European Journal of Radiology Open 12 (2024) 100568

Contents lists available at ScienceDirect

European Journal of Radiology Open

journal homepage: www.elsevier.com/locate/ejro

Insertional Achilles tendinopathy: A radiographic cross-sectional comparison between symptomatic and asymptomatic heel of 71 patients

Kenichiro Nakajima *

Department of Orthopedic Surgery, Yashio Central General Hospital, Saitama, Japan

ARTICLE INFO

Keywords:
Calcaneus
Diagnostic imaging
Heel spur
Pathology
Radiography

ABSTRACT

Purpose: This retrospective study aimed to investigate whether the standard radiographic indicators for Haglund's syndrome are applicable to insertional Achilles tendinopathy.
Methods: Patients who underwent surgery for insertional Achilles tendinopathy in one heel and experienced no pain in the other heel were enrolled in this study. Preoperative calibrated radiographs of the lateral view of the calcaneus were assessed using (1) calcaneal pitch angle, (2) Fowler-Phillip angle, (3) posterior calcaneal angle, (4) Chauveau-Liet angle, (5) X/Y ratio, (6) Haglund's deformity height, (7) Haglund's deformity peak angle, (8) calcification length, (9) calcification width, (10) parallel pitch test, and (11) presence of free body. The Wilcoxon signed rank test and McNemar's test were used for statistical analyses.
Results: Seventy-one patients (52 males; mean age, 57.2; mean body mass index, 27.1) were included. Mean values for each index in the symptomatic and asymptomatic heels were as follows, respectively: (1) 23.5, 23.0 ($p = 0.30$); (2) 58.9, 57.8 ($p < 0.05$); (3) 7.6, 9.2 ($p < 0.05$); (4) 15.8, 13.9 ($p < 0.05$); (5) 2.8, 2.8 ($p = 0.87$); (6) 5.4, 5.0 ($p < 0.05$); (7) 99.6, 99.0 ($p = 0.44$); (8) 10.5, 7.6 ($p < 0.001$); and (9) 5.1, 4.4 ($p < 0.05$). The sensitivity, specificity, and area under curve of significant indicators were as follows, respectively: (2) 0.78, 0.37, 0.55; (3) 0.45, 0.72, 0.58; (4) 0.63, 0.54, 0.57; (6) 0.45, 0.69, 0.59; (8) 0.48, 0.80, 0.66; and (9) 0.63, 0.54, 0.59. The presence of free body also showed a significant difference between both heels ($p < 0.05$).
Conclusion: Some radiographic indicators for Haglund's syndrome are applicable to the diagnosis of insertional Achilles tendinopathy. A comparison of the parameters of Haglund's syndrome with those of insertional Achilles tendinopathy may illuminate the etiology and pathology of insertional Achilles tendinopathy and lead to novel treatments.

1. Introduction

Insertional Achilles tendinopathy is characterized by the exostosis and degeneration of the Achilles tendon at the Achilles tendon insertion [1,2]. Insertional Achilles tendinopathy presents various radiographic characteristics, including exostosis and intra-tendon calcification. However, there is limited research on the radiographic evaluation of this condition [3,4].

Most radiographic evaluations of posterior heel pain are those of Haglund's syndrome [5–12]. In 1928, Haglund reported the case of a 20-year-old woman characterized by the impingement of the Achilles tendon between the shoe and the sharp posterosuperior prominence of the calcaneus and subsequent two bursitis: retrocalcaneal bursitis and subcutaneous calcaneal bursitis [13,14]. To the best of our knowledge, the term Haglund disease was introduced by Ruch in 1970 as an entity characterized by the abovementioned bursitis and huge posterosuperior prominence [15]. Then, the terms Haglund's syndrome and Haglund deformity for the sharp posterosuperior boney prominence were first used by Pavlov et al. and Vega et al. in 1982 and 1994, respectively [9,12]. The radiographic evaluation of Haglund's syndrome has been well characterized in literature, and as radiographic parameters, the calcaneal pitch angle, Fowler-Phillip angle, parallel pitch lines test, and Cheaveau-Liet angle have been widely used for the disease [6,15–17].

The involvement of Haglund deformity in insertional Achilles tendinopathy is controversial [18]. While some surgeons combine posterosuperior prominence resection with other procedures for insertional Achilles tendinopathy surgery [19,20], others believe that posterosuperior prominence resection should not be indicated for the

* Correspondence to: Department of Orthopedic Surgery, Yashio Central General Hospital, 845 Minamikawasaki, Yashio-shi, Saitama 340-0814, Japan.
E-mail address: nakajimakenichiro@hotmail.co.jp.

https://doi.org/10.1016/j.ejro.2024.100568
Received 10 May 2023; Received in revised form 3 May 2024; Accepted 6 May 2024

condition [21–25]. However, a histopathological study reported replacement of posterosuperior prominence cartilage with fibrocartilage in cadavers with insertional Achilles tendinopathy, suggesting involvement of superior Haglund's deformity [26].

We hypothesized that insertional Achilles tendinopathy is associated with Haglund's syndrome and some radiographic indicators for Haglund's syndrome are applicable to insertional Achilles tendinopathy. A comparison of the parameters of Haglund's syndrome with those of insertional Achilles tendinopathy may illuminate the etiology and pathology of insertional Achilles tendinopathy and lead to novel treatments. The purpose of this study was, therefore, to investigate whether previously published radiographic parameters for Haglund's syndrome are applicable to insertional Achilles tendinopathy.

2. Methods

2.1. Patients and inclusion/exclusion criteria

The medical records of consecutive patients with insertional Achilles tendinopathy who underwent an endoscopic surgery (fluoroscopic and endoscopic calcaneal exostosis resection and Achilles tendon debridement) from April 2017 to December 2022 were reviewed [1]. All records were analyzed anonymously. Informed consent was obtained from all patients preoperatively for the use of patient medical records, and there were no patients who declined the use of their records. Ethical approval for this study was obtained from the Institutional Review Board of our hospital (Approval no.: YIHCE2022-11).

Only those patients who underwent endoscopic surgery for insertional Achilles tendinopathy on one heel and experienced no pain on the other were included in this study. Patients who underwent this surgery on both heels were excluded from the study, allowing for a comparison between symptomatic and asymptomatic heels. Patients who underwent this surgery combined with additional procedures for Haglund's syndrome and plantar fasciitis were excluded to eliminate the influence of these conditions on the results.

Insertional Achilles tendinopathy was diagnosed based on tenderness at the Achilles insertion and radiographic presence of the calcaneal exostosis. Haglund's syndrome was diagnosed based on tenderness at the retrocalcaneal bursa. Magnetic resonance imaging was not used to diagnose Haglund's syndrome due to reports of asymptomatic retrocalcaneal bursitis on magnetic resonance imaging [27–29].

2.2. Study design and measurements

The following data on baseline characteristics were obtained from the medical records: sex, age at surgery, and body mass index (BMI).

Preoperative calibrated radiographs of the non-weight-bearing lateral views of the bilateral calcaneus of the symptomatic and asymptomatic heel obtained one-month prior to surgery were used for cross-sectional comparison. The lateral view was obtained as part of the routine three-view examination of the calcaneus. Considering the patient's radiation exposure, an additional weight-bearing lateral view of the calcaneus was not obtained. Radiographic evaluation was performed using the following parameters (Fig. 1), and all measurements were performed by the first author.

(1) Calcaneal pitch angle: The angle between the plantar fascia at the calcaneal insertion and the tangent to the inferior margin of the calcaneus [15].
(2) Fowler-Phillip angle: The angle between the tangent to the inferior margin of the calcaneus and the tangent to the posterior surface of the posterosuperior prominence [16].
(3) Posterior calcaneal angle: The angle between the line perpendicular to the plantar fascia at the calcaneal insertion and the tangent to the posterior surface of the posterosuperior prominence [6].
(4) Chauveau-Liet angle: (Calcaneal pitch angle) - (Posterior calcaneal angle) [6].

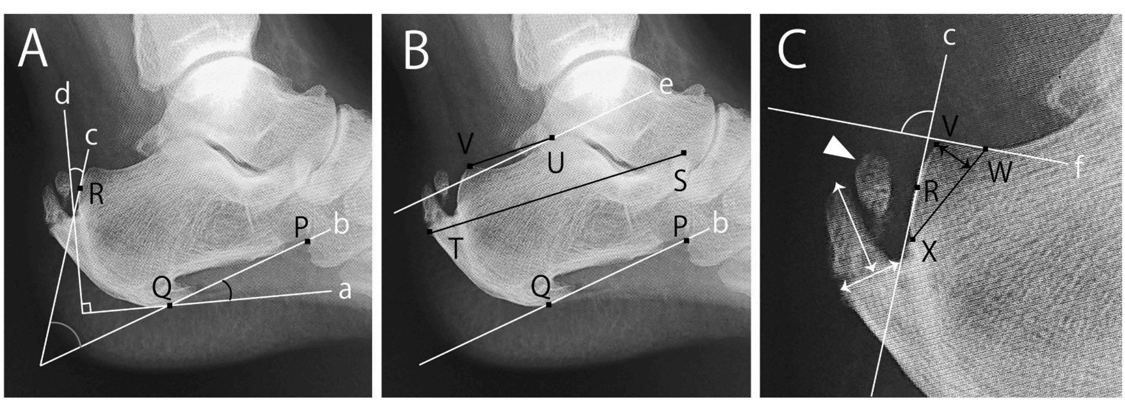

Fig. 1. Radiographic indicators for insertional Achilles tendinopathy. A. Calcaneal pitch angle, Fowler-Phillip angle, Posterior calcaneal angle, and Chauveau-Liet angle. Calcaneal pitch angle is the angle between line a and line b (black arc). Fowler-Phillip angle is the angle between lines b and c (gray arc). Posterior calcaneal angle is the angle between lines c and d (white arc). Chauveau-Liet angle: (Calcaneal pitch angle (black arc)) - (Posterior calcaneal angle (white arc)). P) Antero-inferior margin of the calcaneus. Q) Lowest point of insertion of the plantar fascia to the calcaneus. R) The midpoint of the posterior surface of the posterosuperior prominence. a) The tangent to the plantar fascia at the calcaneal insertion. b) The tangent to the inferior margin of the calcaneus. In this study, this tangent was defined as the line that passes through points P and Q, because some cases had large spur at the insertion of the plantar fascia while the others did not. c) The tangent to the posterior surface of the posterosuperior prominence. In this study, this tangent was set to pass through point R, because some cases had round posterior surface of the posterosuperior prominence, and its tangent was variable. d) The line perpendicular to line a. B. X/Y ratio and parallel pitch lines test. X is the total calcaneal length (ST). Y is the greater tuberosity length (UV). In this study, point U was set at the highest point of the articular surface because some cases had posterior extension facet. Parallel pitch lines test assesses whether the position of point V is over or under line e that passes through point U and is parallel to line b. The test result is positive when point V is over line e. S) The most anterior point of the calcaneus. T) The most posterior point of the calcaneus. U) The highest point of the articular surface. V) The tip of the posterosuperior prominence. e) The line that passes through point U and is parallel to line b. C. Haglund's deformity height, Haglund's deformity peak angle, calcification length, calcification width, and presence of free body. Haglund's deformity height (black arrow) is the distance from point V to the line drawn at the base of the posterosuperior prominence (WX). Haglund's deformity peak angle (white arc) is the angle between lines c and f. Calcification width is the width of the base of the exostosis, and calcification length is the length from the base to the tip of the exostosis (white arrows). Free body is defined as a bone within the Achilles tendon without continuity with the calcaneus (arrowhead). W) The anterior point of the base of the posterosuperior prominence. X) The posterior point of the base of the posterosuperior prominence. f) The tangent to the anterior surface of the posterosuperior prominence.

(5) X/Y ratio: X is the total calcaneal length, i.e., the length from the most anterior point to the most posterior point of the calcaneus. Y is the greater tuberosity length, i.e., the length from the most posterior edge of the posterior facet to the tip of the posterosuperior prominence of the calcaneus [11].
(6) Haglund's deformity height: The distance from the tip of the posterosuperior prominence to the line drawn at the base of the posterosuperior prominence [3].
(7) Haglund's deformity peak angle: The angle between the tangent to the anterior surface and the tangent to the posterior surface of the posterosuperior prominence [3].
(8) Parallel pitch lines test: A line that is tangent to the inferior surface of the calcaneus and passes through the posterior edge of the subtalar articular surface is drawn. When the tip of the posterosuperior prominence is above the line, the test result is determined as positive [17].
(9) Calcification length: The length from the base to the tip of the calcification [3].
(10) Calcification width: The width of the calcification base [3].
(11) Presence of free body: Free body was defined as a bone within the Achilles tendon without continuity with the calcaneus.

2.3. Statistical analyses

For the radiographic assessment of the above-described parameters (excluding parallel pitch lines test and presence of free body), the Wilcoxon signed rank test was used to compare the symptomatic and asymptomatic heels. All two-tailed tests were considered significant when the p-value was less than 0.05. For parameters showing significant differences between the heels, threshold value, sensitivity, specificity, and area under curve (AUC) were calculated using receiver operating characteristic curves. A threshold value was determined to maximize the sum of sensitivity and specificity. For the parallel pitch lines test and presence of free body, the McNemar's test was used for the comparison.

All statistical analyses were performed using EZR (easy R), version 1.54 (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a modified version of R version 4.0.3 commander (The R Foundation for Statistical Computing, Vienna, Austria) [30,31].

3. Results

3.1. Demographics

From the total number of patients with insertional Achilles tendinopathy who underwent surgery, nine patients with bilateral heel pain, three with retrocalcaneal bursitis, and two with plantar fasciitis were excluded. Thus, 71 patients (52 males; mean age, 57.2; mean BMI, 27.1) who met the inclusion criteria were enrolled in this study. Patient baseline characteristics are shown in Table 1.

3.2. Radiographic parameters

The values of each parameter in the symptomatic and asymptomatic heel are shown in Table 2. Among them, the Fowler-Phillip angle, posterior calcaneal angle, Chauveau-Liet angle, Haglund's deformity height, and calcification length and width showed significant differences between both heels. Threshold values, sensitivity, specificity, and AUC for these significant parameters are shown in Table 3. None of these parameters had high sensitivity and specificity. The presence of free body and parallel pitch lines test results are shown in Table 4. The symptomatic heels had a significantly higher proportion of free body than the asymptomatic heels, while no significant differences were observed between both heels in the parallel pitch lines test.

Table 1
Patient baseline characteristics.

	N, Mean ± SD	Range
Total	71	
Female	19	
Male	52	
Age (years)	57.2 ± 11.4	30–80
Height (cm)	168.7 ± 9.8	146–189
Weight (kg)	77.3 ± 17.6	40–147
BMI (kg/m^2)	27.1 ± 5.2	16.6–42.0

Abbreviation; BMI, body mass index; SD, standard deviation.

Table 2
Radiographic comparison between calcaneus of symptomatic and asymptomatic heel.

Parameter	Symptomatic Mean ± SD (range)	Asymptomatic Mean ± SD (range)	*p*-value
Calcaneal pitch angle (degrees)	23.5 ± 4.5 (15–37)	23.0 ± 4.5 (16–37)	$p = 0.30$
Fowler-Phillip angle (degrees)	58.9 ± 6.7 (45–72)	57.8 ± 7.3 (40–80)	**$p < 0.05$**
Posterior calcaneal angle (degrees)	7.6 ± 6.3 (-7–20)	9.2 ± 6.4 (-12–19)	**$p < 0.05$**
Chauveau-Liet angle (degrees)	15.8 ± 8.6 (-2–44)	13.9 ± 8.2 (-2–41)	**$p < 0.05$**
Total calcaneal length (X) (mm)	84.4 ± 6.1 (72–99)	84.1 ± 5.8 (72–97)	$p = 0.21$
Great tuberosity length (Y) (mm)	30.0 ± 3.9 (21–40)	29.8 ± 3.2 (22–37)	$p = 0.34$
X/Y ratio	2.8 ± 0.3 (2.1–4.0)	2.8 ± 0.2 (2.3–3.3)	$p = 0.87$
Haglund's deformity height (mm)	5.4 ± 1.3 (2–8)	5.0 ± 1.2 (2–8)	**$p < 0.05$**
Haglund's deformity angle (degrees)	99.6 ± 9.7 (76–125)	99.0 ± 8.6 (84–123)	$p = 0.44$
Calcification length (mm)	10.6 ± 5.5 (2–25)	7.5 ± 4.8 (0–27)	**$p < 0.001$**
Calcification width (mm)	5.1 ± 1.9 (2–11)	4.4 ± 2.3 (0–11)	**$p < 0.05$**

Obtained using Wilcoxon signed rank test. Abbreviation: SD, standard deviation.

4. Discussion

This study compared the radiographic characteristics of symptomatic and asymptomatic heels in 71 patients with insertional Achilles tendinopathy and found that the Fowler-Phillip angle, posterior calcaneal angle, Chauveau-Liet angle, Haglund's deformity height, calcification length and width, and presence of free body showed significant differences between the heels. This suggested that insertional Achilles tendinopathy is associated with Haglund's syndrome. As previously mentioned, the involvement of Haglund deformity in insertional Achilles tendinopathy is controversial. This study provided evidence supporting their connection.

The significant differences in the Fowler-Phillip, posterior calcaneal, and Chauveau-Liet angles, and Haglund's deformity height suggest that

Table 3
Diagnostic accuracy of parameters showing significant differences.

Parameter	Threshold	Sensitivity	Specificity	AUC (95 %CI)
Calcification length (mm)	11.0	0.48	0.80	0.66 (0.57–0.75)
Calcification width (mm)	5.0	0.63	0.54	0.59 (0.50–0.68)
Chauveau-Liet angle (degrees)	14.0	0.63	0.54	0.57 (0.48–0.67)
Fowler-Phillip angle (degrees)	63.0	0.78	0.37	0.55 (0.46–0.65)
Haglund's deformity height (mm)	6.0	0.45	0.69	0.59 (0.50–0.68)
Posterior calcaneal angle (degrees)	6.0	0.45	0.72	0.58 (0.49–0.67)

Abbreviation: AUC, area under curve; CI, confidence interval.

Table 4
Results of presence of free body and parallel pitch lines test.

	(+)	(-)
Presence of free body		
Symptomatic	56	15
Asymptomatic	32	39
		$p < 0.05$
Parallel pitch lines test		
Symptomatic	29	42
Asymptomatic	28	43
		$p = 0.12$

Obtained using McNemar's Chi-squared test.

the shape of Haglund's deformity and its proximity to the Achilles tendon may be related to the onset of insertional Achilles tendinopathy. Furthermore, all 71 patients in this study were free of retrocalcaneal bursitis, which possibly indicates that the shape of Haglund deformity and its proximity to the Achilles tendon may be a factor in the degeneration of Achilles tendon insertion rather than a current cause of pain. In studies comparing an asymptomatic control group with patients experiencing insertional Achilles tendinopathy, Haglund's syndrome, or posterior heel pain, the Fowler-Phillip angle in the symptomatic and asymptomatic groups was 62.3 and 60.1 according to Lu, 57.1 and 56.5 according to Sundararajan, 62.1 and 61.0 according to Kang, 56.2 and 55.4 according to Singh, and 58.0 and 59.0 according to Tourné, respectively. Except for Tourné, our study reported similar results [3,4,7,11,32].

In the present study, there was no significant difference in the calcaneal pitch angle while there was a significant difference in the Chauveau-Liet angle. This suggests that calcaneal posterior tilt alone has little association with the onset of insertional Achilles tendinopathy, but a combination of calcaneal posterior tilt and the specific shape of the calcaneus may be well associated with disease onset. In the literature, the values of the calcaneal pitch angle in the Haglund syndrome/insertional Achilles tendinopathy group and the control group were 22.1 and 20.3 according to Bulstra, 21.6 and 18.4 according to Sundararajan, 19.9 and 19.7 according to Singh, and 25.5 and 21.7 according to Tourné, respectively [4,5,11,30], with each study demonstrating no significant differences between the groups. Meanwhile, the Chauveau-Liet angle values were 3.7 and − 4.4 according to Sundararajan and 19.1 and 11.5 according to Tourné, for each heel, respectively [4,11]. Although the absolute values differed among the studies, the angle in symptomatic group was larger than that in asymptomatic group.

The length and width of calcification and the presence of free body were also significantly different between the symptomatic and asymptomatic heels in the current study. This suggests that disease onset continued as degeneration progressed at the Achilles tendon insertion. In addition, the significant difference between the two groups regarding the presence of free body suggested that the free body itself may be a cause of pain. Lu et al. compared 37 heels of 31 patients with Haglund syndrome and 40 heels of 27 patients without heel pain and reported 78.4 % and 12.5 % calcification, respectively [7]. Fiamengo et al. compared 16 painful posterior heels with 160 control heels and reported that the incidence of exostosis in painful heels was 9.2 times higher than that in controls [18]. These results were similar to ours.

Given that none of the parameters with significant differences had high sensitivity and specificity (Tables 2 and 3), their diagnostic value for insertional Achilles tendinopathy is limited. Singh et al. reported a sensitivity of 0.73 for the Chauveau-Liet angle, and 0.63 for the parallel pitch lines test, which were similar to our results [33].

This study had several limitations. First, patients with bilateral symptomatic insertional Achilles tendinopathy were excluded, and therefore their radiographic characteristics were unknown. Second, non-weight-bearing radiographs were used for this study; thus, the results of calcaneal pitch angle and posterior calcaneal angle could not be compared with those of other studies using weight-bearing radiographs. Broos et al. conducted a comparison between weight-bearing and non-weight-bearing feet in 20 healthy volunteers using CT-images, reporting calcaneal pitch angles under weight-bearing and non-weight-bearing of 24.6° and 22.7° for the left foot, and 24.1° and 23.1° for the right foot, respectively [34]. However, the difference between symptomatic and asymptomatic heels in this study was not influenced by the non-weight-bearing issue, as both heels were assessed under the same radiographic conditions. Third, this study was cross-sectional, thus the proposed pathology of insertional Achilles tendinopathy mentioned in the discussion section was not validated. Prospective studies are necessary to validate these findings. Fourth, while this study contributed to understanding the pathology of insertional Achilles tendinopathy, the results were not helpful in determining treatment strategies. Fifth, given that the number of enrolled patients was small, subgroup analyses using sex or BMI could not be performed. Sixth, not all previously published parameters could be performed [8,10]. Seventh, there may have been observer bias, as measurements were performed by the first author only. Finally, since this was a single-center, retrospective study conducted at a local hospital, these results may not be generalizable to an outside population.

5. Conclusion

Some radiographic indicators for Haglund's syndrome are applicable to insertional Achilles tendinopathy. This indicates that insertional Achilles tendinopathy may be associated with Haglund's syndrome. The significant differences in the Fowler-Phillip, posterior calcaneal, and Chauveau-Liet angles, and Haglund's deformity height suggest that the shape of the Haglund's deformity and its proximity to the Achilles tendon may be related to the onset of insertional Achilles tendinopathy. No significant difference in the calcaneal pitch angle and a significant difference in the Chauveau-Liet angle suggest that calcaneal posterior tilt alone has little association with the onset of insertional Achilles tendinopathy; however, a combination of calcaneal posterior tilt and the specific shape of the calcaneus bone may be robustly associated with disease onset. The significant differences in the length and width of calcification and the presence of a free body suggest that disease onset continued as degeneration progressed at the Achilles tendon insertion and that the free body itself may be a cause of pain. However, none of the parameters showing significant differences demonstrated high sensitivity and specificity. Consequently, these parameters offer limited diagnostic value for insertional Achilles tendinopathy.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethical Statement

Ethical approval for this study was obtained from the Institutional Review Board of Yashio Central General Hospital (Approval no.: YIHCE2022-11). Written informed consent for the use of patient medical records was obtained from the patients before surgery.

CRediT authorship contribution statement

Kenichiro Nakajima: Writing – original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The author would like to thank Elsevier Language Editing Services for the English editing.

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