

MORPHOMETRIC ANALYSIS OF VARIOUS MEASUREMENTS OF TROCHLEAR ARTICULAR SURFACE OF TALUS OF GUJARATI POPULATION ON THE BASIS OF SEXUAL DIMORPHISM AND RACIAL DIFFERENCES

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ABSTRACT

Introduction: Talus, the tarsal bone of the foot, and scaphoid, the carpal bone of the hand, are homologous. Further, talus is unique in the sense that it has no muscular or tendinous attachments. The purpose of the present study was to determine whether sex or race related morphometric differences in the various measurements of trochlear articular surface of talus could be demonstrated or not.

Material and Methods: Present study was done on 221 dry adult human talus. Various measurements of trochlear articular surface of talus included in the study are length, breadth and height of trochlea of talus as well as trochlear index and arch index of trochlea of talus.

Results: Findings of all measurements of trochlear articular surface of talus in male are more as compared to those of female in the Gujarati population of present study.

Discussion: Findings of various measurements of trochlear articular surface of talus in Gujarati population of present study were compared with the findings of other researchers who studied the same measurements in the different populations.

Conclusion: Length, breadth and height of trochlea of talus as well as arch index of trochlea of talus are useful for the sexual dimorphism of talus in the Gujarati population of present study. Length and breadth of trochlea of talus as well as trochlear index of talus are population specific and can be useful to aid in the identification of individuals of unknown race.

KEY WORDS: Trochlear articular surface of talus, Sexual dimorphism, Racial differences, Gujarati population.

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INTRODUCTION

Due to evolutionary process, human acquire the erect posture. Having erected posture human foot has to play its role in weight bearing and

locomotion. In the human foot, seven tarsal bones occupy the proximal half of the foot. Tarsal bones of the foot and carpal bones of the hand are homologous, but the tarsal elements

are larger, reflecting their role in supporting and distributing the body weight. The talus is the link between the foot and leg, through the ankle joint [1]. Talus is the key tarsal bone of the human foot. It is unique in the sense that it has no muscular or tendinous attachments [2]. Talus is the second largest tarsal bone after calcaneus [3]. Talus is homologous with the scaphoid (the carpal bone of the hand) [4]. Talus has three parts from anterior to posterior: Head, Neck and Body. The head is directed distally and somewhat inferomedially. The neck is the narrow, medially inclined region between the head and body. The body is cuboidal, covered dorsally by a trochlear surface articulating with the distal end of the tibia [1].

Different bones or part of bones have been used to identify the sex and race of unknown individual. Most bones, those are conventionally used for sexual dimorphism are often recovered either in a fragmented or incomplete state, so it has become necessary to use denser or robust bones, those are often recovered intact e.g. patella, talus, calcaneus [5]. All human populations show at least some sexual dimorphic features regarding various parts of the talus. These features are population specific and show racial variations also. In the present study, various measurements of trochlear articular surface of talus have been taken and tried to analyze on the basis of sexual dimorphism and racial differences.

Aims and objectives: 1. To determine the normal range of the values of various measurements of trochlear articular surface of talus, 2. To determine; whether these measurements are useful for the sexual dimorphism of talus or not, 3. To determine; whether these measurements could be used to aid in the identification of individuals of unknown race.

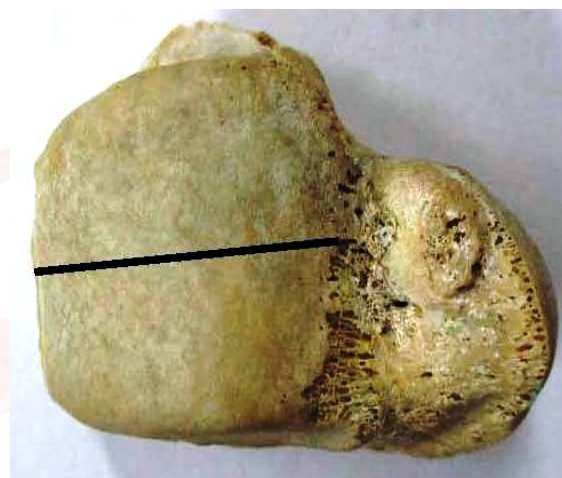
MATERIALS AND METHODS

Present study was conducted on 221 dry adult human talus during the period of five years from 2011 to 2015. The bones were obtained from the dead bodies donated to the Department of Anatomy, Shree M P Shah Government Medical College, Jamnagar. Out of total 221 talus, 127 were of male and 94 were of female. Pathological, fractured or talus of unknown sex were

excluded from the study. Only fully ossified talus of known sex were included in the study. Following measurements of trochlear articular surface of talus were taken in the present study:

Length of trochlea of talus/ trochlear length of talus: Length of trochlea of talus was measured as the distance between the two crossing points of the midsagittal curve of trochlea with the anterior and posterior margins of superior surface. Instrument used: Sliding Caliper

Fig. 1: Showing the measurement of length of trochlea of talus.



Breadth of trochlea of talus/ transverse trochlear breadth of talus: Breadth of trochlea of talus was measured as the distance between the lateral and the medial margins of the superior surface of trochlea of talus in the transverse plane. Instrument used: Sliding Caliper

Fig. 2: Showing the measurement of breadth of trochlea of talus.



Height of trochlea of talus/ trochlear height of talus: Height of trochlea of talus was measured as the distance between the highest and the furthestmost point of the mid-sagittal

curve of trochlea and a perpendicular on the cord joining the two ends points. Instrument used: Co-ordinate Caliper

Fig. 3: Showing the measurement of height of trochlea of talus.



To avoid intra-observer variation, each measurement was taken at three different times and the mean of all three readings was taken as the final reading.

Above mentioned measurements were further used to calculate the following indices:

Trochlear index of talus or length-breadth index of trochlea of talus: Trochlear index of talus was calculated by using following formula:

Trochlear index of talus = Breadth of trochlea of talus/ Length of trochlea of talus

Arch index of trochlea of talus or length-height index of trochlea of talus: Arch index of trochlea of talus was calculated by using following formula:

Arch index of trochlea of talus = Height of trochlea of talus/ Length of trochlea of talus [6]
Student t test was applied and p value was calculated at 95% confidence interval by using statistical aids (SPSS computer software) for comparison of various parameters and indices of trochlear articular surface of talus between male and female. If 'p value' of a particular measurement for male and female is >0.05 , there is no statistically significant difference for that particular measurement between male and female. If 'p value' is between 0.05-0.01, there is statistically significant difference for that particular measurement between male and female. If 'p value' is between 0.01-0.005, it will suggest statistically highly significant difference.

If 'p value' is <0.005 , it will suggest statistically very highly significant difference [7].

RESULTS

As shown in the table 1, in the Gujarati population of present study, mean length of trochlea of talus in male is 39.04 mm, SD is 2.83 mm, range from 31 mm to 47 mm, mean \pm SD from 36.21 mm to 41.87 mm and mean \pm 3SD from 30.55 mm to 47.53 mm. Mean length of trochlea of talus in female is 36.22 mm, SD is 3.03 mm, range from 30 mm to 42 mm, mean \pm SD from 33.19 mm to 39.25 mm and mean \pm 3SD from 27.13 mm to 45.31 mm.

Mean breadth of trochlea of talus in male is 31.13 mm, SD is 1.65 mm, range from 25 mm to 35 mm, mean \pm SD from 29.48 mm to 32.78 mm and mean \pm 3SD from 26.18 mm to 36.08 mm. Mean breadth of trochlea of talus in female is 28.18 mm, SD is 1.82 mm, range from 24 mm to 32 mm, mean \pm SD from 26.36 mm to 30.00 mm and mean \pm 3SD from 22.72 mm to 33.64 mm.

Mean height of trochlea of talus in male is 28.14 mm, SD is 1.68 mm, range from 24 mm to 32 mm, mean \pm SD from 26.46 mm to 29.82 mm and mean \pm 3SD from 23.10 mm to 33.18 mm. Mean height of trochlea of talus in female is 25.97 mm, SD is 2.01 mm, range from 21 mm to 30 mm, mean \pm SD from 23.96 mm to 27.98 mm and mean \pm 3SD from 19.94 mm to 32.00 mm.

Mean trochlear index of talus in male is 0.79, SD is 0.07 mm, range from 0.60 to 0.97, mean \pm SD from 0.72 to 0.86 and mean \pm 3SD from 0.58 to 1.00. Mean trochlear index of talus in female is 0.77, SD is 0.06, range from 0.63 to 0.90, mean \pm SD from 0.71 to 0.83 and mean \pm 3SD from 0.59 to 0.95. Mean arch index of trochlea of talus in male is 0.72, SD is 0.08 mm, range from 0.51 to 0.95, mean \pm SD from 0.64 to 0.80 and mean \pm 3SD from 0.48 to 0.96. Mean arch index of trochlea of talus in female is 0.71, SD is 0.07, range from 0.54 to 0.88, mean \pm SD from 0.64 to 0.78 and mean \pm 3SD from 0.50 to 0.92.

Mean length, breadth and height of trochlea of talus as well as mean trochlear index and arch index of trochlea of talus in male are more as compared to female in Gujarati population of present study.

As shown in table 2, p value for the length,

Table 1: Showing the Sex-Male/Female, N-number of bones taken, Mean, SD-Standard deviation, Standard error of mean, Range (minimum-maximum), Mean \pm SD, Mean \pm 3SD of various measurements and indices of trochlear articular surface of talus of Gujarati population of present study.

Measurements	Sex	N	Mean	SD	Std. Error Mean	Range (min-max)	Mean \pm SD	Mean \pm 3SD
Length of trochlea of talus (mm)	male	127	39.04 mm	2.83 mm	0.25194 mm	31 mm-47 mm	36.21 mm-41.87 mm	30.55 mm-47.53 mm
	female	94	36.22 mm	3.03 mm	0.31261 mm	30 mm- 42 mm	33.19 mm-39.25 mm	27.13 mm-45.31 mm
Breadth of trochlea of talus (mm)	male	127	31.13 mm	1.65 mm	0.14720 mm	25 mm- 35 mm	29.48 mm-32.78 mm	26.18 mm-36.08 mm
	female	94	28.18 mm	1.82 mm	0.18829 mm	24 mm- 32 mm	26.36 mm-30.00 mm	22.72 mm-33.64mm
Height of trochlea of talus (mm)	male	127	28.14 mm	1.68 mm	0.14946 mm	24 mm- 32 mm	26.46 mm-29.82 mm	23.10 mm-33.18 mm
	female	94	25.97 mm	2.01 mm	0.20738 mm	21 mm- 30 mm	23.96 mm-27.98 mm	19.94 mm-32.00 mm
Trochlear index of talus	male	127	0.79	0.07	0.33276	0.60-0.97	0.72-0.86	0.58-1.00
	female	94	0.77	0.06	0.45051	0.63-0.90	0.71-0.83	0.59-0.95
Arch index of trochlea of talus	male	127	0.72	0.08	0.44635	0.51-0.95	0.64-0.80	0.48-0.96
	female	94	0.71	0.07	0.2439	0.54-0.88	0.64-0.78	0.50-0.92

Table 2: Showing the statistical analysis and the results of independent samples test applied to various measurements and indices of trochlear articular surface of talus of Gujarati population of present study.

Independent samples test										
		Levene's Test for Equality of variances		t-test for Equality of Means						
		F	sig	t	df	Sig. (2-tailed)	Mean Difference	Standard Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Length of trochlea of talus (mm)	Equal variances assumed	3.405	0.066	7.102	219	0	2.82384	0.39759	2.04025	3.60743
	Equal variances not assumed			7.033	192.961	0	2.82384	0.4015	2.03196	3.61572
Breadth of trochlea of talus (mm)	Equal variances assumed	3.923	0.049	12.534	219	0	2.95301	0.2356	2.48867	3.41734
	Equal variances not assumed			12.356	189.242	0	2.95301	0.239	2.48156	3.42445
Height of trochlea of talus (mm)	Equal variances assumed	7.589	0.006	8.687	219	0	2.16301	0.24899	1.67229	2.65373
	Equal variances not assumed			8.462	179.047	0	2.16301	0.25562	1.65859	2.66743
Trochlear index of talus	Equal variances assumed	9.366	0.002	1.292	219	0.198	1.68623	0.30555	-0.88682	4.25928
	Equal variances not assumed			1.236	163.853	0.218	1.68623	0.36404	-1.00714	4.3796
Arch index of trochlea of talus	Equal variances assumed	6.078	0.014	2.417	219	0.016	1.83402	0.75886	0.33842	3.32962
	Equal variances not assumed			2.341	174.169	0.02	1.83402	0.78347	0.2877	3.38034

Table 3: Showing the comparison of various measurements and indices of trochlear articular surface of talus of Gujarati population of present study with the findings of the other researchers.

No	Researcher	Population	Sample Size	Sex	PARAMETERS		
					Length of trochlea of talus (mm) (mean \pm sd)	Breadth of trochlea of talus (mm) (mean \pm sd)	Trochlear index of talus (mean \pm sd)
1	Steel DG (1976) [8]	White Americans	28	Male	36.00 \pm 3.20	32.10 \pm 2.10	0.89 \pm 0.06
			29	Female	33.90 \pm 2.20	29.50 \pm 1.40	0.87 \pm 0.06
		Black Americans	33	Male	35.90 \pm 3.60	32.30 \pm 1.80	0.91 \pm 0.07
			30	Female	31.90 \pm 2.80	28.10 \pm 2.20	0.88 \pm 0.09
		White and Black Americans combined	61	Male	35.90 \pm 3.40	32.20 \pm 2.00	0.90 \pm 0.06
			59	Female	32.90 \pm 2.70	28.80 \pm 2.00	0.88 \pm 0.08
2	AMC Murphy (2002) [9]	New Zealander (Kiwis)	24	Male	32.81 \pm 1.99	32.87 \pm 1.26	-
			24	Female	29.98 \pm 1.79	29.51 \pm 1.59	-
3	Bidmos and Dayal (2003) [5]	White south africans	60	Male	35.54 \pm 2.40	32.53 \pm 1.60	-
			60	Female	32.34 \pm 2.80	29.96 \pm 1.80	-
4	Bidmos and Dayal (2004) [10]	Black south africans	60	Male	32.54 \pm 2.70	30.59 \pm 1.76	-
			60	Female	28.80 \pm 2.06	27.91 \pm 1.45	-
5	Torres TB (2010) [11]	Americans	114	Male	36.71 \pm 2.73	35.26 \pm 3.10	-
			113	Female	32.43 \pm 3.38	31.18 \pm 3.93	-
6	Lee UY et al (2012) [12]	Korean	70	Male	33.30 \pm 2.11	28.31 \pm 2.09	-
			70	Female	30.79 \pm 1.40	26.45 \pm 1.84	-
7	Motagi MV et al (2014) [13]	South Indian	25	Male	29.57 \pm 2.86	-	-
			25	Female	30.00 \pm 2.62	-	-
8	Present study - 2017	Gujarati	127	Male	39.04 \pm 2.83	31.13 \pm 1.65	0.79 \pm 0.07
			94	Female	36.22 \pm 3.03	28.18 \pm 1.82	0.77 \pm 0.06

breadth and height of trochlea of talus (for both with equal variances assumed as well as equal variances not assumed) are 0.000, which suggest statistically very high significant difference between the male and female talus for these parameters. P value for the trochlear index of talus is 0.198 when equal variances are assumed and 0.218 when equal variances are not assumed, which suggest that there is no statistically significant difference for trochlear index of talus between male and female. P value for the arch index of trochlea of talus is 0.016 when equal variances are assumed and 0.020 when equal variances are not assumed, which suggest statistically significant difference for arch index of trochlea of talus between male and female.

DISCUSSION

As shown in Table 3, Steel DG (in 1976) [8] measured the length and breadth of trochlea of talus as well as trochlear index of talus in White (28 male and 29 female) as well as Black Americans (33 male and 30 female). In that study, mean length of trochlea of talus in male and female White Americans were 36.00 mm with SD 3.20 mm and 33.90 mm with SD 2.20 mm respectively, while these findings in male and female Black Americans were 35.90 mm with SD 3.60 mm and 31.90 mm with SD 2.80 mm respectively. In that study, mean breadth of trochlea of talus in male and female White Americans were 32.10 mm with SD 2.10 mm and 29.50 mm with SD 1.40 mm respectively, while these findings in male and female Black Americans were 32.30 mm with SD 1.80 mm and 28.10 mm with SD 2.20 mm respectively. In that study, mean trochlear index of talus in male and female White Americans were 0.89 with SD 0.06 and 0.87 with SD 0.06 respectively, while these findings in male and female Black Americans were 0.91 with SD 0.07 and 0.88 with SD 0.09 respectively. Findings of mean length of trochlea of talus in male and female Gujarati population of present study are more as compared to similar findings for male and female White and Black Americans studied by Steel DG. Findings of mean breadth of trochlea of talus in male and female Gujarati population of present study are less as compared to similar findings for male and female White and Black Americans. Find-

ings of mean trochlear index of talus in male and female Gujarati population of present study are less as compared to similar findings for male and female White and Black Americans. In 2002, AMC Murphy [9] measured the length and breadth of trochlea of talus in 24 male and 24 female Kiwis. In that study, mean length of trochlea of talus in male and female Kiwis were 32.81 mm with SD 1.99 mm and 29.98 mm with SD 1.79 mm respectively, while mean breadth of trochlea of talus in male and female Kiwis were 32.87 mm with SD 1.26 mm and 29.51 mm with SD 1.59 mm respectively. Findings of mean length of trochlea of talus in male and female Gujarati population of present study are more as compared to similar findings for male and female Kiwis studied by AMC Murphy. Findings of mean breadth of trochlea of talus in male and female Gujarati population of present study are less as compared to similar findings for male and female Kiwis.

In 2003-04 Bidmos and Dayal [5][10] measured the length and breadth of trochlea of talus in White (60 male and 60 female) as well as Black South Africans (60 male and 60 female). In that study, mean length of trochlea of talus in male and female White South Africans were 35.54 mm with SD 2.40 mm and 32.34 mm with SD 2.80 mm respectively, while these findings in male and female Black South Africans were 32.54 mm with SD 2.70 mm and 28.80 mm with SD 2.06 mm respectively. In that study, mean breadth of trochlea of talus in male and female White South Africans were 32.53 mm with SD 1.60 mm and 29.96 mm with SD 1.80 mm respectively, while these findings in male and female Black South Africans were 30.59 mm with SD 1.76 mm and 27.91 mm with SD 1.45 mm respectively. Findings of mean length of trochlea of talus in male and female Gujarati population of present study are more as compared to similar findings for male and female White and Black South Africans studied by Bidmos and Dayal. Findings of mean breadth of trochlea of talus in male and female Gujarati population of present study are less as compared to similar findings for male and female White South Africans and more as compared to Black South Africans.

In 2010, Torres TB [11] measured the length and breadth of trochlea of talus in 114 male and 113

female Americans. In that study, mean length of trochlea of talus in male and female Americans were 36.71 mm with SD 2.73 mm and 32.43 mm with SD 3.38 mm respectively, while mean breadth of trochlea of talus in male and female Americans were 35.26 mm with SD 3.10 mm and 31.18 mm with SD 3.93 mm respectively. Findings of mean length of trochlea of talus in male and female Gujarati population of present study are more as compared to similar findings for male and female Americans studied by Torres TB. Findings of mean breadth of trochlea of talus in male and female Gujarati population of present study are less as compared to similar findings for male and female Americans.

In 2012, Lee UY et al [12] measured the length and breadth of trochlea of talus in 70 male and 70 female Koreans. In that study, mean length of trochlea of talus in male and female Koreans were 33.30 mm with SD 2.11 mm and 30.79 mm with SD 1.40 mm respectively, while mean breadth of trochlea of talus in male and female Koreans were 28.31 mm with SD 2.09 mm and 26.45 mm with SD 1.84 mm respectively. Findings of mean length and mean breadth of trochlea of talus in male and female Gujarati population of present study are more as compared to similar findings for male and female Koreans studied by Lee UY et al.

In 2014, Motagi MV et al [13] measured the length of trochlea of talus in 25 male and 25 female South Indians. In that study, mean length of trochlea of talus in male and female South Indians were 29.57 mm with SD 2.86 mm and 30.00 mm with SD 2.62 mm respectively. Findings of mean length of trochlea of talus in male and female Gujarati population of present study are more as compared to similar findings for male and female South Indians studied by Motagi MV et al.

Similarities, if any, in the findings of various measurements and indices of trochlear articular surface of talus of different populations may be due to coincidence or due to migrating populations. Differences, if any, in the findings of various measurements and indices of trochlear articular surface of talus of different populations may be due to differences in measuring techniques or may be due to coincidence or may be due to racial variations.

CONCLUSION

We determined the normal range of the values of various measurements and indices of trochlear articular surface of talus in the Gujarati population of present study. Among all the measurements taken in the present study; length, breadth and height of trochlea of talus as well as arch index of trochlea of talus can be used for the sexual dimorphism in talus. Length and breadth of trochlea of talus as well as trochlear index of talus are population specific and can be useful to aid in the identification of individuals of unknown race.

Conflicts of Interests: None

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