Original Research Article

Morphometric Assessment of Tibial Tuberosity and its Clinical Relevance in Indian Population

Swati G[1], Rajan KS[2], Jagdev K[2], Gaurav A[2], Vandana M[1], Rajesh KS[1]

[1]Department of Anatomy, Vardhman Mahavir Medical College, New Delhi, India.
[2]Department of Anatomy, Government Medical College, Amritsar, India.

Abstract

Morphometric parameters of tibial tuberosity can be used to guide treatment and monitor outcome of total knee replacement surgeries. Tibial tuberosity being a tractional apophysis can be a site for recurrent avulsion fractures. Morphometric measurements of tibial tuberosity of 100 adult human tibiae were meticulously recorded with the help of Vernier calipers. Student's t-test was used for statistical analysis with significant level of < 0.05 and 95% confidence interval. The mean distance of tibial tuberosity from the anterior border of intercondylar area was found to be more in males on both sides and statistically significant only on right side (p-value=0.020 on right side). The length of upper smooth and lower rough part of tibial tuberosity were statistically significant on right side (p-value=0.001 and 0.019, respectively). Furthermore, comparison between the two sides of upper smooth part of tibial tuberosity showed the difference being statistically significant only in females (p-value= 0.027 in females). The mean values of breadth of upper smooth and lower rough part of tibial tuberosity were found to be statistically significant on both the sides (p-value on right side = 0.009 and on left side=0.002; p-value on right side=0.008 and on left side=0.012). The present study is an endeavor to provide a base line data with reference to unicompartmental and total knee arthroplasty in Indian population. The results of this research work assume special importance in view of the technical advancements in reconstructive surgical procedures in orthopedic practice.

Keywords: Total knee replacement, tibia, tuberosity

Correspondence:

Swati Gandhi, Department of Anatomy, Vardhman Mahavir Medical College, New Delhi. Tel: +91-9811041982 Email: swatig2883@yahoo.com

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Introduction

In humans, weight bearing is related primarily to the extended knee positions. The size, shape and position of tibial tuberosity are particularly essential in the extension of the knee joint (1). The tibial tuberosity varies from a faint elevation to a prominent part of bone which instigates 2cm below the anterior margin of tibial plateau (2). The tibial tuberosity develops from a secondary ossification centre at the upper end of the tibia. It is an apophysis which ossifies in traction (3). Fusion of the proximal tibial epiphysis, which extends distally towards the tubercle apophysis, may leave a mechanically vulnerable area which predisposes the tuberosity to avulsion injury (4). In Osgood–Schlatter disease, there is partial disruption of fibrous union between the epiphyseal part of tibial tuberosity and the diaphysis in which ossification has not been completed due to repeated tensions by the patellar tendon (5). This condition also has been elucidated as a concomitant finding with tibial tuberosity fractures (6). Hence, it is important for Surgeons and Radiologists to acquaint themselves with relevant knowledge pertaining to the morphometry of tibial tuberosity and its clinical significance. An accurate and repeatable tibial tuberosity measurement system aids in definition of tibial deformity and improvement of tibial prosthesis design for unicompartmental and total knee arthroplasty.

Materials and Methods

An exhaustive pilot study of one hundred adult human tibia bones of known sex and side was done. The study group comprised 50 male and 50 female bones with equal number of right and left sided bones (Table 1). All measurements were recorded with the help of vernier calipers with a least count of 0.01 mm.

Following metric parameters were noted:

1. Distance of tibial tuberosity from the anterior border of intercondylar area: The distance taken from anterior border of intercondylar area upto upper end of tuberosity (CD in Fig.1)
2. Ridge between proximal smooth and distal rough part of tibial tuberosity was noted whether it was distinct or faint.
3. Length of upper smooth part of tibial tuberosity: The distance taken from upper end of tibial tuberosity upto ridge between proximal smooth and distal rough part (EF in Fig.1).
4. Length of lower rough part of tibial tuberosity: The distance taken from ridge upto distal end of tibial tuberosity (FG in Fig.1).
5. Breadth of upper smooth part of tibial tuberosity: The widest transverse diameter of upper smooth part (HI in Fig.1).
6. Breadth of lower rough part of tibial tuberosity: The widest transverse diameter of lower rough part (JK in Fig.1).

The data thus obtained was expressed as means + standard deviation (SD) followed by student's t test on both right and left sided bones of two sexes and p-value < 0.05 was considered significant for analysis. All the statistical tests were performed by using SPSS software (version 12.0). The results were scrutinized and discussed in the light of available literature.

Results

This morphometric study conducted on adult human tibiae of Indian population revealed the under-mentioned important observations.

Table 2 depicted the mean distance of tibial tuberosity from the anterior border of intercondylar area. It is evident from the recorded data that the distance was more in males on both the sides but it was statistically significant only on the right side (p-value = 0.020 on right side and 0.522 on left side). Further, when compared between the two sides, it was more on right side in males and more on left side in females, but the differences were statistically insignificant (p-value in males 0.266 & in females 0.458) (Table 2).

Table 1: Table depicting the description of the study group (N=100)

Sex/Side	Right Tibiae	Left Tibiae	Total
Males	25	25	50
Females	25	25	50

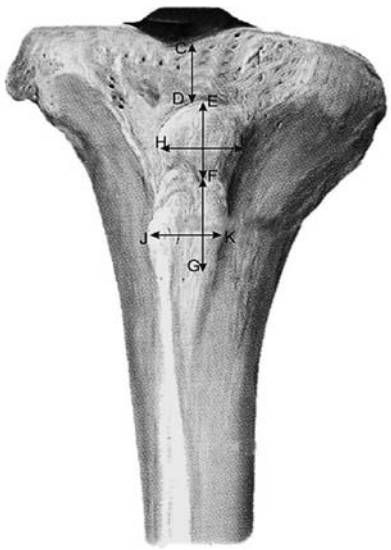

Figure 1: Anterior view of tibia. (CD: Distance of tibial tuberosity from the anterior border of intercondylar area, EF: Length of upper smooth part of tibial tuberosity, FG: Length of lower smooth part of tibial tuberosity, HI: Breadth of upper smooth part of tibial tuberosity, JK: Breadth of lower smooth part of tibial tuberosity)

In all the hundred human tibiae, ridge was found between proximal smooth and distal rough part of tibial tuberosity on both sides.

The mean values and range of length of upper smooth and lower rough part of tibial tuberosity on both sides of both the sexes were stated in Table 3. On statistical evaluation, the difference between the two sexes was significant on right side (p-value = 0.001) but insignificant on left side (p-value = 0.605). Furthermore, when compared between the two sides, in males it was more towards right side and in females it was more towards left side, the difference being statistically significant only in females (p-value = 0.543 in males & 0.027 in females).

The mean values of length of lower rough part of tibial tuberosity was more in males on both the sides, the difference being statistically significant on right side and insignificant on left side (p-value = 0.019 on right side and 0.095 on left side). However, when compared between the two sides in males, it was more on the right side and in females it was more on the left side, the difference

Table 2: Comparison of distance of tibial tuberosity from the anterior border of intercondylar area

Authors (year)	Race	Mean ± S.D (mm) (n)			
		Right (n)		Left (n)	
		Male	Female	Male	Female
Hughes & Sunderland[6] (1946)	Australian	20(50)			
Present Study	North Indians	13.21±3.21(25)	11.31±2.29(25)	12.30±2.42(25)	11.84±2.70(25)

Table 3: Comparison of lengths of upper smooth and lower rough part of tibial tuberosity

Length (mm)	Side	Sex	Mean±S.D(n)	p-value
Upper smooth part	Right	Male	22.50±4.85(25)	0.001
		Female	18.44±3.77(25)	
	Left	Male	21.73±4.04(25)	0.605
		Female	21.11±4.47(25)	
Lower rough part	Right	Male	51.02±11.22(25)	0.019
		Female	44.86±5.74(25)	
	Left	Male	48.98±7.33(25)	0.095
		Female	45.21±8.12(25)	

Table 4: Comparison of breadth of upper smooth and lower rough part of tibial tuberosity

Breadth (mm)	Side	Sex	Mean±S.D(n)	p-value
Upper smooth part	Right	Male	20.34±1.71(25)	0.009
		Female	18.92±1.97(25)	
	Left	Male	20.92±1.61(25)	0.002
		Female	19.33±1.89(25)	
Lower rough part	Right	Male	20.55±2.41(25)	0.008
		Female	18.51±2.84(25)	
	Left	Male	20.37±2.72(25)	0.012
		Female	18.47±2.43(25)	

being statistically insignificant in both the sexes (p-value 0.450 in males and 0.862 in females) (Table 3).

Also, it was observed that length of lower rough part was more than upper smooth part of tibial tuberosity in both sexes and on both sides in Indian population.

The mean values and range of breadth of upper smooth part of tibial tuberosity has been enumerated in Table 4. On statistical analysis, the difference between males and females was significant on both the sides (p-value on right side = 0.009 and on left side = 0.002). Similarly, when compared between the two sides, the measurement was slightly more on left side in both the sexes but the difference was statistically insignificant (p-value = 0.221 in males and 0.465 in females).

The mean values of breadth of lower rough part of tibial tuberosity on both the sides was more in males, the difference being statistically significant (p-value on right side = 0.008 and on left side = 0.012). Similarly, when compared between the two sides, in both the sexes the breadth was more on right side but the difference was statistically insignificant (p-value = 0.802 in males and 0.954 in females)

Discussion

The tibial tuberosity is regarded as one of the reliable rotational landmark for the tibial component in total knee arthroplasty (7). The success of total knee arthroplasty depends on proper alignment of prosthesis component because small alignment errors can predispose to loosening of prosthesis which further becomes the main cause of revision of surgery (8). This study established the morphometric attributes of tibial tuberosity in Indian population. Data thus obtained would provide a basis for designing the

optimal tibial component for unilateral and total knee arthroplasty for Indian population.

Earlier, only Hughes and Sunderland (2) had measured the distance of tibial tuberosity from the anterior border of intercondylar area to be 20 mm in Australian population but irrespective of side and sex (Table 2). This distance could be of great significance for intramedullary nailing which becomes the successful treatment for tibial fractures. The Surgeons and Orthopedicians should be aware of complications of proximal nailing in cases of high tibial fractures as it may cause injury to intraarticular structures (9).

According to Hughes and Sunderland (2), there are various descriptions regarding the insertion of ligamentum patellae. The tendon usually inserts into the distal rough part of the tuberosity (10). It can alternatively insert into the proximal smooth part of the tibial tuberosity (11) and can also send some prolongations to the roughened part of the tibial tuberosity (11).

Squatters are known to show certain adaptational features in the lower extremities. One of the effects of squatting is the greater range of flexion at the knee joint. This greater range of flexion may produce some effects on the upper end of the tibia due to increased pressure of the quadriceps tendon against it (12).

According to Parson's (13), traction epiphysis develops as a result of sesamoid structures. The upper smooth part of tibial tuberosity develops as a result of chondrification in the deeper part of ligamentum patellae. So, it was documented that it had a sesamoid origin phylogenetically (5).

The apophysial nature of the tibial tuberosity can predispose it to tractional injuries. Avulsion fractures of tibial tuberosity are uncommon injuries with a reported incidence of 0.4% to 2.7% which usually occur in young adolescents due to activities like jumping and springing where knee extensors are forcefully contracted. These types of injuries are more predominant in males owing to their greater involvement in athletics and also due to physiologic physiodesis of the proximal tibia in males at a later age. As a result they acquire strong quadriceps which further leads to higher traction stresses (6).

Clinically, these injuries are very significant for surgeons as rare post injury complications could arise such as compartment syndrome which must be taken under consideration (14). Close monitoring and early intervention should be recommended. Furthermore, these injuries should be differentiated from conditions like Osgood-schlatter disease where apophysitis of tibial tuberosity occurs due to recurrent traction by the patellar tendon on the secondary ossification center of tibial tubercle (15). Arthroscopic-assisted open fixation has become the gold standard treatment in recent times.

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