

Utility of Ultrasound Measurement in the Diagnosis of Plantar Fasciitis in a Spanish Population

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ABSTRACT

Objective: To ascertain the correlation between the thickness of the plantar fascia (>4 mm) and chronic unilateral Plantar Fasciitis (PF) as stated in classic diagnostic criteria in a Spanish population. Second objective is to determine if plantar fascia thickness is correlated to foot pain and dysfunction in PF patients in the same study sample.

Design: Observational study of cases and controls.

Subjects: This study included 80 patients with chronic unilateral PF and 40 controls who underwent an ultrasound study in both feet.

Methods: Ultrasound Thickness Measurement (UTM) of the insertional plantar fascia was determined, and pain and foot dysfunction were quantified employing the Visual Analogue Scale (VAS) and Foot Health Status Questionnaire (FHSQ) for the patient group and control participants.

Results: In the PF patients group, the UTM showed a mean of 6.72 mm (SD: 1.26) compared to the mean of 3.39 mm (SD: 0.57) in the control group. Unlike the controls, these patients revealed significantly thickened fascia (>4 mm) (0.001) as accepted in current literature. In patients with UTM > 4 mm, Sensitivity (Se) of 98.8% and Specificity (Sp) of 88.8% were calculated. Nevertheless, from our results the most accurate cut-off value would be 4.41 mm (Se: 100%; Sp: 95%) in our population. The VAS showed a moderate level of positive correlation ($r = 0.537$) versus fascial thickness, as well as a discrete level of negative correlation ($r = -0.451$) with domain 1 of the FHSQ.

Conclusions: We conclude that UTM is slightly higher in our Spanish population than in current literature. This study demonstrates moderate correlation between pain and UTM of the plantar fascia.

INTRODUCTION

Plantar Fasciitis (PF) is a common disease causing some degree of disability. It occurs most frequently as heel pain and 10% of the general middle-aged population has been found to acquire it. It is often reported by those regularly involved in sports (> 25% of foot pathologies occur in athletes/runners). However, even more patients are affected in their 5th to 6th life decade. An estimated one million patients / year in the US seek treatment in Hospitals and Health Services for this condition [1].

The epidemiology of PF in the general population is currently uncertain. An Australian population-based study involving 3,206 randomly selected participants reported a heel pain prevalence of 3.6%. American studies estimate that 7% of older adults

suffer from tenderness beneath the heel [2]. Given the differences in survey design and study populations, it is not surprising that there is wide variability in PF prevalence (2.7%-17.5%) [3].

The etiopathogenesis of this disease remains unclear. Some authors explain it to arise as the result of excessive stretching tension to the fascia, with the occurrence of micro tears and an inflammatory repair process [4]; other authors, however, cite degenerative alterations (hyaline degeneration), without association with inflammatory findings [5]. In the radiographs of these patients there is a good chance of identifying a calcaneal spur, but the causal value of the pain is still to be clearly identified.

Several mechanical factors have been suggested to play a role in the mechanics of this degenerative process, including obesity, tread disturbance, physical activity, and reduced dorsiflexion angle [5-7]. Other demographic characteristics such as ethnicity may also be related to PF [3].

The patient goes through a clinical diagnosis, initially, deduced from the pain aspects narrated by himself and palpation of the pain site [1]. From the data, PF most frequently presents as morning pain, after a sustained period rest [6] and increased pain by the end of the day [8]. Martin et al., standardised these findings [9]. Today, imaging tests offer essential and complementary support. Although Magnetic Resonance Imaging (MRI) is extensively used to diagnose foot pathology, Ultrasound (US) can be a good option in the diagnosis of PF [10].

Several studies have shown that US changes in the plantar fascia structure are compatible with the clinical diagnosis and have currently accepted plantar fascia thickness as a diagnostic criterion of the disease (> 4 mm to be the reference value, considered pathological fascia) [10-20].

Chen JW et al., [21] and Nakhaee et al., [22], ascertain the inter-intra-observer validity as the high quality of reproducibility of the US in measuring the plantar fascia thickness.

We decided to realize a prospective study in a Spanish population having a clinical diagnosis of unilateral PF and perform an US study to ascertain the diagnosis of the disease. This will enable us to determine whether the coexistence between the clinical diagnosis of PF and > 4 mm thickness is

satisfied according to the claims in the existing literature. We will compare these data with a control group that includes healthy people to prove this US criterion's sensitivity and specificity. To ensure higher validity, we will compare the US with the contralateral (non-painful) foot of those patients with unilateral PF to identify if these patients have bilateral structural changes, irrespective of whether they can perceive pain in one foot. This will enable us to establish if the reference value (< 4 mm) in the non-pathological foot is also met in this scenario.

Finally, we will seek evidence for any relationship between the degree of the fascial thickness assessed via US with the intensity of pain and disability they perceive.

To our knowledge there is no similar study published to date in the Spanish population. Our initial hypothesis was that Ultrasound Thickness Measurement (UTM) in Spanish population with PF may be different with respect to other populations.

MATERIAL AND METHODS

Study design

This is an observational study of cases and controls.

Study subjects

We included eighty patients with a clinical diagnosis of unilateral PF of the General Hospital of Alicante. These patients had to fulfill the pain criteria associated with this disease (Martin et al., [9]): pain which rises when the first steps are taken post a period of inactivity, with prolonged standing, insertion pain through palpation, normality in active-passive ankle mobility, normality in tarsal tunnel test, positive windlass test or passive dorsiflexion of the first metatarsophalangeal joint.

Forty control subjects who consulted with us for other diseases not related to the feet were included and underwent an US study on both feet.

Demographic characteristics such as age, sex, laterality, Body Mass Index (BMI) and coexistence of Diabetes Mellitus (DM) were recorded for both groups. Standard standing radiographs were taken of each patient to rule out other possible causes of pain.

Inclusion criteria

Patients aged between 25 and 75 years were recruited for the study. They had typically only unilateral pain and symptoms for at least three months of evolution. Control

subjects were within the same age range of the study. Both before inclusion in this study, informed consent were obtained.

Exclusion criteria

Those patients with bilateral PF, earlier local trauma, prior foot surgery, and rheumatologic or autoimmune disease were excluded from this study, as well as those who had experienced previous corticosteroid infiltration. Control subjects were excluded if they had heel pain or other feet pathologies over the previous six months.

Study variables

Image variable (UTM of the plantar fascia): We performed a sagittal imaging of the plantar fascia with an US scanning and measured the insertion thickness. It was calculated as the distance from the level of the distal edge of the calcaneus, between the deep and superficial layers of the plantar fascia (Figure 1) [10]. Three measurements of the plantar fascia were taken to avoid error due to transducer obliquity, and the average of the 3 was recorded.



Figure 1: Ultrasound thickness of the plantar fascia measured as the distance between the two “x” markers at the distal edge of the calcaneus.

A physician having significant experience, performed this exploration using one US scanner: Hitachi Aloka F-37 (10-15 MHz linear probe).

The plantar fascia was evaluated via US maintaining the patient lying in the prone position, with the knee extended and the ankle fixed in a neutral position. Care was taken to position the US probe in the longitudinal plane parallel to the long axis of the plantar fascia (Figure 1).

In this study, for the 80 patients, measurements were taken from both the painful and the asymptomatic contralateral foot. Moreover, US study was done on both feet for the 40 controls.

Clinical variables: In order to correlate the UTM with the intensity of the clinical experience, data on the severity of pain were recorded, using VAS and the specific foot questionnaire (FHSQ) [23] which assesses the characteristics of the pain and disability through eight independent domains. The result is a value that ranges from 0 (poor health status) to 100 (optimal health status), with higher values indicating better foot health status [24].

The validity of FHSQ is proven for this disease and includes a cross-cultural adaptation in its Spanish translation [25]. We decided to use only the first four domains as they are specific to foot health (1: foot pain, 2: foot function, 3: footwear, 4: perception of general foot health) and ignored the final four domains which deal with general health status.

Statistical analysis

Data analysis was carried out with the SPSS v21 software package. The Kolmogorov-Smirnov test was used to analyse the distribution of each variable.

A Chi-square test was used for qualitative variables such as sex, laterality, and coexistence of DM. After demonstrating normal distribution, a Student's t-test was used for quantitative variables such as age, BMI and UTM.

Receiver Operating Characteristic (ROC) curve analysis was performed to determine the best cut-off values for measurement of UTM. Following this, the sensitivity, specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV) were all obtained for UTM and cut-off point. In all hypotheses, a p-value of less than 0.05 determined statistical significance.

The hypothesis of whether UTM had any correlation with the intensity of pain and/or dysfunction (VAS-FHSQ) was established through the use of a linear correlation test and dispersion diagram, as well as a linear regression model, in the case of identifying the type of relationship.

Ethical criteria

This project was approved by the Ethical Committee in the Clinical Investigation Unit of the General Hospital of Alicante.

RESULTS

Demographic characteristics of the study population

Clinical characteristics of all patients is presented in Table 1. There were no significant differences in terms of sex, age, laterality, BMI, or coexistence of DM between PF and control groups. However, we observed a higher BMI (28 kg/m²) in both groups, indicating overweight in our study population (Table 1).

Table 1: Demographic characteristics of control and PF groups:			
	Patient group	Control group	P value
Sex(M/F)	23/57	16/24	0.098 ^a
Age (years) Mean ± SD	49.9 ± 10.8	50.1 ± 10.1	0.940 ^b
Side (L/R)	43/37	40/40	0.752 ^a
BMI Mean ± SD	28.4 ± 4.2	27.2 ± 5.4	0.107 ^b
DM	6	6	0.210 ^a

M/F: Male/Female; SD: Standard deviation; L/R: Left/Right; BMI: Body mass index (Kg / m²); DM: Diabetes Mellitus; a: X²; b: T samples independent

Patients versus controls

In the patient group, 98.7% (79/80 feet) had >4 mm UTM of plantar fascia versus 11.2% (9/80 feet) with >4 mm UTM in the control group. Chi-square test revealed a statistically significant association (p= .000). In the patient group, UTM of the plantar fascia showed a mean of 6.72 mm (SD: 1.26) versus 3.39 mm (SD: 0.57) for the control group (p< 0.001).

ROC curve analysis between control and PF group for a 4 mm UTM reference value, showed a sensitivity: 98.8%, specificity: 88.8%, PPV: 89.8%, NPV: 98.6%. The Area Under the Curve (AUC) was estimated to be 0.997 (Figure 2). Moreover, the best cut-off value for a 100% sensitivity and 95% specificity was 4.41 mm UTM.

Patients group: painful versus contralateral foot

In the patient group, 46.2% (37/80 feet) of contralateral foot, had UTM>4 mm of plantar fascia compared to 98.7% (79/80 feet) of painful foot. Chi-square test revealed statistically significant association (p= .000).

In the contralateral foot, UTM of plantar fascia showed a mean of 4.08 mm (SD: 0.54) versus 6.72 mm (SD: 1.26) for the painful foot (p=.000).

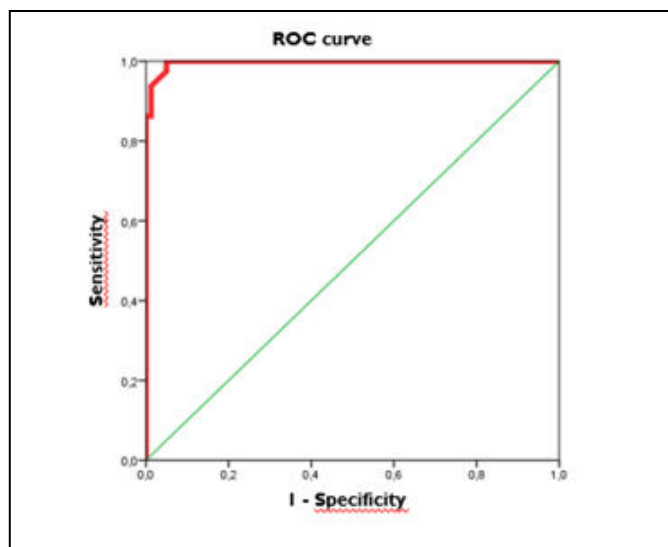


Figure 2: ROC curve to estimate the sensitivity and specificity of the > 4mm UTM, in the diagnosis of PF.

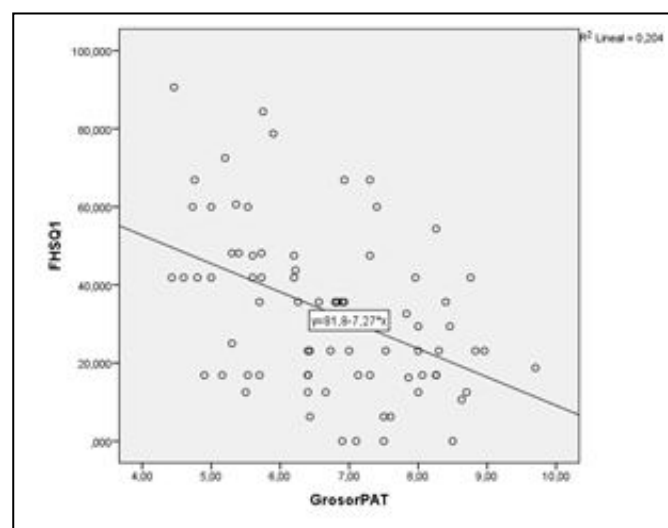


Figure 3: Correlation between UTM and VAS.

UTM of plantar fascia versus severity of the pain

Concerning the hypothesis of a correlation between UTM of the plantar fascia and the variables of pain and dysfunction, it was possible to confirm a moderate level of positive correlation on the VAS (Pearson r = 0.537), which means, the greater the fascial thickness, the higher the degree of VAS recorded (p=.000). A discrete level of negative correlation was also noted (Pearson r = -0.451) with FHSQ 1 (p=.000) in

which the greater the thickness the worse the score in FHSQ1. No statistically significant association was identified with the remaining FHSQ domains (FHSQ 2: $p=0.25$; FHSQ 3: $p=0.58$; FHSQ 4: $p=0.05$).

However, in these correlations, the regression test did not reveal a powerful predictive model. Although significance was evident ($p=.000$), it could explain only 30% of the relationship with VAS (Figure 3) and 20% with FHSQ1 (Figure 4).

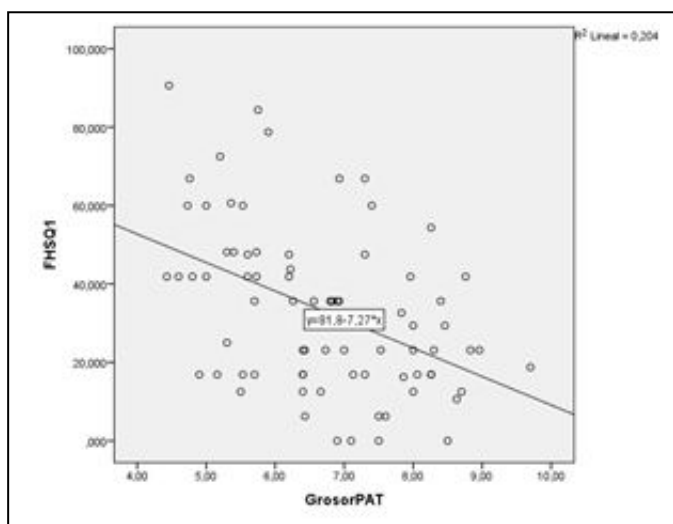


Figure 4: Correlation between UTM and FHSQ1.

DISCUSSION

In this study, the plantar fascia's US thickness, has slightly exceeded the value reported by other authors (10-20) except in Genc's study. This may be related to ethnic differences, although we could not find data on this subject in the current literature. The different variability could support this hypothesis in terms of prevalence between countries and ethnic groups. Nahin et al., [3]. Found differences in prevalence between Hispanic whites, Non-Hispanic whites, and Non-Hispanic blacks. However, they did not measure fascial thickness between ethnic groups.

Moreover, we cannot ignore BMI's influence in our study population, as our results indicated overweight (28.38Kg/m²). As previous authors reported, BMI > 25 kg/m² is related to increased thickness at the plantar fascia even in asymptomatic subjects (18,26,27). Genc et al., [18] explored the effectiveness of corticosteroid infiltration in a PF and control groups. At baseline, the PF group showed fascia thickness was 6.3 mm (SD: 1.3) compared to 3.6 mm (SD: 0.3) in their control group. These results are very similar to ours but found in a

Turkish population. This could be explained because their mean BMI value was 28 kg/cm² as in our study population. These findings support the role of BMI on increasing fascial thickness. Furthermore, obesity rates in Europe vary greatly [28]. A cross-sectional study compared obesity estimates from 16 European countries, using a uniform protocol and comparable methods, on a total of 14,685 adults. They found a moderate increase (27%) in obesity prevalence over the last two decades in Spain. Ordonana [29] analyses the contribution of genetic factors to variation in height, weight, and BMI in two independent samples of middle-aged female twins from The Netherlands and Spain and they found significant differences on anthropomorphic measures between the two groups. Spanish women had a higher BMI and were more prone to age-related weight gain than Dutch women, which accounts for a higher prevalence of overweight and obesity in this sample. In summary, their model confirms the importance of additive genetic and non shared environmental influences on BMI.

In the current literature most of the authors (10-20) found a lower UTM than us except Genc, although these studies were performed in non-Spanish population.

Another relevant result of our study is that the reference value of 4.0 mm UTM has an adequate diagnostic validity since we obtained a 98.8% sensitivity, 88.8% specificity and the AUC was 0.997. Nevertheless, we consider the 4.41 mm cut-off value is likely to be more accurate as it represents 100% sensitivity and 95% specificity in our Spanish population. This should be related to ethnic or BMI differences as discussed above.

Our second objective was to determine a correlation between plantar fascia thickness and foot pain or dysfunction in PF patients. We could identify a moderate level of positive correlation proportional between UTM of the plantar fascia and the intensity of pain, measurable both via the VAS and from the foot pain domain of FHSQ. This suggests that the greater the pain these patients experienced, the more substantial the plantar fascia's thickness. However, the predictive model that quantifies the spike in thickness (in millimetres) gives the quantitative indication of escalation in the measured pain but not the relevant power. Gamba et al., [30], concluded plantar fascia thickness did not correlate with pain

(VAS), AOFAS, or any item of the SF-36 but this was explained by the inclusion of patients with recalcitrant PF.

When analyzing the remaining domains of FHSQ questionnaire, there is a specific relation in the perception of the general foot health domain. In this study, we couldn't find a significant correlation in foot function and footwear domains.

Regarding whether it is possible to apply UTM to the contralateral foot compared to painful foot in the patient group, we found the presence of significant differences in comparative thicknesses (6.72 vs 4.08 mm). Although some patients slip UTM >4.41 mm (22/80 feet), we still considered an acceptable method to discriminate from the contralateral foot in unilateral PF because the higher diagnostic validity is in our population 4.41 mm.

In their study Hammer et al., [19], investigated the effect of Extracorporeal Shock Wave Therapy (ESWT) on the ultrasonographic appearance in patients with proximal PF. The mean thickness of the plantar fascia on the contralateral side before treatment was 4.3 mm SD: 1.1. These results could be comparable to ours in the contralateral side (4.08 mm SD: 0.54) although we cannot ignore the plantar fascia was measured about 2 cm distal of the medial calcaneal tuberosity instead of distal edge of the calcaneus.

Previous research has shown that plantar fascia thickness is increased in DM [31]. A potential mechanism that may explain such findings should be related to Advanced Glycation End products (AGE) formation. These AGE formations would be increased in patients with DM and could cause increased plantar fascial thickness [32]. As showed in the results, DM is equally distributed in the case and control groups, so it does not influence our results. We also excluded the influence of sex, age and laterality.

Our study had several limitations. First, US scanning of plantar fascia were performed by a single sonographer, although he was a doctor with extensive experience in this matter. In addition, MRI is considered the gold standard in this disease, but US has shown a similar diagnostic validity. Finally, we decided to use only the first 4 domains of the FHSQ and excluded the remaining 4 as we considered that they were not directly related to self-perceived foot health.

CONCLUSION

We conclude that UTM is slightly higher in our Spanish population than in current literature. This study demonstrated moderate correlation between pain and UTM of the plantar fascia.

CONFLICT OF INTERESTS AND FUNDING SOURCES

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