



THE MORPHOMETRIC STUDY OF THE PROXIMAL END OF THE TIBIA FOR DETERMINATION OF SEX AND AGE AT TERTIARY HOSPITAL

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ABSTRACT

Background- Morphometry is an important tool used in studies to understand the relationship of variables, such as age and sex, between organisms. Present study was carried out to ascertain sexual dimorphism of proximal epiphyseal breadth of tibia and develop appropriate standards for sex determination from tibia in central Indian population. **Material and Methods:** Present study was single-center, observational study, conducted in dry adult human tibia of known gender, regular in shape, from adult individuals of the Indian population, ten measurements were made on the joint face of the tibial plateau with help of digital vernier calipers. **Results:** 384 bones (192pairs) were in adequate condition and were therefore included in the study. The mean AP diameter for the medial condyle was more for right side than left while the transverse diameter was more for left side than right. The mean AP and the transverse diameter for the lateral condyle was greater on the left side. On comparing the two condyles it was seen that both anteroposterior and transverse measurement were greater for the medial condyle. No statistically significance ($p > 0.05$) was seen on comparing the different parameters for both the sides. All parameters (APM, TM, APL, TL, ATI, PTI, API, AI, PI & TD) were larger in males as compared to females, difference was statistically significant. **Conclusion:** Total transverse diameter (TTD) and Antero posterior diameter of Lateral condyle (APLC) are considered as best parameters of sex determination. According to their percentage of accuracy, various parameters are arranged in the order of discrimination of sex from best to least as follows: TTD > APLC > APMC > TDMC = APD > TDLC > L.

Keywords: morphometric study, tibia, tibial plateau, total transverse diameter (TTD), antero posterior diameter of Lateral condyle (APLC)

INTRODUCTION

The tibia is the large long bone located on the medial side of the leg with two ends and a shaft. Its proximal end articulates with the lower end of femur to form the knee joint along with patella¹ The distal narrow end of tibia and the lower end of fibula articulate with the talus to form the ankle joint. It is homologous with the radius of the upper limb.²

Morphometry is an important tool used in studies to understand the relationship of variables, such as age and sex, between organisms.³ The tibia is an ideal long bone of the limb which is used for sex determination, as it resists the erosive forces which act and it remains unaffected even after the burial of the body.

Sexual dimorphism in the tibia indicates not only the general growth and the musculoskeletal activity, but also the genetic structure of the population. Sexual dimorphism of distal epiphyseal breadth of tibia has been studied in different populations.⁴ Present study was carried out to ascertain sexual dimorphism of proximal epiphyseal breadth of tibia and develop appropriate standards for sex determination from tibia in central Indian population.

MATERIAL AND METHODS

Present study was single-center, observational study, conducted in department of Anatomy, at NIMS medical college associated hospital (SMS medical college, Mahatma Gandhi medical college and National Institute Medical Sciences and Research and other Medical Colleges), Jaipur, Rajasthan, India. Study duration was of 2 years (January 2020 to December 2019). Study approval was obtained from institutional ethical committee.

Inclusion criteria

- Dry adult human tibia of known gender, from adult individuals of the Indian population, those tibias which are regular in shape will be included in our study

Exclusion criteria

- An advanced state of deterioration at the measurement site (tibial plateau), signs of trauma and bone from individuals under the age of 18 years at the time of death.
- Tibia which are broken, Unossified bones, bones with diseases and injuries, tibia with any deformity and malformation, abnormal shaped tibia will not be included

The inclusion criteria were intact bone with no signs of trauma or apparent anomalies from adult humans, since differences between sexes are only evident after puberty due to the influence of the environment, hormones and musculature. Ten measurements were made on the joint face of the tibial plateau with help of digital vernier calipers.

1. **APM:** Anteroposterior diameter of the joint surface of the medial condyle. Distance between anterior and posterior margins of medial condyle of the tibia.
2. **TM:** Transverse diameter of the joint surface of the medial condyle. Distance between intercondylar eminences to the medial edge of medial condyle of tibia.
3. **APL:** Anteroposterior diameter of the joint surface of the lateral condyle. Distance between anterior and posterior margins of lateral condyle of the tibia
4. **TL:** Transverse diameter of the joint surface of the lateral condyle. Distance between intercondylar eminences to the lateral edge of lateral condyle of tibia.
5. **ATI:** Anterior transverse measure of inter-condyle area.
6. **PTI:** Posterior transverse measure of inter-condyle area.
7. **Total transverse diameter (TTD):** Distance between the two most laterally projecting points on the medial and lateral condyles of the proximal particular region of the tibia
8. **API:** Anteroposterior measure of inter-condyle area. A straight line passes exactly through the middle of the medial and lateral tubercle of intercondylar eminence from most anterior to the most posterior point
9. **AI:** Anterior measure of inter-condyle area.
10. **PI:** Posterior measure of inter-condyle area.

Mean and standard deviation values were calculated for all measurements. The data were submitted to the Kolmogorov-Smirnov test using GraphPad Prism 5.01. The student's t-test was used for the comparisons of means with normal distribution and the Mann-Whitney test was used for the comparisons of means with non-normal distribution. A 95 % confidence level was used in all cases. Thus, p-values < 0.05 were considered indicative of statistical significance.

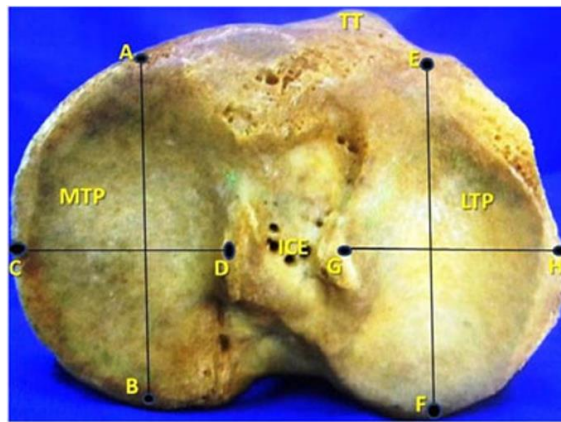


Figure 1 Tibial plafond

RESULTS

The morphometric study conducted on adult human tibia revealed the under-mentioned important observations in a tabulated form. After the application of the eligibility criteria, 384 bones (192pairs) were in adequate condition and were therefore included in the study.

The mean AP diameter for the medial condyle was more for right side than left while the transverse diameter was more for left side than right. The mean AP and the transverse diameter for the lateral condyle was greater on the left side. On comparing the two condyles it was seen that both anteroposterior and transverse measurement were greater for the medial condyle. No statistically significance ($p > 0.05$) was seen on comparing the different parameters for both the sides.

Table 1: Descriptive statistics of morphometric measurement

Parameters	Min	Max	Mean \pm SD	95% CI
APM	4.3	76.6	40.72 \pm 5.79	(40.14, 41.3)
TM	21.3	79.2	30.39 \pm 5.29	(29.81, 30.96)
APL	26.1	91	37.99 \pm 6.36	(37.35, 38.62)
TL	20.1	82	30.22 \pm 6.38	(29.58, 30.85)
ATI	15.9	71	23.94 \pm 5.88	(23.35, 24.53)
PTI	10.9	67.6	17.81 \pm 5.53	(17.25, 18.36)
API	30.5	68.6	44.48 \pm 5.43	(43.94, 45.02)
AI	15.1	39	25.36 \pm 3.89	(24.97, 25.75)
PI	14	30.3	20.57 \pm 2.58	(20.31, 20.83)
TD	36.5	89.7	66.92 \pm 5.66	(66.36, 67.49)

The values of the morphometric variables of the tibias were higher for the male sex compared to the female sex. In this study Total transverse diameter (TTD) was found 68.8 mm in males which is almost similar and the same was found in case of females 62.2 mm. Antero-posterior diameter of medial condyle in males 41.72mm and females 38.02mm

The measurements of TDLC in the present study in case of males was in accordance with study while in case of females it was on higher side. In males it is 38.93mm and in females it is 35.42 mm. Antero- posterior diameter of medial condyle (APMC) Both in case of males and females APMC is found to be on the lower side. Antero- posterior diameter 46.22mm in male and 39.74mm in female. In the present study, we have measured a new parameter i.e. APD of the upper end of tibia. The values were 68.43 mm in males and 62.8 mm in females.

Mediolateral and anteroposterior length were 66.33 and 42.52 mm, respectively. Anatomical profile of tibial condyle for Indians is smaller, hence highlighting the need for sizing of prosthesis specific to the population.

All parameters (APM, TM, APL, TL, ATI, PTI, API, AI, PI & TD) were larger in males as compared to females, difference was statistically significant.

Table 2: Descriptive statistics of morphometric measurement of male and female

Parameters	Male (n = 281)			Female (n = 103)			P - Value	Significance
	Min	Max	95% CI	Min	Max	95% CI		
APM	4.3	76.6	(41.03, 42.4)	30.1	54.5	(37.15, 38.89)	0.00000	All are highly significant
TM	21.3	79.2	(30.13, 31.56)	22.2	41.2	(28.26, 30.01)	0.003288	
APL	27.2	91	(38.13, 39.72)	26.1	46.3	(34.64, 36.2)	0.000000	
TL	20.5	82	(30.56, 32.13)	20.1	38.9	(26.4, 27.87)	0.000000	
ATI	17	71	(23.95, 25.44)	15.9	35.8	(21.22, 22.53)	0.000000	

PTI	10.9	67.6	(17.72, 19.17)	11.5	23.2	(15.64, 16.48)	0.000000
API	35.6	68.6	(45.68, 46.76)	30.5	52.1	(38.85, 40.63)	0.000000
AI	15.6	39	(25.68, 26.52)	15.1	37.2	(22.57, 24.1)	0.000000
PI	14.3	30.3	(20.79, 21.36)	14	24.4	(18.72, 19.68)	0.000000
TD	36.5	89.7	(67.84, 69.02)	51.7	74.2	(61.79, 63.81)	0.000000

DISCUSSION

The purpose of the study was to determine which variable of the upper end of tibia is best for metric diagnosis of sex. The upper end of the tibia is markedly expanded from side to side, to form two large condyles. Medial condyle is larger than the lateral condyle. Its superior surface articulates with the medial condyle of the femur. The articular surface is oval and its long axis is anteroposterior. The central part of the surface is slightly concave and comes into direct contact with the femoral condyle. The peripheral part is flat and is separated from the femoral condyle by the medial meniscus. The lateral margin of the articular surface is raised to cover the medial intercondylar tubercle.²

The lateral condyle overhangs the shaft more than the medial condyle. The superior surface of the condyle articulates with the lateral condyle of the femur. The lower end of the tibia is slightly expanded. It has five surfaces. Medially, it is prolonged downwards as the medial malleolus.

Total transverse diameter (TTD)

In this study TTD it is found 68.8 mm in males which is almost similar to the Murphy⁵ i.e. 71.3 mm and the same was found in case of females i.e. 62.2 mm. TTD of both males and females in the present study was found to be similar to the study done by Murphy.⁵

Antero-posterior diameter of medial condyle (APDMC)

In the present study APM was found to be lying in between the study of Kazuhiro Sakaue⁶ and Janamala *et al.*,⁷ i.e. in males 41.72mm and females 38.02mm. No other literature was found in other studies.

Antero-posterior diameter of lateral condyle (TDLC)

The measurements of TDLC in the present study in case of males was in accordance with study while in case of females it was on higher side. In males it is 38.93mm and in females it is 35.42 mm. Antero- posterior diameter of medial condyle (APMC) Both in case of males and females APMC is found to be on the lower side i.e. 41.8 mm & 36.6 mm when compared with other studies.^{8,9,10,11}

Antero- posterior diameter of intercondyle (API)

In the present study the API both in case of males and females was found to be also similar to the study done by Kazuhiro Sakaue⁶ and Janamala *et al.*,⁷ i.e. 46.22mm in male and 39.74mm in female.

Transverse diameter of tibia (TD)

In the present study, we have measured a new parameter i.e. APD of the upper end of tibia. The values were 68.43 mm in males and 62.8 mm in females. This variable can be used to discriminate sex with 73 % accuracy. No data is available about this parameter being used for sexing the tibia.

Table 3: Values (in cm) of morphometric variables of tibias from males and females and differences between sexes (data expressed as mean and standard deviation)

Parameter	Male (cm)	Female (cm)	Difference between sexes (cm)	p
APM	4,707 ± 0,406	4,334 ± 0,317	0,373	< 0.000000
TM	3,024 ± 0,307	2,702 ± 0,298	0,322	= 0.003288
APL	4,023 ± 0,414	3,549 ± 0,382	0,481	< 0.000000
TL	3,405 ± 0,323	2,991 ± 0,281	0,414	< 0.000000
ATI	3,365 ± 0,425	2,818 ± 0,307	0,547	< 0.000000
PTI	1,788 ± 0,307	1,555 ± 0,222	0,233	< 0.000000
TD	1,167 ± 0,279	1,054 ± 0,262	0,113	< 0.000000
API	5,140 ± 0,377	4,596 ± 0,303	0,544	< 0.000000
AI	2,865 ± 0,249	2,565 ± 0,210	0,3	< 0.000000
PI	2,297 ± 0,344	2,031 ± 0,225	0,266	< 0.000000

Korean cadaveric study,¹² 3D computerized tomography scans were used and they reported that the mediolateral tibial plateau measured 73.5 ± 5.6 mm. In our study the mediolateral tibial plateau measured 67.2 ± 5.8 and this closely resembles the Korean study. This study also reported that the parameters they observed were lower than the size of commercially available knee implants. They also mentioned that the smaller implants could lead to mediolateral under-sizing and the larger ones could cause mediolateral overhang. They believed that their data may offer a guideline for preparing total knee prostheses for Koreans

The French study³, it is mentioned that the length of medial tibial plateau is 50.8 ± 3.3 mm and the lateral is 47.2 ± 3.3 mm. In a South Indian study it is mentioned that the length is significantly longer for the medial tibial plateau and measured 39.8 ± 3.8 mm and the lateral plateau measured 33.6 ± 3.7 mm.⁷ In the present study, also the length is longer for the medial tibial plateau and it measured 42.7 ± 4.1 and the lateral measured 37.5 ± 3.9 . The comparison of above measurements shows the length given the French study are larger, that may be due to their study which was done on data obtained from CT-scan and also because of ethnic factors. Our study gives morphometry of tibial plateau similar to the South Indian study mentioned.

In the present study, the total mean AP length of the medial condyle was 40.19 ± 5.11 mm and that of the lateral condyle was 36.41 ± 4.29 mm which shows an obvious difference between the two tibial plateaus. The same observation was made by Servien *et al.*,¹³ who did a morphometric analysis between the medial and lateral tibial plateaus.

The results of this study will provide recommendations for creating suitable tibial prosthetic components for unicompartmental and TKA surgeries in the Eastern Indian population. Anatomists, anthropologists, medical students, and researchers will also benefit from this morphometric analysis. One limitation of the study was its geographical restriction to one state in India, so the generalisability of the study to the entire Indian population should be interpreted cautiously.

CONCLUSION

The values of the morphometric variables of the tibiae were higher for the male sex compared to the female sex. The length of medial tibial plateau was greater than the lateral. The breadth of the medial tibial plateau was also slightly more than that of lateral. The two tailed p-value is less than 0.0001 for length and breadth and by conventional criteria; this difference was considered to be extremely statistically significant.

Sex determination cannot be done by using any single variable. Although tibia is not an ideal bone meant for sex determination but it can be used for sex determination with 80 – 85 % of accuracy. According to the % of accuracy Total transverse diameter (TTD) and Antero posterior diameter of Lateral condyle (APLC) are considered as best parameters of sex determination. According to their percentage of accuracy, various parameters are arranged in the order of discrimination of sex from best to least. Their order of arrangement are as follows: TTD > APLC > APMC > TDMC = APD > TDLC > L.

Conflict of Interest: None to declare

Source of funding: Nil

REFERENCES

1. Dr. Neha Rai, Dr. Sheema Nair, Dr. Vishal Bankwar, Dr. Nimish Rai, Naresh Thanduri. "Sex determination of adult human tibia in central Indian population". International Journal of Medical and Health Research ISSN: 2454-9142, Impact Factor: RJIF 5.54 www.medicalsciencejournal.com Volume 3; Issue 5; May 2017; Page No. 82-84.
2. Musa K. Misiani, Thomas Amuti* , Shane Darbar, Pamela Mandela, Emily Maranga, Moses Obimbo." Sex determination from dimensions of distal tibiae in adult Kenyans: A discriminant function analysis". Translational Research in Anatomy 20 (2020) 100075.
3. Seema, Anupama Mahajan. "Determination of Sex from the Tibia in the Punjab Zone". Journal of Clinical and Diagnostic Research. 2012 August, Vol-6(6): 935-937.
4. Kishan R. Siddapur. " Study on Anthropometric Parameters of Dry Tibia of Human Origin to aid Gender Identification in Forensic Investigation". Arab Journal of Forensic Sciences & Forensic Medicine 2017; Volume 1 Issue (5), 532-539.
5. Murphy WA, Gantner GE. Radiologic examination of anatomic parts and skeletonized remains. Journal of Forensic Science. 1982 Jan 1;27(1):9-18
6. Kazuhiro S. Sexual determination of long bones in recent Japanese. Anthropol Sci 2004; 112: 75-81.
7. Ratna priyanka Janamala , Dr. Subhadra Devi Velichety , Dr.Tirupati Rao padi , Dr.Ravindra kumar Boddeti , P.Sirisha." Percentage accuracy of sexing human adult tibia by Discriminant function analysis". Int J Biol Med Res. 2012; 3(2): 1739-1742.
8. Nadia Ahmad, Deepa Singh, Aksh Dubey, S. L. Jethani. "Morphometric Analysis of Proximal End of the Tibia". National Journal of Clinical Anatomy Vol. 8 No. 2/2019.
9. AU Katchy, AU Agu, IT Ikele, E Esom, NJ Nto." The Morphology of Proximal Tibia Geometry amongst the Igbos of South East Nigeria and its Implication in Total Knee Replacement". Nigerian Journal of Clinical Practice | Volume 22 | Issue 10 | October 2019.

10. Elham Karimi; Reza Zandi; Mohsen Norouzian; Ali Birjandinejad. "Correlation of Anthropometric Measurements of Proximal Tibia in Iranian Knees with Size of Current Tibial Implants". the archives of bone and joint surgery. abjs.mums.ac.ir volume 7. number 4. july 2019.
11. Chandni Gupta, Jitendra Kumar, Sneha Guruprasad Kalthur, Antony Sylvan D'souza." A morphometric study of the proximal end of the tibia in South Indian population with its clinical implications". Saudi Journal of Sports Medicine | May - August 2015 | Volume 15 | Issue 2.
12. Lee, Je & Han, Seung-Ho & Chung, In. (2010). Sex Determination from the Tibia in Korean Population. Korean Journal of Physical Anthropology. 23. 61. 10.11637/kjpa.2010.23.2.61.
13. Servien E, Saffarini M, Lustig S, Chomel S, Neyret P. Lateral versus medial tibial plateau: Morphometric analysis and adaptability with current tibial component design. Knee Surg Sports Traumatol Arthrosc. 2008;16(12):1141-45.