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Anatomical morphometry of superior articular surface of proximal end of dried human tibiae in Rajasthan population

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Abstract---Background: The geometric mismatch between patient anatomy and implant components responsible for failure of knee replacement surgeries. Aim of the study: To study anatomical morphometry of superior articular surface of proximal end of dried human tibiae in Rajasthan population. Materials and methods: The present study was conducted in the Department of Anatomy, S.M.S. Medical College, Jaipur. The study period was from approval of plan till 15th December 2019. The study is a descriptive type of observational study. 120 dry tibiae (60 right sided and 60 left sided) were required as sample size. Results: The difference in the mean AP diameter of medial condyle between right and left side was found to be statistically non-significant. The difference in the mean transverse diameter of the medial condyle values between right and left side was found to be statistically non-significant. The difference in the mean AP diameter of the lateral condyle between right and left side was found to be statistically non-significant. The difference in the mean transverse diameter of the lateral condyle between right and left side was found to be statistically non-significant. The difference in the mean AP diameter of the total tibial condyle between right and left

side was found to be statistically non-significant. The difference in the mean transverse diameter of the total tibial condyle between right and left side was found to be statistically non-significant. Conclusion: So the morphometric indices of present study would be of immense help to manufacture the tibial component of knee prostheses in Rajasthan population for both UKA and TKA.

Keywords---TKA, UKA, condylar area, tibia.

Introduction

The tibia forms the skeleton of medial part of leg. TIBIA is a Latin word which means shin bone or reed pipe.¹ So it also called shin bone. It is preaxial bone in lower limb. It is the second largest bone in the body.² Tibia has a triangular shaft and two expanded ends. The Proximal end of tibia plays an important role in transmission of body weight from the femur above to the talus below. Proximal end of tibia consists medial condyle, lateral condyle and in between there is the irregular intercondylar area. Superior articular surface of Medial and lateral Condyle articulates with the corresponding medial and lateral condyles of femur. Upper end of tibia, lower end of femur and posterior articular surface of patella combinedly form the knee joint. Information regarding morphometry of proximal end of tibia is vital as it provides reliable method of assessing knee deformity. Knee joint is the largest joint in the body. Structurally it is a complex and compound synovial joint. Functionally, the knee joint is condylar and modified hinge variety of synovial joint³. There are two condylar joints between tibia and femur and a saddle joint between patella and femur⁴. The joint takes part in important function of controlling the center of body mass and posture, necessitating a large range of movement in three dimensions coupled with the ability to withstand high forces.

Osteoarthritis is the most common pathological disorder of the knee joint and other forms of arthritis like inflammatory and post traumatic arthritis are also painful conditions for knee joint. Knee replacement surgeries- Unicompartmental knee arthroplasty (UKA) and Total knee arthroplasty (TKA) are the most popular and cost effective treatment of present days which give a painfree stable knee to the patient⁵ and improve the quality of life of patient. Further improvement in quality of life of patient have been achieved by recent technological advancements in prosthetic design, instrumentation, surgical techniques and rehabilitation. Indians are the part of Asian-pacific population and they have a smaller build and stature in comparison of western population. The prosthesis for knee replacement surgeries which are presently being used are best suited for the western population therefore leading to implant size incompatibility with the resected bony surfaces⁶. This geometric mismatch between patient anatomy and implant components responsible for failure of knee replacement surgeries. So proper Implant sizing can help to avoid complications and maximize outcome.

Dimensions of each condyle and intercondylar area are the requisite for planning the knee replacement surgeries and for designing knee prosthesis as accurate sizing and proper placement of the component decide the success of these knee

replacement surgeries. Hence, the present study will give information of morphometric parameters of superior articular surface of proximal end of dried human tibia in Rajasthan region. These morphometric data will be beneficial for orthopedist as a guide for the treatment and to monitor the outcome of surgeries and for biotechnologists to design the knee prostheses for local population and to Anatomist for teaching purpose in relevance of variations in Morphometry according to population.

Materials and Methods

The present study was conducted in the Department of Anatomy, S.M.S. Medical College, Jaipur. The study period was from approval of plan till 15th December 2019. The study is a descriptive type of observational study. 120 dry tibiae (60 right sided and 60 left sided) were required as sample size. The ethical clearance for the study was approved from the ethical committee of the hospital.

Eligibility criteria-

- Inclusion Criteria – Dried, intact bones of unknown age and sex.
- Exclusion Criteria – Damaged bone, incomplete bone, bone with gross pathological changes, and bone with damaged superior articular surface.

After applying inclusion and exclusion criteria 120 dried human tibiae (right sided=60) (left sided=60) of unknown age and sex were selected for present study from the Department of Anatomy, S.M.S. Medical College, Jaipur, Rajasthan. Medial condyle and lateral condyle of proximal end of each bone were identified. The anteroposterior and transverse diameter of medial condyle, lateral condyle and total tibial condyle were measured with the help of digital Vernier Calipers. The measurements were taken on 3 occasions and the average of the 3 values were taken as the representative measurement. The intra observer variation was minimized by taking the measurement at 3 times. The data were tabulated and analyzed statistically.

Statistical analysis was performed with the SPSS, version 21 for Windows statistical software package (SPSS inc., Chicago, IL, USA). The Categorical data was presented as numbers (percent) and were compared among groups using Chi square test. The quantitative data was presented as mean and standard deviation and were compared by students t-test. Probability was considered to be significant if less than 0.05.

Fig 1:- showing AP (anteroposterior) diameter (AB) and Transverse diameter (CD) of total tibial condyle of left tibia

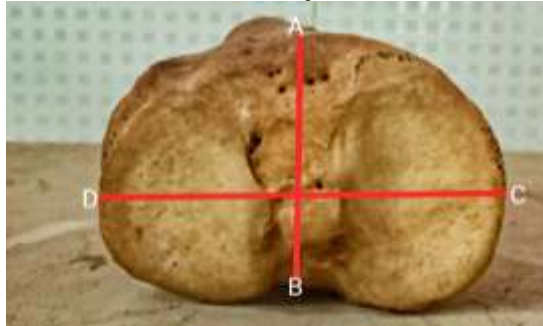


Fig 2: Showing measurement of APM (Anteroposterior diameter of medial condyle)



Fig 3: Showing measurement of TM (Transverse diameter of medial condyle)



Fig 4: Showing measurement of APL (Anteroposterior diameter of lateral condyle)



Fig 5: Showing measurement of TL (Transverse diameter of lateral condyle)



Results

Table 1 shows the comparison of AP diameter of medial condyle between right and left tibia. The mean AP diameter of the medial condyle was 42.33 ± 3.92 mm on the right side and 41.84 ± 4.19 mm on the left side and the total mean AP diameter of medial condyle was 42.08 ± 4.05 mm. The difference in the mean AP diameter values between right and left side was found to be statistically non-significant ($p=0.512$) [Graph 1]. Table 2 shows the comparison of transverse diameter of medial condyle between right and left tibia. The mean transverse diameter of the medial condyle was 28.59 ± 3.27 mm on the right side and 28.97 ± 3.73 mm on the left side and the total mean transverse diameter of medial condyle was 28.78 ± 3.50 mm. The difference in the mean transverse diameter values between right and left side was found to be statistically non-significant ($p=0.556$) [Graph

2]. Table 3 shows the comparison of AP diameter of lateral condyle between right and left tibia. The mean AP diameter of the lateral condyle was 37.81 ± 3.82 mm on the right side and 37.55 ± 4.50 mm on the left side and the total mean AP diameter of lateral condyle was 37.68 ± 4.15 mm. The difference in the mean AP diameter values between right and left side was found to be statistically non-significant ($p=0.735$) [Graph 3]. Table 4 shows the comparison of transverse diameter of lateral condyle between right and left tibia. The mean Transverse diameter of the lateral condyle was 29.37 ± 4.16 mm on the right side and 28.45 ± 4.35 mm on the left side and the total mean transverse diameter of lateral condyle was 28.91 ± 4.26 mm. The difference in the mean transverse diameter values between right and left side was found to be statistically non-significant ($p=0.239$) [Graph 4]. Table 5 shows comparison of AP diameter of total tibial condyle between right and left tibia. The mean AP diameter of the total tibial condyle was 45.28 ± 2.93 mm on the right side and 44.68 ± 4.29 mm on the left side and the total mean AP diameter of total tibial condyle was 44.98 ± 3.67 mm. The difference in the mean AP diameter values between right and left side was found to be statistically non-significant ($p=0.372$) [Graph 5]. Table 6 shows the comparison of transverse diameter of total tibial condyle between right and left tibia. The mean transverse diameter of the total tibial condyle was 67.92 ± 4.13 mm on the right side and 66.77 ± 5.40 mm on the left side and the total mean transverse diameter of total tibial condyle was 67.35 ± 4.82 mm. The difference in the mean transverse diameter values between right and left side was found to be statistically non-significant ($p=0.191$) [Graph 6].

Table-1: Comparison of AP diameter of medial condyle (mm) between Right and Left Tibia

	Right Side		Left Side		Total (n=120)	
	Mean	SD	Mean	SD	Mean	SD
AP Diameter (mm)	42.33	3.92	41.84	4.19	42.08	4.05
Median	42		41		42	
P value	0.512 (NS)					

Graph 1: Showing comparison of AP diameter of medial condyle between Right and Left tibia

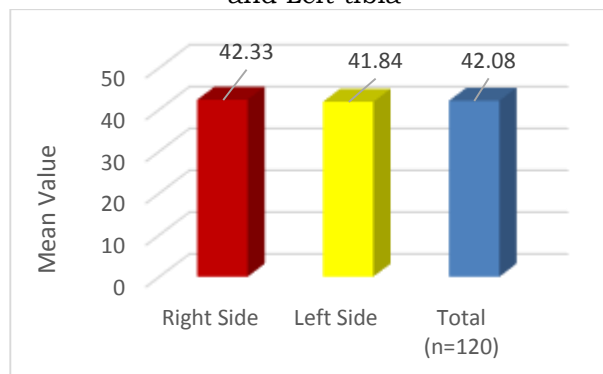


Table-2: Comparison of Transverse diameter of Medial Condyle (mm) between Right and Left Tibia

	Right Side		Left Side		Total (n=120)	
	Mean	SD	Mean	SD	Mean	SD
Transverse Diameter (mm)	28.59	3.27	28.97	3.73	28.78	3.50
Median	28		28		28	
P value	0.556 (NS)					

Graph 2: Showing Comparison of Transverse diameter of Medial Condyle between Right and Left Tibia

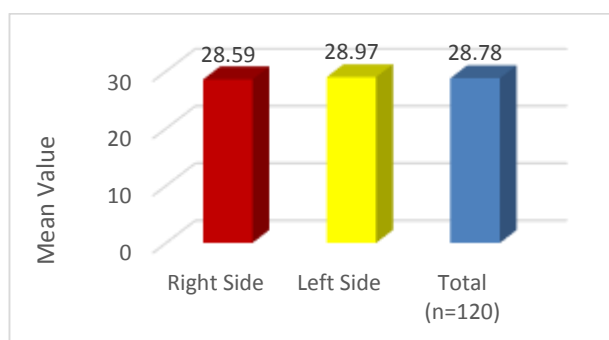


Table-3: Comparison of AP diameter of lateral condyle between Right and Left Tibia

	Right Side		Left Side		Total (n=120)	
	Mean	SD	Mean	SD	Mean	SD
AP Diameter (mm)	37.81	3.82	37.55	4.50	37.68	4.15
Median	38		37		37	
P value	0.735 (NS)					

Graph 3: Showing Comparison of AP diameter of Lateral Condyle between Right and Left Tibia

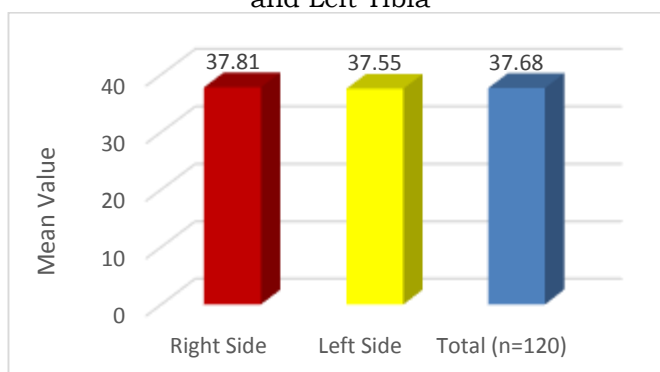


Table-4: Comparison of Transverse diameter of lateral condyle between Right and Left Tibia

	Right Side		Left Side		Total (n=120)	
	Mean	SD	Mean	SD	Mean	SD
Transverse Diameter (mm)	29.37	4.16	28.45	4.35	28.91	4.26
Median	29		29		29	
P value	0.239 (NS)					

Graph 4: Showing Comparison of Transverse diameter of lateral condyle between Right and Left Tibia

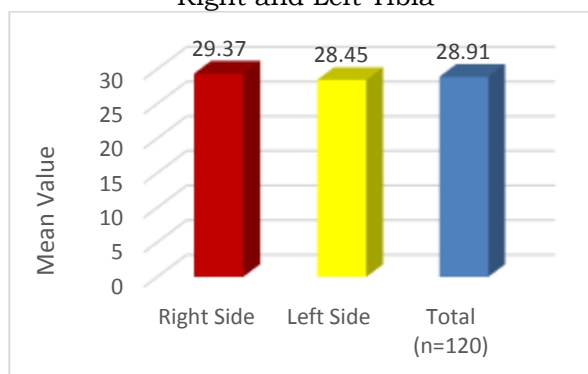


Table-5: Comparison of AP diameter of total tibial condyle between Right and Left Tibia

	Right Side		Left Side		Total (n=120)	
	Mean	SD	Mean	SD	Mean	SD
AP Diameter (mm)	45.28	2.93	44.68	4.29	44.98	3.67
Median	46		45		45	
P value	0.372 (NS)					

Graph 5: Showing Comparison of AP diameter of total tibial condyle between Right and Left Tibia

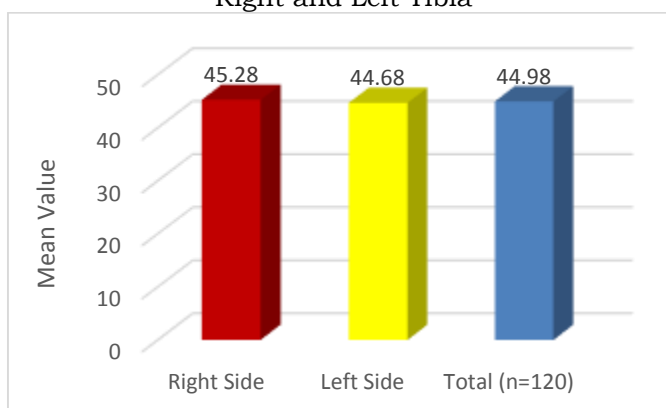
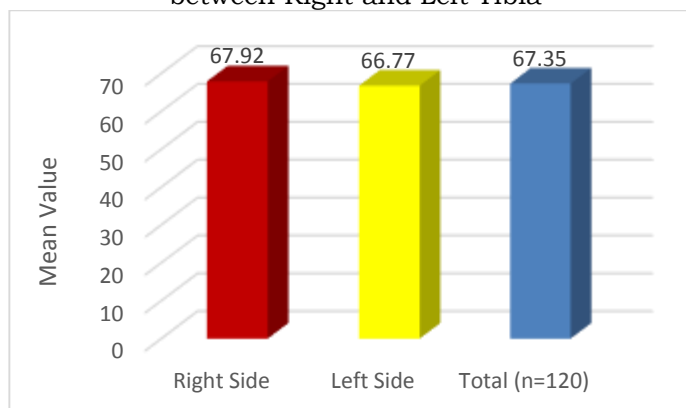


Table-6: comparison of Transverse diameter of total tibial condyle between Right and Left Tibia

	Right Side		Left Side		Total (n=120)	
	Mean	SD	Mean	SD	Mean	SD
Transverse Diameter (mm)	67.92	4.13	66.77	5.40	67.35	4.82
Median	68		66		68	
P value	0.191 (NS)					

Graph 6: Showing Comparison of Transverse diameter of Total Tibial Condyle between Right and Left Tibia



Discussion

Superior articular surface of proximal end of tibia plays an important role in the function of the knee. There is a significant variability is found in the Anthropometry of different populations across the world as well as across the nation. As the Indians having smaller anatomical profiles and most of the commercially available prostheses are designed for the western population. So Indian patients are at the risk of getting a prosthesis which is oversized in procedures like UKA and TKA.¹³ Implantation of oversized prosthesis can lead to incompatibility with the resected bones. The present study establishes the data for the various parameters of the proximal end of tibiae in Rajasthan population.

AP diameter and Transverse diameter

In the present study the mean AP diameter of the medial condyle on right side was 42.33 ± 3.92 mm and on left side was 41.84 ± 4.19 mm, and total mean AP diameter of medial condyle obtained 42.08 ± 4.05 mm (Refer Table-1 and Graph - 1). The mean Transverse diameter of the medial condyle was 28.7 ± 3.27 mm and 28.59 ± 3.73 mm on right and left side respectively. Total mean Transverse diameter obtained 28.78 ± 3.50 mm in present study (Refer Table-2 and Graph-2). In both of these parameters no statistically significant difference found between right and left side because p value was $>.05$ for both parameters. Servien et al⁵ also studied on medial and lateral tibial plateau in French population and analyzed the compatibility of tibial component design. He showed the AP diameter

of medial condyle to be 50.8 ± 3.3 mm. Bae DK and Park JY⁷ reported the AP diameter of medial condyle 48.03 ± 3.1 mm in Korean population. In NCAP population AP diameter was found 45.48 ± 0.52 mm for right side and 49.66 ± 1.39 mm for left side by Vasanthi A et al⁸ and transverse diameter of medial condyle was found 24.27 ± 1.01 mm and 22.50 ± 1.04 mm on right and left side respectively. In North Indian population Srivastava et al⁹ reported the AP diameter to be 38.63 mm and 39.94 mm on right and left side respectively, And the transverse diameter was found 29.73 mm on right side and 27.5 mm on left side by them. Murlimanju BV et al reported the AP diameter of medial condyle 40.6 ± 3.9 mm on right side and 39.2 ± 3.6 mm on left side and the Transverse diameter was 26.9 ± 2.9 mm on right side and 26.6 ± 2.7 mm on left side in South Indian population¹⁰. Thus the dimensions of medial condyle in present study are closely similar to North Indian population but shows considerable difference from the results of French, Korean and NCAP population. Mean AP diameter of medial condyle in South Indian population was also found closer to present study.

Lateral condyle

In the present study the mean AP diameter of the lateral condyle on right side was 37.81 ± 3.82 mm and on left side was 37.55 ± 4.50 mm, and total mean AP diameter of lateral condyle obtained 37.68 ± 4.15 mm (Refer Table-3 and Graph-3). The mean Transverse diameter of the lateral condyle was 29.37 ± 4.16 mm and 28.45 ± 4.35 mm on right and left side respectively. Total mean Transverse diameter obtained 28.91 ± 4.26 mm in present study (Refer Table-4 and Graph-4). In both of these parameters no statistically significant difference found between right and left side because p value was $>.05$ for both parameters. Servient et al studied on medial and lateral tibial plateau in French population and analyzed the compatibility of tibial component design. He showed the AP diameter of lateral condyle to be 47.2 ± 3.3 mm⁵. Bae DK and Park JY reported the AP diameter of lateral condyle 39.8 ± 2.9 mm in Korean population⁷. In NCAP population AP diameter was found 40.05 ± 0.42 mm for right side and 41.54 ± 0.42 mm for left side by Vasanthi A et al⁸, and transverse diameter of lateral condyle was found 23.26 ± 1.02 mm and 22.38 ± 1.04 mm on right and left side respectively. In North Indian population Srivastava et al⁹ reported the AP diameter to be 36.47 mm and 36.94 mm on right and left side respectively, and the transverse diameter was found 29.21 mm on right side and 29.77 mm on left side by them. Murlimanju BV et al¹⁰ reported the AP diameter of lateral condyle 34.8 ± 3.7 mm on right side and 32.6 ± 3.4 mm on left side and the Transverse diameter was 26.5 ± 3.4 mm on right side and 25.7 ± 2.5 mm on left side in south Indian population. Thus the dimensions of lateral condyle of present study found closer to the North Indian populations but shows considerable difference from the results of French, Korean, South Indian and NCAP populations.

Comparison between AP diameter of medial condyle and lateral condyle

When dimensions of medial and lateral condyles were compared, it was analyzed that medial condyle had longer AP diameter than the lateral condyle, as in the present study the total mean AP diameter of medial condyle was 42.08 mm and of lateral condyle was 37.68 mm. which shows an obvious difference between medial and lateral condylar surfaces. This asymmetry was observed by Westrich

et al¹¹ and he emphasized the need for a knee arthroplasty procedure which takes into account the difference between the lateral and medial tibial condyles to ensure complete tibial coverage. Fitzpatrick et al¹² observed that the lateral tibial plateau would need a different tibial implant, round in shape and with a smaller AP diameter/transverse diameter ratio. So This information should be taken into account for prosthesis designing in Rajasthan population to achieve maximum tibial coverage and to reduce the chances of complications regarding symmetrical implants.

Total Tibial Condyle

AP diameter: This parameter is important for flexion – extension spacing¹³. In present study the mean AP diameter on right side was 45.28 ± 2.93 mm and on left side was 44.68 ± 4.29 mm. and total mean AP diameter of total tibial condyle was 44.98 ± 3.67 mm.(Refer Table-5 and Graph-5) p value found $>.05$ in present study for this diameter which is statistically not significant. This negates the need for measurements specific to individual sides. Mensch et al reported the mean AP diameter 48.9 ± 2.3 mm in American population in 1975¹⁴. Kwak DS et al observed this AP diameter 47.3 ± 3.8 mm in Korean population¹⁵. In 2009 Cheng FB et al studied the Chinese population and observed that mean AP diameter was 51.3 ± 2.0 mm in male and 45.7 ± 1.9 mm in female population¹⁶. Chaichankul C et al reported this AP diameter 46.04 ± 4.4 mm in Thai population¹⁷. Lakati KC et al found this diameter 49.38 mm in Kenyan population¹⁸. Thus the mean AP diameter of complete superior articular surface of proximal end of tibia (ATC) of present study found closely similar to Chinese female population but smaller than Other populations such as American, Korean, Chinese male, Thai and Kenyan populations.

Transverse diameter: This parameter is important to determine adequate coverage of the resected bone surface and to ensure tension free wound closure. This diameter is also called bicondylar width. In present study the mean Transverse diameter on right side was 67.92 ± 4.13 mm and on left side was 66.77 ± 5.40 mm. and total mean transverse diameter of total tibial condyle was 67.35 ± 4.82 mm.(Refer Table-6 and Graph-6) p value found $>.05$ in present study for this diameter which is statistically not significant. This negates the need for measurements specific to individual sides. Mensch et al reported the mean Transverse diameter 80.3 ± 3.7 mm in American population in 1975¹⁴. Kwak DS et al observed this Transverse diameter 73.5 ± 5.6 mm in Korean population¹⁵. In 2009 Cheng FB et al studied the Chinese population and observed that mean Transverse diameter was 76.4 ± 2.8 mm in male and 68.8 ± 4.6 mm in female population¹⁶. Chaichankul C et al reported this Transverse diameter 68.8 ± 5.8 mm in Thai population¹⁷. Lakati KC et al found this diameter 69.38 mm in Kenyan population¹⁸. In present study the mean Transverse diameter of superior articular surface of proximal end of tibia found closely similar to Chinese female and Thai population and comparatively smaller than the American, Korean, Chinese male and Kenyan population.

Conclusion

On comparison of present study with studies in different populations, it was concluded that anatomical profile of Indians is smaller so this study also

emphasizing the need of population specific prosthesis. To obtain the best possible stability and load transfer after knee replacement surgery, it is essential for the geometry of the tibial component to match the resected surface as closely as possible. So the morphometric indices of present study would be of immense help to manufacture the tibial component of knee prostheses in Rajasthan population for both UKA and TKA. These population specific prostheses would ensure optimal tibial implant coverage, which has been found to be a key factor in long term survivorship of the prosthesis.

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