ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Morphometric analysis and articular surface area of calcaneus

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Manuscript Info

Manuscript History:

Received: 15 March 2015
Final Accepted: 29 April 2015
Published Online: May 2015

Key words:

tarsals, calcaneus, articular facets

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Abstract

The morphometry along with the articular surface area of facets on calcaneus has been reported to a limited extent in the past. The present study was undertaken to measure the morphometric parameters like length and width of calcaneus along with the surface area of its articular facets. The study was carried out on 25 pairs of calcanei i.e., 25 right and 25 left calcanei. The measurements included the length and width of bones measured at specific points using a digital vernier caliper with least count of 0.01mm. The articular facets were traced and their surface area was measured using a graph paper. The average of left and right side for all the parameters was taken and p-value was calculated by using Student's t- test. The result showed a clear left sided dominance in both the morphometric parameters and articular surface area of calcaneus with highly significant p-value. The present data can be of use to the orthopaedic surgeons in performing various surgeries on the foot like corrective surgeries for congenital talipes equino varus, ankle reconstruction etc.

INTRODUCTION

The human foot combines mechanical complexity and structural strength where ankle serves as foundation, shock absorber and propulsion engine. Tarsus and metatarsus are arranged to form intersecting longitudinal and transverse arches. Hence thrust and weight are not transmitted from the tibia to the ground directly through the tarsals alone but are distributed to the tarsals, metatarsal bones and ends of longitudinal arches.[1] Bones of the foot form a functional unit that allows weight to be distributed to a wide platform so as to maintain balance when standing, enable conformation and adjustment to terrain variations and perform shock absorption.[2] The present study was carried out on calcaneus in order to measure the morphometric parameters i.e; length and width, along with the surface area of the articular facets present on it.

MATERIAL AND METHODS

25 pairs of grossly normal human calcanei of right and left side were procured from the department of Anatomy, PGIMS, Rohtak, Haryana. The bones were labeled and put in separate sealable plastic bags. Morphometric measurements:- Measurements were taken by using a digital vernier caliper with least count of 0.01mm. Measurement was done by following a standard method details of which are given below:-

The total length was measured in horizontal position. For the length (AB) the anterior point was taken at the upper part of cuboidal articular facet situated on the anterior surface of calcaneus. Posterior point was taken on rough bony part for the attachment of tendo calcaneus. The measurements were taken in decimal system and put into tabular form. Mean length (AB) for the left and right side was charted as AB-L and AB-R respectively. The width of the bone was measured at three places i.e., at the proximal end (GH), at the distal end (CD) and at an intermediate point (EF) which was halfway between the length of the bone as shown in figure-1.

RESULTS:-

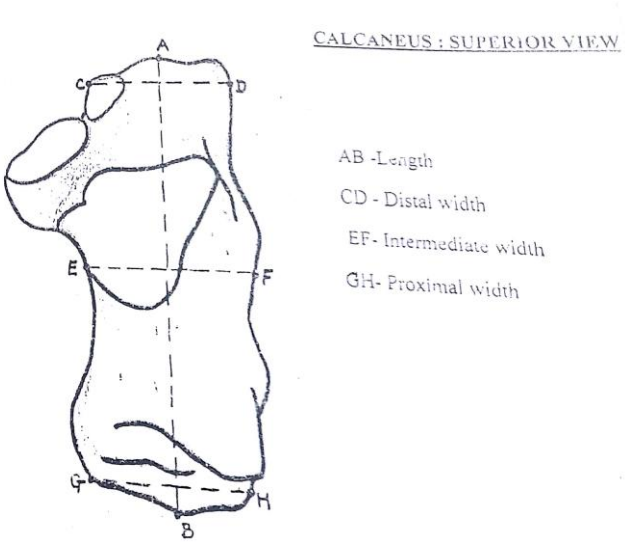

FIGURE-1 showing the points for measuring the calnaneus

Measurement of the surface area of the articular facets

For the measurement of surface area of articular facets on calcaneus, first the outline of articular facets present on the calcaneus as shown in figure-2 and 3; were drawn by covering each facet with white paper and taking its impressions with a crayon. These markings were traced on a tracing paper which was later traced onto a graph sheet using a carbon. The number of squares present inside the facet outline was counted using a magnifying hand lens. The surface area of single small square on graph sheet measured $1mm^2$. The squares within the outline of facet covering half and more than half were counted.[3]

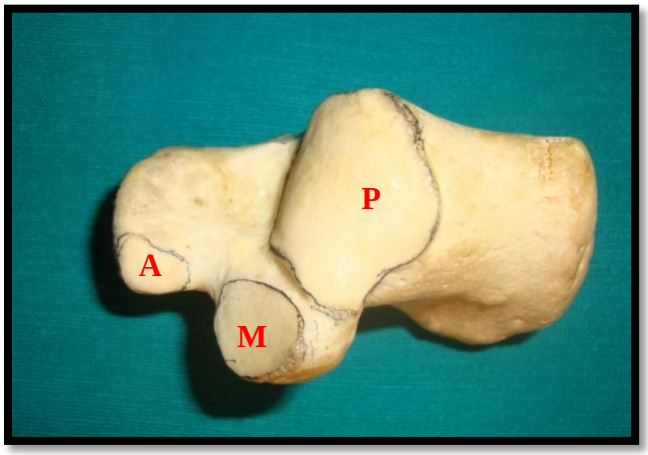

FIGURE-2. SHOWING SUPERIOR SURFACE OF CALCANEUS WITH ANTERIOR (A), MIDDLE (M) AND POSTERIOR (P) FACETS OF CALCANEUS.

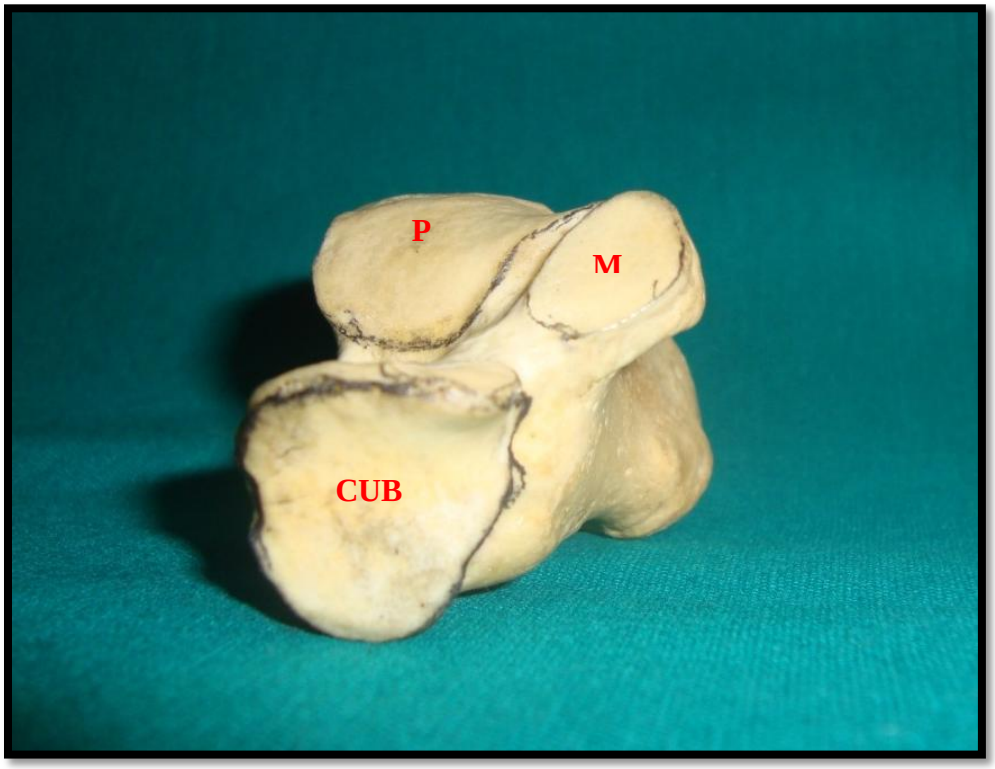

FIGURE-3. SHOWING ANTERIOR ASPECT OF CALCANEUS WITH FACET FOR CUBOID (CUB).

STATISTICAL METHODS- All the data regarding the measurements and surface area of articular facets was put in tabulated form by using Microsoft excel worksheets and statistical results were obtained by applying Student's t-test.

The result of the morphometric measurements and surface area is shown in tables 1 and 2 is as follows:-

Table-1 Showing the Morphometric parameters of Left and Right Calcaneus.

PARAMETERS OF CALCANEUS	Mean ± SD	t-value	p- value
Mean length left (AB-L)	73.12 ± 5.98	61.040	0.000
Mean length right (AB-R)	72.90 ± 5.84	62.325	0.000
Mean distal width left (CD-L)	25.16 ± 3.71	33.884	0.000
Mean distal width right (CD-R)	24.90 ± 3.50	35.560	0.000
Mean intermediate width left (EF-L)	29.26 ± 3.157	46.344	0.000
Mean intermediate width right (EF-R)	29.19 ± 3.50	41.646	0.000
Mean proximal width left (GH-L)	30.63 ± 2.322	65.958	0.000
Mean proximal width right (GH-R)	30.59 ± 2.564	59.640	0.000

TABLE 2- SHOWS THE SURFACE AREA OF ARTICULAR FACETS OF CALCANEUS.

Parameters	Mean ± SD	t-value	p-value
Posterior facet for left talus (PT –L)	487.12 ± 101.91	23.898	0.000
Posterior facet for right talus (PT-R)	476.88 ± 101.93	23.391	0.000
Anterior left calcaneal facet (A-L)	80.77 ± 31.34	7.731	0.000
Anterior right calcaneal facet (A-R)	77.22 ± 28.78	8.049	0.000

Middle left calcaneal facet (M-L)	169.00 ± 27.73	18.283	0.000
Middle right calcaneal facet (M-R)	164.55 ± 36.06	13.688	0.000
Anterior middle facet fused left (AM-L)	312 ± 75.85	18.96	0.000
Anterior middle facet fused right (AM-R)	308.35 ± 80.16	19.44	0.000
Cuboid facet left (CUB-L)	404.56 ± 75.33	26.85	0.000
Cuboid facet right (CUB-R)	403.40 ± 75.01	26.89	0.000

The above tables show the morphometric measurements and surface area of all the facets of the calcaneus on both left and right side. On applying the Student's t- test the p- value was <0.001 i.e.; highly significant. All the readings of the left side were higher than right side for both the morphometric parameters as well as the surface area of articular facets.

DISCUSSION-

The result showed a clear left sided tarsal asymmetry in all the morphometric parameters. All the parameters had higher values on the left side also the p-value was found out to be highly significant.

Many studies done in the past have noted asymmetry in the laterality of the upper limb and lower limb bones. In our department many workers found asymmetry in the bones of upper and lower limbs. S.R Chhibber and Inderbir Singh (1970) studied asymmetry in muscle weight and dominance of lower limb. They observed that right and left lower limbs were not equally developed and left lower limb of majority was dominant regardless of their upper limb dominance and handedness.[4]

Euk T (2001) studied the asymmetry of human long bones and found out that asymmetry was more pronounced in upper limb than the lower limb and left leg was dominant leg in both left and right handers.[5] Zeenat Fatima Zaidi (2011) studied the incidence, etiology and clinical implications of body asymmetries and observed that asymmetry was less pronounced in case of tarsals and metatarsals. Length and weight of femur, tibia and fibula showed a right dominance however hip bones had a higher incidence of heavier bones on the left side.[6] Pradeep Bokaria et al (2012) studied anthropometric measurements on 60 tibias and observed statistically significant higher cross-sectional index on the left side.[7]

Gajendra Singh, Chhandamayee Mohanty (2005) studied side dominant pattern in weight and length of 50 lower limb paired bones and concluded higher incidence of heavier and longer bones on right side suggesting right dominance in femur, tibia and fibula whereas in case of the tarsals and metatarsals this asymmetry was less pronounced.[8] Dr.Riaz Ahmad (2006) studied weights of 198 calcanei and 150 tali and found that bones of right side were heavier than bones of the left side.[9]

In the present study of 25 pairs of calcanei , higher mean values were observed in 17 pairs on the left side i.e.;68% on the left side and 32% on the right side which corresponded with studies done in the past. [4,5,7,10]

CONCLUSION

The result showed a clear left sided dominance in all parameters and a significant difference (with p- value <0.001 i.e.; highly significant) between the measurements of left and right side. The present study throws light on the normal variation in the measurements on the left and the right side and this data can be of use to the orthopaedic surgeons in performing various surgeries on the foot like corrective surgeries for congenital talipes equino varus, ankle reconstruction and replacement, fracture fixation of calcaneus, ankle, subtalar and triple arthrodesis, corrective osteotomies etc.

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