels of patients with plantar fasciitis.

**Level of evidence:** Level III, Diagnostic Study.

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## Introduction

Plantar fasciitis (PF), generally a self-limiting condition, is identified as one of the most common causes of heel pain in adults. It affects both sedentary and athletic populations, with more than one million people diagnosed per year in the USA.<sup>1,2</sup> It may be considered that PF emerges due to excessive and prolonged standing or running, which causes an acute inflammation or micro-

tears, and degenerative changes at the calcaneal enthesion and plantar fascia. The persistence of these risk factors inhibits the regular repair process thus collagen degeneration occurs, causing the structural changes of the plantar fascia. Furthermore, perifascial edema may occur and a thicker heel pad develops in these patients.<sup>1–3</sup> Increased heel pad thickness causes a loss of elasticity. The thickness of the plantar fascia causes a decrease in the elasticity of the fascia and a decrease in shock absorbing capabilities. The main risk factors for PF can be listed as: excessive foot pronation (pes planus), excessive running, high arch (pes cavus), leg length discrepancy, obesity [Body Mass Index (BMI) greater than 30 kg/m<sup>2</sup>], occupations that require prolonged standing and walking, sedentary lifestyle, and tightness of the Achilles tendon and intrinsic foot muscles.<sup>4–7</sup>

PF is diagnosed primarily based on the patient's medical history and physical examination. However, diagnostic imaging, including

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ultrasonography (USG) and magnetic resonance imaging (MRI), may be needed for the diagnosis of recalcitrant cases. Both imaging methods reveal increased plantar fascia thickness and tissue abnormalities in the presence of PF. Ultrasonography, a non-invasive and inexpensive method compared to MRI, is useful in ruling out soft tissue pathology of the heel. The findings of USG supporting the diagnosis of plantar fasciitis are characterized with proximal plantar fascia thickness larger than 4 mm and areas of hypoechogenicity.<sup>1–3,8–10</sup>

Heel pad thickness is a significant indicator for the stresses occurred in tissues.<sup>11–15</sup> A recent study demonstrated that the thickness of the heel pad was significantly greater in patients with plantar heel pain but not PF.<sup>6</sup>

To the best of our knowledge, there is not any study present concerning with the measurement of the thickness of the heel fat pad in the patients with PF in the literature. In this study, we purposed to investigate the thickness of the heel fat pad in patients with PF.

## Materials and methods

This study was performed in the Orthopaedics and Traumatology Department of our university hospital with the contributions of the Radiology Department. This research was designed as an institutional, prospective study and included 50 patients with unilateral PF. This study was approved by the Institutional Ethics Committee of our university. The study was conducted according to the Helsinki Declaration. Informed consents were obtained from the patients. Patients with bilateral PF were excluded from the study.

The diagnosis of PF was made on the basis of clinical examination and radiologic evaluation. Fifty patients who were diagnosed with PF of single feet and followed for at least one year were included in this study. These patients had to be generally healthy without having a known history of systemic disease with symptoms similar but not limited to plantar heel pain, rheumatoid arthritis, seronegative arthritis, gout and diabetes mellitus. Exclusion criteria included a history of previous foot surgery, recent trauma to the foot, congenital deformity of the lower extremity, or previous corticosteroid injection in the heel. Complete orthopedic examination was performed on all of the patients who were included in this study. Patients' feet, the one with pain and the other one without pain, were evaluated at the same time and the data obtained from these feet were compared.

### Anthropometric measurement technique

Anteroposterior and lateral radiograms of the patients' feet, under loading conditions, were taken as previously described in the literature.<sup>16</sup> The angle of the medial arch (AMA), first metatarsophalangeal angle (FMTPA), thickness of heel pad (THP), thickness of first metatarsal fat pad (TFMFP) of both feet (Figs. 1–3), and BMI for all patients were measured and the demographic characteristics, including occupation, age, sex, and shoe type preference were recorded.

The bones forming the medial longitudinal arch in the foot are calcaneus, navicular, three cuneiforms and first to third metatarsal bones and head of the talus. The first metatarsophalangeal angle is the angle between the first metatarsus and first proximal phalanx. The first metatarsal fat pad is located at under the head of the first metatarsal bone. The heel pad is located at under calcaneus. All of these parameters are important measures for the evaluation of the foot biomechanics.<sup>6,17</sup>

The AMAs and FMTPAs were measured on the radiograms. A single USG device (Philips EPIQ 5 L12-5 50 mm 12-5 MHz linear-

array transducer, Philips Medical System, Andover, MA, USA) was used throughout the study by a single operator to measure the unloaded THPs and TFMFPs of all the patients. A method has been developed to take ultrasound measurements by reviewing previous studies.<sup>18–20</sup> The patients were placed on the examination table in a prone position so that their feet were free outside the table. The plantar heel was marked in the sagittal plane to be divided into three equal sections, and the measurements were made in the center line. The first metatarsal fat pad thickness measurement was performed by placing the probe on the plantar surface of the first metatarsal head. The ultrasound probe was connected to a dynamometer capable of measuring compression loading and fixed to a portable stand. The loads applied to the heels were kept within a certain range (0.1–0.2 g). The pressure refers to the force applied to the unit area. Since the surface area of the probe is constant, the applied load also reflects the applied pressure. Necessary measurements were taken on the ultrasonographic images captured under constant pressure (Fig. 3). The THP was determined by measuring the shortest distance between the medial calcaneal tuberosity and the skin surface (Fig. 4).

### Statistical analysis

Statistical analysis of the study was performed with Statistical Package for the Social Sciences ver. 21 (SPSS, Chicago, IL). A paired t-test was used to evaluate the differences among the measurement of the angle of medial arch (AMA), first metatarsophalangeal angle: (FMTPA), the thickness of heel pad (THP), the thickness of first metatarsal fat pad (TFMFP). A linear regression test was used to evaluate the correlation between body-mass index (BMI), age, sex, weight, AMA, FMTPA, THP, and TFMFP. A chi-square test was used to compare the incidence of PF in occupation matched the painful and painless feet. P values less than 0.05 were considered statistically significant.

## Results

Patients included 29 women (58%) and 21 men (42%). Thirty patients (60%) complained about their right foot while rest 20 (40%) complained about their left foot. The mean age of the patients was 46.5 years old (range: 22–70 years old).

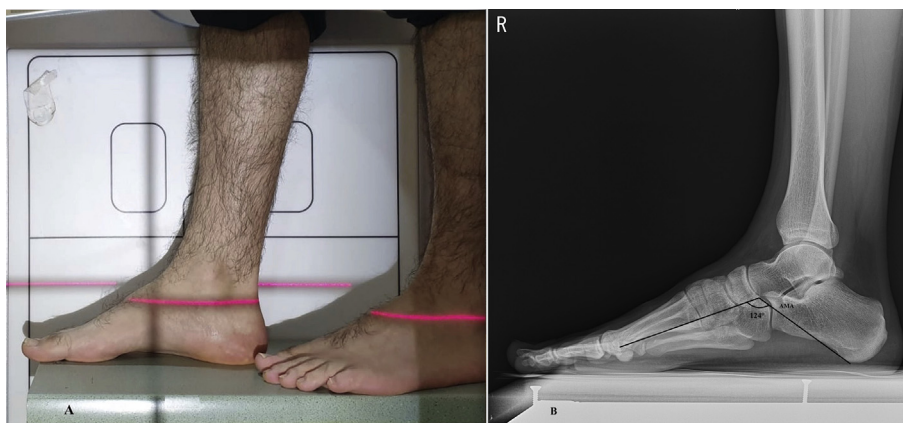
The occupational distribution was as follows: eighteen (36%) housewives, nine (18%) retired, eight (16%) workers, six (12%) officials, four (8%) teachers, four (8%) university students, one (2%) bus driver. While there were no professional athletes in the study group, four patients (8%) were interested in sports (two footballs, one bodybuilding, and one aerobics and stepping). On the other hand, fifty-four percent of the patients had a sedentary lifestyle. When the AMA, FMTPA, THP and TFMFP values in the foot with pain of the patients were compared, there was no statistically significant difference were found between the sedentary patients' and the non-sedentary patients' ( $p = 0.300$ ,  $p = 0.598$ ,  $p = 0.661$  and  $p = 0.930$  respectively).

The mean duration of the complaints was 29.13 months (ranging from 1–120 months). Initial examination questions revealed that in 28 patients (56%), the pain started with the first few steps in the morning and decreased after walking for a few minutes. Twelve (24%) patients had pes planus. A calcaneal spur was observed in 33 (66%) of the heels with pain, whereas calcaneal spurs were seen in only 11 (22%) of the heels without pain.

The mean values of the weight, height and BMI were 80.46 kg (ranging from 55 to 110 kg), 167.26 cm (ranging from 150 to 179 cm), and 28.72 kg/m<sup>2</sup> (ranging from 19.04 to 39.14 kg/m<sup>2</sup>), respectively. The BMI was over 30 kg/m<sup>2</sup> in 33 of the 50 patients (66%), while it was less than 30 kg/m<sup>2</sup> in the remaining 17 patients



**Fig. 1.** Weight-bearing anteroposterior foot radiography is taken at an angle of 15° with the patient standing. Central beam targets lateral cuneiform. B. FMTPA describes the angle between the first metatarsal and the proximal phalanx.



**Fig. 2.** Lateral x-ray of weight-bearing foot, A. Taken while the patient is standing. Central beam targets lateral cuneiform. B. AMA, the angle between lines drawn from the inferior calcaneus to the inferior edge of the joint between the talus and navicular to the first metatarsal head.

(34%). Patients with a BMI higher than 30 kg/m<sup>2</sup> were considered to be obese. When we compared the AMA, FMTPA, THP and TFMFP values in the painful feet of the patients, there were no statistically significant difference observed between the obese patients' and non-obese patients' ( $p = 0.291$ ,  $p = 0.812$ ,  $p = 0.372$  and  $p = 0.633$  respectively).

The mean AMAs of feet with pain and without pain were 122.56° (ranging from 107 to 142°) and 120.60° (ranging from 108 to 140°), respectively. The mean FMTPAs of feet with pain and without pain were 14.72° (ranging from 7 to 35°) and 14.40° (ranging from 8 to 29°), respectively. The mean THPs of feet with pain at the point of the medial calcaneal tubercle and the mean TFMFPs of the feet with pain at the point of the first metatarsal head were 19.45 mm (ranging from 12 to 29 mm) and 6.75 mm (ranging from 3 to 16 mm), respectively. The mean THPs of feet without pain at the point of the medial calcaneal tubercle and the mean TFMFPs of the feet without pain at the point of the first metatarsal head were 19.94 mm (ranging from 13 to 29 mm) and

6.75 mm (ranging from 3 to 16 mm), respectively. It was observed that the mean AMA in the heels with pain was significantly higher than that of the heel without pain ( $p < 0.05$ ) and the mean THP in the heels with pain was significantly thinner than that of the heel without pain ( $p < 0.05$ ).

When a correlation analysis was performed, significant relationships between age and AMA, and between age and THP were found (coefficient-  $\beta$ : 0.56, T: 2.42,  $p < 0.05$  for AMA; coefficient-  $\beta$ : 0.89, T: 2.01,  $p < 0.05$  for THP). However, no other significant relationships among the other parameters were observed.

## Discussion

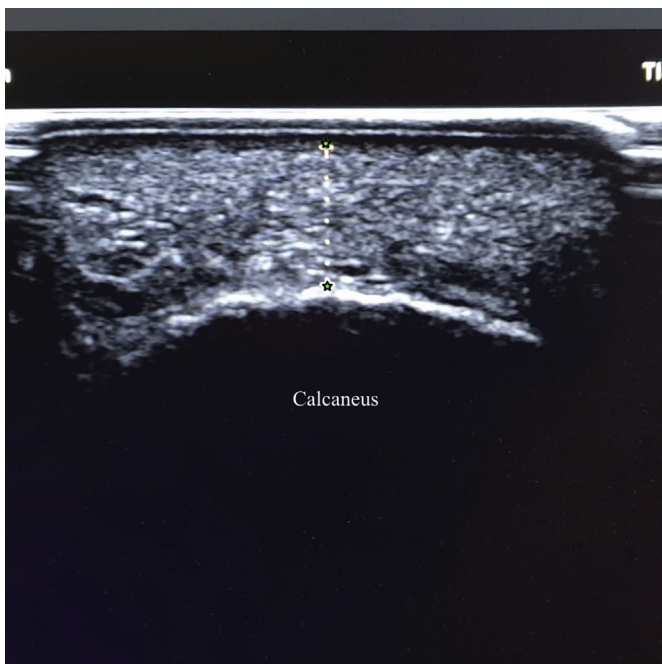
Plantar fasciitis (Heel Pain Syndrome, Heel Spur Syndrome) is the most common cause of the heel pain and is a local inflammatory disorder in the plantar aponeurosis of the foot. The exact etiology of PF is unknown. However, it is believed that persistent and frequent microtraumas to the planar face of the heel may cause





**Fig. 3.** A. The position of the ultrasound probe connected to the dynamometer targeting the heel of the patient in the prone position. B. Ultrasonographic measurement of heel fat pad thickness under constant pressure. (yellow arrow, dynamometer display; green arrow, ultrasound probe; blue arrow, dynamometer sensor.)

micro tears at the site of the adhesion of the plantar fascia to the calcaneus; chronic inflammatory reactions and a delayed tissue repair process are also suspected in the pathogenesis of PF.



**Fig. 4.** The measurements of the thickness of heel pad at the point of the medial calcaneal tubercle.

Currently, it is hypothesized that PF is a degenerative disorder that especially affects collagen or the plantar fascia.<sup>1–3</sup> There are three main reasons for the etiology of plantar fasciitis. These are; mechanical causes (pronated foot, external rotated foot, pes cavus and obesity), degenerative causes (increased foot pronation of the heel fat pad atrophy and age) and systemic causes (rheumatoid arthritis, systemic lupus erythematosus, gout, ankylosing spondylitis and Reiter's syndrome).<sup>21</sup> In addition, it has been reported by Rajput et al<sup>21</sup> that footwear is involved in the etiology of plantar fasciitis. Improper footwear preferences can trigger the occurrence of the plantar fasciitis, aggravate the existing condition or reduce the response to the treatment.<sup>21</sup> Footwear modification or orthotics are widely used in the treatment of plantar fasciitis, although their efficacy is not clear.<sup>22,23</sup> Shoes that reduce pronation, partially increase heel height or rocker-sole shoes are the preferred footwear modifications in plantar fasciitis.<sup>24</sup> In this study, we have not observed a significant relationship between plantar fasciitis and footwear preferences of the patients.

The THP is an important indicator for the stresses seen in the tissues. It has been reported that the THP in healthy adults ranges from 12 mm to 28 mm.<sup>12–15,17,25</sup> On the other hand, in a recent study, Rome et al demonstrated that the THP was significantly greater in patients with plantar heel pain while PF was not.<sup>6</sup> In the present study, it was found that the THP of the heels with pain was statistically thinner than that of the heels without pain; and the mean AMA in the heels with pain was significantly higher than that of the heel without pain. While there was no significant difference between FMTPAs of the patients with and without heel pain. Our findings concerning the thinning of the heel pad or decreasing of the THP is consistent with the literature.<sup>6,12–15,17,25</sup> It can be considered that the thinning of the heel pad may be due to heel pad

degeneration caused by chronic microtraumas. In addition, the mechanical properties of the heel pad in the elderly are different from the youth. The elderly have a thicker and stiffer heel fat pad compared to young people.<sup>20</sup> This greatly reduces the shock absorption capacity of the heel fat pad and, as a result, makes it more susceptible to injury.<sup>20</sup> The intrinsic and extrinsic muscles of the foot weaken with aging and the medial longitudinal arch cannot provide adequate support and consequently, the foot arch height decreases.<sup>26</sup> In the present study, significant relationships between age and AMA and between age and THP were found.

It has been known that pes planus is an important risk factor for the development of PF.<sup>1,4,17</sup> In this study, we identified that 24% of the patients had pes planus. This finding is also consistent with the literature.

Obesity is known as an important risk factor for the development of PF.<sup>1–4</sup> In the present study, we observed that the rate of obesity in women was higher than in men. Our obesity rate was 66%. It is believed that PF is a disorder related to excessive and prolonged standing or weight-bearing.<sup>1–4</sup> Baxter et al demonstrated that sports were a contributing factor in half of the patients with heel pain.<sup>27</sup> Since the present study included only four patients who participated in sports, we were not able to evaluate the effect of sports doing in the development of PF.<sup>1–4,28</sup> In the present study, 54% of patients with PF had a sedentary lifestyle. It is known that the risk of developing PF is higher in individuals with a sedentary lifestyle and obese compared to normal population.<sup>1–4,28</sup> It is also mentioned in the literature that sedentary lifestyle and obesity causes heel pain without causing obvious structural changes in the foot.<sup>29</sup> Similarly, in our study, no significant difference was found between the foot structures of both obese patients and sedentary patients compared to other patients.

This study has some limitations. The first is that there is no control group. Fat pad thickness differences between dominant and non-dominant feet in a healthy population is quite possible.<sup>19</sup> However, there was no statistically significant difference in the dominant and non-dominant distribution of the painful feet of the patients in this study ( $p = 0.203$ ). The second limitation is that patients' heel fat pad thicknesses are only measured in the case of non-weight-bearing. Weight-bearing measurements could not be carried out because we did not have the proper equipment to allow measurements under load. The third limitation is that the heel fat pad thicknesses of the patients could not be measured again after the treatment.

In conclusion, to the best of our knowledge, no previous studies concerning the relationship between THP and PF were conducted. Heel pain in PF is related to THP and loss of elasticity. Insufficient heel pad reduces shock absorption and causes heel pain. In the present study, it was seen that the heel pad was thinner in the painful heels of patients with plantar fasciitis. The results indicate that USG is an accurate, reliable and non-invasive imaging technique for measurement of THP in the diagnosing of plantar fasciitis. However, in order to evaluate the usefulness of this method in the follow-up of patients after treatment, clinical studies are needed in larger case series.

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## Conflicts of interest

All of the authors state that there is no conflict of interest.

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