

An Audit of Dorsal Morphology of 30 Adult-Paired Cadaveric Calcaneal Specimen – An Osteological Study

Rebecca Murerwa, Thomas Amuti, Nikita Muuthuri, Anita Wambui, Innocent Ouko, Julius Ogeng'o

Department of Human Anatomy, University of Nairobi

Correspondence to: Thomas Amuti. P.O. Box 30197 – 00100, Nairobi. Email: tomamuti@gmail.com.

Abstract

Background: The calcaneus exhibits variations of articular facets and calcaneal sulcus width. These variations influence occurrence of osteoarthritic conditions, which have significant prevalence in our setting, and are essential during surgeries involving the foot. Despite this, local data on calcaneal facets remains undocumented. **Materials and methods:** Sixty calcanei were obtained from the National Museum of Kenya. The number, type and shapes of their facets were documented and calcaneal sinus width was measured. Images were taken and collected data was represented in tables and figures. **Results:** The calcanei had 1-3 articular facets. The common calcaneus type noted was type 1B on the right calcaneus and 1B on the left. The least type was type 4 on the right and 2C on the left. In terms of shape, type 1 and 4 calcanei had non-rounded facets while type 2 had

rounded facets. The width of the sulcus calcanei was narrowest among type 1 calcanei in the right foot at 0.53 mm. On the left foot, type 2 calcanei had narrower calcaneal sulcus width, 0.455 mm (0.35 – 0.60).

Conclusion: Our findings may aid in surgeries of the foot and in providing a link between local calcaneal variations and prevalence of osteoarthritic foot conditions.

Keywords: calcaneal-facets, sinus tarsi, arthritis.

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Introduction

The calcaneus is the largest tarsal bone (1- 3). It bears variations in the number and shape of talo-calcaneal facets. Numerically, the bone is known to have one to three facets. Morphologically, these facets have further been classified into types. Type 1 calcanei have two facets; an anteromedial and a posterior facet. Type 2 have 3 facets, an anterior, middle and posterior one. Type 3 calcanei have 2 facets also, a middle and a posterior one while type 4 has one facet; a combined anteroposteromedial facet. Population variations on the prevalence of the types of calcanei have been noted. Data from the Caucasian (4, 5) populations showed that their calcanei predominantly had 3 facets, however, in the Indian (6), Nigerian (4), Thai (7) and Turkish populations (8), 2 facets per calcanei were most common.

As regards the shape of the facets, despite their reported concavity, a study done in the Nigerian population (1), showed that the anterior and middle facets were mostly oval while the anteromedial facet was elongated and the posterior facet was rounded in their population.

Furthermore, notable variations on the calcaneal sulcus have been reported. The calcaneal sulcus is the dorsal groove that articulates with the tarsal sulcus to form the

sinus tarsi at the sub-talar joint. Since the tarsi allows for the passage of structures, its width is of significant clinical importance. Collected data has shown variations in this width with the Turkish (7), Indian (10) and Korean population (11), having values of 6.15, 21.1- and 5.16-mm. Variations in width size could have clinical implications such as bone and tendon pains by causing compression of structures.

The reported variations of the calcaneus, especially those on the type as well as the shapes of the facets have been shown to influence surgical procedures, internal and external fixation in various diseases of the foot such as talocalcaneal arthritis, pes planus, congenital dysmorphology and valgus deformities (11). Some of these osteoarthritic disorders such as pes planus (12, 13), have been shown to bear significant prevalence in Kenya (43.2%) (14). There is however a dearth of data on the morphological variations of the calcaneal facets as well as the calcaneal sinus in our setting. This data may be relevant in contributing to the pre-existing scanty knowledge on the influence of the variations of the talo-calcaneal facets on prevalence of osteo-arthritic disorders in our setting as well as provide local data that may be useful in orthopaedic surgeries.

Materials and Methods

The present study is a descriptive cross-sectional study, with a sample size of 60 dried calcanei (30 right and 30 left calcanei) from The National Museum of Kenya in Nairobi. The specimens used were of adult Kenyans (18 to 65 years). Stratification by gender was difficult due to missing information from the identification cards. Calcanei that showed structural deformities were also not used for the study. Ethical approval for the use of osteological specimen was provided by the Department of Human Anatomy, University of Nairobi and the National Museum of Kenya as per the Kenyan constitution.

The calcanei were first randomly sampled from where they were classified (based on the calcaneal facet number and type), following the classification by Laxmi et al., (2017) (15):

Type 1: One continuous facet is situated on the sustentaculum tali extending on to the antero-medial corner of the distal part of the calcaneus. The facet can either be constricted or not constricted. The other facet is posterior to the first.

The constriction of the anterior facet and the posterior is defined as a temporary point of separation of the two facets by Jung et al., 2015 (11); and the extent of the constriction/separation is defined as the degree of separation. The degree of separation of the facets ranges from 2.00 to 1.00, with a grade of 2.00 being those facets whose anterior and middle facets are completely separated (type 2 facets), 1.00 as those that are fused into a single facet (with no point of constriction) and finally, those with constrictions being graded between 1.00 and 2.00. Specifically, the degree of separation in constricted facets is calculated by the following formula: $1.00 + \text{the ratio of disconnected parts at the constriction to the total width of the anterior and middle facets}$.

Type 2: Two articular facets are present, one on the sustentaculum tali (anterior and middle facets) and the other on the distal part of the calcaneus (posterior facet). The distance between the middle and anterior facets of the sustentaculum facets further sub divide the type 2 facets into 4 subdivisions: With type 2A having the distance between the anterior and middle facets being < 2 mm; 2B: between 2-5 mm; 2C: > 5 mm with large an anterior facet and 2D: > 5 mm with a small anterior facet.

Type 3: Two facets are present with the anterior one restricted to the sustentaculum tali

Type 4: A single facet is situated on the sustentaculum tali extending on to the antero-medial corner of the distal part of the body of the calcaneus. This facet is continuous with the posterior talar facet of the calcaneus.

The shapes of each facet per calcanei were also documented.

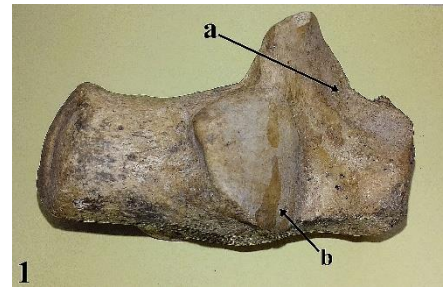


Figure 1: Image showing the type 1 calcaneal facet (non-constricted) a. anteromedial facets (non-constricted), b. posterior facet

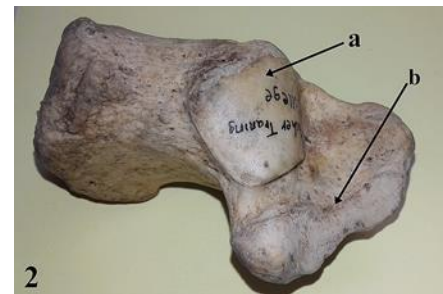


Figure 2: Image showing the type 1 calcaneal facet (constricted), a. posterior facet, b. anteromedial facets (constricted)



Figure 3: Image showing the type 2 calcaneal facet, a. posterior facet, b. middle facet, c. anterior facet



Figure 4: Image showing the type 4 calcaneal facet, a. combined antero-medio-posterior facet

To measure the calcaneal sulcus width, a Vernier Callipers was used. The width of the sulcus tarsi was defined as the shortest distance (16) between the antero-middle facet and the posterior facet in type 1, the shortest distance between the middle and posterior facets in type 2 and the shortest distance between the middle and posterior facets in type 3. At least three measurements of the calcaneal sulcus were taken from where the average was taken as the calcaneal sulcus width. Data collected was entered into and analysed using SPSS version 21. P value was considered significant at 95% confidence interval. The findings were represented in tables and figures.

Results

Morphology of the calcaneal facets

All the calcanei had articular facets that ranged in number from 1 to 3. Further, the most prevalent calcaneus type noted was type 1B followed by 1A on the right calcaneus. The least type was type 4. On the left calcaneus, type 1B was most common followed by 1A then 2A and 2B. The least common type were types 2C, and 4 (Table 1). Paired t test revealed significant differences between the right and left calcaneal types (p value = 0.001). It is also worth noting that in our setting, a type 3 calcaneus was not documented.

With regard to facet shape, all combined anterior and middle facets (type 1) and the combined single facet (type 4) calcanei were non-rounded. The type 1 calcanei were elongated in shape. The type 4 were v-shaped. Calcanei having the type 2 facet configuration (all three facets) on the other hand had rounded anterior, middle and posterior facets. These findings were similar on both the right and left calcaneal groups. Paired t test done to compare the right vs left calcaneal shapes revealed no significant differences.

Table 1: Table showing the percentages of various types of calcaneal facets

VARIABLE	1A	1B	2A	2B	2C	2D	3	4
RIGHT CALCANEAL TYPE	20%	47%	13%	10%	6%	-	-	4%
LEFT CALCANEAL TYPE	22%	40%	13%	13%	4%	-	-	8%

Width of the calcaneal facets

The width of the sulcus calcanei was noted to be narrowest among calcaneal with a type 1 facet arrangement in the right foot at 0.53 mm (0.30 – 1.20). On the left foot however, calcanei with a type 2 arrangement had the narrower calcaneal sulcus width, 0.455 mm (0.35 – 0.60) (Table 2).

Table 2: Table showing the width of the sulcus calcanei for the different calcanei types

CALCANEUS	CALCANEAL TYPE	MEAN WIDTH OF CALCANEAL SULCUS (cm)	RANGE (cm)
RIGHT CALCANEUS	1	0.53	0.30-1.20
	2	0.56	0.34-1.49
LEFT CALCANEUS	1	0.46	0.30-0.78
	2	0.455	0.35-0.60

Discussion

Predominant calcaneal facet type 1

The calcaneal facet type 1 was the most dominant in the study setting. Our findings were different from those of the British (4) and American (5) populations where the predominant calcanei facet type was type 2. Our findings were however similar to those of the Indian (6), Nigerian (4), Thai (7) and Turkish populations (8) where type 1 was most prevalent. The variance could have a root cause in genetic heterogeneity where owing to differences in genetic makeup, populations might bear differences on calcaneal anatomy similar to those seen in other bones (17).

It has been suggested that the facet number is an important factor in subtalar joint stability and formation of osteophytes that facilitate development of osteoarthritis. Studies have shown that subtalar joints which have the type 2 facet configuration are comparatively more stable and have a less chances for developing arthritis (12). This clinical outcome is likely due to the fact that facets with the anterior, middle and posterior facets (type 2) provide an 'osseous tripod' for the talus to sit on and to prevent excess motion of the talar head. Thus, the subtalar joint with this tripod support is less likely to suffer trauma or biomechanical stress and the incidence of osteoarthritis has been shown to be less in such cases (11). Secondly, it has been documented that facets with a type 1 configuration have smaller facet areas as compared to the rest. Therefore, in these individuals, more pressure may be exerted on these facers, leading to damage of the facet tissue and subsequent osteophyte formation (11). It is also important to note that individuals with type 1 and 2 facets

have been shown to have asymmetric wear patterns which might cause heavy pain, possibly leading to a habitually inclined position of the foot during walking, that predisposes to osteophyte formation and subsequent osteoarthritis (11).

Similar calcaneal facet shape

The most common shape among the combined anterior and middle facets (type 1) and the combined single facet (type 4) calcanei was non-rounded. Further, these combined anterior and middle facets were elongated in shape whereas the combined single facets were v-shaped. Calcanei having the type 2 facet configuration on the other hand had rounded anterior, middle and posterior facets. These findings were similar on both the right and left calcaneal groups. These findings were similar to data derived from the Nigerian population (1).

Non rounded facets have been linked to an osseous block in eversion and joint incongruence. This means that in people with this type of facet, osteoarthritic conditions may be prevalent. Rounded facets, on the other hand, have been linked to enabled-joint congruency throughout a wide range of movement. This means that in populations with rounded surfaces, osteoarthritic conditions may not be as prevalent as in areas where the population has flat/non-rounded facets (16). Owing to the significant number of cases of osteoarthritic conditions and paucity of data on the morphological variations on the number of calcaneal facets in our setting, findings of this study may suggest that due to having non rounded facets, this may add to the major factors that contribute to the high number of osteoarthritic conditions in our setting.

Similar calcaneal sulcus width

The calcaneal sulcus in our setting was similar in width to those reported from the Korean (11) and Anatolian populations (17) where the average values were 5.16 and 5.98 mm respectively. Our values were however lower than those reported in the Indian (9) and Turkish (7) populations where the values were 21.1 and 6.15 mm. The population differences may be due to genetic heterogeneity among populations. In our setting therefore, it may be important for surgeons to note the different values especially during subtalar implants, flaps and foot prostheses to avoid post-surgical pain and in any surgeries involving the foot.

Conclusion

Data obtained in our setting varies with that from other populations and may therefore prove useful in surgical procedures of the foot as well as in providing a possible basis on the influence of calcaneal facet variation in the local prevalence of osteoarthritis.

Conflict of interest: none declared.

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