

A morphological and morphometric study of human calcanei and their articular facets

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Abstract

Introduction: Calcaneum is the longest, strongest and biggest of all the tarsal bones of the proximal row. Anterior and posterior articulations between the calcaneus and talus form a functional unit termed the talocalcaneal or subtalar joint. Talocalcaneal joint maintains eversion and inversion of the foot. Differences with respect to race, as well as individual characteristics, suggest that the articular facets play a key role in both static and dynamic kinetics of the foot and ankle.

Materials and Methods: The present study was carried out with 50 calcanei, 25 bones of right side and 25 bones of left side of unknown sex which were obtained from the Department of Anatomy, Government Medical College, Amritsar. Any calcaneum looking pathological on general examination was discarded from the study. All the parameters were taken by using standard digital vernier calliper which is capable of measuring to the nearest of 0.01mm.

Aim: 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

Results: Type I - Fused anterior and middle talar facet with a separate posterior facet in 33 cases - 66% (Rt 18 cases - 36%, Lt 15 cases - 30%), Type II - Separate anterior and middle talar facet in 10 cases - 20% (Rt 5 cases - 10%, Lt 5 cases - 10%), with a separate posterior talar facet, Type III - Absence of anterior articular facet in 2 cases - 4% (Rt 1 case - 2%, Lt 1 case - 2%) and Type IV - All the three facets i.e. anterior, middle and posterior facets were seen on the superior surface of the calcaneus but anterior and middle facets incompletely separated from each other in 5 cases - 10% (Rt 1 cases - 2%, Lt 4 cases - 8%).

Conclusion: The individual and racial differences of the anatomic construction of calcaneal talar articular facets influence the static and kinetic dynamics of foot.

Keywords: Calcaneum, Talar articular facets, Subtalar joint.

Introduction

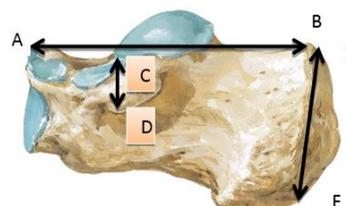
Calcaneum is the longest, strongest and biggest of all the tarsal bones of the proximal row.^{1,2} It is also referred to as heel bone and forms a major component of the skeleton of the hindfoot and prominence of the heel. This bone is unique, since it is the first tarsal bone to ossify. The purpose of the calcaneus is to transmit the weight of the body to the ground and act as a strong lever for the calf muscles.^{3,4} It is well designed to sustain high tensile, bending and compressive forces. However, high instantaneous loads often result in fracture.⁵ It is located posteroinferior to the talus, providing support to the ankle joint. It measures about 3.5 inches in length and about 1.5 inch at its widest point.^{6,7} Calcaneum fractures are also known as "Lover's Fracture," or "Don Juan Fracture." The name lover's fracture is derived from the fact that a lover may jump from great heights while trying to escape from the lover's spouse.⁸ If untreated, they can interfere with normal coupled motion of ankle and subtalar joint and result in permanent pain, loss of motion and deformity.⁹ The morphology of human calcanei and their articular facets is of interest to anatomists, but more importantly the relationship is critical in anthropometry, kinesiology, orthopaedic surgery, physical therapy and rehabilitation. Differences with respect to race, as well as individual characteristics, suggest that the articular

facets play a key role in both static and dynamic kinetics of the foot and ankle.¹⁰⁻¹² The present study was designed to attain a complete knowledge about morphology and morphometry of talar articular facets.

Materials and Methods

Material for the present study comprised of 50 (25 right and 25 left) calcanei which were obtained from the Department of Anatomy, Government Medical College, Amritsar.

Any calcaneum looking pathological on general examination was discarded from the study. These were labelled from 1-50 with suffix R(Right) or L(Left). Study will be conducted after taking approval of Institutional Ethics Committee, Government Medical College, Amritsar.



AB: Length; **CD:** Breadth; **EF:** Height
Fig. 1: Measurements of calcaneum

Each calcaneum was carefully examined for various types of articulating facets for talus and were categorised into four types.

Type I - Fused anterior and middle talar facet with a separate posterior facet

Sub type cn: The fused facet was constricted

Sub type NC: The fused facet was not constricted

Type II: Separate anterior and middle talar facet

Sub type A: With narrow separation <2mm

Sub type B: With moderate separation 2- 5 mm

Sub type C: With wide separation >5mm

Type III: Absence of anterior articular facet

Type IV: All the three facets i.e. anterior, middle and posterior facets were seen on the superior surface of the calcaneus but anterior and middle facets incompletely separated from each other.

Results

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, height and breadth of right and left calcaneus at level of significance.

Table 1: Gross anatomical dimensions of calcanei (50)

Dimensions	Right n = 25	Left n = 25	Total n=50	t-value	p-value
	Mean±S.D.	Mean±S.D.	Mean±S.D.		
1. Length	67.6±6.05	70.28±5.39	68.94±1.89	1.98	0.05
2. Breadth	36.84±3.48	40.56± 6.1	38.70±2.63	2.64	0.01
3. Height	42.40±8.32	45.08±7.04	43.24±4.00	1.22	0.22

It was found that there were no statistically significant differences in the average values of right and left calcanei in their gross anatomical dimensions i.e length, breadth and height.

Table 2: Shape and surface area of fused anterior and middle talar facets

Shape	Right			Left			Total	
	N	%	Surface area (mm ²)	N	%	Surface area (mm ²)	N	%
Elongated (El)	12	24	260.84±124.92	12	24	194.45±39.23	24	48
Elongated constricted (Elcn)	8	16	233.82±82.53	8	16	233.5±68.04	16	32
Total	20	40	---	20	40	---	40	80

In the present study, the most common shape of fused anterior and middle facets was elongated (El) in total 24 cases – 48% (Rt 12 cases – 24%, Lt 12 cases – 24%). Elongated constricted (Elcn) was present in 16 cases – 32% (Rt 8 cases – 16%, Lt 8 cases – 16%). The surface area of right side fell in the range of 260.84±124.92 mm² (Elongated) and on left side was 194.45±39.23mm² (Elongated).

Table 3: Shape and surface area of middle talar facet

Shape	Right			Left			Total	
	N	%	Surface Area (mm ²)	N	%	Surface area (mm ²)	N	%
Oval (O)	4	20	101.25±34.08	5	10	114±11.53	9	18
Round (R)	1	2	50.00	0	0	---	1	2
Total	5	10	---	5	10	---	10	20

In the present study, the most common shape of middle talar facet was oval (O) in 9 cases – 18% (Rt 4 cases – 20%, Lt 5 cases – 10%). The least common shape was round (R) in one case (2%). The surface area of facet was large in oval (O) shaped (Rt101.25±34.08 mm², Lt 114±11.53mm²) and small in round (R) shaped (Rt 50.00mm²).

Table 4: Shape and surface area of anterior talar facet

Shape	Right			Left			Total	
	N	%	Surface Area (mm ²)	N	%	Surface Area (mm ²)	N	%
Irregular (Irr)	0	0	---	1	2	0	1	2
Oval (O)	1	2	30	0	0	---	1	2
Oval Irregular (OIrr)	1	2	86	1	2	34	2	4
Round (R)	3	6	44±120.65	3	6	64.5±3.54	6	12
Total	5	10	---	5	10	---	10	20

In the present study, the most common shape of anterior talar facet was found to be round (R) in 6 cases – 12% (Rt 3 cases – 6%, Lt 3 cases – 6%) while the least common shape was irregular (Irr) with a incidence of 2%.



Fig. 2: Showing type I(CN) fused anterior and middle talar facets with a constriction in between



Fig. 3: Showing type I (NC) fused anterior and middle talar facets



Fig. 4: Showing type II subtype A with narrow separation <2mm



Fig. 5: Showing type II subtype B with moderate separation 2-5 mm

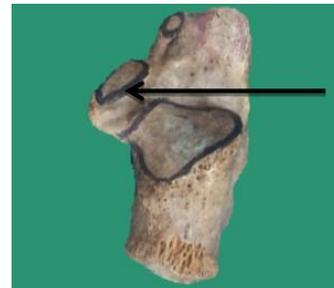


Fig. 6: Showing type II subtype C with wide separation >5 mm



Fig.7: Showing type III absence of anterior articular facet



Fig. 8: Showing type IV- all the three facets i.e. anterior, middle and posterior talar facets were seen on the superior surface of the calcaneus but anterior and middle talar facets incompletely separated from each other

Discussion

The racial and sexual variations in the morphology of talar articular facets of calcaneum is well documented by earlier researchers. Four different pattern types as described by Jha and Singh,¹³ Gupta et al,¹⁴ Saadeh et al¹⁵ and Kullar J S et al.¹⁶ Three different types were described by Campos and Pellico,¹⁷ Bunning and Barnett¹² and Drayer-Verhagen.¹⁸ Two facet configuration was documented by Testut,¹⁹ Laidlaw,²⁰ Sharrafian S K²¹ and Padmanabhan.²² However, we chose the four different pattern grouping as it best categorizes the patterns of the talar facets observed in the present study.

Table 5: Comparison of types of articular facets of calcanei

No	Workers	Year	N	(% of types of calcanei)									
				I	Cn	NC	II	A	B	C	III	IV	V
1	Bunning and Barnett ¹²	1965	194	33	--	--	67	--	--	--	--	--	--
2	Jha and Singh ¹³	1972	1600	59.5	33.75	25.75	37.5	--	--	--	2.87	0.12	--
3	Gupta et al ¹⁴	1977	401	67	--	--	26	--	--	--	5	2	--
4	Drayer-Verhagen ¹⁸	1993	191	54.45	--	--	26.7	--	--	--	18.85	--	--
5	Campos and Pellico ¹⁷	1989	176	54	29	25	40	16	24	--	6	--	--
6	Saddeh et al ²¹	2000	300	63	--	--	30.3	20.3	6.7	3.4	4.7	2	--
7	Muthukumaravel et al ²³	2011	237	65.82	--	--	33.33	--	--	--	--	0.42	0.42
8	Garg R et al ²⁴	2013	310	72.26	--	--	24.52	--	--	--	1.3	1.6	0.32
9	Chavan et al ²⁵	2014	60	68.33	--	--	25	--	--	--	6.66	--	--
10	Kori et al ²⁶	2015	600	73.9	58.8	15.1	21.5	9	11.3	1.2	3.6	0.3	0.6
11	Kullar J S et al ¹⁶	2015	200	72.5	30.0	42.5	25.5	10.5	15	--	1.5	1.5	--
13	Rajshree et al ²⁷	2016	45	66.6	--	--	31.3	--	--	--	--	--	2.2
14	Present study	2017	50	66	36	30	20	4	10	6	4	10	--

In the present study, the type I calcanei was the most common (66%) and the observation was in consonance with previous studies where mostly the figures ranged between 54.0-59.5%. However, Koriet al²⁵ reported the incidence of type I calcanei somewhat higher (73.9%). Bunning and Barnett¹² has reported the incidence of type I calcanei only 33%.

Further, in type I, two subtypes were found i.e. constricted (cn) and not constricted (NC). Type I (cn) was observed in 36% cases. However these figures described by other workers i.e. Jha and Singh¹³ - 33.75%, Campos and Pellico¹⁷-29% and Koriet al²⁶-58.8%. Type (NC) was observed in 33% cases.

The incidence of type II calcanei was 20% in the present study and this figure is comparable with the work of Koriet al²⁶ who gave the incidence as 21.5%. However much higher figures have been reported by some workers i.e. 67% by Bunning and Barnett.¹²

Further, in type II, three subtypes were found i.e. A, B and C. Type II (A) was found to be present in 4% cases, Type II (B) in 14% cases and Type II (C) in 8% cases which on comparison do not coincide with the Campos and Pellico,¹⁷ Saddeh et al,¹⁵ Kori et al²⁶ and Kullar J S et al.¹⁶

In the present study, the incidence of type III calcanei was 2% in 4 cases. It was highest 18.85% in studies of Drayer-Verhagen¹⁸ followed by Chavan et al²⁵ (6.66%). In other studies it ranged between 1.3%-5.52%.

The incidence of type IV calcanei in the present study was very high i.e. 5%. However, much low figures have been reported by some workers i.e. 0.12% by Jha and Singh.¹³

The results of the present study showed a wide range of variations in the incidences of various types of calcanei compared to previous workers. These variations may be due to population differences, type of gait and built of an individual or the place of living whether it is plane or hilly area.

Conclusion

The individual and racial differences of the anatomic construction of calcaneal talar articular facets influence the static and kinetic dynamics of foot. A thorough knowledge of calcaneal facet type and shape is important for all surgeries in subtalar region, better treatment and management options for calcaneal fractures.

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Conflict of interest: None Declared

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