Section: Anatomy

Original Research Article

OSTEOMETRIC MORPHOMETRY OF THE PROXIMAL TIBIAL END IN THE INDIAN POPULATION FROM A FORENSIC PERSPECTIVE, HIGHLIGHTING ITS CLINICAL SIGNIFICANCE

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Abstract

Background: The assessment of the distal femoral fragment's physical dimensions is essential in designing prostheses for knee operations and provides important information for estimating a person's height in forensic investigations. The aim is osteometric morphometry of the proximal tibial end in the Indian population from a forensic perspective, highlighting its clinical significance. **Materials and Methods:** This investigation was conducted on 35 adult tibias obtained from the Anatomy department of a medical institution. The tibias were dry and preserved. A total of 35 completely calcified and treated desiccated bones were used for examination. Tibia bones that were not fully ossified, damaged, or showed anomalies were eliminated from the research. The proximal end of the tibia is examined using the following parameters: Anteroposterior diameter of medial condyle, Transverse diameter of medial condyle, Anteroposterior diameter of lateral condyle, Transverse diameter of lateral condyle, Anterior transverse diameter of intercondylar area, Posterior transverse diameter of intercondylar area, Anteroposterior diameter of intercondylar area, Anterior diameter of intercondylar area, Posterior diameter of intercondylar area and Transverse diameter. **Result:** In the present study, the mean APM 41.57±3.52 and 37.98±2.52, TM31.02±4.25 and29.52±3.11, APL39.11±3.74 and35.66±3.06, TL 31.43±3.15 and27.28±2.22, ATI 24.69±3.85 and22.03±2.15, PTI 18.71±3.16 and 15.99±1.96, API 46.79±3.99and40.02±2.85, AI 25.99±2.85 and23.54±2.58, PI 21.24±2.41 and18.96±1.67, TD 69.05±3.69and63.33±2.85wasobserved in male and female , which shows clear statistical difference between male and female parameters. In the present study the mean of AP in Right side 35.25±2.85and in left side 35.98±2.89 of MC and the mean of TR in Right side 28.05±2.02 and in left side 27.14±2.11of MC. In the present study the mean of AP in Right side 35.25±3.25and in left side 35.74±3.14of LC and the mean of TR in Right side 25.74±2.04and in left side 26.71±1.14 of LC. In the present study the mean of ANT in Right side 14.14±1.41 and in left side 14.52±1.25of ICA and the mean of TR in Right side 12.26±1.11and in left side 12.45±1.03 of ICA. **Conclusion:** The presence of variations in the geometry and architecture of the knee is a well recognised fact that is independent of gender and human ethnicity. This research determines the morphometric characteristics of the proximal end of the tibia in the Indian population and identifies sexual differences in all measured parameters of the proximal tibia. The bones that were classified based on demarcation points had a higher level of confidence compared to those classified based on identification points.

INTRODUCTION

Human skeletal remains provide significant insights into the study of biological diversity across human groups, including both geographical and historical dimensions. Examining human bones not only offers comprehension of the natural ageing process, but also aids in comprehending the biological, behavioural, cultural, and environmental elements that impact human ways of life. This

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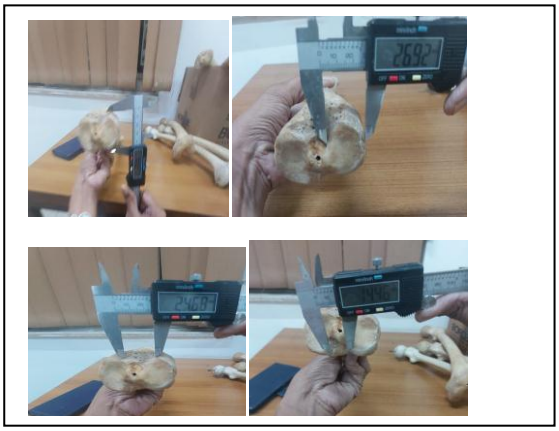
comprehension, in return, enhances a more profound knowledge of variation at the individual and population levels across different periods and locations, as well as the discovery of new human traits. These variances are often examined in the context of gender, age, and ethnicity, as well as the interplay between these factors, in order to further our comprehension of human existence.[1,2] The knee is a multifaceted synovial joint that primarily serves to regulate posture and body weight, as well as enable many everyday movements such as walking, standing, climbing, jogging, kicking, leaping, and changing directions.[3] The distal portion of the thigh bone and the proximal portion of the shin bone have a crucial function in transferring the weight of the body via the joint between the shin and thigh bones. Nevertheless, there are several instances in our everyday endeavours when the sideways and front-to-back measurements of the knee joint come into play. The significance of the epiphysis and diaphysis of the tibia in this context has been well demonstrated.[4-6] Prolonged weight-bearing on the knee joint may result in many pathological diseases, such as inflammatory arthritis, posttraumatic arthritis, and age-related osteoarthritis, which are often seen.[7,8] The most often done procedure to address these chronic diseases is Total Knee Arthroplasty (TKA) or Unicompartmental Knee Arthroplasty (UKA). The fundamental principle of TKA involves removing the uppermost part of the proximal tibia and substituting it with an artificial tibial component. The effectiveness of the surgery or intervention depends not only on the sufficient balance of soft tissues, but also on the accurate alignment in both rotational and sagittal planes, while minimising any excess protrusion of the components.[7,8] The efficacy of this technique mostly relies on the careful choice, exact measurement, and perfect positioning of the components. The size of the prosthesis in the front-back and side-to-side directions is crucial for preserving the bending and stretching of the joint and ensuring sufficient covering of the removed bone surface. It also allows for wound healing without any stress.[9-11] The morphometric measures of the proximal tibia are essential for attaining favourable results in complete knee replacement procedures. Typical morphometric metrics are the medial posterior slope, lateral posterior slope, proximal tibial length, medial condyle area, and lateral condyle area. These measures serve the purpose of both assessing knee abnormalities and providing guidance for therapeutic therapies, as well as monitoring results for patients who have had complete knee replacement surgeries.[7,12,13] Nevertheless, the ethnic and geographical differences, including the relatively smaller size and physical structure of the Asian population in comparison to the Western population, prevent the straightforward application of measures from the Western population to the Asian population or any other subgroup. Moreover, there will be discrepancies among subpopulations. The majority of prostheses currently on the market are most compatible with individuals from Western populations. Due to the significant differences in morphometric measures across various populations globally, it is probable that Asian people, especially the Indian population, are at risk of having excessively large components in both UKA and TKA procedures.[14,15]

MATERIALS AND METHODS

This investigation was conducted on 35 adult tibias obtained from the Anatomy department of a medical institution. The tibias were dry and preserved. A total of 35 completely calcified and treated desiccated bones were used for examination. Tibia bones that were not fully ossified, damaged, or showed anomalies were eliminated from the research. The proximal end of the tibia is examined using the following parameters: APM - Anteroposterior diameter of medial condyle, TM - Transverse diameter of medial condyle, APL - Anteroposterior diameter of lateral condyle, TL - Transverse diameter of lateral condyle, ATI - Anterior transverse diameter of intercondylar area, PTI - Posterior transverse diameter of intercondylar area, API - Anteroposterior diameter of intercondylar area, AI - Anterior diameter of intercondylar area, PI - Posterior diameter of intercondylar area and TD - Transverse diameter. Once the values of all the parameters are obtained, the data is connected with the record section of the bone bank at the specific medical college.

RESULTS

[Table 1] shows the comparing morphometric measurement between male and female. In the present study, the mean APM 41.57±3.52 and 37.98±2.52, TM31.02±4.25 and29.52±3.11, APL39.11±3.74 and35.66±3.06, TL 31.43±3.15 and27.28±2.22, ATI 24.69±3.85 and22.03±2.15, PTI 18.71±3.16 and 15.99±1.96, API 46.79±3.99and40.02±2.85, AI 25.99±2.85 and23.54±2.58, PI 21.24±2.41 and18.96±1.67, TD 69.05±3.69and63.33±2.85wasobserved in male and female , which shows clear statistical difference between male and female parameters.



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[Table 2] show that in the present study the mean of AP in Right side 35.25±2.85and in left side 35.98±2.89 of MC and the mean of TR in Right side 28.05±2.02 and in left side 27.14±2.11of MC. In the present study the mean of AP in Right side 35.25±3.25and in left side 35.74±3.14of LC and the mean of TR in Right side 25.74±2.04and in left side 26.71±1.14 ofLC. In the present study the mean of ANT in Right side 14.14±1.41 and in left side 14.52±1.25of ICA and the mean of TR in Right side 12.26±1.11and in left side 12.45±1.03 ofICA.

Table 1: Comparing morphometric measurement between male and female

Parameters	Male (n=20)	Female (n=15)	p- value
APM	41.57±3.52	37.98±2.52	0.001
TM	31.02±4.25	29.52±3.11	0.002
APL	39.11±3.74	35.66±3.06	0.001
TL	31.43±3.15	27.28±2.22	0.001
ATI	24.69±3.85	22.03±2.15	0.001
PTI	18.71±3.16	15.99±1.96	0.001
API	46.79±3.99	40.02±2.85	0.001
AI	25.99±2.85	23.54±2.58	0.001
PI	21.24±2.41	18.96±1.67	0.001
TD	69.05±3.69	63.33±2.85	0.001

Table 2: Right side and left side of the parameter

	MC		LC		ICA		P value
	AP	TR	AP	TR	ANT	POST	
Right side=15	35.25±2.85	28.05±2.02	35.25±3.25	25.74±2.04	14.14±1.41	12.26±1.11	
Left side =20	35.98±2.89	27.14±2.11	35.74±3.14	26.71±1.14	14.52±1.25	12.45±1.03	

Table 3: Regression analysis of parameter

	Male	Female
	95% CI	95% CI
APM	42.25(39.88-45.55)	38.33(36.33- 39.69)
TM	30.33(29.45- 33.52)	28.85(26.63- 31.85)
APL	37.58(36.69-40.22)	35.63(33.74- 37.85)
TL	29.96(27.22- 33.36)	27.55(25.52- 28.57)
ATI	24.52(22.22- 26.85)	23.36(22.78- 24.63)
PTI	18.85(16.52-20.52)	16.66(14.96-17.34)
API	45.54(42.52-47.63)	38.21(37.77- 39.98)
AI	24.52(22.58- 27.52)	23.37(21.25- 25.52)
PI	20.23(19.54-22.25)	18.96(17.36- 20.23)
TD	66.63(65.58- 68.22)	60.58(59.39- 65.56)

DISCUSSION

The research found that the average anteroposterior diameter of the medial tibial condyle was 41.57±3.52in in males and 37.98±2.52in in females. This indicates a significant statistical difference between the measurements of males and females. The findings of our investigation align with the research done by Osemeke et al,[16] which reported average measurements of 4.77±0.46 cm in males and 4.06±0.48 cm in females. The transverse diameter (TD) of the tibial condyle was measured as 69.05±3.69 in males and 63.33±2.85 in females. In a research done by Osemeke et al., it was found that males had identical findings for the right and left tibia, with values of 7.61±0.73 and 7.74±0.67 respectively, resulting in a total of 7.68±0.69. For women, the values for the right and left tibia were 6.73±0.60 and 6.84±0.63 respectively, resulting in a total of 6.78±0.61. A statistically significant correlation was seen between the values of men and women ($p<0.05$), however there was no significant difference between the two groups in terms of these parameters. These results corroborate the research done by Gupta et al.[17] Ivan's investigation revealed that the right and left tibia condyles had TD values of 6.62±0.51 and 6.66±0.56, respectively, resulting in an overall mean value of 6.64±0.53.

The average anteroposterior intercondylar length was found to be 46.79±3.99 in males and 40.02±2.85 in females. Osemeke et al,[16] measured the anteroposterior (AP) length of the intercondylar area in men and women. In males, the AP length was found to be 4.82±0.42 for the right tibia and 4.61±0.32 for the left tibia, with a mean total of 4.72±0.31. In women, the AP length was recorded as 3.88±0.42 for the right proximal tibia and 3.64±0.38 for the left proximal tibia, with a mean total of 3.76±0.40. In a research done by Gupta et al,[17] it was discovered that the right and left anterior-posterior (AP) lengths of the intercondylar area of the tibia were measured to be 4.25±0.42 and 4.49±0.44, respectively. The overall average value was determined to be 4.57±0.53, which aligns with the findings of this study.

The anteroposterior (AP) diameter of the lateral condyle of the tibia was measured as 39.11±3.74 in males and 35.66±3.06 in females. Osemeke et al,[16] reported that the anteroposterior (AP) diameter of the lateral condyle was measured to be 4.29±0.28 in

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males and 3.67±0.30 in females. In a study conducted by Gupta et al,[17] it was found that there is a significant relationship between the length of the medial condyle on the right and left sides and the thickness of the lateral condyle. The study reported the average transverse and anteroposterior (AP) diameter of the medial and lateral condyle of the tibia on the right side as 2.70±0.24 cm and 4.55±0.46 cm, respectively. On the left side, the average transverse and AP diameter of the medial and lateral condyle were reported as 2.66±0.24 cm and 4.08±0.27 cm, respectively. For the southern Indian population, the average transverse and AP diameter of the medial and lateral condyle on the left side were reported as 2.76±0.27 cm and 4.36±0.47 cm, respectively. On the left side, the average transverse and AP diameter of the medial and lateral condyle were reported as 2.92±0.32 cm and 4.06±0.40 cm, respectively.

A study done by 18 researchers discovered that the average anteroposterior (AP) length (diameter) of the medial and lateral condyle was 4.08±0.42 and 3.67±0.41 for the right side, and 4.13±0.42 and 3.54±0.39 for the left side. The study also identified no statistically significant differences in other tibia characteristics between the two limbs. In a research done by Ivan et al,[18] the average transverse and anteroposterior (AP) diameters of the medial and lateral condyles of the right tibia were discovered to be 2.97±0.28 cm and 3.86±0.36 cm, respectively. On the left side, the measurements were 2.92±0.27 cm and 3.64±0.24 cm for the medial condyle, and 2.75±0.25 cm and 3.99±0.37 cm for the lateral condyle. The mean transverse and AP diameters on the left side were 2.97±0.30 cm and 3.69±0.26 cm, respectively.

Asala SA et al also reported comparable findings, namely, the anterior-posterior (AP) length of the medial and lateral tibia was measured to be 5.08±0.33 and 4.72±0.33, respectively.[19] In a research done by Luo W et al, it was discovered that the AP length of the medial tibia condyle was 4.80±0.31 and the AP length of the lateral tibia condyle was 3.98±0.29.[20]

The results of this osteometric investigation demonstrate sexual dimorphism in almost all examined parameters, providing valuable information for sex identification and subsequent establishing of identity. An examination and in-depth investigation of identification and details reveal a significant disparity in characteristics between men and girls, indicating a larger proportion of variations. Additional bones must be recognised using the identification point rather than the demarcation point in both the distal femur and proximal tibia. The investigation revealed that the range where sex could not be determined was modest in the identification point analysis, but wider in the demarking point analysis. This aligns with the research undertaken by the previous authors on identification and delineation point analysis.[19-21] The majority of metrics showed higher identification and demarking points for men compared to females, indicating the utility of these factors in determining sex.

CONCLUSION

The presence of variations in the geometry and architecture of the knee is a well recognised fact that is independent of gender and human ethnicity. This research determines the morphometric characteristics of the proximal end of the tibia in the Indian population and identifies sexual differences in all measured parameters of the proximal tibia. The bones that were classified based on demarcation points had a higher level of confidence compared to those classified based on identification points. It is not always required for all characteristics to intersect the demarcation points in order to determine the sex. The anatomical variations in the proximal tibia between males and females may serve as a biological means of identifying one's sex and can contribute to the development of knee prosthesis specifically tailored for the Indian population, where utmost accuracy is essential.

REFERENCES

1. Corrieri B, Márquez-Grant N. What do bones tell us? The study of human skeletons from the perspective of forensic anthropology. SciProg. 2015;98(4):391-402. doi: 10.3184/003685015X14470674934021.
2. Abul Hossain M. Significance of the structure of human skeleton. Am J Med Sci Med. 2018;6(1):01-4. Available from: http://pubs. doi: 10.12691/ajmsm-6-1-1.
3. Pradhan RR, Korukonda S, Patro GC. Jami SagarPrusti Morphometric analysis of the Proximal End of the Dry Adult Tibia: A Cross-sectional Study from Eastern India. J ClinDiagn Res. 2023 Oct;17(10):AC01-4.
4. Pooja B, Babita PS, Sabita M. Morphometric study of proximal end of tibia with its clinical implications in north Indian population. J Evol Med Dent Sci. 2018;7(23):2801-6. doi: 10.14260/jemds/2018/632.
5. Nayak AK, Sahni C, Gupta M, Tiwari PK, Mishra A, Devadas D. Anthropometric analysis of distal femur parameters in the eastern Uttar-Pradesh population. Cureus. 2023 Jan 18;15(1):e33945. doi: 10.7759/cureus.33945, PMID 36820105, PMCID PMC9938003.
6. Coughlin KM, Incavo SJ, Churchill DL, Beynnon BD. Tibial axis and patellar position relative to the femoral epicondylar axis during squatting. J Arthroplasty. 2003;18(8):1048-55. doi: 10.1016/s0883-5403(03)00449-2, PMID 14658111.
7. Dejour H, Bonnin M. Tibial translation after anterior cruciate ligament rupture. Two radiological tests compared. J Bone Joint Surg Br. 1994;76(5):745-49. doi: 10.1302/0301-620X.76B5.8083263, PMID 8083263.
8. Kane RL. The functional outcomes of total knee arthroplasty. J Bone Joint Surg (American). 2005;87(8):1719-24.
9. Heck DA, Robinson RL, Partridge CM, Lubitz RM, Freund DA. Patient outcomes after knee replacement. ClinOrthopRelat Res. 1998;356(356):93-110. doi: 10.1097/00003086-199811000-00015, PMID 9917673.
10. Martinez-Cano JP, Herrera-Escobar JP, Arango Gutierrez AS, Sanchez Vergel A, Martinez-Rondanelli A. Prospective quality of life assessment after hip and knee arthroplasty: short- and mid-term follow-up results. Arthroplast Today. 2017;3(2):125-30. doi: 10.1016/j.artd.2016.09.008, PMID 28695185.
11. Genêt F, Schnitzler A, Lapeyre E, Roche N, Autret K, Fermanian C, et al. Change of impairment, disability and patient satisfaction after total knee arthroplasty in secondary

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care practice. Ann Readapt Med Phys. 2008;51(8):671-82. doi: 10.1016/j.annrmp.2008.08.002, PMID 18801590.
12. Brandon ML, Haynes PT, Bonamo JR, Flynn MI, Barrett GR, Sherman MF. The association between posterior-inferior tibial slope and anterior cruciate ligament insufficiency. Arthroscopy. 2006;22(8):894-99. doi: 10.1016/j.arthro.2006.04.098, PMID 16904590.
13. Sundar S, Patnaik S, Ubaydullaev B, Kolandavelu V, Rajan D. Tibial plateau slopes in Indian patients with or without anterior cruciate ligament injury: A magnetic resonance imaging study. J OrthopSurg (Hong Kong). 2016;24(3):289-93. doi: 10.1177/1602400303, PMID 28031492.
14. Surendran S, Kwak DS, Lee UY, Park SE, Gopinathan P, Han SH, et al. Anthropometry of the medial tibial condyle to design the tibial component for unicondylar knee arthroplasty for the Korean population. Knee Surg Sports TraumatolArthrosc. 2007;15(4):436-42. doi: 10.1007/s00167-006-0188-5, PMID 16964513.
15. Verma M, Joshi S, Tuli A, Raheja S, Jain P, Srivastava P. Morphometry of proximal femur in Indian population. J ClinDiagn Res. 2017 Feb;11(2):AC01-4. doi: 10.7860/JCDR/2017/23955.9210. PMID 28384844, PMCID PMC5376818.
16. Osemeke BE, Ibiwari BW, Christiana OU, Rotimi OD. Osteometric morphometry of the proximal tibia end in Nigerian population: forensic and clinical implications. Int J Appl Res. 2020;6:117-23.
17. Gupta C, Kumar J, Kalthur SG, D'Souza AS. A morphometric study of the proximal end of the tibia in south Indian population with its clinical implications. Saudi J Sports Med. 2015;15(2):166-9. doi: 10.4103/1319-6308.156354.
18. Ivan AS. Morphometric study of proximal end of tibia. Available from: https://www.rguhs.ac.in/cdc/onlinecdc/uploads/01_M010_25888.doc. Vol. 75; 2014.
19. Asala SA, Mbajiorgu FE, Papandro BA. A comparative study of femoral head diameters and sex differentiation in Nigerians. ActaAnat (Basel). 1998;162(4):232-7. doi: 10.1159/000046438, PMID 9831772.
20. Luo W, Stanhope SJ, Sheehan FT. Using two palpable measurements improves the subject-specific femoral modeling. J Biomech. 2009;42(12):2000-5. doi: 10.1016/j.jbiomech.2009.05.006, PMID 19520371.
21. Singh SP, Singh SP. Identification of sex from the humerus. Indian J Med Res. 1972;60(7):1061-6. PMID 4661453.

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