



# Insertional Achilles Tendinopathy is Associated with Morphologic and Radiographic Alignment Features of the Foot: A Retrospective Cohort Study

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## BACKGROUND

- Insertional Achilles tendinopathy (IAT) associated with calcification and degeneration of the insertion is a common disorder. (Figure 1)
- Presently, there is little understanding of the etiology, pathogenesis, and biomechanics of this disease entity, although excessive tension at the Achilles insertion associated with calcaneus abnormalities have been considered a contributing factor.
- Multiple imaging modalities have been used to investigate a possible correlation between calcaneus morphology and IAT. However, no prognostic criteria have yet been found.



Figure 1 Demonstration of a control foot (left) and a foot with Insertional Achilles Tendinopathy (right, red circle)

## OBJECTIVE

The goal of this study was to investigate the morphology of the calcaneal tuberosity in both normal control and IAT groups, to propose a novel angular measurement of the enlarged tuberosity, and to evaluate the correlation of this morphological change with radiographic alignment features of the hindfoot and arch height in the IAT group.

## METHODS

- First, lateral weightbearing radiographs of 40 control feet were used to study morphology of normal calcaneal tuberosities by mapping contour of the tuberosity onto part of a standard circle (SC) scaled by the height and width of the calcaneus (Figure 2).
- Secondly, 40 enlarged IAT tuberosities were mapped and compared to their respective SCs to develop a new angular measurement, the Pathologic Achilles Insertion Angle (PAIA), using the weightbearing point of the calcaneus as the apex of the PAIA to rotate and fit the each enlarged curve to its SC (Figure 3).
- Lastly, medical records of 85 patients with symptomatic IAT were retrospectively reviewed. The PAIA was used for the morphological evaluation. The lateral view of subtalar joint alignment (LVSJA), calcaneal Pitch Angle, ratio of the Medial Cuneiform Base Height/Cuboid Height, ratio of the Medial Cuneiform Base Height/Fifth Metatarsal Height were also evaluated and correlation of PAIA to each of the above parameters was studied.

## RESULTS

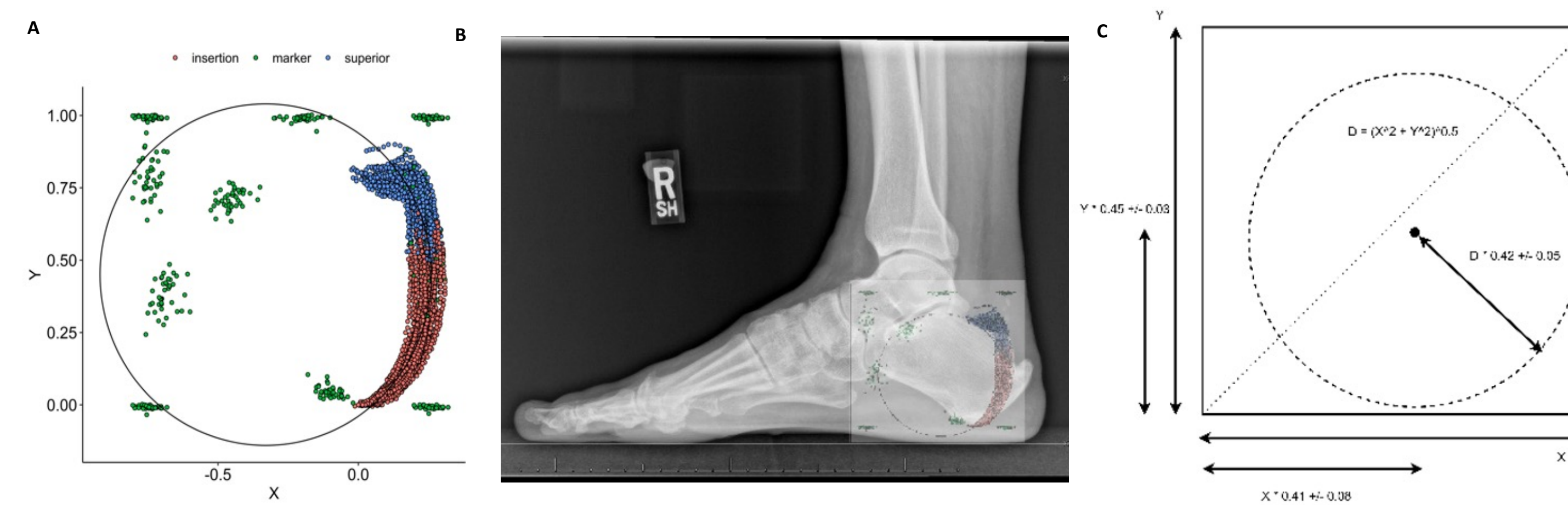


Figure 2. Lateral weightbearing images of 40 control feet were used to determine the size of the calcaneus and contour of the tuberosity. The shape of the calcaneus was mapped onto part of a circle the Standard Circle (SC) whose center and radius were statistically fitted and scaled in relation to the height and width of the calcaneus. Green dots are the preliminarily established bone anatomical markers. Red and blue dots denote the insertion and superior parts of the calcanei outlined. X and Y axis of the figure are normalized by calcaneus height and width (A); Overlap between the standard curve and the weightbearing XR image of a foot with IAT (B); Parameterization of the standard circle indicates that the center of the SC is away from the anterior end of the calcaneus by 41% of its width, and above the weightbearing point by 45% the height of the calcaneus. The radius of the standard curve is approximately 42% the diagonal of the smallest rectangle containing the calcaneus (C).

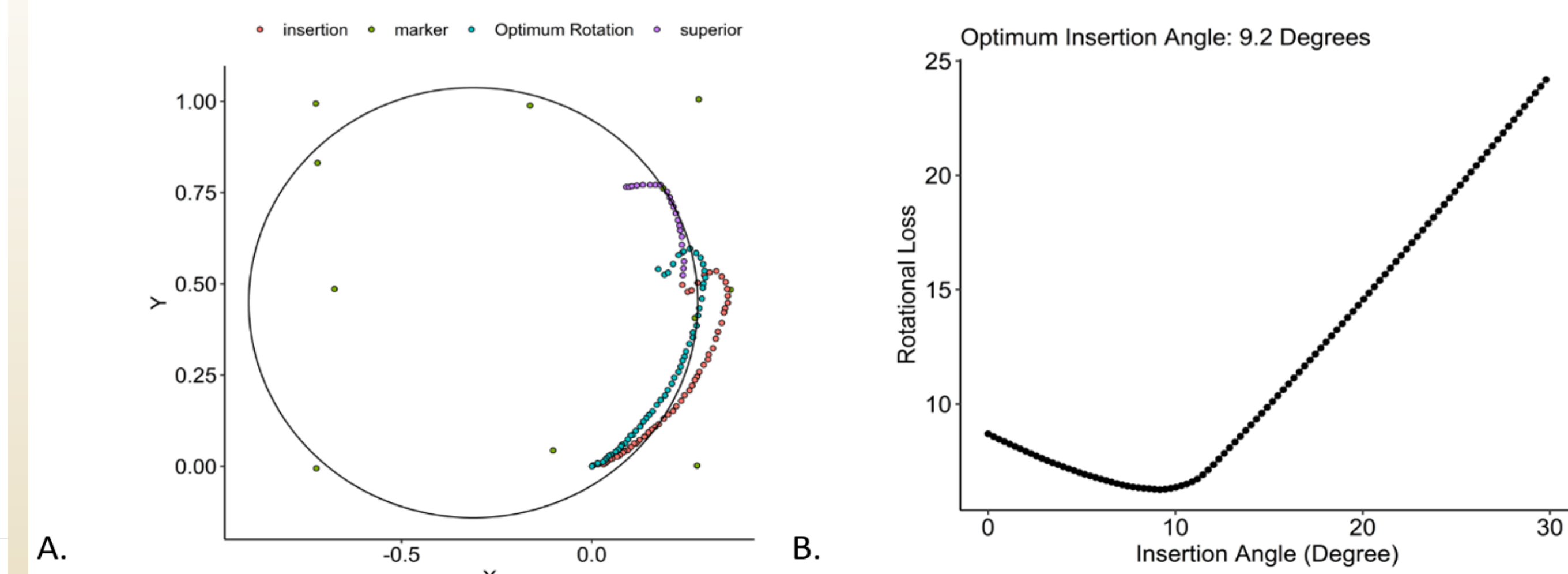


Figure 3. The diseased posterior calcaneal tuberosity of a patient with IAT was outlined and compared to its respective standard circle (SC). An angle was calculated by which the diseased calcaneus curve was rotated around the weightbearing point to fit the SC. This angular measurement was defined as the Pathologic Achilles Insertion Angle (PAIA). Figures 3A and 3B show the simulated optimal rotation of which insertion angle is calculated to minimize the gross rotational loss from the standard circle. In Figure 3A, purple and red dots are the outlined diseased posterior calcaneal tuberosity, and the teal dots are the simulated movement of the posterior tuberosity to the SC with the PAIA calculated from the loss plot (Figure 3B).

Hindfoot Alignment Comparison	Difference Between PAIA Means	95% Confidence Limits		N	Medial Cuneiform Base Height/Cuboid Height	Medial Cuneiform Base Height/Fifth Metatarsal Height	PAIA (degree)
Neutral - Valgus	0.494	-3.046	4.034	59	1.69 ± 0.28*	2.69 ± 1.73	13.29±5.38
Neutral - Varus*	4.020	0.697	7.343	14	1.96 ± 0.38*	3.42 ± 1.78	9.27±4.78
Valgus - Varus	3.526	-0.871	7.924	12	1.52 ± 0.26*	2.25 ± 0.74	12.80±7.47

Table 1. Measurements of Arch Height for the three subgroups in the group of patients with IAT.

Table 2. Comparison between means of PAIA among neutral, valgus and varus hindfoot groups.  
\*: Statistically significant difference detected.

- There were 38 males and 47 females with a mean age 54.59 (range 34-80), pitch angle 21.37 degrees (range 12.18-33.20) and PAIA 12.56 degrees (range 2.45-29.79).
- The LVSJA showed that 59 patients had a neutral hindfoot (69.41%), 14 had a varus (16.47%), and 12 (14.12%) had a valgus hindfoot.
- Among these three subgroups, there were significant differences of the calcaneus Pitch angle, and the Medial Cuneiform Base Height/Cuboid Height between the valgus and varus hindfoot groups, and the valgus and neutral hindfoot groups, but not the varus and neutral hindfoot groups.
- No difference was found in the Medial Cuneiform Base Height/Fifth Metatarsal Height between any two of the three subgroups.
- The PAIA difference between the neutral and varus hindfoot groups was significantly larger than the others. There was no significant correlation between PAIA and the calcaneal Pitch angle, as well as the two arch height indexes. (Tables 1-2)

## CONCLUSIONS

- This study is the first to include the morphology of the calcaneus, the hindfoot and arch height features in assessing IAT.
- The newly introduced angular measurement (PAIA), reports information of both the position and the shape of the calcaneus and is found to be significantly smaller in patients with a varus hindfoot than those with a neutral hindfoot.
- Further investigation with a larger sample size to study possible correlations among clinical symptoms, calcaneus morphology, and alignment of the feet will be helpful to guide both diagnosis and treatment of IAT.

## REFERENCES

- Chimenti RL, Cychosz CC, Hall MM, Phisitkul P. Current concepts review update: insertional Achilles tendinopathy. Foot Ankle Int 2017;38:1160-9
- Krishna Sayana M, Maffulli N. Insertional achilles tendinopathy. Foot Ankle Clin 2005;10:309-20
- Holmes GB, Lin J. Etiologic factors associated with symptomatic Achilles tendinopathy. Foot Ankle Int 2006;27:952-9