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To study the morphological and morphometeric pattern of talar articular facets on adult dry human calcaneal bones.

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Abstract

Background: Patterns of articular facets of talus on calcaneum effect the stability of talocalcaneal joint and also the development of osteoarthritis. This study was conducted to determine the morphological and morphometric patterns of talar articular facets on calcaneum in study population.

Material and methods: This descriptive study was conducted on 80 human calcanei of adults, irrespective of sex. Vernier caliper was used to measure length, width and interface Tal distance in centimeters. The calcaneii were classified into V patterns based on shape of the talar articular facets.

Results: Among 80 dry adult calcanei,60%belongs to left side and 40% belongs to right side. Only four morphometric patterns were found in our study, most common pattern was pattern 1 followed by 4, 2 and 3. Left sided calcanei had pattern 1 to 4 while right sided had only pattern 1, 2 and 4. Middle articular facets was oval (60%) in most other cases, followed by elongated (25%), then pear shaped (10%) and then round (5%). Shape of the posterior articular facet was either irregular and convex (21.3 %.) or oval and convex (78.7%), No

statistically significant difference was found between length and width of calcaneum on both sides.

Conclusion: The incidence of pattern 1 was more common in our study population than Europeans population. Our study population is at greater risk of developing subtalar arthritis due to pattern 1 prominence. There is need for modifications of Western operative techniques to suit the Indian patients.

Keywords: Calcaneal articular facets, talo - calcaneal joint, articular facet pattern.

Introduction

The calcaneus is a weight bearing tarsal bone situated below the talus and extends behind the talus. The dorsal or superior surface has articular facets on the body and the sustentaculum Ali by which it articulates with the talus [1]. Human are distinguished from animals on the basis of Bipeds nature, where foot represents the structure which directly strike the ground during locomotion, and for this reason, it is highly adapted and specialized [1]. Talus provide support to the ankle joint because of its posterio inferior position [2]. The "osseous tripod" pattern of facets on the calcaneum, gives a better stability for the sub talar joint. Subjects with fused anterior and middle facet with a separate posterior facet have less stability and are more prone to osteoarthritis and subjects having calcaneal spur are more likely to develop osteoarthritis [3]. The variations on the facet of calcaneii in subjects of Indian and Western countries are because of difference in life style like wearing shoes, squatting habit, genetic and racial differences. So, the morphology of the articular facets of the talus and calcaneum is the interest of discussion in the field of anatomy [1]. Hence the relations between them is critical in anthropometry, kinesiology, orthopedic surgery, physical therapy and rehablitaion [2]. In depth anatomic information is therefore necessary to enable further development of treatment procedures [2]. After going through the available literature it was revealed that there is dearth of literature regarding morphology and morphometric study of calcaneum. Therefore, a curious desire developed to conduct this study.

Aims and objectives

To study the morphological and morphometeric pattern of talar articular facets on adult dry human calcaneal bones.

Material and methods

This was an observational study conducted at Post Graduate Department of Anatomy. 80 human dry calcaneii of adults, irrespective of sex between 2019 to 2021. By convenience sampling method, dry and macerated bones form adults were taken irrespective of sex and all calcaneii with completeness in all respects and correct measurements were included in study. Pathological and broken off (incomplete) calcaneii were excluded. Instruments used were stainless steel sliding Vernier caliper with a 0.02cm accuracy in centimeter (cm) scale, measuring tape, digital camera and marker pen. Data including, length of calcanium (cm), distance between anterior point of upper part of articular facets or facet for cuboid to the post rough bony part were ten do calcaneum is attached, width of calcaneum in cm was distance from medial calcaneal tuberosity and lateral calcaneal tuberosity. Interface Tal distances: In cm measuring when the articular facets are apparent to be separate, the distance between them is measured. Where the posterior most point of anterior facet was taken as the anterior point and the anterior most point of the posterior facet was taken as posterior point. These include:

a) Distance between anterior and middle facets.

b) Distance between middle and posterior facets.

c) Distance between and posterior facets. Photographs were taken by digital camera for different patterns of talar and calcaneii reading were taken thrice and an average was taken as real.

The patterns of talar articular facets were classified according to the configuration of the superior talar articular facets using Bunning and Barnett (1963) [4]and Anjaneyulu et al., (2014) [1] classifications into V patterns.

Results

This study was conducted on 80 dry adult calcaneii irrespective of sex, to **s**tudy variations in the morphometric patterns of articular facets on adult dry human calcaneii. Among the 80 calcaneii studied, 48 (60%) belongs to left side and 32 (40%) belongs to right side. Only four morphometric patterns were found in our study (Figure 1-3), pattern 5 was absent, pattern 1 was most common followed by pattern 4, 2 and 3. Left sided calcaneii had pattern 1 to 4 while right sided calcaneii had only pattern 1, 2 and 4 as shown in table 1.

Pattern 1 has two subtypes: subtype 1a and 1b. Subtype 1b was common on left side while 1a was common on right sided calcaneii. Pattern 4 has 3 subtypes: subtype 4a, 4b and 4c. Subtype 4b was commonest on right side while 4a was commonest on left side as shown in table 1.

Shape of middle articular facets was oval in 60% followed by elongated (25%), then pear shaped (10%) and then round (5%). Shape of the posterior articular facet was irregular and convex or oval and convex, oval and convex was found in 78.7% and irregular and convex in 21.3%. Fused anterior and middle articular facet was found in 60 calcaneii. The most common shape of fused anterior and middle articular facet was elongated constricted (45%) followed by elongated oval (43.33%) and least common was oval convex (1.66%). Anterior articular facet was present in 20 calcaneii, and 60% of them were round in shape and 30% oval in shape. Independent sample t-test showed that there was no significant difference ($p>0.05$) in the calcaneal measurements between the left and right sides with respect to length, width, interface Tal distance between A-M, M-P and A-P facets as shown in table 2.

Discussion

In this study, the length of calcaneii of left side was 7.64±0.55cm and right side was 7.71±0.49 cm and the width was 3.17±0.26 on left side and 3.23±0.29 on right side. The length of the calcanei was 7.10±0.70 cm on the left side and 7.01±0.72 cm on the right side, while the width of the calcanei was about 2.77±0.38 cm on the left side and2.77±0.37 cm on the right side as studied by Ukoha UU et al [5] in contrast to the findings of Chavan SK et al [6] who reported the length of the calcaneii to be 8.8 cm on the right side and 9.0 cm on the left side. In our study the length and width of calcaneii were slightly bigger in dimensions when compared to Ukoha UU et al [5] but smaller in size when compared to Chavan SK et al [6]. 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 calcaneii of left and right sides as shown in table 2.

The interface Tal distance between the anterior and posterior facets, anterior and middle facets and posterior and middle facets of left and right side calcaneii also showed no significant difference. Our findings correlate with Ukoha UU et al [5].

In our study Pattern 1 was found to be most common with an incidence of 75% in contrast to a study

conducted by Ukoha UU et al [5]. which had pattern 1 in 55.45%, while works of Bunning PSC and Barnett CH [7] and Saadeh FA et al [8] who worked on Africans (Nigeria and Egypt) and gave the incidence of pattern1 to be somewhat as higher as 63% respectively. Pattern 2 was found in this study with an incidence of 7.5% which was almost similar to (7.72%) by Ukoha UU et al [5]. Pattern 3 was found with an incidence of 2.5% in our study, in contrast to (12.73%) in Nigerian population, 4.7% in Egyptian studies Saadeh FA et al [8]. but was not found in the work of Bunning PSC and Barnett CH [7]. Pattern 4 was found with an incidence of 15% in the present study, 24.0% in a study by Ukoha UU et al [5].36% in the works of Bunning PSC and Barnett CH [7] and 30.3% in the works of Saadeh FA et al [8].

Pattern 5 was found in the works done by Bunning PSC and Barnett CH [7] was 1% and the works of Saadeh FA et al [8] was 2% but was not found in this study.

Our finding was similar to Ukoha UU et al [5] as shown in table 3. In pattern 1, subtype 1a was equal on both sides (14/ 28) 50% each but subtype 1b was more common on left side (25/32) 78.12% as compared to right side (7/32) 21.87%. In a study by Ukoha UU et al [5] sub type II (36.8%) was dominant on left calcaneii in contrast to previous works where the findings of Nagar SK et el [9].

Jagdev SK et al [10] and Gindha GS et al [11] showed dominance of subtype II on the right calcaneii. Pattern 4 subtype a and c had equal percentage on right and left side (50% each) but 4b was more common on right side (5/6) 83.33%, for subtype 4b similar findings were recorded by Ukoha UU et al [5] but opposite findings were recorded by Nagar SK et al [9] and Jagdev SK et al [10] they found pattern 4, subtype b to be dominant on the left calcaneii with an incidence of 51.56% and58.6% respectively as shown in table 3.

Bruckner's hypothesis [12] and the findings of Francine DV [13] stated that talar facet morphology is the key for subtalar joint stability. The three-facet morphology of the calcaneum has better stability and is less prone for arthritis. The osseous tripod appearance of talus on calcaneum offers less mobility for the talus over the calcaneum, thereby preventing injuries and strain to the talus over the calcaneum.

However, studies indicate that the Indian population have more number of two facet morphology of the calcaneum leading on to increased incidence of Osteoarthritis.

In this study 3 facet morphology was seen only in 18 calcaneii (12 calcaneii of pattern 4 and 6 calcaneii of pattern 2) out of 80 calcaneii hence our population is more at risk of developing osteoarthritis. The most common shape of the anterior talar articular facet was round in 5/9 (55.6%) on left side and 7/11 (63.7%) on right side. These findings are inconsistent with the works of Jagdev SK et al [10]and Ukoha UU et al [5].

This also suggests a racial variation of the articular facets. The most common shape of posterior talar articular facet was oval and convex in this study with 37/48 (77.1%) on left side and 26/32 (81.3%) on right side. This finding in our study is consist ant with Ukoha UU et al [5] and Williams PL et al [14].

The most common shape of the middle articular facet was oval in our study with an incidence of 6/11 (54.5%) on right and 6/ 9 (66.7%) on left calcaneii. This finding in our study was consistent with Ukoha UU et al [5]. The most common shape of the fused anterior and middle facets was elongated, with elongated constricted the commonest in subtype 1a, with the incidence of subtype

1a 14/27 (51.58%) in left and 13/27 (48.15%) in right calcaneii respectively and elongated oval in subtype 1b with an incidence of 20/26 (76.92%) in left and 6/26 (23.07%) in right calcaneii respectively. This finding is consist ant with the Ukoha UU et al [5]in which most common shape of the fused anterior and middle facets was elongated, with elongated oval more common in subtype II and elongated constricted common in subtype I.

Conclusion

The incidence of pattern 1 is more common in our study population as compared to Europeans. Our study population is at greater risk of developing subtalar arthritis due to pattern 1 prominence. There is need for modifications of Western operative techniques to suit the Indian scenario. The present study data will be useful for orthopedic surgeons for performing various corrective surgeries for CTEV and in ankle reconstructive surgeries.

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Legend Tables and Figures

Table 1: Different morphometric patterns of the talar articular facets on the left and the right sided adult dry calcaneii.

Pattern	Left Side (%)	Right Side (%)	Total (%)
1a	14(32.5)	14(48.28)	28(38.89)
1b	25(58.14)	7(24.4)	32(44.44)
2	03(6.25)	03(9.37)	06(7.5)
3	02(4.17)	0(0)	02(2.5)
4a	2(4.64)	2(6.9)	4(5.56)
4b	1(2.33)	5(17.23)	6(8.33)
4c	1(2.33)	1(3.45)	2(2.78)
5	0	0	0
Total	48(100)	32(100)	80(100)

Table 2: Showing the Comparision of morphometric parameters between left and right sided calcaneii.

Morphometric parameters	Side	No.	Mean ± SD	t-value	p-value
Length	Left	48	7.64±0.55	-0.35	0.724
	Right	32	7.71±0.49		
Width	Left	48	3.17±0.26	-1.05	0.29
	Right	32	3.23±0.29		
Interface Tal distance between A-M V facets	Left	4	0.43±0.33	-0.16	0.87
	Right	8	0.45±0.22		
In4Rterfacetal distance between M-P Facets	Left	48	0.63±0.17	1.55	0.12
	Right	32	0.58±0.12		
Interface Tal distance between A-P facets	Left	46	1.45±0.28	0.30	0.76
	Right	32	1.43±0.25		

Table 3: Comparison of present study with previous studies.

Study	**Year**	**Country**	**N**	**1(%)**	**2(%)**	**3(%)**	**4(%)**	**5(%)**
Burning and Barnett[6]	1965	Britain	194	33	-	-	67	-
	1965	Veddah	10	60	-	-	-	40
	1965	India	78	78	-	-	22	-
	1965	Nigeria	492	63	-	-	36	1
Saadeh et al[7]	2000	Egypt	300	63	-	4.7	30.3	2
Nager et al[8]	2012	West India	529	76.37	-	1.13	22.30	-
Gindha et al[10]	2015	North India	325	69.53	-	0.31	29.85	0.62

Jagdev et al[9]	2015	India	200	72.5	-	1.5	30	0.5
Ukoha et al[4]	2017	Southern Nigeria	220	55.45	7.72	12.73	24.09	-
Present study	2020	North India	80	75	7.5	2.5	15	-

Figure 1: Showing pattern 1a (Picture 1) and1b (Picture 2) of the talar articular facet on adult dry calcaneum.

Picture 1:

Picture 2:

Figure 2: Showing pattern 2 (Picture 3) and 3 (Picture 4) of the talar articular facet on adult dry calcaneum.

Picture 3:

Picture 4:

Figure 3 Showing pattern 4a (Picture 5), 4b (Picture 6) and 4c (Picture 7) of the talar articular facet on adult dry calcaneum.