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A Guideline for the Localization of Treatment Points in Heel Pain

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ABSTRACT

Aim: To determine the target point in the calcaneal region for injection and neuroablation applications in the treatment of plantar fasciitis and Baxter neuropathy using a newly developed three-dimensional approach, providing a more accurate and personalized localization method.

Material and Methods: Data from 65 patients who underwent MRI for suspected foot pathology were retrospectively analyzed. The Baxter nerve and the adhesion point of the plantar fascia were identified. Three-dimensional measurements of the medial (horizontal), inferior (longitudinal), and posterior (sagittal) distances from this target area to the skin surface were performed. Correlations between these distances and patient gender as well as shoe size were evaluated. Statistical analyses included descriptive methods, normality testing, and appropriate parametric/non-parametric tests ($p<0.05$ was considered statistically significant).

Results: The mean medial, inferior, and posterior distances were 24.26 ± 4.36 mm, 25.97 ± 3.62 mm, and 42.40 ± 4.60 mm, respectively. Inferior and posterior distances were significantly shorter in women than in men ($p < 0.001$). A positive correlation was observed between shoe size and both inferior ($r = 0.407$, $p < 0.01$) and posterior ($r = 0.653$, $p < 0.001$) distances.

Conclusion: This study presents a novel three-dimensional method to enhance anatomical localization for the treatment of plantar fasciitis and Baxter neuropathy. Findings demonstrate that gender and shoe size significantly influence distance measurements, supporting the use of this approach to achieve more precise and personalized therapeutic strategies. Furthermore, future prospective and large-scale studies will contribute to confirming its clinical effectiveness.

Keywords: Fasciitis, plantar; mononeuropathies; radiofrequency ablation; injections.

Topuk Ağrısında Tedavi Noktalarının Lokalizasyonu için Bir Kılavuz

ÖZ

Amaç: Bu çalışma, plantar fasiit ve Baxter nöropatisi tedavisinde enjeksiyon ve nöroablasyon uygulamaları için üç boyutlu yeni bir yöntemle kalkaneal bölgedeki hedef noktayı belirlemeyi ve daha doğru, kişiselleştirilmiş bir lokalizasyon yöntemi sunmayı amaçlamaktadır.

Gereç ve Yöntemler: Ayak patolojisi şüphesiyle MR yapılan 65 hastanın verileri retrospektif olarak incelendi. Baxter siniri ile plantar fasyanın yapışma noktası hedeflendi. Hedef bölgenin deri yüzeyine olan medial (yatay), inferior (longitudinal) ve posterior (sagital) mesafeleri üç boyutlu ölçümle kaydedildi; bu ölçümler cinsiyet ve ayakkabı numarası ile korele edildi. İstatistiksel analizlerde tanımlayıcı yöntemler, normal dağılım değerlendirmesi ve uygun parametrik/non-parametrik testler kullanıldı ($p<0,05$ anlamlı kabul edildi).

Bulgular: Medial, inferior ve posterior mesafelerin ortalamaları sırasıyla 24,26 ± 4,36 mm, 25,97 ± 3,62 mm ve 42,40 ± 4,60 mm olarak bulundu. Inferior ve posterior mesafeler kadınlarda erkeklere göre anlamlı olarak daha kısaydı ($p < 0,001$). Ayakkabı numarası arttıkça inferior ($r = 0,407$; $p < 0,01$) ve posterior ($r = 0,653$; $p < 0,001$) mesafelerde anlamlı artış gözlendi.

Sonuç: Bu çalışma, plantar fasiit ve Baxter nöropatisi tedavisinde anatomik lokalizasyonu iyileştirmek için yenilikçi bir üç boyutlu yöntem sunmaktadır. Cinsiyet ve ayakkabı numarasının mesafe ölçümlerini etkilediği belirlenmiş olup, geliştirilen yaklaşım daha doğru ve kişiselleştirilmiş tedavi stratejilerine katkı sağlayacaktır. Ayrıca, gelecekte yapılacak prospektif ve geniş ölçekli çalışmalar yöntemin klinik etkinliğini doğrulamaya katkı sağlayacaktır.

Anahtar Kelimeler: Fasiit, plantar; mononöropatiler; radyofrekans ablasyonu; enjeksiyonlar.

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INTRODUCTION

It has been reported that the prevalence of foot pathologies ranges from 61% to 79% and this condition negatively affects the quality of life of individuals (1). Plantar fasciitis is most common in the 40-60 age range, regardless of gender, and accounts for 15% of foot problems in the general population (2). It has been reported that the lifetime prevalence of plantar fasciitis in the general population is approximately 10% and similar rates are observed among runners (3). Furthermore, a recent systematic review of articles published between 2000 and 2017 revealed that plantar fasciitis was the second most frequently published topic in five high-impact general medical journals (4).

The plantar fascia begins at the toes and adheres to the medial calcaneal tubercle. Thickening or tearing of the fascia at this attachment site is called plantar fasciitis (5). On physical examination, tenderness at the site of attachment of the fascia to the medial tubercle of the calcaneus is considered a pathognomonic finding of plantar fasciitis (6). Injections commonly used in the treatment of plantar fasciitis are performed in this area (7).

Baxter neuropathy occurs as a result of compression of the Baxter nerve and causes medial heel pain that is usually indistinguishable from plantar fasciitis (8). Baxter's nerve is also known as the first branch of the lateral plantar nerve or the inferior calcaneal nerve (9). Baxter neuropathy accounts for approximately 20% of cases of chronic heel pain (10). In the literature, it has been reported that Baxter neuropathy is the most common cause of plantar heel pain of neural origin, with pain originating from the medial calcaneal nerve coming second (11).

In the treatment of Baxter neuropathy, neuroablation with radiofrequency can be applied for chronic heel pain. The anatomical location of the nerve is critical for the success of this treatment. The Baxter nerve passes approximately 5.5 mm anterior to the medial calcaneal tubercle (12). In this study, measurements were made based on this estimated route of the nerve. In addition, neuroablation therapy in this area can be applied not only in Baxter neuropathy but also in cases where chronic plantar fasciitis does not respond to treatment (13,14). This increases the clinical importance of this region in terms of both plantar fascia injections and neuroablation treatments for heel pain.

In the literature, injection and neuroablation treatments are usually performed under USG guidance (15,16). However, because it is practical in clinical practice, injections are performed by palpation (blinded) method, and inadvertently performing these procedures in the fat pad on the sole of the foot leads to atrophy in this region (16,17). In addition, it is known that injections that are not performed in the appropriate area of the heel may have side effects such as nerve damage and muscle weakness (18). In the literature, there are studies comparing these two methods and it has been shown that ultrasound-guided localization is more accurate and treatment results are more successful (19). The accuracy of ultrasound guidance in injections into the joints of the foot was reported to be 64%, while the accuracy of blinded injections using only reference points was reported to be 24% (20). In clinical neuroablation treatments, it is often preferred to use a neural stimulation technique to the estimated area instead of ultrasonography because it is practical for nerve localization (21). In the literature, it is emphasized that application to the correct point in injection and neuroablation treatments is critical for treatment success and patient safety. However, despite such strong scientific evidence, these procedures are usually performed blinded because it is faster and easier in practice. Reference points such as the tip of the medial malleolus, calcaneal tubercle and navicular tuberosity (Heimkes Triangle), which are used in the literature to define this treatment point, are landmarkers developed for the tarsal tunnel (22). Additionally, the distances and locations of these points relative to the heel region can make their use as references more complex.

The originality of this study lies in the introduction of a three-dimensional, MRI-based method that defines treatment entry points relative to the patient's skin surface. Unlike previous approaches that rely mainly on bone landmarks or ultrasound guidance, this method provides personalized localization by incorporating individual variables such as gender and shoe size. In this way, the proposed approach offers a novel and practical contribution to the optimization of injection and neuroablation treatments for plantar fasciitis and Baxter neuropathy.

In our study, we aimed to perform nerve localization in a three-dimensional plane more easily and precisely by taking the anatomical boundaries of the region as a reference in the treatment applied to the heel region. This research aims to provide an approach that can be used in neuroablation treatments applied in plantar fascia injections and heel pain, which will provide more practical and effective guidance for clinical applications.

MATERIAL AND METHODS

This retrospective study examines data from patients who underwent foot MR imaging due to suspected foot pathologies at a tertiary medical center between January 1, 2022, and December 31, 2024. A total of 65 patients were included in the study. A post-hoc power analysis was performed using GPower software (version 3.1, Universität Düsseldorf, Germany). Based on the effect sizes obtained from the comparison of inferior (Y) and posterior (Z) distance measurements between genders (Cohen's $d = 1.24$ and 1.21, respectively), with an alpha error probability of 0.05 and the given sample size ($n=65$), the achieved power ($1–\beta$) was calculated as greater than 0.95. This indicated that the sample size was sufficient to detect statistically significant differences between groups. Patients to be included in the study were identified by scanning through the hospital archive system and automation system. Inclusion criteria included being 18 years of age or older, having undergone foot MRI within the specified date range, and having complete hospital records. Exclusion criteria included patients with a history of acute trauma to the foot or ankle, patients with foot deformity, and patients who did not have an MRI to evaluate the entire foot.

Demographic and clinical data of the patients included in the study included information such as age, gender, and shoe size. The European (EU) shoe sizing system was used in this study. Foot MRI images were retrospectively analyzed through the radiologic archive system to determine the target area. The 5.5 mm anterior region of the medial calcaneal tubercle, where the insertion of the plantar fascia and the Baxter nerve are located, was targeted. The distances of this area to the inferior, medial and posterior skin surface were measured in three different planes using the XYZ coordinate system. The distance to the medial skin was coordinated as the X axis (horizontal axis), the distance to the inferior skin as the Y axis (longitudinal axis) and the distance to the posterior skin as the Z axis (sagittal axis) (Figure 1a and 1b). Thanks to these measurements, the most appropriate treatment point specific to each patient's heel structure was determined according to the reference points on the skin and the treatment entry points were optimized by taking into account individual variables such as gender and shoe size (Figure 1c).

This study was conducted after the approval of the Clinical Research Ethics Committee of a tertiary medical institution [approval number 2025/29, granted on 10 February 2025], ensuring patient confidentiality and data anonymization. This retrospective study aims to determine personalized calcaneal treatment points in the light of the data obtained from foot MR images and thus to increase treatment efficacy.

Statistical Analysis

Descriptive statistics for numerical variables were presented as mean ± standard deviation, median, minimum and maximum values, while categorical variables were expressed as both numbers (n) and percentages (%). The conformity of numerical data to normal distribution was evaluated by the Shapiro-Wilk test. An independent sample t-test was used to compare distance measurements between genders. The relationship between shoe size and distance measurements was analyzed with Spearman's correlation coefficient. All statistical analyses were conducted using IBM SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, NY, USA). A p-value of <0.05 was considered statistically significant.

RESULTS

The mean age of the 65 patients included in the study was 40.22±12.20 years (18–73) and the mean shoe size was 40.92±2.43 (36–46). X, Y and Z distance values of these patients were analyzed and their relationships with gender and shoe size were evaluated. The findings obtained through statistical analysis are presented in detail in tables and figures.

The mean X, Y and Z values of all patients were 24.26±4.36, 25.97±3.62 and 42.40±4.60, respectively. There was no statistically significant difference between men and women in terms of X value (p>0.05). On the other hand, significant differences were found between Y and Z values, and women had shorter Y and Z values than men (p<0.001). According to Table 1, Y and Z values are affected by gender, while the X value is independent of gender.

Table 1. Comparison of X, Y, Z values between men and women

	All Patients	Females (n=31)	Males (n=34)	p value
	Mean ± SD	Mean ± SD	Mean ± SD	(Females vs. Males)
X (horizontal distance)	24.26±4.36	23.58±4.52	24.88±4.19	0.233 [a]
Y (longitudinal distance)	25.97±3.62	23.97±3.08	27.79±3.10	**<0.001 [a]**
Z (sagittal distance)	42.40±4.60	39.90±3.90	44.68±4.00	**<0.001 [a]**

a: Independent Samples t test, SD: Standard Deviation

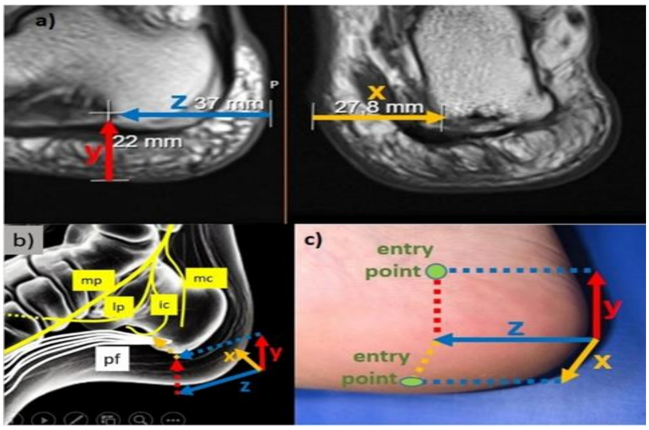

Figure 1. a) Image showing the measurement of the distances of the estimated treatment site located in front of the medial calcaneal tubercle to the skin surface in the X, Y and Z axes in the inferior, medial and posterior directions. b) Schematic representation explaining the relationship of the obtained measurements with the relevant anatomical structures. c) Image showing the localization on the skin of the entry points to be used during treatment. mp, medial plantar nerve; lp, lateral plantar nerve; ic, inferior calcaneal nerve; mc, medial calcaneal nerve; pf, plantar fascia.

While there was no statistically significant correlation between the shoe size of the patients and the X value (p>0.05), a statistically significant moderate positive correlation was found with the Y values (r=0.407, p<0.01) and a statistically significant strong positive correlation was found with the Z values (r=0.653, p<0.001) (Figure 2). In the study, the mean X distance was 24.26±4.36, while the mean Y distance was 23.97±3.08 for women and 27.79±3.10 for men, and the mean Z distance was 39.90±3.90 for women and 44.68±4.00 for men (Table 2). While there was no statistically significant correlation between shoe size and X and Y values in women (p>0.05), a moderate, positive, and statistically significant correlation was found with the Z value (r=0.506, p<0.01). Accordingly, as the shoe size of women increases, the Z distance value also increases. In men, there was no statistically significant correlation between shoe size and X, Y, and Z values (p>0.05). These findings indicate that Y and Z distances are affected by individual factors such as gender and shoe size, while X distance is independent of these variables. The correlations between shoe size and Y and Z distances are further illustrated in Figure 3. Consideration of these measurements during treatment and surgical approaches to the relevant region may contribute to improving clinical outcomes.

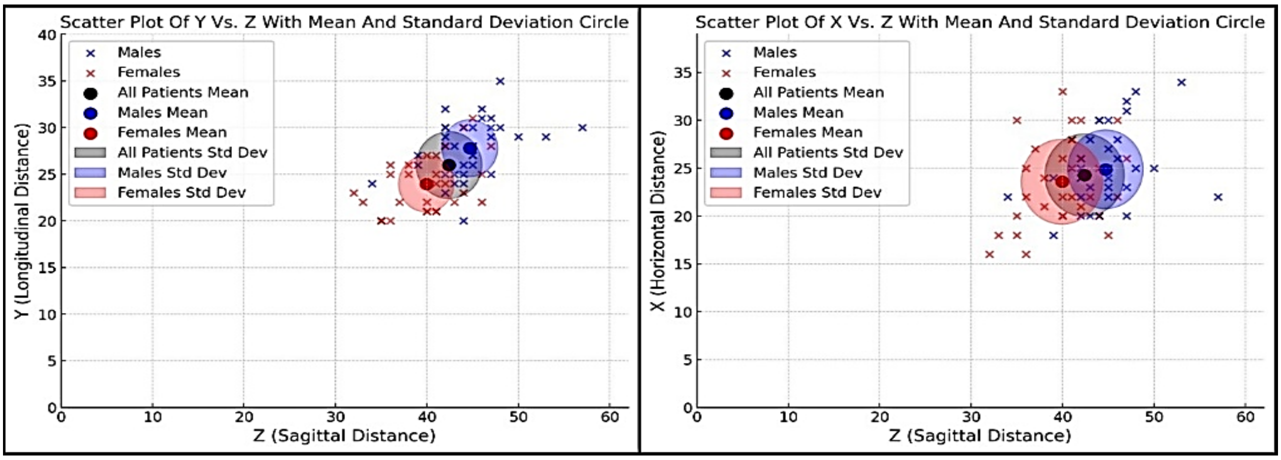

Figure 2. Visualization of Y-Z and X-Z Distance Measurements of Patients with Scatter Plot Graphs: With Mean and Standard Deviation Values

Table 2. Correlations between patients' shoe size and X,Y,Z values

	All Patients		Females (n=31)		Males (n=34)	
	Shoe size		Shoe size		Shoe size	
	r*	p	r*	p	r*	p
X (horizontal distance)	0.176	0.162	0.209	0.260	0.103	0.562
Y (longitudinal distance)	**0.407**	**0.001**	-0.118	0.529	0.189	0.284
Z (sagittal distance)	**0.653**	**<0.001**	**0.506**	**0.004**	0.230	0.190

* Spearman's correlation coefficient, p: p-value

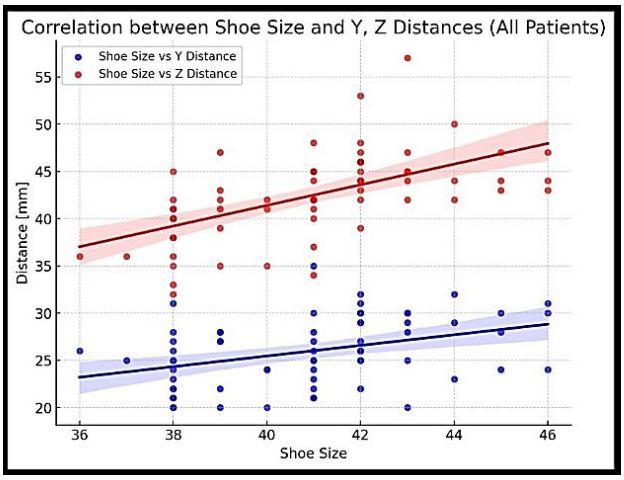

Figure 3. Graph showing the correlation between shoe size and Y and Z.

DISCUSSION

Plantar fasciitis is one of the most common causes of heel pain, which occurs as a result of inflammation and micro-tears at the attachment site of the plantar fascia to the medial calcaneal tubercle (6). The plantar fascia is a dense connective tissue structure located on the sole of the foot and extending from the medial tubercle of the calcaneus to the toes, providing resistance against tensile forces (5). Conservative approaches are at the forefront in the treatment process, and in refractory cases, injection therapies and ablation methods applied to the adhesion area of the plantar fascia to the medial calcaneal tubercle are considered as clinically effective alternatives (7).

Baxter neuropathy is characterized by indistinguishable heel pain resulting from compression or irritation of the Baxter nerve (8,10). It has been reported that the Baxter nerve may be compressed, especially in association with conditions such as plantar fasciitis or calcaneal spur, and may lead to chronic heel pain (23). Treatment includes removal of pressure on the nerve, stretching exercises, injections, and surgical decompression or radiofrequency neural ablation when necessary (24).

The Baxter nerve, which is the subject of this study, is an important anatomical structure targeted in injection and neuroablation treatments performed in the heel region. Injections in the wrong localization may lead to inadequate treatment efficacy as well as side effects such as nerve damage, muscle weakness and atrophy of the sub-heel fat pad (16-18). Therefore, accurately determining nerve localization in the heel region becomes highly important.

In the literature, superficial bone landmarks such as the tip of the medial malleolus, the calcaneal tubercle and the navicular tuberosity (Heimkes Triangle) are frequently used to locate the Baxter nerve and adjacent structures (22,25,26). However, these reference points were mostly developed to determine the localization of the tarsal tunnel region (22). In heel injection or neuroablation applications, the use of these landmarks may require complex calculations and may not always be practical due to variations in distances that depend on foot size and shape (22,25,26).

In a study conducted by Choi et al. in 2025, the distance of the Baxter nerve from the posterior aspect of the calcaneus to the posterior aspect of the calcaneus in the line between the posterior process of the calcaneus and the medial malleolus was measured using ultrasonography and calculated as 43.77 ± 5.31 mm on average (26). Compared to the USG method used in this study, the millimetric localization of the nerve can be determined more precisely with MRI. In our study, we aimed to measure the distances of the nerve to the posterior, medial and inferior skin surface of the heel in three different planes (X, Y, Z) using MRI. Thus, we aimed to provide an easier and more precise localization by referring to the skin borders of the heel itself instead of bony structures. In the literature, there are studies similar to ours that evaluate the distance of nerves from the skin surface to define safe surgical approaches. These studies aim to minimize nerve injuries and optimize surgical techniques by using anatomical reference points (27,28).

When imaging methods are examined, it is seen that both USG and MRI are widely used in the evaluation of heel pathologies. While USG provides an advantage in the detection of superficial nerves, it may be insufficient in cases requiring detailed evaluation, and therefore MRI is preferable (29,30). Additionally, USG is an operator-dependent method, and its diagnostic reliability may decrease with inexperienced practitioners. In contrast, MRI visualizes the nerve morphology and its relationship with surrounding tissues in detail, allowing a clearer assessment of nerve compression and structural changes in the heel region (18).

In other anatomical studies in the literature, the localization of the Baxter nerve was determined with reference to the edge of the Heimkes triangle between the medial malleolus and the calcaneal tubercle. As a result of the measurements, it was determined that the nerve was located an average of 17 mm from the center of this line (22,25). However, the distance between the reference points in this measurement technique can change easily with ankle movements and can be affected by various parameters such as foot size (31). Furthermore, the method is relatively more complex to implement. In our method, the use of the anatomical borders of the heel region as a reference and the ease of localization in three axes make the method more practical and useful.

This study provided a three-dimensional (X, Y, Z axes) evaluation of the anatomical structures in the heel region using MR imaging and contributed to the precise localization of target points in injection and neuroablation procedures applied in the treatment of plantar fasciitis and Baxter neuropathy. For percutaneous treatment methods to be performed medially, the entry point for treatment can be determined at an average distance of 42.40±4.60 mm from the posterior and 25.97±3.62 mm from the inferior of the heel, and treatment can be applied by entering an average of 24.26±4.36 mm from this region. In our study, the distance to the inferior and posterior region of the heel was found to be affected by gender and shoe size. Therefore, the entry points of the injection and neuroablation catheter can be determined more precisely by taking these factors into consideration.

In particular, the statistically significant correlations between shoe size and the Y and Z distances highlight the potential influence of anatomical variations on heel morphology. This finding suggests that the relationship between anatomical structure and shoe size warrants further investigation in future studies.

Limitations of this study include the limited sample size and lack of data due to its retrospective design. In addition, the proposed three-dimensional MRI-based localization method has not yet been validated in clinical practice, and its reproducibility in real treatment settings remains to be established. Potential influences of individual variables such as foot dominance, body mass index, and variations in patient positioning during imaging were not evaluated, and these factors may have affected the measurements. Future prospective, multicenter, and larger-scale studies are warranted to confirm the clinical applicability of this approach and to provide more comprehensive evaluations for optimization of treatment methods.

CONCLUSION

This study presents a novel method for refining anatomical localization in the treatment of plantar fasciitis and Baxter neuropathy. The findings revealed that the distances to the inferior and posterior surfaces of the heel were affected by factors such as gender and shoe size. The significant differences in these distances between men and women emphasize the importance of individualized planning in treatment applications. This three-dimensional approach may improve the accuracy of application by optimizing treatment entry points and contribute to patient safety by reducing the risk of complications. Future studies with larger, prospective cohorts will further confirm these findings and facilitate the development of standardized, evidence-based guidelines for heel interventions in plantar fasciitis and Baxter neuropathy.

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