

## A Morphometric Study of the Proximal End of Tibia in North East Karnataka Population with Its Clinical Implication

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### Abstract

**Introduction:** The present study aims to assess different morphometric parameters of condylar and intercondylar surface of tibia and to compile the results, analyze and formulate a baseline data for future studies with relevance to North-East Karnataka population. Total knee arthroplasty (TKA) and unicompartmental knee arthroplasty (UKA) are frequently done procedures for the treatment of various forms of arthritis and knee injuries. The knee prosthesis, which is used for these procedures, requires adequate sizing specific to the population. Hence the aim of the present study is to measure various parameters of the proximal end of the tibia in North east Karnataka population in Bidar district. **Materials and Method:** Sixty (32 Right and 28 Left) adult fully ossified tibia bone were taken and various parameters of the proximal end of tibia were measured using a vernier caliper. Statistical analysis of the parameter was done. Comparison between various parameters of right and left side was done using paired 't' test. **Result:** In our study the mean transverse, the anteroposterior diameter of total, medial and lateral condyles of tibia are 6.29, 4.16, 2.66, 4.08, 2.80, 3.35 cm. The area of medial, lateral and total tibial condyle is 10.86, 9.50 and 26.30 cm. The mean length between the upper end of tibia and tibia tuberosity and the mean circumference of the upper end of tibia is 2.16 and 19.11cm. Groove for ligamentum patellae is found in 100% of cases. **Conclusion:** The result of these study will be helpful for anatomist, anthropologist, to Orthopedition in cases of UKA, TKA procedures and meniscal transplantation. This study is also helpful to prepare prosthesis of accurate size related to Bidar district population.

**Keywords:** Tibia; Medial Condyle; Lateral Condyle; Arthroplasty; Area.

### Introduction

The lower limb is primarily adapted for weight bearing and locomotion. In man weight bearing is related mainly to extended knee position. The knee joint is a compound synovial joint which brings out the significant function of adjusting the centre of body mass and posture, requiring a great range of movement in three dimensions together with the capability to bear high forces [1].

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Tibia is the medial bone of the leg. It has a shaft with two expanded ends. The proximal end of tibia, expanded especially transversely, is a bearing surface of body weight transmitted through the femur; it has massive medial and lateral condyle, an intercondylar area and tibial tuberosity. The condyle overhang the shaft's proximal posterior surface and both have proximal articular surfaces separated by an irregular intercondylar area. The proximal tibial surface slopes posteriorly and downwards relative to the shaft's long axis; the tilt is more marked in habitual squatters. The relationship between the different weight bearing situations and the anteroposterior and medio-lateral dimensions of diaphysis and epiphysis of the tibia is well established [2]. Information regarding morphometry of upper end of tibia is vital as it provides reliable method of assessing knee deformity. Morphometric parameters of upper end of tibia can be used to guide treatment and monitor outcome of total knee

replacement surgeries [3].

The proximal end of tibia is a crucial component of the knee joint through the tibio-femoral articulation and plays a vital role in the conduction of body weight from the femur above to the talus below. The knee joint is affected by several forms of arthritis such as inflammatory and posttraumatic arthritis and Osteoarthritis is the most common pathological disorder and the treatment for that is usually total knee arthroplasty (TKA) or unicompartmental knee arthroplasty (UKA) [4].

Total knee arthroplasty is a precision surgery, requiring accurate soft tissue balancing and resection of bone thickness equal to the thickness of the prosthetic component implanted, so that the flexion-extension spacing are equal, allowing joint stability throughout the range of motion. The success of total knee arthroplasty depends to a large extent on prosthetic selection and accurate sizing and proper placement of the components [5]. Maximum implant coverage on the resected bone surface would decrease the stress applied to the bony implant interface, which has been found to be a reason contributing to the long term survivorship in TKA [6]. Unicompartmental knee arthroplasty is presently developing as a satisfactory possibility for the treatment of unicompartmental arthritis of the knee in elderly patients [7]. Indian and Chinese, as a part of the Asian subpopulation, have a smaller build and stature compared with the Western population. It has long been suspect that, considering the large variability of the anthropometry of different populations of the world, ethnic groups such as Indians, are likely to develop technical errors in both unicompartmental knee arthroplasty and total knee arthroplasty with most of the commercially available prosthesis because of the non availability of smaller sized components [8]. There are no published studies on the anthropometry of the proximal tibia in North-East Karnataka population which may differ from different part of India; hence the results obtained from this study would provide valuable data on the average dimensions of the tibia of North-East Karnataka population which will be helpful for total knee arthroplasty and unicompartmental knee arthroplasty of this region.

#### *Aims and Objectives of the Study*

1. To measure various parameters of the proximal end of tibia.
2. To provide data for sizing of tibial component in unicompartmental knee arthroplasty and total knee arthroplasty prosthesis in North - East Karnataka population with comparison of data

in different part of India.

## **Material and Method**

### *Study Centre*

Department of Anatomy, Bidar Institute Of Medical Sciences Bidar

### *Duration of the Study*

6-8 months

### *Study Design*

Cross sectional

### *Sample Size*

The pilot study will be done in the Department of Anatomy BRIMS Bidar by taking 30 tibia of right side and 30 tibia of left side.

### *Inclusion Criteria*

60 fully ossified and processed dry tibial bones of both sides irrespective of age sex and race.

### *Exclusion Criteria*

Unossified bones, bones with diseases and injuries.

### *Data Collection and Methods*

Method of collection of data is by measuring the following parameters of the proximal end of the tibia by using Vernier calliper-

1. Anteroposterior diameter of medial tibial condyle
2. Transverse diameter of medial tibial condyle
3. Anteroposterior diameter of lateral tibial condyle
4. Transverse diameter of lateral tibial condyle
5. Transverse diameter of total tibial condyle
6. Anteroposterior diameter of intercondylar region
7. Circumference of the upper end
8. Length between upper end and tibial tuberosity
9. Area total tibial condyle
10. Area medial tibial condyle
11. Area lateral tibial condyle
12. Presence or absence of groove for ligamentum patellae.

Area of the condyle is measured using following formula.

$$\text{Area of condyle} = \text{AP} \times \text{TD of condyle}$$

Statistical analysis for all the parameters was done. Paired sample "t" test was done to see the statistical significance between right and left side.

**Consent**

Consent from professor and HOD of Department of Anatomy is taken.

**Result**

The mean and range of all the parameters of the right, left and total tibia is shown in Table 1. Groove for ligamentum patelle on the tibial tuberosity is present in 100% of cases. There is no statistically significant relation between right and left AP diameter of medial condyle, AP diameter of lateral condyle,

transverse diameter of medial tibial condyle, transverse diameter of lateral condyle, transverse diameter of total tibial condyle, AP diameter of Intercondylar region, Circumference of upper end of tibia, Length between upper end of tibia and tibial tuberosity, and area of total tibial condyle, medial tibial condyle lateral tibial condyle as p value is >0.05 ( Table 2).

In our study the area covered by medial tibial condyle is 41.57% and by lateral condyle is 36.84% out of the total condylar area on right side. The area covered by medial tibial condyle is 40.76% and by lateral condyle is 35.38% out of the total condylar area on left side. AP diameter of medial tibial condyle in right and left tibia is  $4.10 \pm 0.375$  and  $4.06 \pm 0.398$  respectively where as Transverse diameter of medial tibial condyle in right and left tibia is  $2.69 \pm 0.271$ ,  $2.63 \pm 0.273$  respectively, AP of lateral tibial condyle in right and left tibia is  $3.43 \pm 0.355$  and  $3.27 \pm 0.439$  respectively whereas Transverse diameter of lateral tibial condyle is  $2.86 \pm 0.335$  and  $2.75 \pm 0.355$  respectively. AP diameter of intercondylar region in

**Table 1:** The Mean, Range and standard deviation of all the parameters of Right & left Tibia

Parameters	Mean +-SD				TOTAL	SD	Range		Total
	Right	SD	Left	SD			Right	Left	
AP Length of MTC	4.10	0.375	4.06	0.398	4.08	0.383	3.49-4.85	3.54-4.86	3.49-4.86
TD Length of MTC	2.69	0.271	2.63	0.273	2.66	0.271	2.21-3.22	2.25-3.13	2.21-3.22
AP Length of LTC	3.43	0.355	3.27	0.439	3.35	0.401	2.38-4.17	2.53-4.16	2.38-4.17
TD Length of LTC	2.86	0.335	2.75	0.355	2.80	0.346	2.22-3.44	2.22-3.34	2.22-3.44
TD Length of TTC	6.33	0.435	6.25	0.465	6.29	0.447	5.62-7.19	5.55-6.99	5.55-7.19
AP Length of TCR	4.19	0.374	4.14	0.365	4.16	0.368	3.33-4.89	3.54-4.68	3.33-4.89
Circumference of Upper end of Tibia	18.68	1.490	9.60	1.342	19.11	1.485	17.00-22.00	17.00-22.00	17.00-22.00
Length between Upper end & Tibial Tuborsity	2.68	0.376	2.65	0.513	2.66	0.441	2.12-3.65	2.12-3.75	2.12-3.75
Area of TTC	26.60	3.673	25.94	3.483	26.30	3.572	19.08-33.31	19.75-31.31	19.08-33.31
Area of MTC	11.06	1.861	10.63	1.675	10.86	1.775	8.46-15.06	7.96-14.25	7.96-15.06
Area of LTC	9.80	1.699	9.18	2.050	9.50	1.879	6.97-13.23	6.39-13.36	6.39-13.36

Note:- AP: Anteroposterior Diameter, TD:-Transverse Diameter, MTC:- Medial tibial condyle, LTC:- Lateral tibial condyle, TTC:- Total tibial condyle, ICR:- Inter condylar region

**Table 2:** Statistical Analysis

Parameters	T value	P value	Infezence
AP MTC-t	0.399	0.65	Non Significant
TD MTC	0.852	0.80	Not Significant
AP LTC	1.538	0.93	Not Significant
TD LTC	1.229	0.888	Not Significant
TD TTC	0.685	0.752	Not Significant
AP TCR	0.523	0.699	Not Significant
C Upper end	2.516	0.007	Not Significant
L between U end & TT	0.255	0.600	Not Significant
Area TTC	0.714	0.761	Not Significant
Area MTC	0.942	0.825	Not Significant
Area LTC	1.265	0.892	Not Significant

Note:- AP: Anteroposterior Diameter, TD:-Transverse Diameter, MTC:- Medial tibial condyle, LTC:- Lateral tibial condyle, TTC:- Total tibial condyle, ICR:- Inter condylar region

right and left tibia is  $4.19 \pm 0.374$  and  $4.14 \pm 0.365$  respectively whereas Transverse diameter of total tibial condyle is  $6.33 \pm 0.435$  &  $6.25 \pm 0.465$  respectively.

Circumference of upper end of tibia in right and left side is  $18.68 \pm 1.490$  and  $19.60 \pm 1.342$ . Length between upper end of tibia and tibial tuberosity is  $2.68 \pm 0.376$  and  $2.65 \pm 0.513$ . Above finding shows that all measurements of right side tibia is either equal or little bit more than left side except Circumference of upper end where left side value is more than right.

## Discussion

The geometry and anatomy of the knee is variable, irrespective of gender and human race and it should be considered carefully during designing process of the tibia prosthesis for the TKA.

Yan et al found the AP and transverse diameter on the proximal tibia section as  $4.9 \pm 0.39$  cm and  $7.3 \pm 0.56$  cm respectively. In our study we got almost similar values of AP diameter as  $4.16 \pm 0.368$  but transverse diameter is  $6.29 \pm 0.447$  cm which is low than Yan et al study [9].

Ivan et al [4] found the mean transverse length on the right, left, and total tibia as  $6.66 \pm 0.56$ ,  $6.62 \pm 0.51$  and  $6.64 \pm 0.53$  Cm. Our values of our study are almost similar to their study and our values are,  $6.33 \pm 0.435$ ,  $6.25 \pm 0.465$  and  $6.29 \pm 0.447$  [4]. Ivon found mean antero posterior length of medial condyle on the right, left, & total tibia as  $4.08 \pm 0.42$ ,  $4.13 \pm 0.42$ , and  $4.10 \pm 0.42$  cm and values are almost similar in our study as  $4.10 \pm 0.375$ ,  $4.06 \pm 0.398$  and  $4.08 \pm 0.383$ . The mean AP length of lateral condyle on right, left & total tibia in her study was  $3.54 \pm 0.39$ ,  $3.67 \pm 0.41$  and  $3.61 \pm 0.40$  Cm. In our study the values are almost similar i.e.  $3.43 \pm 0.355$ ,  $3.27 \pm 0.439$  and  $3.35 \pm 0.401$ .

The mean intercondylar AP length on right, left, & total tibia was  $4.25 \pm 0.42$ ,  $4.49 \pm 0.44$ , and  $4.20 \pm 0.43$  cm in her study & we got the values as  $4.19 \pm 0.374$ ,  $4.14 \pm 0.365$ ,  $4.16 \pm 0.368$  which is near about same as above study. She also found the mean circumference of the upper end of tibia on the right, left & total tibia as  $13.36 \pm 1.5$ ,  $19.33 \pm 1.44$  and  $19.35$  cm which is almost similar to our study i.e.  $18.68 \pm 1.490$ ,  $19.60 \pm 1.342$  &  $19.11 \pm 1.485$  cm respectively. The mean length from upper end of tibia to the tibial tuberosity in her study on the right, left and total tibia was  $4.47 \pm 0.61$ ,  $4.60 \pm 0.68$ , and  $4.54$  cm while in our study the values are  $2.68 \pm 0.376$ ,  $2.65 \pm 0.513$  and  $2.70 \pm 0.441$  cm which is far less than Ivon study. The groove for ligamentum patellae was present in 73.91 of total number of bones

in Ivon study while in our study we got that in 100%. Of bones. She found no statistical significance in any parameters of tibia on right and left side which coincides our study.

Chadani gupta et al [10] in 2015 found the mean transverse length on the right, left, and total tibia as  $6.77 \pm 0.31$ ,  $6.88 \pm 0.65$ , and  $6.83 \pm 0.51$  cm where as our values are little bit less than chadani gupta study i.e.,  $6.33 \pm 0.435$ ,  $6.25 \pm 0.465$  &  $6.29 \pm 0.447$  cm. She found the mean Ap length of medial condyle on the right, left, and total tibia as  $4.55 \pm 0.29$ ,  $4.36 \pm 0.47$  and  $4.45 \pm 0.40$  cm. Whereas our values are almost similar to study as  $4.10 \pm 0.375$ ,  $4.06 \pm 0.398$ , and  $4.08 \pm 0.383$ .

The mean Antero posterior length of lateral condyle on the right, left & total tibia in her study was,  $4.08 \pm 0.27$ ,  $4.06 \pm 0.40$  and  $4.07 \pm 0.34$  cm where as our values are somewhat less than her study i.e.  $3.43 \pm 0.355$ ,  $3.27 \pm 0.439$ , &  $3.35 \pm 0.401$  cm.. The mean intercondylar Ap length on the right left and total tibia in her study was  $4.66 \pm 0.32$ ,  $4.49 \pm 0.44$  and  $4.57 \pm 0.39$  cm. Whereas values of our study are almost similar. i.e.  $4.19 \pm 0.374$ ,  $4.14 \pm 0.365$  and  $4.16 \pm 0.368$  which is almost similar to her study.

She also found the mean circumference of upper end of tibia on right, left, & total tibia as  $18.95 \pm 0.68$ ,  $19.07 \pm 1.65$ , and  $19.02 \pm 1.27$  cm, where as our study shows similar values as  $18.68 \pm 1.490$ ,  $19.60 \pm 1.342$  and  $19.11 \pm 1.485$ . The mean length of upper end of tibia to tibia tuberosity in her study on right, left & total tibia was  $5.06 \pm 0.59$ ,  $5.24 \pm 0.71$ , and  $5.15 \pm 0.65$  cm while our study indicates less value i.e.  $2.68 \pm 0.376$ ,  $2.65 \pm 0.513$  and  $2.66 \pm 0.441$  cm. She found the groove for ligamentum patellae was present in 100% of bones which is similar to our study i.e. in 100% of bones.

Shivastava et al [11] found the mean transverse, Ap diameter of medial and lateral condyle on right side as 2.97, 3.86 cm and 2.92, 3.64 cm. They found the mean transverse, Ap diameter of medial and lateral condyle on left side as 2.75, 3.99 cm and 2.97, 3.69 cm. while in our study we got the values as 2.69, 4.10 cm and 2.86, 3.43 cm on the right side and 2.63, 4.06, and 2.75, 3.27 cm on the left side. They found total tibial condyle, medial condyle, lateral condyle area on right & left side as 29.88, 11.52, 10.75 and 29.51, 11.01, 10.52 cm<sup>2</sup>. These values are somewhat more than our values i.e. 26.60, 11.06, 9.80 and 25.94, 10.63, 9.18 cm<sup>2</sup>.

Srivastava et al found that area covered by medial condyle is 38.56%. and by lateral tibial condyle is 35.97% out of total condyle area on right side. The area covered by medial tibial condyle is 37.32% and by lateral tibial condyle is 35.65% out of total tibial condyle area on left side which was little higher to

our study as the values in our study are 41.58% and 36.84% for medial and lateral condyle in right side and 40.97%, 35.38% on left side.

Knee osteoarthritis is one of the most common causes of disability in adults. The damage results from a complex interplay of joint integrity, biochemical processes, genetic and mechanical forces. Total and unicompartmental joint replacement have become the gold standard for treatment of osteoarthritis and other degenerative disorders of knee [12].

Total knee arthroplasty and UKA are both meticulous surgeries which necessitate the precision in the prosthesis sizing to ensure an effective result as well as long term survival of the same. The current challenges in knee prosthetic design are centered on attempting to produce normal kinematics, reducing wear & tear and hence achieving greater longevity. Hence suitable prosthetic design is crucial to restore the normal function in patients postoperatively [13]. Inadequate tibial coverage can lead to tibial implant collapse because of the load being [14].

### Conclusion

Conventional prostheses available in the market are designed for Caucasians; Indians having smaller anatomical profiles would need smaller sized components of knee prosthesis. Hence the result of this study would be significant value in the manufacture of tibial component of knee prosthesis in the Indian population for both UKA as well as TKA. This study also confirms sizing of tibial component of south Indian population by comparing from other parts of country.

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