

A Cross Sectional Study to Assess Morphometry of Upper End of 80 Cadaveric Tibiae in a Tertiary Care Centre of Central India

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ABSTRACT

BACKGROUND

Osteoarthritis of knee joint is one of the major health problems, due to the evolution of erect posture. Upper weight bearing end of tibia is most vulnerable to damage in such patients. Total knee arthroplasty and unicompartmental arthroplasty are the most frequently done procedures, which require the use of adequate knee prosthesis. So, the present study was focused at providing morphometric data of upper articular end of tibia for designing the tibial component of prosthesis.

METHODS

The present study has been conducted in SAMC & PGI, Indore in the Department of Anatomy. 80 dry tibia bones were studied, of which 33 were right sided and 47 were left sided. Maximum anteroposterior (AP) length and width of upper surface of medial and lateral condyles and intercondylar area were measured with digital vernier caliper.

RESULTS

The average anteroposterior diameter was found to be greater than the transverse diameter for both the condyles and the intercondylar area, irrespective of side. Furthermore, the anteroposterior diameter and the transverse diameter of medial condyle was more than that of lateral condyle on both the sides. In intercondylar area, the anteroposterior diameter was found to be more on right side while transverse diameter was more on left side.

CONCLUSIONS

The present study demonstrates the accurate complete comparative measurements of all the parameters of upper surface of medial and lateral condyles and intercondylar area. The morphometric data obtained will provide guidelines for designing tibial component of knee prosthesis in central Indian population. Apart from clinical significance, the study has anthropological and medicolegal importance as well.

KEYWORDS

Morphometry, Upper End of Tibia, Knee Joint

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DOI: 10.18410/jebmh/2021/499

How to Cite This Article:

Agichani SR, Medhi B, Harioudh SK. A cross-sectional study to assess morphometry of upper end of 80 cadaveric tibiae in a tertiary care centre of central India. J Evid Based Med Healthc 2021;8(30):2714-2718. DOI: 10.18410/jebmh/2021/499

*Submission 07-04-2021,
Peer Review 17-04-2021,
Acceptance 07-06-2021,
Published 26-07-2021.*

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BACKGROUND

The upper end of tibia presents medial and lateral condyles. Its superior surface has articular surfaces (facets) for articulation with the corresponding femoral condyles. The medial articular surface is oval, elongated anteroposteriorly and longer than the lateral articular surface. The lateral tibial articular surface is circular and overhangs the shaft posterolaterally above the fibular facet. Separating these two articular areas, is the narrow non-articular intercondylar area, central part of which is raised to form intercondylar eminence having medial and lateral intercondylar tubercles. In habitual erect bipedal posture, lower limb is primarily adapted for weight bearing and locomotion. The upper surface of expanded proximal end of tibia is a surface for bearing body weight which is transmitted through femur. The relatively incongruent nature of the joint surfaces makes the knee joint inherently unstable particularly on lateral side. On medial aspect, the relatively concave tibial surface and fixed posterior horn of medial meniscus, lends some degree of stability.

Both Menisci play an important role in providing stability particularly as they move with femoral condyles. Ligaments are also vital for maintaining stability of knee joint.¹ In spite of all these factors, the knee joint is usually affected by several forms of arthritis of which osteoarthritis is the most common pathological disorder and the treatment for that is usually total knee arthroplasty (TKA) or unicompartmental knee arthroplasty (UKA).² Hence the morphometry of upper end of tibia provides a reliable method of assessing any knee deformity. Also, it will help in designing tibial prosthesis in technically demanding knee joint surgeries.³ For construction of such prosthesis, population specific appropriate sizing is required. Therefore, in the present study various parameters of tibial plateau are measured in dry bones of central Indian population.

The present study has been undertaken to provide morphometric data for designing tibial component of prosthesis that can be used in patients of knee joint osteoarthritis in central Indian population. We also wanted to measure maximum anteroposterior and transverse diameters of articular surface of medial condyle, lateral condyle and intercondylar area of tibia.

METHODS

The present cross-sectional study was conducted in the Department of Anatomy, SAIMS, and IMCRC, Indore from June 2020 to December 2020. 80 cadaveric - dry, processed adult tibia bones were utilized for the present study. The age and sex of these bones were not known. Only those tibiae were included in the present study, which showed no signs of damage due to any cause. Tibia bones were divided into 2 groups- Right sided - 33 tibia & Left sided - 47 tibia. On each bone under study, following parameters were measured as shown in figure-1.

1. The maximum anteroposterior diameter of upper surface of medial condyle, extending between its anterior and posterior borders.

2. The maximum transverse diameter of upper surface of medial condyle, extending between its medial and lateral borders.
3. The maximum anteroposterior diameter of upper surface of lateral condyle, extending between its anterior and posterior borders.
4. The maximum transverse diameter of upper surface of lateral condyle extending between its medial and lateral borders.
5. The maximum anteroposterior diameter of upper surface of intercondylar area extending between its anterior and posterior borders.
6. The transverse diameter of upper surface of intercondylar area between two tubercles of intercondylar eminence.
7. These parameters were measured with the help of digital vernier caliper. The observations were tabulated. Their mean and standard deviation was calculated.

Statistical Analysis

The obtained values were then analysed statistically using statistical package for social sciences (SPSS) software. Unpaired t-test was used to analyze the data, and conclude whether the difference in anteroposterior & transverse diameter of medial condyle, lateral condyle and intercondylar area, on right and left side is statistically significant or not. $P < 0.05$ is considered to be significant.

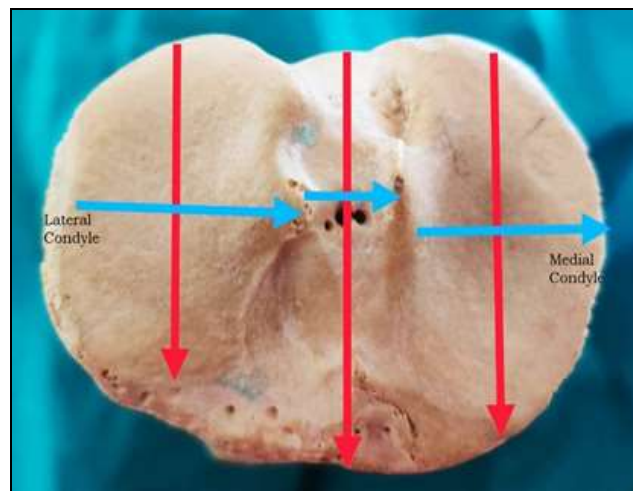


Figure 1. AP Diameters of Medial Condyle, Intercondylar Area & Lateral Condyle Denoted by Red Arrows; Transverse Diameters of the Same Denoted by Blue Arrows

RESULTS

Observations on the Right Side

Medial Condyle

The anteroposterior diameter ranged between 28.9 mm to 46.07 mm and its mean was found to be 39.25 mm whereas the transverse diameter ranged between 20.56 mm to 36.33 mm and its mean was found to be 27.99 mm.

Lateral Condyle

Here the measurements of anteroposterior diameter revealed the minimum of 29.37 mm and maximum of 40.04 mm and the mean was 35.43 mm.

While the measurements of transverse diameter revealed the minimum of 23.57 mm and maximum of 32.20 mm and the mean was 27.00 mm.

Intercondylar Area

The anteroposterior diameter depicted a range of 29.73 mm to 47.45 mm and the mean was found to be 40.18 mm similarly, the transverse diameter depicted a range of 7.42 mm to 13.84 mm and the mean was found to be 10.89 mm.

S. No.	Diameter	Right Side		Range		Left Side		Range	
		Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum
1	AP	39.25	3.92	28.90	46.07	38.15	3.00	29.76	43.86
2	Transverse	28.00	3.27	20.56	36.33	28.46	2.89	21.73	36.31

Table 1. Mean, SD & Range of Medial Condyle in mm

S. No.	Diameter	Right Side		Range		Left Side		Range	
		Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum
1	AP	35.43	2.70	29.37	40.04	34.71	2.76	28.35	39.23
2	Transverse	27.00	2.09	23.57	32.20	27.76	2.15	21.89	32.75

Table 2. Mean, SD & Range of Lateral Condyle in mm

S. No.	Diameter	Right Side		Range		Left Side		Range	
		Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum
1	AP	40.18	3.53	29.73	47.45	39.69	3.40	31.12	46.75
2	Transverse	10.89	1.49	7.42	13.84	10.98	1.19	7.70	13.81

Table 3. Mean, SD & Range of Intercondylar Area in mm

Observations on the Left Side

Medial Condyle

The anteroposterior diameter ranged between 29.76 mm to 43.86 mm and its mean was found to be 38.14 mm whereas the transverse diameter ranged between 21.73 mm to 36.31 mm and its mean was found to be 28.46 mm.

Lateral Condyle

Here the measurements of anteroposterior diameter revealed the minimum of 28.35 mm and maximum of 39.23 mm and the mean was 34.70 mm. While the measurements of transverse diameter revealed the minimum of 21.89 mm and maximum of 32.75 mm and the mean was 27.76 mm.

Intercondylar Area

The anteroposterior diameter depicted a range of 31.12 mm to 46.75 mm and the mean was found to be 39.69 mm. Similarly, the transverse diameter depicted a range of 7.7 mm to 13.81 mm and the mean was found to be 10.98 mm.

Statistical Inferences

Anatomical Structure	Diameter	Side	Mean	SD	T Value	P Value
Medial condyle	AP	Right	39.25	3.92	1.42	0.79
		Left	38.15	3.01		
	Transverse	Right	28	3.27	0.68	0.25
		Left	28.46	2.89		

Table 4. Calculations for Medial Condyle

Anatomical Structure	Diameter	Side	Mean	SD	T Value	P Value
Lateral condyle	AP	Right	35.43	2.70	1.15	0.13
		Left	34.71	2.76		
	Transverse	Right	27	2.09	1.56	0.06
		Left	27.76	2.15		

Table 5. Calculations for Lateral Condyle

Anatomical Structure	Diameter	Side	Mean	SD	T Value	P Value
Inter condylar area	AP length	Right	40.18	3.53	0.63	0.27
		Left	39.69	3.40		
	Transverse	Right	10.89	1.50	0.29	0.38
		Left	10.98	1.19		

Table 6. Calculations for Intercondylar Area

The anteroposterior diameter was found to be greater than the transverse diameter for both the condyles and the intercondylar area, irrespective of side. Furthermore, the anteroposterior diameter of medial condyle was more than that of lateral condyle on both sides but the transverse diameter of medial condyle was more than that of lateral only on right side. In intercondylar area, the anteroposterior diameter was found to be more on right side while transverse diameter was more on left side.

Referring to tables - 4, 5 & 6, it is found that difference in AP & transverse diameter of medial condyle, lateral condyle, and intercondylar area, on right and left side is not statistically significant.

DISCUSSION

Although many studies have been conducted on the upper end of tibia, still there are lacunae regarding the same. So, the present study attempts to establish the morphometric parameters of the upper end of tibia in central Indian population. The data obtained in our study will definitely aid in designing tibial prosthesis for knee replacement surgeries.

Previously only Servien et al. (2008)⁴ had measured AP diameter of medial and lateral condyle in 37 cases of French population irrespective of sex and side of tibia. It was found to be 50.8 +/- 3.3 mm in medial condyle and 47.2 +/- 3.3 mm in lateral condyle. However, in our study conducted on 80 cases, we found average AP diameter of medial condyle to be 38.60 mm and that of lateral condyle to be 35.00 mm irrespective of sex and side of the bones. Dimensions of the medial condyle are more than that of lateral condyle but measurements in central Indian population are less than that of French population.

Khurshid et al. (2019),⁵ in their study on 30 dry adult human tibia, observed AP diameter of superior articular surface of medial condyle to be 39.1 +/- 3.9 mm and transverse diameter to be 26.1 +/- 2.7 mm. While AP diameter of lateral condyle was found to be 35.1 +/- 3.2 mm and transverse diameter to be 25.4 +/- 3.1 mm. The AP

diameter of intercondylar area was found to be 40.9 +/- 4.4 mm. However, in our study conducted on 80 cases, we have found average AP diameter of medial condyle to be 38.60 mm and transverse diameter to be 28.27 mm. The calculated average AP diameter of lateral condyle was 35.00 mm and transverse diameter was 27.44 mm while AP diameter of intercondylar area was 39.89 mm irrespective of side of the bones.

Chaitra D et al. (2020),⁶ conducted their study on 75 adult dry bones of which 32 were right sided and 43 were of left side. They found the average AP diameter of medial condyle on right side to be 39.51 +/- 3.23 mm and on left side to be 38.95 +/- 4.56 mm. The measurements of average AP diameter of lateral condyle on right side were 33.57 +/- 3.06 mm and that of the left side were 32.86 +/- 3.004 mm. Transverse diameter of medial condyle on right was found to be 26.35 +/- 2.81 mm and on left side was 27.24 +/- 2.75 mm; and that of lateral condyle on right side was 24.71 + 2.49 mm and on left side was 25.39 + 3.26 mm.

In our study, we found the average AP diameter of medial condyle on right side to be 39.25 +/- 3.92 mm and on left side to be 38.15 +/- 3.01 mm; AP diameter of lateral condyle of right side was 35.43 +/- 2.70 mm and of left side was 34.71 +/- 2.76 mm. The average transverse diameter of right sided medial condyle was 28 +/- 3.26 mm and that of left side was 28.46 +/- 2.89 mm; transverse diameter of lateral condyle on right side was found to be 27.00 +/- 2.09 mm and on left side, was found to be 27.76 +/- 2.15 mm.

The measurements of all the parameters are greater than that of study by Chaitra D et al. (2020) except the AP diameter of medial condyle which is comparable to their study. Srivastava et al. (2015)⁷ found the mean transverse, AP diameter of medial and lateral condyle on right side as 29.7, 38.6 mm and 29.2, 36.4 mm. They found the mean transverse, AP diameter of medial and lateral condyle on the left side as 27.5, 39.9 mm and 29.7, 36.9 mm. These findings are comparable with the findings in our study.

Gupta C et al. (2015)⁸ in their study on 50 dried tibiae in south Indian population found the same parameters to be 27, 45.5 mm and 26.6, 40.8 mm on the right side and 27.6, 43.6 mm and 29.2, 40.6 mm on the left side. On comparing our findings with their study, the transverse diameter is found to be comparable while the average AP diameter is less than that found in their study. Total knee arthroplasty and UKA are both meticulous surgeries which necessitate the precision in the sizing of prosthesis to ensure an effective result as well as long term survival of the same. Suitable prosthetic design is crucial to restore the normal function in patients post-operatively.

Ahmad N et al. (2019)⁹ in their study on 60 adult human dry and processed tibia of both sides which are grossly normal and complete, estimated the morphometric measurements of the medial condyle, lateral condyle, and intercondylar area of tibia. The total mean AP length of the medial condyle on right and left side was 40.18 mm and 40.21 mm respectively; that of the lateral condyle was 35.94 mm on right and 37.02 mm on left side which shows an obvious difference between the two tibial plateaus. We have calculated similar results on right side but left sided

measurements are slightly lower than their findings. They found the mean transverse diameter of the medial condyle of right and left side as 28.46 mm and 28.27 mm respectively; that of lateral condyle was found to be 27.89 mm and 27.92 mm respectively. These values are almost similar to the values obtained in our study.

The importance of anteroposterior diameter of the prosthesis is to maintain the flexion-extension spacing, and that of the transverse diameter is to adequately cover the resected bone surface, and confirm tension-free wound closure. To reduce the stress applied to the bone implant interface, it is required to get the maximal implant coverage on the resected bone surface. It is one of the factors contributing to long-term survival of prosthesis in total knee replacement (TKR). An insufficient tibial coverage can lead to collapse of the tibial implant because the load will be transferred to the cancellous bone instead of the cortical bone.⁹

Mukhia R et al. (2020)¹⁰ in their study on upper end of sixty dry tibia bones in Nepalese population, found the average anteroposterior measurements to be 46.38 mm and 39.14 mm and average transverse measurements were 28.79 mm and 27.86 mm respectively for medial and lateral condyles of both sides. The anteroposterior and transverse measurements of intercondylar area of tibia were 47.75 mm and 7.11 mm on the right side and 49.81 mm and 7.25 mm respectively on the left side ($P < 0.05$). In our study AP measurements are comparatively lesser than that found in their population; but transverse diameters are found to be almost similar for both the condyles. On comparing the measurements of intercondylar area, AP diameters were found to be lesser while transverse diameter was greater in our study.

Yan JH et al. (2010)¹¹ in their study in Chinese population had measured anteroposterior measurements of medial and lateral condyle of tibia and found it to be 48.0 ± 3.1 mm and 39.8 ± 2.9 mm respectively. The results in our study revealed comparatively smaller dimensions of the condyles in Indian population; but dimensions of medial condyle are found to be more than that of lateral condyle which coincided with the findings in their study. The anatomy of articular surfaces of bones forming knee joint is highly variable irrespective of gender and race. These facts should be kept in mind during designing of knee prosthesis.

Zalawadia AZ et al. (2018),¹² have stated that obesity is one of the important causes of high incidence of osteoarthritis. Total knee replacement is considered beneficial for reducing pain and improving the lifestyle of patients with severe osteoarthritis. So accurate morphometric data of the upper end of tibia is important in making the design of total knee joint replacement prosthesis. Mismatch of selected prosthesis may lead to severe complications like cruciate ligament rupture, less movements of knee joint after surgery and even loosening of prosthesis. So, knee prosthesis made according to morphometric data of femur and tibia will give excellent results in early mobility of patients as well as lesser complications after surgery.

Vasanthi A et al. (2017)¹³ in their research on 100 dry human tibia bones in north coastal Andhra Pradesh

population, found the average AP diameter of medial condyle on right side to be 45.48 mm and on left side to be 49.66 mm; AP diameter of lateral condyle of right side was 40.05 mm and of left side was 41.54 mm. In our study, we have found the AP diameter of medial and lateral condyle on both sides to be lesser than that found in their study. Furthermore, they found the transverse diameter of right medial condyle to be 24.277 mm whereas on left medial condyle to be 22.509 mm and it was statistically significant. The transverse diameter of right lateral condyle to be 23.26 mm whereas on left lateral condyle to be 22.38 mm. On comparison of data of both condylar measurements, right medial condyle measurements were significantly higher. The results in our study revealed comparatively larger dimensions of transverse diameter of medial and lateral condyles in central Indian population.

Pooja B et al. (2018)¹⁴ in their morphometric study of proximal end of tibia with its clinical implications in north Indian population conducted on 224 dry tibias found that the mean AP and transverse diameters of medial tibial condyle were more than the AP and transverse diameter of lateral tibial condyle. The measurements of medial condyle on both sides were significantly greater than that of lateral condyle. The measurements of both the condyles on both sides were significantly greater in males ($P < 0.05$). These findings are similar to our findings except that we have not considered gender in our study.

Rodriguez-Merchan EC (2011)¹⁵ has stated that, information on the morphometry of the proximal articular surface of the tibia is helpful to the orthopaedic surgeon as the current challenges in knee prosthetic design are centered on attempting to produce normal kinematics, decrease wear and tear and achieving greater longevity. In order to achieve correction of varus and valgus deformities of the knee during knee arthroplasty, well designed prosthesis is essential.

CONCLUSIONS

The present study depicts the morphometry of upper end of tibia in central Indian population. Thus, it provides population specific information in designing appropriate unicompartmental and total knee prosthesis. It will be of help to orthopaedic surgeons, in performing surgeries required for osteoarthritis. The success of this procedure depends on selection of accurate prosthesis with its proper placement. Hopefully, the morphometric analysis of the proximal articular surface of tibia performed in the current research work should prove to be beneficial in achieving success in our aim of improving condition of patients of osteoarthritis especially in central India.

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.

Financial or other competing interests: None.

Disclosure forms provided by the authors are available with the full text of this article at jebmh.com.

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