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Study of the morphologic and morphometric patterns of talar articular facets on dry adult calcaneal bones in South-Eastern Nigerian population

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Estudio de los patrones morfológicos y morfométricos de las facetas articulares del talar en huesos calcáneos secos adultos en la población del Sureste de Nigeria

Ukoha Ukoha Ukoha[1], Obazie Izuchukwu Feechukwu[2], Chioma Onuoha[1]

College of Health Sciences, Nnamdi Azikiwe University, Nnewi - Nigeria
Anambra State University, Uli - Nigeria

[1]Department of Anatomy, College of Health Sciences, Nnamdi Azikiwe University, Nnewi
[2]Department of Human Anatomy, Anambra State University, Uli

E-mail de autor: Obazie Izuchukwu Feechukwu fejoeobazie@yahoo.com

Abstract

Background: Calcaneum is the largest and longest tarsal bone in the foot and forms the prominence of the heel. The middle third of the superior surface of calcaneus provides an articular facet for the talus bone.
Objective: The study seeks to observe the variations in the morphology and morphometry of the talar articular facets on the superior surface of dry calcaneal bones of adult human in South-Eastern Nigerian population.
Materials and methods: The study was carried out with 220 adult non-pathological dry calcanei, 111 bones of left side and 109 bones of right side of unknown sex from bone banks of various medical colleges in South-Eastern Nigeria. Each calcaneus was examined for various patterns of articulating facets for talus, the shapes of the facets and the length, width and interfacetal distances were also documented.
Results: Pattern 1 was common in the present study (59.6% right and 51.4% left). Pattern 2 has an incidence of 7.3% on the right and 8.1% on the left side. Pattern 3 was found with an incidence of 11.9% on the right and 13.5% on the left side and pattern 4 was found with an incidence of 21.1% on the right and 27% on the left side constituting the second most common pattern of talar articular facets on the superior surface of the calcaneus. The oval shape was common in the anterior and middle talar articular facets with an incidence of 52.86% and 64.39% respectively, oval and convex was common in the posterior facet (70% cases) and the elongated shape was common among the fused anterior and middle facet (63.12%) with elongated oval common in subtype 2 (27.87%) and elongated constricted common in subtype 1 (35.25%). The length of the calcanei was recorded at a mean±SD of 7.10±0.70cm (left side) and 7.01±0.72cm (right side) and that of the width was recorded at 2.77±0.38cm (left side) and 2.77±0.37cm (right side). The distance between the Anterior and Middle facets was mean±SD of 0.50±0.15cm (left side) and 0.48±0.15cm (right side), the Posterior and Middle facets at 0.59±0.20cm (left side) and 0.56±0.17cm (right side) and that between the Anterior and Posterior facets at 1.43±0.27cm (left side) and 1.42±0.29cm (right side).
Conclusion: The individual and racial differences of the anatomic construction of calcaneal talar articular facets influence the static and kinetic dynamics of foot. A good knowledge of the calcaneal facet pattern and shape would assist better treatment and management options for calcaneal fractures. It also necessitates a modification of western surgical techniques to suit the Nigerian scenario for calcaneal osteotomy.

Keywords: calcaneum, talar articular facets, pattern, shape, south-eastern nigerian population

Resumen

Introducción: *El calcáneo es el hueso tarsiano más grande y más largo del pie y forma la prominencia del talón. El tercio medio de la superficie superior del calcáneo proporciona una faceta articular para el hueso talus.*
Objetivo: *El estudio busca observar las variaciones en la morfología y morfometría de las facetas articulares del talar en la superficie superior de huesos calcáneo secos de humanos adultos en la población en la población del Sureste de Nigeria*
Materiales y métodos: *El estudio se realizó con 220 calcáneos secos no patológicos adultos, 111 huesos del lado izquierdo y 109 huesos del lado derecho de sexo desconocido de los bancos óseos de varios colegios médicos en el sureste de Nigeria. Cada calcáneo fue examinado para diversos patrones de facetas articuladas para el astrágalo, las formas de las facetas y la longitud, el ancho y las distancias interfacetales también fueron documentadas.*
Resultados: *El patrón 1 fue común en el presente estudio (59,6% derecho y 51,4% izquierdo). El patrón 2 tiene una incidencia de 7.3% a la derecha y 8.1% a la izquierda. El patrón 3 se encontró con una incidencia de 11,9% a la derecha y 13,5% a la izquierda y patrón 4 con una incidencia de 21,1% a la derecha y 27% a la izquierda constituyendo el segundo patrón más frecuente de articulación talar articular Facetas en la superficie superior del calcáneo. La forma ovalada era común en las facetas articulares anterior y media del talón con una incidencia de 52,86% y 64,39% respectivamente, ovales y convexos eran comunes en la faceta posterior (70% de los casos) y la forma alargada era común entre*

la parte anterior y media (63,12%) con ovalo alargado común en el subtipo 2 (27,87%) y alargada constreñida común en el subtipo 1 (35,25%). La longitud del calcáneo se registró con una media ± DP de 7,10 ± 0,70 cm (lado izquierdo) y 7,01 ± 0,72 cm (lado derecho) y la anchura se registró a 2,77 ± 0,38 cm (lado izquierdo) y 2,77 ± 0,37 Cm (lado derecho). La distancia entre las facetas anterior y media fue de media ± DP de 0,50 ± 0,15cm (lado izquierdo) y 0,48 ± 0,15cm (lado derecho), las facetas Posterior y Media a 0,59 ± 0,20cm (lado izquierdo) y 0,56 ± 0,17cm (Lado derecho) y entre las facetas anterior y posterior a 1,43 ± 0,27 cm (lado izquierdo) y 1,42 ± 0,29 cm (lado derecho).

***Conclusión:** Las diferencias individuales y raciales de la construcción anatómica de las facetas articulares del talón calcáneo influyen en la dinámica estática y cinética del pie. Un buen conocimiento del patrón y forma de la facetas del calcáneo ayudaría a mejorar el tratamiento y las opciones de manejo de las fracturas del calcáneo. También requiere una modificación de las técnicas quirúrgicas occidentales para adaptarse al escenario nigeriano para la osteotomía calcánea.*

***Palabras clave:** calcáneo, facetas articulares del talar, patrón, forma, población nigeriana del sudeste*

Introduction

Calcaneum or os calcis is the largest and longest tarsal bone in the foot and forms the prominence of the heel.[1]

It is located posteroinferior to the talus, providing support to the ankle joint.[2-3]

It measures about 8.50 cm in length and about 3.50 cm at its widest point.[4]

The middle third of the superior surface of the calcaneus carries the posterior talar facet, oval and convex anteroposteriorly, for articulation with the body of the talus. The posterior calcaneal facet can be divided into two portions, an anterolateral portion and a posteromedial portion.[5]

This facet articulates with the head of the talus and may be divided in about half the cases by a non-articular zone creating middle and anterior talar facets, the incidence of which varies with race and sex.[6]

The posteromedial portion lies almost in the transverse plane making an angle of approximately 40° with the anterolateral portion.

Distal (anterior) to the posterior articular facet a rough depression narrows into a groove on the medial side, the sulcus calcanei, which complete the sinus tarsi with the talus. Anterior third is partly articular. Distal and medial to the sulcus calcanei an elongated articular area covers the sustentaculum tali.[7]

This facet is often divided by a non-articular interval at the anterior limit of the sustentaculum tali, forming middle and anterior talar facets, the incidence of which varies with sex and race.[8]

The talar articular facets on calcaneus show marked and very frequent variations.[9-10]

Variations of the articular facets in the superior surface of the calcaneus for the talus may be a consequence of external factors or of .anthropological factors such as the angle of talar torsion or the angle of declination of the talus in the adult and the angle between the longitudinal axis of the talar body and the talar neck.[11]

Morphological variability of the calcaneal facets could result from differences in gait or other habits influencing these articular areas post-natally or it could be indicative of genetically determined variation.[12]

While a consensus exists in the anatomic literature about the morphology of the posterior facet, there are divergent descriptions of the anterior facet.[13-6-10]

The morphology of the articular facets of the calcaneus and its morphometric values has been a subject of interest to anatomists.[10]

The calcaneus is specifically designed to withstand the daily stresses of weight bearing, thus it is the most common tarsal bone to be fractured and it accounts for about 1-2% of all fractures and about 70-75% of it are intraarticular.[14]

The articular facets of the sustentaculam tali have a variety of configurations and are functionally important because they influence the subtalar joint stability. In various alignments of foot, such as the talocalcaneal arthritis and coalition, intra articular fractures and congenital dismorphology, flat foot, valgus deformities, the size and shape of the bones, the relationships of the talus and calcaneus with each other and other bones of the foot must be considered for the internal and external fixation and surgical procedure.[15]

There are many studies on talar articular facet of human calcaneus, which has showed wide variations in the facet.[16] However, this subject is interesting but comparing the large Nigerian population and the amount of study carried on the variation of facets is much less.

The present study was thus planned to analyze the morphology and morphometric patterns of talar articular facets of South-Eastern Nigerians.

Materials and method

220 dry adult human calcanei (111 left and 109 right) of unknown sex and age from Osteology units of different medical colleges in Southern Nigeria were used for the study.

Inclusion Criteria

In the selection of the calcanei, the following criteria was taken into consideration:

- The bones were adult calcanei of both sexes.
- The calcanei was complete in all respects so as to give the correct measurements.
- The calcanei were non – pathological

Exclusion Criteria

- Pathological calcanei
- Calcanei with broken off parts (incomplete calcanei)

Method of Data Collection

The patterns of the talar articular facets of calcanei and the shapes of the different articular facets were examined and the calcaneus sorted out according to the type of pattern present.

A marker was used to encircle the facetal margins to clearly mark the separation between the facets, and the distance between them measured with a sliding vernier caliper of 0.02cm accuracy. The length and width of calcanei of right side and left side were also measured and A 16.0 mega pixel digital camera used to take photographs of different patterns of talar articular facets of the calcanei.

All measurements were done three times and an average taken.

Measurement Parameters

- Length of calcaneus (cm)
- Width of calcaneus (cm)
- Interfacetal distances (cm)

Measurement of calcaneal length: The total length of the calcaneum was measured between anterior points of upper parts of the articular facets or facet for cuboid to the posterior rough bony part for the attachment of the tendocalcaneus with a sliding venier caliper of 0.02 accuracy in centimeter (cm) scale.

Measurement of the calcaneal width: The width of the calcaneum was measured from the medial calcaneal tuberosity to the lateral calcaneal tuberosity with a sliding caliper in cm scale.

Measurement of interfacetal distances: when the articular facets are separate entities, the distance between them were measured with vernier caliper in cm scale. The posterior most part of the anterior facet was taken as the anterior point and the anterior most part of the posterior facet was taken as the posterior point. These include:

- Distance between anterior and middle facets
- Distance between middle and posterior facet
- Distance between anterior and posterior facets.

Fig. 1: Showing the measurements of length and width of the calcaneus

Classification of calcaneal articular facets

The patterns of talar articular facets were found and classified according to the configuration of the superior talar articular facets using Bunning and Barnett[17-12] and Anjaneyulu et al[18] classifications. The following patterns were observed

I. *Pattern 1:* fused anterior and middle articular facets with a separate posterior facet, which corresponds to group C of Anjaneyulu et al[18] classification. This is further divided into two sub types: **Pattern 1a:** which has constricted facet; **Pattern 1b:** which has no constricted facet

II. *Pattern 2:* three facets are seen on the superior surface of the calcaneus with anterior and middle facets incompletely separated from each other.

III. *Pattern 3:* absence of anterior articular facet corresponding to findings of Jha et al 19, and Anjaneyulu.[18]

IV. *Pattern 4:* anterior, middle and posterior facets present i.e. presence of the three articular facets. Based on the degree of separation between the anterior and middle facets, it is divided into three subtypes: **Pattern 4a:** separation between the facets is less than 0.35cm; **Pattern 4b:** separation between the facets is between 0.35cm-0.5cm; **Pattern 4c:** separation between the facets is greater than 0.5cm

V. *Pattern 5:* anterior, middle and posterior facets all fused together i.e. all the three facets form a continuum.

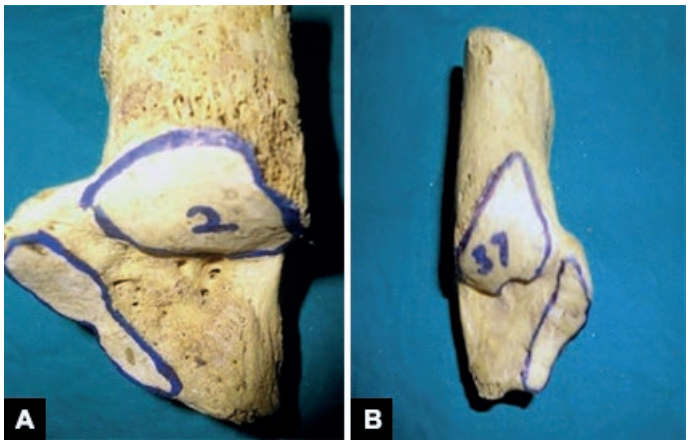

Fig. 2: Pattern 1 shows fused anterior and middle facets. A) Right calcaneus; B) Left calcaneus

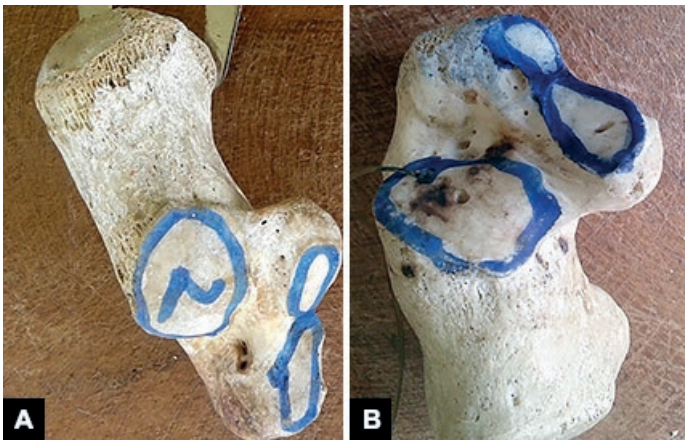

Fig. 3: Pattern 2 shows anterior and middle facets incompletely separated from each other. A) Right calcaneous; B) Left calcaneous

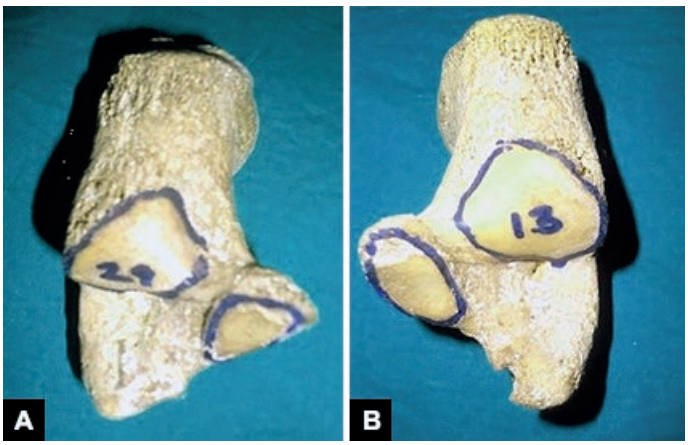

Fig. 4: Pattern 3 shows absence of anterior talar facet. A) Right calcaneous; B) Left calcaneous

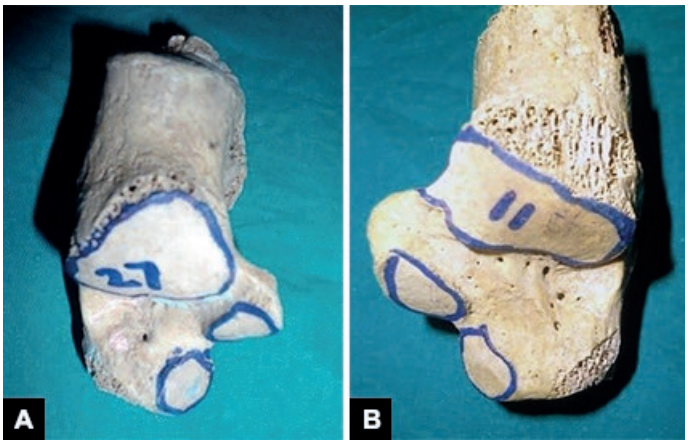

Fig. 5: Pattern 4 shows all the three facets present. A) Right calcaneous; B) Left calcaneous

Statistical Analysis

The data collected was analyzed using Statistical Package for Social Sciences (SPSS) Version 20.0. The frequency of distribution, mean and standard deviation of the different calcaneal measurements were derived. An independent t-test was used to determine the differences in the measurement of length and width of right and left calcaneus at ($p>0.05$) level of significance.

Results

Pattern	Left Side *Frequency (%)*	Right side *Frequency (%)*	Total
1	57 (51.4)	65 (59.6)	122
2	09 (8.1)	08 (7.3)	17
3	15 (13.5)	13 (11.9)	28
4	30 (27.0)	23 (21.1)	53
5	00	00	00
Total	111 (100)	109 (100)	220

Table I: Different morphometric patterns of the talar articular surfaces on right and left sides of the adult dry calcaneus

Pattern	Subtype	Left Side *Frequency (%)*	Right Side *Frequency (%)*	Total
1	I	25 (28.7)	39 (44.3)	64
2	II	32 (36.8)	26 (29.5)	58
3	A	05 (5.8)	5 (5.7)	10
4	B	10 (11.5)	10 (11.4)	20
5	C	15 (17.2)	8 (9.1)	23
Total		87 (100)	88 (100)	175

Table II: Subtypes of the patterns 1 and 4 on the left and right sides

Of all these, pattern 1 showed the greatest prevalence in both left (51.4%) and right sides (59.6%), followed by pattern 4 in left (27.0%) and right (21.1%) sides while Pattern 5 was not found in the present study.

From this table, it is evident that pattern 1 subtype II is dominant on the left side (36.8%) while pattern 1, subtype I is dominant on the right side. The incidence of pattern 4 subtype C is higher on the left side (17.2%) while the incidence of pattern 4, subtype B is higher on the right side (11.4%).

Shapes	Right calcaneus				Left calcaneus				Total
	n*	II (n=8) (%)	III (n=13) (%)	IV (n=23) (%)	n*	II (n=9) (%)	III (n=15) (%)	IV (n=30) (%)	(Rt+Lt) (n=98) (%)
Oval	31	50	61.53	86.61	32	55.56	60	60	64.39
Pear shaped	3	12.5	15.38	00	3	8.89	00	3.33	6.12
Triangular	1	00	00	4.35	3	00	00	10	4.08
Irregular	2	00	00	8.69	1	11.11	00	00	3.06
Round	5	25	23.07	00	9	00	26.67	16.67	14.28
Elongated	2	12.5	00	4.35	6	11.11	13.33	10	8.16
TOTAL	44	100	100	100	54	100	100	100	100

n*= total number of calcaneus of left and right side with the different shapes

Table III: Shapes of the middle facet of left and right calcaneus

From this table, the most common shape of the middle articular facet was oval in all patterns of talar articular facet in 98 cases with an incidence of 64.39% and the least common shape was irregular with an incidence of 3.06%.

Shapes	Right calcaneus					Left calcaneus					Total
	n*	I (%)	II (%)	III (%)	IV (%)	n*	I (%)	II (%)	III (%)	IV (%)	n=220
Oval & convex	74	73.85	37.5	61.54	65.21	80	75.44	77.78	60	70	70
Irregular & convex	35	26.15	62.5	38.46	34.79	31	24.56	22.22	40	30	30

n*= the number of calcaneus of left and right side with the different shapes

Table IV: Shapes of the posterior talar facet

The most common shape of posterior talar articular facet is oval and convex in 154 cases (74 right and 80 left calcaneus) with an incidence of 70% while the least common shape was irregular and convex with an incidence of 30% in 66 cases (35 right calcaneus and 31 left calcaneus).

Shapes	Right calcaneus				Left calcaneus				Total
	n*	II (n=9) (%)	IV (n=30) (%)	Total (%)	n*	II (n=8) (%)	IV (n=23) (%)	Total (%)	(Rt+Lt) (n=70) (%)
Oval	20	44.44	53.33	28.57	17	50	56.52	24.29	52.86
Triangular	5	33.33	6.67	6.99	4	37.5	4.35	5.71	12.85
Irregular	1	00	3.33	1.43	00	00	00	00	1.43
Round	9	11.11	26.67	12.86	5	12.5	17.39	7.14	20
Elongated	3	11.11	10	4.29	5	00	21.74	7.14	11.43
TOTAL	39	100	100		31	100	100		

n*= total number of calcaneus of left and right side with the different shapes

Table V: Shapes of the anterior talar articular facet

The most common shape of the anterior talar articular facet was oval in 37 cases with an incidence of 52.86%, while the least common shape of the anterior talar articular facets is irregular found only on the left calcaneus with an incidence of 1.43%.

Shapes	Right Calcaneus			Left Calcaneus			Total
	n*	Subtype I	Subtype II	n*	Subtype I	Subtype II	(Rt+Lt)
		n=39 (%)	n=26 (%)		n=25 (%)	n=32 (%)	n=122 (%)
Oval	10	00	38.46	8	00	25	14.75
Irregular	8	15.38	7.69	7	12	12.5	12.29
Curved hockey stick	7	17.95	00	5	20	00	9.84
Elongated oval	14	00	53.85	20	00	62.5	27.87
Elongated constricted	26	66.67	00	17	68	00	35.25

n*= total number of calcaneus of left and right side with the different shapes

Table VI: Shapes of the fused anterior and middle facet

The most common shape of the fused anterior and middle facets as seen only in pattern 1 is elongated shape, with elongated oval more common in subtype II and elongated constricted common in subtype I with an incidence of 27.89% and 35.25% respectively.

Measurement	Left Side	Right Side	t-Value	P-Value
Length	7.10±0.70	7.01±0.72	0.886	0.376
Width	2.77±0.38	2.77±0.37	0.085	0.932
Anterior-Middle	0.50±0.15	0.48±0.15	0.556	0.581
Posterior-Middle	0.59±0.20	0.56±0.17	1.086	0.279
Anterior-Posterior	1.43±0.27	1.42±0.29	0.160	0.873

Mean±SD

Table VII: Calcaneal measurements

Independent sample t-test showed that there was no significant difference (p>0.05) in the calcaneal measurements between the left and right sides.

Discussion

The racial and sexual variations in the morphology of talar articular facets of calcaneum is well documented by earlier researchers,[20] four different pattern types as described by Saadeh et al,[13] Williams et al,[8] Gupta et al.[21] Jha and Singh,[19] and Madhavi and Antonisamy.[22]

Three different types were described by Campos and Pellico,[11] Bunning and Barnett,[12] and Drayer-Verhagen.[23] Two facet configuration was documented by Testut,[24] Laidlaw,[25] Sharrafian,[26] and Padmanabhan.[27]

However, we chose the four different pattern grouping as it best categorizes the patterns of the talar facets observed in the present study.

In this study, **(Table VII)** the length of the calcaneus was found to be about 7.01±0.72 cm on the right side, and 7.10±0.70 cm on the left side, while the width of the calcaneus was about 2.77±0.38 cm on the left side and 2.77±0.37 cm on the right side, in contrast to the findings of DuVries,[4] who gave the measurement of the calcaneal length to be about 8.50 cm and the width about 3.50 cm, and the findings of Chavan et al.[16] who reported the length of the calcaneus to be 8.8 cm on the right side and 9.0 cm on the left side.

This concurs with the consensus that the talar articular facets of the calcaneus may vary racially. The independent T-test done in this present research at the level of p> 0.05 significance shows no significant difference in both the length and width of the calcaneus of left and right sides.

In the present study, the middle talar facet was present as a separate facet on the superior surface of sustentaclum tali in 98 cases; out of which 28 has absence of anterior articular facet. In 54.45%, it was fused with the anterior facet while in 7.73%; the middle facet was incompletely separated from the anterior facet.

The most common shape of the middle facet was oval in all patterns of talar articular facets **(Table III)** with an incidence of 64.39% (31.68% right and 32.71% on left calcaneus).

The middle facet was pear shaped in 6.12 % (3.06 % on both sides), triangular in 4.08% (1.02% on the right side, and 3.06% on the left side), round in 14.28% (9.18% on the left side and 5.10% on the left side), elongated in 8.16% (6.12% on the left side and 2.04% on the left calcaneus), and the least common shape were irregular with an incidence of 3.06% (2.04% right and 1.02% left).

These findings are inconsistent with the works of Jagdev et al[28] who found oval to be the most common shape of the middle articular facets in 19.5% cases, but found the least common shape to be oval irregular with an incidence of 0.5%.

The most common shape of the posterior facet was oval and convex **(Table IV)** in 70% with no significant difference on the right and left calcaneus (33.64% on the right and 36.36% on the left calcaneus). It was compared with the works of Jagdev et al[28] where the most common shape was described as irregular and convex with an incidence of 27.5% on the right and 25% on the left calcaneus, and the works of Williams et al[8] where the most common shape was described as oval and convex which is consistent with the present study.

In the present study, the shape irregular and convex was less frequent in 30% (right=15.91% and left=14.09%). The anterior facet is present as a separate entity in 31.82% (7.73% belongs to pattern 2 and 24.10% belongs to pattern 4).

The most common shape of the anterior facet **(Tables IV and V)** is oval present in 52.86% (28.57% on the left calcaneus and 24.29% on the right calcaneus). The anterior facet was triangular in 12.85% (6.99% left and 5.71% right), round in 6.36% and elongated in 3.64%.

The least common shape of the anterior talar articular facet found in this present study was irregular shaped found with an incidence of 0.45% only on the left calcaneus. These findings are inconsistent with the works of Jagdev et al[28] who found the most common shape of the anterior facet to be oval in 20.5% cases and the least common shape to be pear and triangular in 0.5% cases respectively, this also suggests a racial variation of the articular facets.

The middle and anterior talar facets were fused in 55.45%. The most common shape of the fused facets was elongated with elongated oval more common in subtype II with an incidence of 27.87% (16.39% on the left calcaneus and 11.48% on the right calcaneus) and elongated constricted more common in subtype I with an incidence of 35.25% (right= 21.31% and left =13.94%).

Oval shape was found only in subtype II with an incidence of 14.75%(6.56% on the left calcaneus and 8.19% on the right calcaneus) and the least common shape of the fused pattern was curved hockey stick shape with an incidence of 4.10% on the left calcaneus and incidence of 5.74% on the right calcaneus found only in subtype I and irregular shape found in 12.29% (5.74% on the left and 6.55% on the right calcaneus).

The number and arrangement of the articular facets on the superior surface of the calcaneus designated to carry the head of the talus varies from each other as described variously by different authors. **(Table VIII)**

From this table, it is evident that the result of this study is consistent with the studies done previously.

Pattern 1 was found to be the most common with an incidence of 122 (55.45%) in consonance with the works of Bunning and Barnett 12 and Sadeeh et al[13] who worked on Africans (Nigeria and Egypt) and gave the incidence of pattern 1 to be somewhat higher as 63% respectively.

Pattern 2 was rarely found in this study with an incidence of 17 cases (7.72%) but was never found in previous studies.

Pattern 3 was found with an incidence of 28 (12.73%) in the present study, 4.7% in Egyptian studies[13] but was not found in the works of Bunning and Barnett12.

Pattern 4 was found with an incidence of 53 (24.0%) in present study, 36% was found in the works of Bunning and Barnett[12], and 30.3% was found in the works of Sadeeh et al.[13]

Pattern 5 with fused anterior, middle and posterior facet found in the works done by Bunning and Barnett[12] 1% and the works of Saddeh et al 13 2% was not found in this study.

Pattern 1 was also found to be dominant in India, Pakistani, American, Spanish and Turkish race. Whereas in European studies, (Britain, and Belgium), pattern 4 was found to be dominant.

This findings provides a positive correlation between the variations in the morphology of the calcaneus with racial factors thus, the variations are probably genetically determined and were not developmental responses to physical activities.

Stydy	Year	Country	N*	I (%)	II (%)	III (%)	IV (%)	V (%)
Burning & Barnett	1965	Britain	194	33	__	__	67	__
	1965	Veddah	10	60	__	__	__	40
	1965	Indian	78	78	__	__	22	__
	1965	Nigeria	492	63	__	__	36	1
Jha and Singh	1972	India	1600	33.75	__	2.87	13.37	__
Gupta et al	1977	India	401	67	__	5	26	2
Campos & Pellico	1989	Spain	176	53.41	__	6.82	39.77	__
Saddeh et al	2000	Egypt	300	63	__	4.7	30.3	2
Barbaix et al	2000	Belgium	134	25	__	11	64	__
Priya et al	2006	South India	71	67.6	__	7.04	25.35	__
Uygur et al	2009	Turkish race	221	58.37	__	4.98	34.39	2.2
Wajid and sarah	2010	Pakistani	350	62.9	__	__	28.6	8.6
Muthukumaravel et al	2011	South India	237	65.82	__	__	33.33	0.42
Nagar et al	2012	West India	529	76.37	__	1.13	22.30	__
Schweta et al	2013	West India	205	64.88	__	4.39	28.78	1.95
Rohin et al	2013	India	310	72.26	__	1.3	24.52	1.6
Anjaneyulu et al	2014	India	100	62	__	5	31	2
Chavan et al	2014	India	60	68.33	__	6.66	25	__
Jagdev et al	2015	India	200	72.5	__	1.5	30	0.5
Gindha et al	2015	North India	325	69.53	__	0.31	29.85	0.62
Present study	2015	Southern Nigeria	220	55.45	7.72	12.73	24.09	__

n* total number of calcanei bones studied

Table VIII: Comparison of present study with previous studies

Study	Year	Country	Right calcaneus		Left calcaneus	
			n*	I (%)	n*	I (%)
Nagar et al	2012	West India	260	78.46	269	74.34
Chavan et al	2014	India	30	76.67	30	60
Gindha et al	2015	India	167	36.92	158	32.3
Jagadev et al	2015	India	100	37.5	100	35
Present study	2015	Southern Nigeria	109	59.6	111	51.4

n* = total number of calcaneus of right and left side studied

Table IX: Comparison of incidence of pattern 1 of left and right calcaneus with previous studies

The patterns of talar articular facets shows marked difference in occurance between the left and right calcaneus.

In the present study, pattern 1 was found to be 59.6% in the right calcaneus and 51.4% in the left calcaneus.

Though previous authors did not mention the statistical significance of the difference between two sides, from observation it could be noted that right side was always greater than left side.

These differences can be attributed to the following possible reasons. Right lower limb is the initiator of any attempt at the locomotion; hence, the skeletal elements of the right foot have to share the maximum load of forces while inertia is being broken to gain momentum.

Right lower limb share proportionately more weight bearing time than left limb and this affects the facetal development on the talus and calcaneus.[16]

Study	Year	Right calcaneus					Left calcaneus				
		Pattern 1		Pattern 4			Pattern 1		Pattern 4		
		I (%)	II (%)	A (%)	B (%)	C (%)	I (%)	II (%)	A (%)	B (%)	C (%)
Nagar et al	2012	38.23	61.76	35.18	44.44	20.37	44.5	55.5	29.68	51.56	18.75
Jagadev et al	2015	32	68	41	58	00	51.4	48.6	41.4	58.6	00
Gindha et al	2015	15.69	21.23	8.62	4.92	00	12	20.30	12	4.3	00
Present study	2015	44.3	29.5	5.7	11.4	9.1	28.7	36.8	5.8	11.5	17.2

Table X: Comparison of the incidence of the different subtypes of left and right calcaneus with other studies

Incidence of the different subtypes of pattern 1 and pattern 4 also varies between right and left calcaneus **(Table X)**.

In the present study, pattern 1, subtype I (44.3%) was dominant in the right calcaneus while subtype II (36.8%)was dominant in left calcaneus in contrast to previous works on left and right calcaneus where the findings of Nagar et al,[9] Jagdev et al[28] and Gindha et al[29] shows dominance of subtype II on the right calcaneus.

Jagdev et al[28] found subtype I (51.4%) to be dominant on the left calcaneus, while the works of Nagar et al,[9] and Gindha et al 29 was in consistent with the findings of the present study on the left calcaneus, giving the figures as 55.5% and 20.30% respectively.

Pattern 4 which was the second most common pattern in the present study was also subdivided into three according to the degree of separation between the anterior and middle facets.

Subtype B was found to be dominant on the right calcaneus (11.4%) while subtype C was dominant (17.2) in the left calcaneus.

Comparing with available literature, the findings of this study on the right calcaneus is consistent with the works of Nagar et al[9] and Jagdev et al,[28] who gave the figures as 44.44% and 58% respectively, but varies with the findings of Gindha et al,[29] who found subtype A to be dominant on both right and left calcaneus of north Indian population with an incidence of 8.62% and 12% respectively. Nagar et al[9] and Jagdev et al[28] found pattern 4, subtype B to be dominant on the left calcaneus with an incidence of 51.56% and 58.6% respectively.

Study	Year	Country	n* (%)	Pattern 1		n* (%)	Pattern 4		
				I (%)	II (%)		A (%)	B (%)	C (%)
Campus & Pellico	1989	Spain	54	29	25	42	5	21	16
Sharada	2012	South India	67	50.3	16.6	28.6	13.66	9.66	3
Nagar et al	2012	North India	76.37	41.33	58.66	22.30	32.20	48.30	19.49
Anjaneyulu et al	2014	Northeast India	62	43	19	31	10	11	5
Present study	2015	Southern Nigeria	55.45	29.09	23.63	24.09	4.54	9.09	10.45

n* = total percentage of the different patterns

Table XI: Comparison of the incidence of the subtypes with other studies

In **Table XI**, it can be deduced that the incidence of the different subtypes of the articular facet for the head of talus varies with race, area and population of study. In the present study, pattern 1 subtype I and pattern 4, subtype C was dominant with an incidence of 29.09% and 10.45% respectively.

Pattern 1 subtype I and pattern 4 subtype B is dominant in Spanish population with an incidence of 29% and 21% respectively from the findings of Campos and Pellico.[11]

When the articular facets were separate entities, the distance between them were measured, and no significant difference was observed between the left and right calcaneus ($p>0.05$).

The distance between the anterior and posterior facets ranges from 1 cm to about 2 cm on the left and about 0.98 cm to about 2.08 cm on the right with a mean distance of about1.43±0.27 cm on the left side and 1.42±0.29 cm on the right.

The distance between the anterior and middle facets ranges from 0.28 cm to about 0.86 cm on the right and about 0.2 cm to about 0.80 cm on the left with a mean distance of about 0.50±0.15 cm on the left and 0.48±0.15 cm on the right calcaneus.

The distance between the posterior and middle facet ranges from 0.3 cm to 1.15 cm in the left calcaneus and about 0.23 cm to 1.14 cm on the right calcaneus with a mean distance of about 0.59±0.20 cm on the left and about 0.56±0.17 cm on the right calcaneus. However, comparative studies are not available for these findings.

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