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Research Article

OSTEOMETRIC MORPHOMETRY OF PROXIMAL TIBIAL END IN INDIAN POPULATION: A FORENSIC POINT OF VIEW WITH ITS CLINICAL IMPORTANCE

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ABSTRACT

Objectives: Considering the importance of sexual dimorphism to the identification of skeletons for scientific, medical and forensic purposes, the aim of the present study was to investigate the gender of the person based on morphometric aspects of the proximal end of tibia in Indian population.

Material and Method: This prospective descriptive study was carried out on 385 dry, adult tibias, which were collected from the department of Anatomy department of a medical college in north India. 385 fully ossified and processed dry bones were used to study. Unossified, injured or anomalous tibia bones were excluded from the study. Proximal end of tibia is studied under various parameters. After obtaining the values of the all parameters, data is corelated with the record section of the bone bank of the particular medical college.

Result: It shows that, there is significant difference between male and female parameters and all results were statistically significant.

Conclusion: This study will help to provide a basis for application in forensic science, in prosthesis, and in clinical practice also.

Keywords: Anteroposterior diameter of medial condyle, Anteroposterior diameter of lateral condyle, Transverse diameter, Anterior diameter of intercondylar area, Posterior diameter of intercondylar area.

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INTRODUCTION

Morphometry means the measurements of distances between pairs of anatomically homologous points, tangent points, and extremes of structures. It is the study of variations in measurements and correlations between theses such measurements (covariations). Morphometry is an important asset used in studies to understand the relationship of variables, such as age and sex, between organisms. Morphological and morphometric differences between males and females are studied and can be demonstrated through anatomic, biological, and physiological analyses.

Regarding the morphology of the skeleton, differences detected in the body structures can be essential to the determination of sex from the analysis of bones based on sexual dimorphism, which is clearly evidenced by the dimensions of bone structures [1,2]. Indeed, the identification of sex based on skeletal characteristics plays a crucial role in forensic medicine and anthropology [1].

Not all characteristics of the human skeleton serve as a reference for metric methods used to define sex in anthropological examinations or forensic investigations [3,4]. The bones most commonly used for this purpose are the mandible, skull, pelvis, long bone, and scapula. The skull and pelvis constitute the most often used and efficient sets of characters in morphological analyses and are extremely important to the identification of sex [5,6]. Long bones also play an important role in the evaluation of sexual dimorphism [7].

The tibia is a long bone that supports a large part of the body weight and is directly related to movements of the person. This bone also possesses strong dimorphic characteristics. The proximal portion of the tibia expands, forming a surface to support the body weight, the force of which is transmitted through the femur bone. The medial and lateral condyles, intercondylar area, and tibial tuberosity are located at this end of the tibia [8]. Morphometry is a reliable method for the evaluation of structures in this region of the tibia for medical purposes [9]. Morphometric variables are also important to forensic experts as a method for the identification of an individual based on his or her unique characteristics [10]. Considering the importance of sexual dimorphism to the identification of skeletons for scientific, medical, and forensic purposes, the aim of the present study was to investigate the gender of the person based on morphometric aspects of the proximal end of tibia in Indian population.

METHODS

This prospective descriptive study was carried out on 385 dry, adult tibias, which were collected from the department of Anatomy of a medical college in north India. 385 fully ossified and processed dry bones were used to study.

Unossified, injured, or anomalous tibia bones were excluded from the study.

Proximal end of tibia is studied under following parameters:

1. APM - Anteroposterior diameter of medial condyle
2. TM - Transverse diameter of medial condyle
3. APL - Anteroposterior diameter of lateral condyle
4. TL - Transverse diameter of lateral condyle
5. ATI - Anterior transverse diameter of intercondylar area
6. PTI - Posterior transverse diameter of intercondylar area
7. API - Anteroposterior diameter of intercondylar area
8. AI - Anterior diameter of intercondylar area
9. PI - Posterior diameter of intercondylar area
10. TD - Transverse diameter.

After obtaining the values of the all the parameters, data are correlated with the record section of the bone bank of the particular medical college.

Table 1: Parameters and their identification point for gender confirmation

S.no	Parameter	Identification point
1	APM	40 mm above male 40 mm below female
2	APL	35 mm above male 35 mm below female
3	TM	30 mm above male 30 mm below female
4	TL	25 mm above male 25 mm below female
5	ATI	25 mm above male 25 mm below female
6	PTI	17 mm above male 17 mm below female
7	API	40 mm above male 40 mm below female
8	AI	25 mm above male 25 mm below female
9	PI	20 mm above male 20 mm below female
10	TD	65 mm above male 65 mm below female

APM: Antero-posterior diameter of Medial condyle, TM: Transverse diameter of Medial condyle, APL: Antero-posterior 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: Antero-posterior diameter of intercondylar area, AI: Anterior diameter of intercondylar area, PI: Posterior diameter of intercondylar area, TD: Transverse diameter

Table 2: Gender-wise values of parameters

Parameters	Male (n=281)			Female (n=103)		
	Min	Max	95% CI	Min	Max	95% CI
APM	41.7	76.6	(41.03, 42.4)	30.1	54.5	(37.15, 38.89)
TM	21.3	79.2	(30.13, 31.56)	22.2	41.2	(28.26, 30.01)
APL	27.2	91	(38.13, 39.72)	26.1	46.3	(34.64, 36.2)
TL	20.5	82	(30.56, 32.13)	20.	38.9	(26.4, 27.87)
ATI	17	71	(23.95, 25.44)	15.9	35.8	(21.22, 22.53)
PTI	10.9	67.6	(17.72, 19.17)	11.5	23.2	(15.64, 16.48)
API	35.6	68.6	(45.68, 46.76)	30.5	52.1	(38.85, 40.63)
AI	15.6	39	(25.68, 26.52)	15.1	37.2	(22.57, 24.1)
PI	14.3	30.3	(20.79, 21.36)	14	24.4	(18.72, 19.68)
TD	36.5	89.7	(67.84, 69.02)	51.7	74.2	(61.79, 63.81)

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, TD: Transverse diameter

RESULTS

Table 1 shows the identification point of each parameter. Table 2 shows the minimum and maximum values of each parameter in both the genders. Table 3 shows the values of t-test and p value, which is highly significant in each parameter. Each parameter is higher in male in comparison with female parameter.

DISCUSSION

In the present study, the mean anteroposterior diameter of medial tibial condyle was observed as 41.72±5.89 in male and 38.02±4.52 in female, which shows clear statistical difference between male and female parameters. The results of our study are in consistent with the study conducted by the Osemeke *et al*., [11] who observed 4.77±0.46 cm in male and 4.06±0.48 cm in female. Transverse diameter (TD) of the tibial condyle was observed as 68.43±5.03 and 62.8±5.22 in male and female, respectively. A study conducted by Osemeke *et al*. observed the similar results, i.e., 7.61±0.73 and 7.74±0.67 for right and left tibia in men with a total of 7.68±0.69; in women, it was 6.73±0.60 and 6.84±0.63 for right and left with a total of 6.78±0.61. There was a statistically significant relation between values of men and women ($p<0.05$), but no significant side difference in both parameters. These findings are in agreement with the study conducted by the Gupta *et al*. [12] the study conducted by Ivan [13] found 6.62±0.51 and 6.66±0.56 for right and left TD of tibia condyle with a total mean value of 6.64±0.53. We observed the mean anteroposterior intercondylar length 46.22±4.61 and 39.74±4.6 in male and female respectively. Osemeke *et al*. [11] observed the anteroposterior (AP) length of intercondylar region 4.82±0.42 and 4.61±0.32 for right and left tibia in men with a mean total of 4.72±0.31, whereas women recorded 3.88±0.42 and 3.64±0.38 for right and left proximal tibia, with a mean total of 3.76±0.40. A study conducted by, Gupta *et al*. [12], found 4.25±0.42 and 4.49±0.44 for right and left AP length of intercondylar region of tibia with a total mean value of 4.57±0.53, which is again in consistent with this study.

AP diameter of lateral condyle of tibia was observed as, 38.93±6.8 in male and 35.42±4.02 in female. Osemeke *et al*. [11] observed the AP diameter of lateral condyle as 4.29±0.28 in male and 3.67±0.30 in female, respectively. A study conducted by Gupta *et al*. [12] reported a significant relation between the right and left AP length of medial condyle and TD of lateral condyle; they reported the mean transverse, AP diameter of medial and lateral condyle of tibia on the right side as 2.70±0.24, 4.55±0.46 cm and 2.66±0.24, 4.08±0.27 cm and 2.76±0.27, 4.36±0.47 cm and 2.92±0.32, 4.06±0.40 on the left side for the southern Indian population. A study conducted by 18, shows that the mean AP length (diameter) of medial and lateral condyle as 4.08±0.42 and 3.67±0.41 for the right, 4.13±0.42 and 3.54±0.39 for the left and she found no statistical significance difference in any parameters of tibia on both limbs. A study conducted by Ivan *et al*. [13] observed the mean transverse, AP diameter of medial and lateral condyle of tibia on the right side as 2.97±0.28, 3.86±0.36 cm and 2.92±0.27, 3.64±0.24 cm and 2.75±0.25, 3.99±0.37 cm and 2.97±0.30, 3.69±0.26 on the left side [14],

Table 3: Comparing morphometric measurement between male and female

Parameters	Male (n=281)	Female (n=103)	Mean difference	t-test	p-value	Significance
APM	41.72±5.89	38.02±4.52	3.70	6.52	0.000000	All are highly significant
TM	30.84±6.13	29.14±4.53	1.71	2.96	0.003288	
APL	38.93±6.8	35.42±4.02	3.51	6.18	0.000000	
TL	31.35±6.75	27.13±3.82	4.21	7.64	0.000000	
ATI	24.7±6.4	21.88±3.38	2.82	5.57	0.000000	
PTI	18.45±6.21	16.06±2.19	2.39	5.57	0.000000	
API	46.22±4.61	39.74±4.6	6.48	12.21	0.000000	
AI	26.1±3.59	23.34±3.97	2.76	6.20	0.000000	
PI	21.07±2.43	19.2±2.49	1.87	6.58	0.000000	
TD	68.43±5.03	62.8±5.22	5.63	9.46	0.000000	

APM: Antero-posterior diameter of Medial condyle, TM: Transverse diameter of Medial condyle, APL: Antero-posterior 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: antero-posterior diameter of intercondylar area, AI: Anterior diameter of intercondylar area, PI: Posterior diameter of intercondylar area, TD: Transverse diameter

also observed the similar results, i.e., AP length of medial and lateral tibia to be 5.08±0.33 and 4.72±0.33, respectively. A study conducted by [15], also observed the similar results, i.e., AP length of medial and lateral tibia condyle to be 4.80±0.31 and 3.98±0.29, respectively.

The findings from this osteometric study reveals sexual dimorphism in almost all parameters measured which is a perfect lead in the process of sex identification and consequently establishment of identity. Identification and detail study analysis for sex determination show a higher percentage of differences between males and females. More bones need to be identified with the identification point compared to demarking point in both the distal femur and proximal tibia. As the fact is that the overlapping range where sex could not be identified was small in the identification point analysis but larger in the demarking point analysis. This agrees with the study conducted by the previous authors on identification and demarking point analysis [14-16]. Both identification and demarking points for males were greater than those of females in the majority of parameters, which shows an indication of the usefulness of these parameters in sex determination.

CONCLUSION

Variability in geometry and anatomy of the knee exists irrespective of gender and human race is a well-known fact. This study establishes the morphometric attributes of proximal end of tibia in North Indian population and found sexual dimorphism in all parameters of the proximal tibia measured. The bones which were sexed using demarking points were however of greater degree of certainty than those sexed using identification points and it is not always necessary for all parameters to cross the demarking points for sex identification. The difference in proximal tibia anatomy between genders provides a biological profiling system for sex identity and would add to the design of knee prostheses for the North Indian population where perfect precision is required. This study will help to provide a basis for the application in forensic science, in prosthesis, and in clinical practice also.

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