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# Association of posterior calcaneal enthesophytes with ultrasonographic Achilles tendon abnormalities: A comparative radiographic and ultrasonographic study

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## Abstract

Achilles tendinopathy may be accompanied by tendon thickening and fibrillar pattern abnormalities on ultrasonography. Posterior calcaneal enthesophytes are frequently identified on lateral ankle radiographs, but their relationship with Achilles tendon abnormalities remains unclear. The aim of this study was to assess the associations of posterior calcaneal enthesophyte presence and length with ultrasonographic findings of the Achilles tendon. A hospital-based cross-sectional study included 46 patients with heel or posterior ankle pain, with 54 ankles used as the unit of analysis. Enthesophyte presence and length were assessed using lateral ankle radiography, whereas Achilles tendon thickness and fibrillar pattern abnormalities were evaluated using ultrasonography. Associations were analyzed using Fisher's exact test, and continuous measurements were compared using the Mann–Whitney U test. Posterior calcaneal enthesophytes were identified in 40.7% of ankles. Tendon thickening and fibrillar pattern abnormalities were observed in 1.9% and 9.3% of ankles, respectively. Enthesophyte presence was not significantly associated with tendon thickening ($p$=0.407), and tendon thickness did not differ significantly between ankles with and without enthesophytes ($p$=0.063). Fibrillar pattern abnormalities were observed in 22.7% of ankles with enthesophytes and in none of the ankles without enthesophytes ($p$=0.008). An enthesophyte length ≥0.85 mm was associated with fibrillar pattern abnormalities ($p$=0.005) but not tendon thickening ($p$=0.370). Median enthesophyte length was greater in ankles with fibrillar abnormalities than in those without abnormalities (2.50 mm vs 0.00 mm; $p$=0.005). This study highlights that posterior calcaneal enthesophytes were associated with fibrillar pattern abnormalities but not tendon thickening. Since ultrasonographic abnormalities were uncommon and clinical outcomes were not assessed, these preliminary cross-sectional associations require confirmation in larger prospective studies.

**Keywords**: Achilles tendinopathy, lateral ankle radiography, posterior calcaneal enthesophytes, ultrasonography, fibrillar pattern abnormalities

## Introduction

The Achilles tendon is the largest and strongest tendon in the human body and plays a crucial role in locomotion by transmitting forces generated by the gastrocnemius and soleus muscles to



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the calcaneus. During activities such as walking, running, and jumping, the tendon is exposed to substantial mechanical loads, making it particularly susceptible to overuse injuries and degenerative changes [1]. Achilles tendinopathy is a common musculoskeletal disorder characterized by pain, stiffness, and impaired function, affecting both athletes and non-athletes. The condition represents a substantial clinical burden because it can markedly limit daily activities and athletic performance [2,3]. A population-based study estimated the annual incidence of midportion Achilles tendinopathy at 1.85 cases per 1,000 persons, with only approximately one-third of cases associated with sports participation, indicating that the condition also substantially affects non-athletes [4]. In running populations, the lifetime occurrence of Achilles tendinopathy has been reported to reach approximately 52%, demonstrating a considerably greater burden among individuals exposed to repetitive tendon loading [5].

Posterior calcaneal enthesophytes are abnormal bony projections located at the Achilles tendon insertion and are considered to develop as adaptive responses to repetitive mechanical loading and chronic traction forces at the enthesis [6,7]. These osseous changes are frequently associated with insertional heel pain and have been proposed as potential imaging markers of Achilles tendon pathology. Lateral ankle radiography is widely recognized as a simple and reliable method for detecting posterior calcaneal enthesophytes, whereas ultrasonography provides detailed evaluation of tendon abnormalities, including tendon thickening, fibrillar pattern abnormalities, hypervascularization, and associated bursitis [8-10]. The combination of these imaging modalities may therefore offer a comprehensive assessment of both bony and soft-tissue alterations.

Despite the frequent identification of posterior calcaneal enthesophytes on radiographs, their relationship with Achilles tendinopathy remains controversial. Some studies have suggested that enthesophytes are associated with tendon pathology and tend to be larger in symptomatic individuals, whereas others have shown that these findings may also occur in asymptomatic populations [11-15]. Consequently, whether the presence and size of posterior calcaneal enthesophytes truly reflect underlying tendon abnormalities remains uncertain. Furthermore, data regarding posterior calcaneal enthesophytes in Indonesia are limited, and no study from Aceh, the westernmost province of the Indonesian archipelago, has specifically evaluated their relationship with ultrasonographic findings of Achilles tendinopathy. Therefore, the aim of this study was to assess the associations of posterior calcaneal enthesophyte presence and length on lateral ankle radiographs with Achilles tendon thickness, tendon thickening, and fibrillar pattern abnormalities on ultrasonography.

## Methods

### Study design and setting

A hospital-based cross-sectional study was conducted to assess the associations between posterior calcaneal enthesophytes on lateral ankle radiographs and ultrasonographic Achilles tendon findings. The study was conducted at the Radiology Department of Dr. Zainoel Abidin Hospital, Banda Aceh, Indonesia, between October 2025 and April 2026.

### Participants and criteria

Participants were patients presenting with heel pain or posterior ankle pain who underwent lateral ankle radiography at Dr. Zainoel Abidin Hospital during the study period. Inclusion criteria were age ≥30 years, availability of lateral ankle radiographs of adequate quality for evaluation of the posterosuperior aspect of the calcaneus, and willingness to undergo Achilles tendon ultrasonography. A lateral ankle radiograph was considered adequate when it provided a true or near-true lateral projection with clear visualization of the posterior calcaneus and Achilles tendon insertion, adequate exposure and contrast, and no artifacts or superimposition affecting enthesophyte identification or measurement. Exclusion criteria were a history of calcaneal fracture or ankle sprain within the previous six weeks, systemic diseases that could alter tendon structure (such as gout arthritis with extensive tophi or active inflammatory arthritis), non-diagnostic radiographic images, and refusal to participate.

In this study, the ankle was used as the unit of analysis, and each eligible ankle was assessed independently. Ankles were subsequently classified according to the presence or absence of posterior calcaneal enthesophytes on lateral ankle radiographs.

## Sample size and sampling method

Participants were selected using non-probability sampling with a total sampling approach. All patients with heel pain or posterior ankle pain who underwent lateral ankle radiography and fulfilled the predefined inclusion and exclusion criteria during the study period were included. All eligible participants subsequently underwent Achilles tendon ultrasonography.

## Study procedures

Eligible patients were identified at the Radiology Department of Dr. Zainoel Abidin Hospital. After eligibility assessment and written informed consent, lateral ankle radiographs were obtained using a Diagnostic X-Ray System FDR SMART X 40S (Premium Ceiling Dual Detector with FDR D EVO GL). For the lateral projection, the affected ankle was positioned laterally with the foot dorsiflexed, and the X-Ray beam was centered at the medial malleolus perpendicular to the tibial axis. An adequate radiograph included the distal third of the tibia and fibula, superimposition of the medial and lateral margins of the talar trochlea, and clear visualization of the posterior calcaneus and Achilles tendon insertion.

A posterior calcaneal enthesophyte was defined as an abnormal osseous projection arising from the posterior calcaneus at the Achilles tendon insertion. Its presence was recorded as present or absent. Enthesophyte length was measured in millimeters from its base to its apex. Each measurement was repeated three times, and the mean value was used in the analysis. Radiographs were interpreted by the investigator under the supervision of a musculoskeletal radiologist.

All participants subsequently underwent Achilles tendon ultrasonography using a Voluson S8 ultrasound system equipped with a 7–15 MHz high-frequency linear transducer and Color Doppler (GE Healthcare). Participants were examined in the prone position with the foot resting over the edge of the examination table. The tendon was evaluated in longitudinal and transverse planes from the proximal tendon to its calcaneal insertion. In the longitudinal plane, the transducer was aligned parallel to the tendon fibers; in the transverse plane, it was positioned perpendicular to the tendon. Dynamic plantar flexion and dorsiflexion were performed when needed, and the transducer angle was adjusted to minimize anisotropy. Ultrasonographic measurements and interpretations were performed by the investigator under the supervision of a musculoskeletal radiologist using prespecified sonographic criteria.

## Study variables

The outcome variables were ultrasonographic findings associated with Achilles tendinopathy, including Achilles tendon thickness, tendon thickening, and fibrillar pattern abnormalities. Tendon thickness was measured in millimeters at the predefined examination points and classified as thickened when it exceeded 6 mm at any measurement point. A fibrillar pattern abnormality was defined as focal or diffuse disruption or loss of the normal parallel hyperechoic fibrillar architecture, with or without hypoechoic areas, after excluding anisotropy. Additional ultrasonographic findings, including enthesitis and retrocalcaneal bursitis, were documented descriptively. Enthesitis was defined as insertional tendon thickening or hypoechogenicity, with or without calcification or cortical erosion. Retrocalcaneal bursitis was defined as pathological fluid distension of the retrocalcaneal bursa accompanied by increased vascularity on Color Doppler examination.

The primary predictor variables were the presence and length of posterior calcaneal enthesophytes on lateral ankle radiographs. Enthesophyte presence was recorded as a binary variable, whereas enthesophyte length was measured continuously in millimeters. Participant characteristics, including age, sex, and body mass index, were obtained from medical records and study forms. Body mass index was calculated as weight divided by height squared (kg/m$^2$) and categorized as <18.5, 18.5–22.9, 23.0–24.9, 25.0–29.9, or ≥30 kg/m$^2$. The operational definitions and >6-mm threshold were specified in the thesis methodology.

### Statistical analysis

Data obtained from radiographic and ultrasonographic examinations were analyzed using SPSS version 27.0 (IBM Corp., Armonk, NY, USA). The distributions of continuous variables were assessed using the Shapiro–Wilk test. Associations between categorical variables were analyzed using Fisher's exact test because several cells had expected frequencies below five. Achilles tendon thickness and enthesophyte length were compared between independent groups using the Mann–Whitney U test when their distributions were non-normal. Exact two-sided *p*-values were used where appropriate, and $p<0.05$ was considered statistically significant.

## Results

### Participant characteristics

A total of 46 eligible patients were included in the study and their characteristics are presented in **Table 1**. Since some patients (n=8) presented with bilateral symptoms, a total of 54 ankles were available for analysis. The ankle was used as the unit of analysis. Most participants were female (63.0%), and the majority were overweight or obese (80.4%). Posterior calcaneal enthesophytes were identified in 22 ankles (40.7%). Tendon thickening and fibrillar pattern abnormalities were observed in 1 (1.9%) and 5 (9.3%) ankles, respectively, whereas no cases of enthesitis or retrocalcaneal bursitis were detected. The mean enthesophyte length was 0.98±1.40 mm, and the mean Achilles tendon thickness was 4.00±0.69 mm (**Table 1**).

Table 1. Baseline demographic and imaging characteristics of the study sample

| Variable | Frequency (%) |
|---|---|
| Age group (n=46) | |
| Adult (30–64 years) | 46 (100.0) |
| Sex (n=46) | |
| Male | 17 (37.0) |
| Female | 29 (63.0) |
| Body mass index (kg/m$^2$) (n=46) | |
| <18.5 | 2 (4.3) |
| 18.5–22.9 | 7 (15.2) |
| 23.0–24.9 | 10 (21.7) |
| 25.0–29.9 | 20 (43.5) |
| ≥30 | 7 (15.2) |
| Enthesophytes (radiography) (n=54) | |
| Present | 22 (40.7) |
| Absent | 32 (59.3) |
| Tendon thickening (ultrasonography, USG) (n=54) | |
| Present | 1 (1.9) |
| Absent | 53 (98.1) |
| Fibrillar pattern abnormalities (USG) (n=54) | |
| Present | 5 (9.3) |
| Absent | 49 (90.7) |
| Enthesitis (USG) (n=54) | |
| Present | 0 (0.0) |
| Absent | 54 (100.0) |
| Retrocalcaneal bursitis (USG) (n=54) | |
| Present | 0 (0.0) |
| Absent | 54 (100.0) |
| Enthesophyte length (mm), mean±SD (n=54) | 0.98±1.40 |
| Achilles tendon thickness (mm), mean±SD (n=54) | 4.00±0.69 |

SD: standard deviation

### Associations between the presence of posterior calcaneal enthesophytes and ultrasonographic Achilles tendon findings

Among the 32 ankles without posterior calcaneal enthesophytes, none showed tendon thickening (**Table 2**). Among the 22 ankles with enthesophytes, tendon thickening was identified in one ankle (4.5%), while 21 ankles (95.5%) showed no thickening. The presence of posterior calcaneal enthesophytes was not significantly associated with Achilles tendon thickening ($p=0.407$) (**Table 2**). The median Achilles tendon thickness was 3.80 mm (range: 2.90–4.70 mm) among ankles without enthesophytes and 4.05 mm (range: 3.10–6.20 mm) among ankles with enthesophytes. The difference was not statistically significant ($p$=0.063) (**Table 2**).

Table 2. Association between the presence of posterior calcaneal enthesophytes and tendon thickening

| Ultrasonographic finding | Radiograph of posterior calcaneal | | $p$-value |
|---|---|---|---|
| | No enthesophytes (n=32) | Enthesophytes (n=22) | |
| Tendon thickening, n (%) | | | 0.407[a] |
| No | 32 (100.0) | 21 (95.5) | |
| Yes | 0 (0.0) | 1 (4.5) | |
| Achilles tendon thickness (mm) | | | |
| Median (min–max) | 3.80 (2.90–4.70) | 4.05 (3.10–6.20) | 0.063[b] |

[a] Analyzed with Fisher's exact test
[b] Analyzed with Mann–Whitney U test

Fibrillar pattern abnormalities were detected exclusively in ankles with posterior calcaneal enthesophytes. Among the 22 ankles with enthesophytes, 17 (77.3%) had no fibrillar abnormalities and five (22.7%) exhibited fibrillar abnormalities. In comparison, all 32 ankles without enthesophytes had no fibrillar abnormalities. Fisher's exact test demonstrated a statistically significant association between posterior calcaneal enthesophytes and fibrillar pattern abnormalities ($p$=0.008) (**Table 3**).

Table 3. Association between the presence of posterior calcaneal enthesophytes and fibrillar pattern abnormalities

| Radiograph of posterior calcaneal | Ultrasonographic finding | | Total | $p$-value[a] |
|---|---|---|---|---|
| | No fibrillar abnormalities | Fibrillar abnormalities | | |
| | n (%) | n (%) | | |
| Enthesophytes | 17 (77.3) | 5 (22.7) | 22 (100.0) | 0.008* |
| No enthesophytes | 32 (100.0) | 0 (0.0) | 32 (100.0) | |

[a] Analyzed using Fisher's exact test
* Statistically significant at $p$<0.05

## Comparison of enthesophyte length according to ultrasonographic findings of Achilles tendinopathy

Enthesophyte length was categorized using 0.85 mm as the cutoff. Tendon thickening was not observed in any of the 34 ankles with an enthesophyte length <0.85 mm, whereas it was identified in one of the 20 ankles (5.0%) with an enthesophyte length ≥0.85 mm. This association was not statistically significant ($p$=0.370) (**Table 4**). Fibrillar pattern abnormalities were also absent in all ankles with an enthesophyte length <0.85 mm but were detected in five of the 20 ankles (25.0%) with an enthesophyte length ≥0.85 mm. The association between enthesophyte length category and fibrillar pattern abnormalities was statistically significant ($p$=0.005) (**Table 4**).

Table 4. Association between enthesophyte length and ultrasonographic findings

| Ultrasonographic finding | Enthesophyte length category | Radiograph of posterior calcaneal | | | $p$-value[a] |
|---|---|---|---|---|---|
| | | No enthesophytes | Enthesophytes | Total | |
| | | n (%) | n (%) | n (%) | |
| Tendon thickening | <0.85 mm | 34 (100.0) | 0 (0.0) | 34 (100.0) | 0.370 |
| | ≥0.85 mm | 19 (95.0) | 1 (5.0) | 20 (100.0) | |
| Fibrillar pattern abnormalities | <0.85 mm | 34 (100.0) | 0 (0.0) | 34 (100.0) | 0.005* |
| | ≥0.85 mm | 15 (75.0) | 5 (25.0) | 20 (100.0) | |

[a] Analyzed using Fisher's exact test
* Statistically significant at $p$<0.05

When analyzed as a continuous variable, the median enthesophyte length was 0.00 mm among ankles without tendon thickening and 4.40 mm in the single ankle with tendon thickening. This difference was not statistically significant ($p$=0.074) (**Table 5**). The median enthesophyte length was greater among ankles with fibrillar pattern abnormalities than among those without abnormalities (2.50 mm vs 0.00 mm; $p$=0.005) (**Table 5**).

Table 5. Comparison of enthesophyte length according to ultrasonographic findings

| Ultrasonographic finding | n | Enthesophyte length | | $p$-value[a] |
|---|---|---|---|---|
| | | Median (mm) | Range (mm) | |
| Tendon thickening | | | | 0.074 |
| No | 53 | 0.00 | 0–5.0 | |
| Yes | 1 | 4.40 | 4.4–4.4 | |
| Fibrillar abnormalities | | | | 0.005* |
| No | 49 | 0.00 | 0–5.0 | |
| Yes | 5 | 2.50 | 1.4–4.4 | |

[a] Analyzed using the Mann–Whitney U test
* Statistically significant at $p<0.05$

## Discussion

This study demonstrated that the presence and length of posterior calcaneal enthesophytes showed different relationships with ultrasonographic findings of Achilles tendinopathy. Neither enthesophyte presence nor enthesophyte length was significantly associated with tendon thickening, although ankles with enthesophytes tended to show greater tendon thickness. In contrast, both the presence and greater length of posterior calcaneal enthesophytes were significantly associated with fibrillar pattern abnormalities. However, because fibrillar abnormalities were identified in only five ankles, these findings should be interpreted as preliminary cross-sectional associations rather than evidence that enthesophytes identify early tendinopathy or have established clinical utility.

From a biomechanical perspective, the Achilles tendon is subjected to substantial mechanical loads during activities such as walking and running, which are known to influence tendon adaptation and degeneration [16,17]. Biomechanical studies have demonstrated that strain distribution within the Achilles tendon is not uniform, particularly near the insertion site, where regions of stress concentration and stress shielding may predispose the tendon to structural alterations [18]. The mechanical forces are transmitted primarily to the tendon insertion on the calcaneus, making the enthesis a principal site of repetitive microtrauma. In response to chronic mechanical stress, adaptive changes occur not only within the tendon but also in the adjacent bone, resulting in enthesophyte formation in response to repeated traction [19,20].

Tendon pathology does not necessarily manifest initially as tendon thickening. The continuum model describes tendon pathology as progressing through reactive tendinopathy, tendon disrepair, and degenerative tendinopathy, with subsequent refinements emphasizing the dynamic nature of these stages [21,22]. During the early stages, the predominant alterations involve collagen disorganization and increased proteoglycan content without marked morphological enlargement [23]. Nevertheless, disease stage and symptom duration were not assessed in the present study; therefore, the absence of tendon thickening cannot be interpreted as evidence that the participants were in an early stage of tendinopathy. Previous imaging studies have indicated that structural abnormalities may occur without proportional changes in tendon morphology and should be interpreted within the overall clinical context [24]. Furthermore, the relationship between bone and tendon changes may not be linear because these tissues respond differently to chronic mechanical loading [25].

Fibrillar pattern abnormalities were detected exclusively in ankles with posterior calcaneal enthesophytes, and the association was statistically significant. Furthermore, ankles with fibrillar abnormalities demonstrated greater enthesophyte lengths than those without abnormalities. These findings demonstrate an association between posterior calcaneal enthesophytes and tendon microstructural alterations in the present sample; however, the small number of ankles with fibrillar abnormalities limits the precision and generalizability of this observation. From a pathophysiological perspective, fibrillar abnormalities reflect collagen disorganization, accumulation of non-collagenous matrix components, and reduced echogenicity, which are characteristic features of early tendinopathy [16,22]. Previous studies have suggested that microstructural abnormalities may precede overt morphological changes and that ultrasonography plays an important role in detecting early tendon pathology [24,26]. The present cross-sectional findings are consistent with a relationship between enthesophytes and fibrillar abnormalities but cannot establish the temporal sequence of these imaging changes.

No significant association was observed between enthesophyte length and tendon thickening. This finding suggests that the size of posterior calcaneal enthesophytes does not necessarily reflect the degree of tendon morphological enlargement. Previous studies have suggested that enthesophyte size primarily reflects cumulative mechanical loading rather than the severity of tendinopathy itself [13,14]. Moreover, enthesophyte formation represents an adaptive process occurring at the tendon-bone interface, whereas tendon thickening reflects soft-tissue remodeling and collagen degeneration, indicating that bone and tendon tissues may respond differently to chronic mechanical stress [19]. This distinction is supported by histological studies showing that enthesophytes develop through adaptive changes at the enthesis and by clinical studies demonstrating that tendon thickening is associated with functional impairment and symptoms [27,28]. Consequently, these processes may not occur in parallel. Recent evidence has further shown that improvements in tendon mechanical properties and clinical outcomes may occur independently of changes in tendon morphology or thickness, supporting the concept that tendon adaptation and recovery are not necessarily accompanied by reductions in tendon size [29,30].

This study has some limitations. The relatively small sample size and single-center setting may have limited the statistical power to detect certain associations. Only one ankle showed tendon thickening and five showed fibrillar pattern abnormalities, resulting in sparse data and imprecise estimates. In addition, the cross-sectional design precludes establishing temporal or causal relationships between enthesophyte formation and tendon alterations. Because the ankle was used as the unit of analysis and eight participants contributed bilateral observations, potential within-participant correlation may not have been fully accounted for. Clinical parameters such as pain severity, symptom duration, activity limitation, and functional scores were not evaluated; therefore, the relationship between imaging findings and clinical manifestations could not be comprehensively assessed. Furthermore, diagnostic-performance measures were not calculated, precluding conclusions regarding the clinical or screening utility of enthesophytes. Larger prospective multicenter studies incorporating clinical outcome measures, adequate numbers of positive cases, and statistical methods accounting for bilateral observations are required to validate the observed associations and determine their clinical relevance.

## Conclusion

Posterior calcaneal enthesophyte presence and length were not significantly associated with Achilles tendon thickening. In contrast, both enthesophyte presence and greater enthesophyte length were associated with fibrillar pattern abnormalities on ultrasonography. Given the cross-sectional design, the small number of ankles with ultrasonographic abnormalities, and the absence of clinical outcome measures, these findings should be considered preliminary and hypothesis-generating. Further prospective studies with larger populations and clinical assessments are required to validate these associations and determine their clinical relevance.

### Ethics Approval

The study protocol was approved by the Health Research Ethics Committee of Dr. Zainoel Abidin Hospital, Banda Aceh, Indonesia (333/ETIK-RSUDZA/2025).

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### Competing interests

The authors declared no conflict of interest.

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**Underlying data**

Derived data supporting the findings of this study are available from the corresponding author on request.

**Declaration of artificial intelligence use**

Artificial intelligence (AI) tool, ChatGPT, was used in language refinement (improving grammar, sentence structure, and readability of the manuscript). Authors confirmed that all AI-assisted processes were critically reviewed by the authors to ensure the integrity and reliability of the results. The final decisions and interpretations presented in this article were solely made by the authors.

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