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A Morphometric Analysis of Tibial Tuberosity in Northeast population of India

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ABSTRACT

The tibial tuberosity is a bony landmark located at the proximal end of the tibia. The tibial tuberosity can rang from a slight elevation to a more prominence that begins around 2cm below the anterior margin of the tibial plateau. Avulsion fractures, which occur when soft tissue separates from the bone, can occur in various parts of the body. In the case of tibial tuberosity avulsion fractures, they typically affect adolescent males, resulting from the bony insertion of the patellar tendon being pulled away due to a sudden and forceful contraction of the quadriceps muscles. Consequently, this type of fracture is more commonly observed in males. The ligamentum patellae may attach to the upper smooth part of the patella and its adjoining margins, or it may be connected to the lower rough area, with some fibers extending to the lower rough part of the tibial tuberosity. Avulsion fractures can occur at any soft tissue attachment point on the bone. In most cases, the failure of the bone is the result of either a sudden, tensile force applied to the bone through the soft tissue or chronic repetitive avulsive stresses causing a piece of bone to be pulled away by the soft tissue. Tibial tuberosity avulsion fractures typically occur in adolescent males due to the avulsion of the bony insertion of the patellar tendon, which is caused by sudden violent contraction of the quadriceps muscles. As a result, this type of fracture is more commonly found in males. The mean tuberosity distance from the joint surface was 29.2mm (SD 3.5, range 16.6-38.6mm) and was larger in males than females (30.7mm (SD 2.9) vs. 27.6mm (SD 3.3); $p<0.001$). Furthermore, the tuberosity distance from the joint surface increased by an average of 0.18mm per 1.0cm increase in height ($p<0.001$).

Keyword: Tibial tuberosity, Ligamentum Patellae, Screw size, Tensile force, Bone etc.

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INTRODUCTION

The tibial tuberosity is a bony landmark present at the proximal end of tibia. It is the truncated apex of a triangular area, where the anterior condylar surface merges. It varies from a faint elevation to a prominent part of bone which instigates 2cm below the anterior margin of tibial plateau.[1] In females, ossification begins in the anterior tuberosity at the age of 11, with fusion occurring between the anterior tuberosity and epiphysis at 12 years of age. Fusion is completed by the age of 17. In males, the process is delayed by one year, with ossification starting distally and the proximal part fusing with the epiphysis before the distal part..[2] During the fetal period, the hyaline cartilage outgrowth gradually moves towards the distal end in front of the metaphysis. After 4-6 months postnatally, a growth plate forms below the tibial tuberosity. This growth plate consists of three distinct zones: (1) a zone of enchondral bone formation, (2) a zone of intramembranous bone formation through fibrocartilage, and (3) a zone of intramembranous bone formation in fibrous tissue.[3] The ligamentum patellae inserts either to the upper smooth portion and adjacent margins of the patella, or it can insert to the lower rough area of tibial tuberosity. It may also be connected to the upper smooth part with some fibers extending to the lower rough part of the tibial tuberosity.[4] Avulsion fractures can occur in any part of the body where soft tissue connects to the bone. This type of bone injury typically occurs due to a sudden, forceful pulling of the soft tissue from the bone, or as a result of repetitive stress over time.[8] Avulsion fractures around tibial tuberosity occur in adolescent males due to sudden contraction of the quadriceps muscles.[9]

Aims and Objectives

Aim of my study is morphometric study of tibial tuberosity in northeast population of India.

Objectives

1. To measure length and circumference of tibia.
2. To measure distance of tuberosity from upper surface of tibia.
3. To differentiate male from female gender from tibial tuberosity.
4. To determine length and breadth of upper smooth and lower rough part of tibial tuberosity.
5. To determine shape of upper smooth part and lower rough part of tibial tuberosity.
6. To find statistical analysis of measured data.

MATERIALS AND METHOD

22 dry tibia bones were collected irrespective of age and gender from the department of Anatomy, Gauhati Medical College and Hospital. Main materials used are vernier callipers and measuring tape. They were analysed to identify the shapes of both the genders. Accordingly male tibial bones have more prominent tibial tuberosity and females have less

prominent of tibial tuberosity. Depending upon the shape of the groove between upper smooth and lower rough part of tibial tuberosity we can classify its types as semilunar, round triangular, oval or quadrangular. With the help of vernier calliper we measured different parameters of tibial tuberosity.

Statistical analysis

The study involved the statistical analysis of measurements taken from 22 dry tibia bones obtained from the Anatomy department of Gauhati Medical College and Hospital, without consideration of age or gender. Vernier calipers and a measuring tape were used as the primary tools for the analysis. The objective of the examination was to delineate the characteristics of tibial bone shapes in both genders. The study observed that male tibial bones tend to have a more prominent tibial tuberosity, while females exhibit a less prominent tibial tuberosity. Based on the shape of the groove between the upper smooth and lower rough parts of the tibial tuberosity, these bones were categorized as semilunar, round, triangular, oval, or quadrangular. Measurements of various parameters of the tibial tuberosity were conducted using vernier calipers, and the data was analyzed using the jamovi 2.5.3 app. The sample size, mean, median, mood, standard deviation, standard error, length, and breadth parameters of both the upper smooth and lower rough part of the tibial tuberosity were measured. Statistical analyses, including student's t-test, standard deviation, p value, coefficient of interval (CI 95%), and interquartile range (IQR), were evaluated. Finally, the data was represented graphically using the Jamovi software

RESULTS AND DISCUSSION

Depending on the shape of the groove and presence and absent of the groove which is separating upper smooth part and lower rough part there are total 4 types of tibial tuberosity.

Table 1: Shapes of upper smooth part and lower rough part of tibial tuberosity depending upon the type of groove in between them.

Groove	Type of groove	Upper smooth part	Lower rough part
+	Dome shape	Semilunar	Triangular
+	Horizontal	Quadrangular	Quadrangular
+	Oblique	Oval	Oval
-	None	Round	Round

Table 2: Total number of different shapes of upper smooth and lower rough part of tibial tuberosity depending upon shapes of the groove separating these two parts

Parts of tibial tuberosity	Semilunar	Triangular	Quadrangular	Oval	Round	Total
Upper smooth part	12	0	3	1	6	22
Lower rough part	0	9	8	3	2	22

Table 3: Sidewise distribution of length and breadth of upper smooth part and lower rough part of tubial tuberosity.

Side	Upper smooth part		Lower rough part		Total
	Length(cm)	Breadth (cm)	Length	Breadth	
Right	1.77	1.95	2.43	2.27	
Left	1.75	1.92	2.08	1.95	

Table 4: Sex wise and Sidewise distribution of length and breadth of tibial tuberosity.

Sex	Right		Left	
	Length (cm)	Breadth (cm)	Length (cm)	Breadth (cm)
Male	1.77	1.6	2.48	2.28
Female	1.71	1.71	1.77	1.67

Biostatistics

Statistical data's for upper smooth part of tibial tuberosity (A)

Descriptive

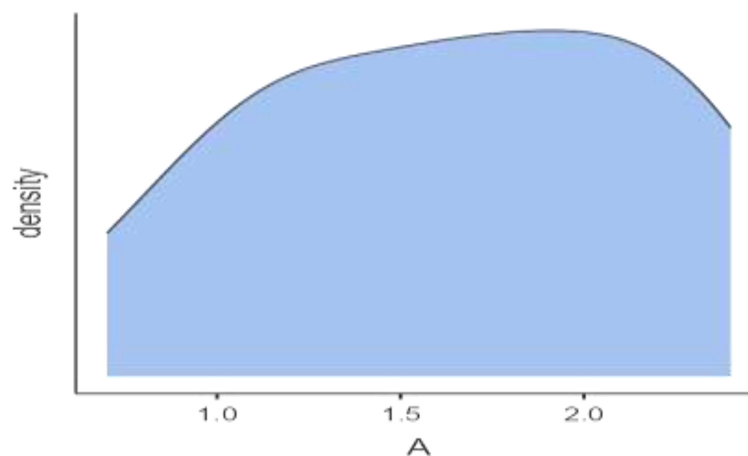
	A
N	12
Mean	1.65
Std. error mean	0.157
95% CI mean lower bound	1.30
95% CI mean upper bound	2.00
Median	1.70
Mode	1.10 [a]
Standard deviation	0.545
IQR	0.950
Range	1.70

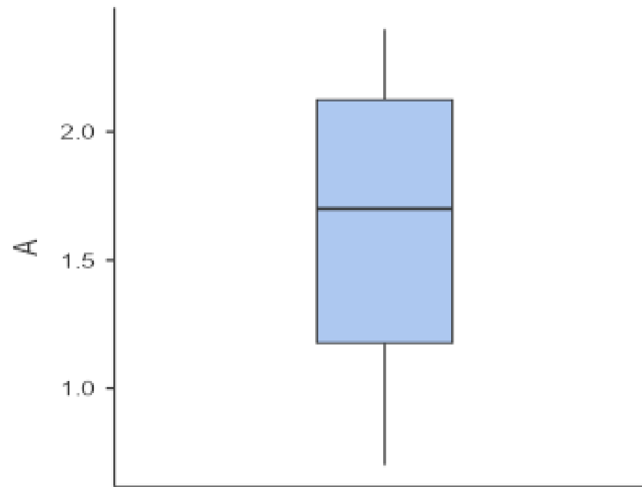
Note. The CI of the mean assumes sample means follow a t-distribution with N - 1 degrees of freedom

[a] More than one mode exists, only the first is reported

Plots

A





One Sample T-Test				
		Statistic	df	p
A	Student's t	10.5	11.0	< .001

Note. H_a $\mu \neq 0$

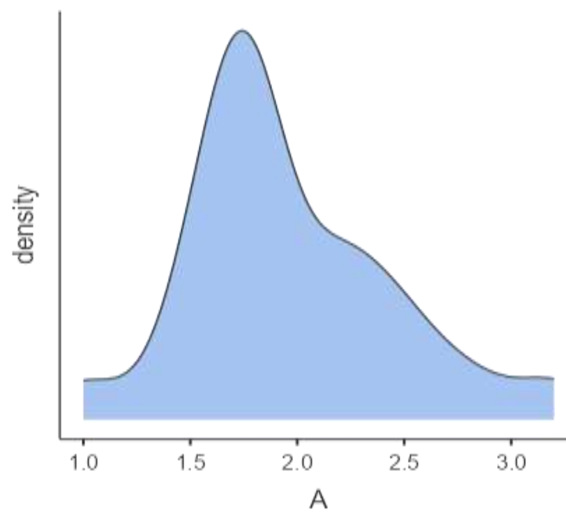
[2] Statistical date's of lower rough part of tibial tuberosity (B) -

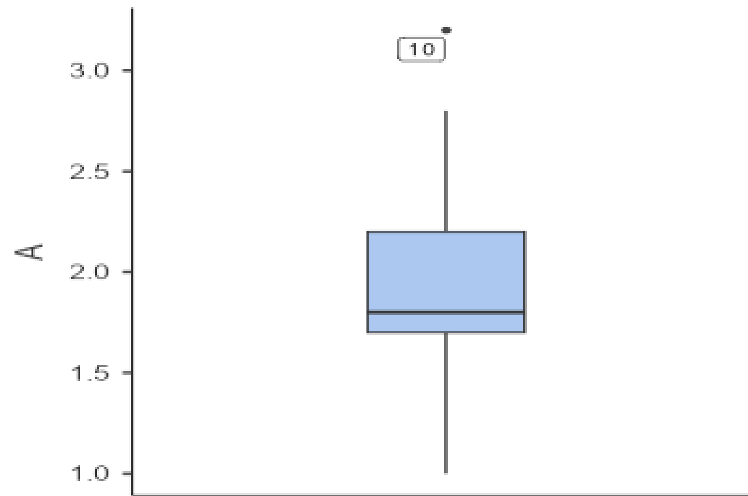
Descriptive	
	B
N	21
Mean	1.97
Std. error mean	0.108
95% CI mean lower bound	1.74
95% CI mean upper bound	2.19
Median	1.80
Mode	1.80
Standard deviation	0.495
IQR	0.500

Note. The CI of the mean assumes sample means follow a t-distribution with N - 1 degrees of freedom

Plots

B





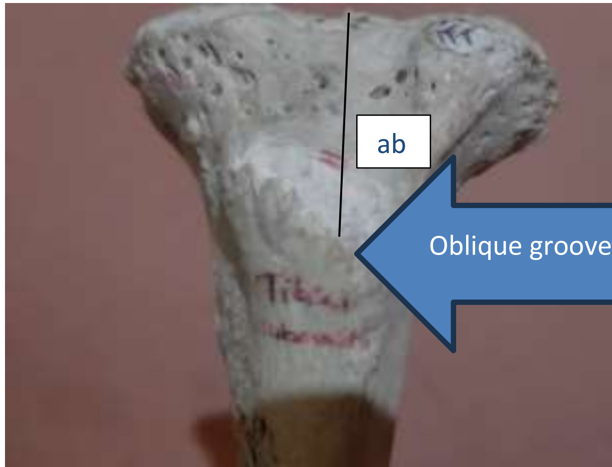
One Sample T-Test

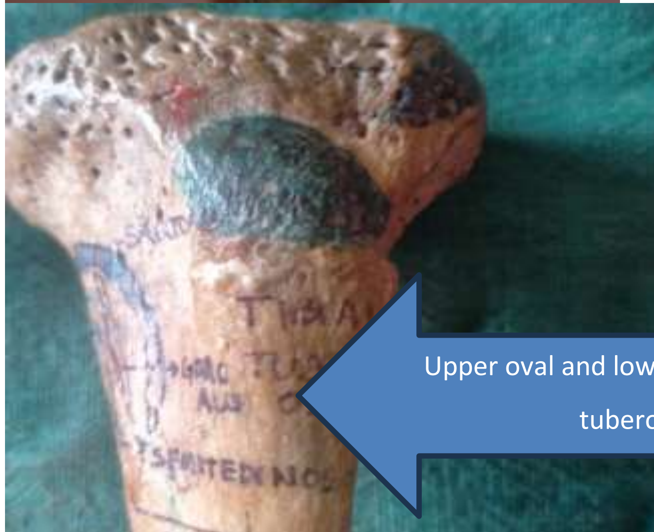
One Sample T-Test				
		Statistic	**df**	**p**
B	Student's t	18.2	20.0	< .001
Note. H_a $\mu \neq 0$				

Distance between tibial tuberosity and tibial joint surface in males (C) and females (D):

Descriptives		
	C	**D**
N	8	13
Missing	7	2
Mean	1.88	1.77
Median	2.00	2
Standard deviation	0.354	0.599
Minimum	1	1
Maximum	2	3

One Sample T-Test				
		Statistic	**df**	**p**
C	Student's t	15.0	7.00	< .001
D	Student's t	10.6	12.00	< .001
Note. H_a $\mu \neq 0$				





Upper round and lower triangular part of tibial tuberosity

No groove, round tibial tuberosity

In their study, Bhat R, Amar D N, Rathan R, and Samapriya N analyzed the morphometry of the tibial tuberosity (TT) and observed side and gender differences. They found that the

whole and distal length of TT was greater on the left side than on the right, indicating a difference in the vertical extent of the patellar tendon fiber attachment. Additionally, they noted that the maximum breadth of TT was greater on the right side than on the left, indicating a wider and firmer attachment of the patellar tendon on the right side.

Moreover, the researchers found that, except for the proximal breadth, all parameters measured for TT morphometry were greater in males than in females. This suggests that the patellar tendon transmits more force in males, leading to increased TT dimensions. They further explained that TT is a traction apophysis, indicating that avulsion fracture of the tibial tuberosity occurs more frequently in the male population than in females. In my study it was found that length of distal part of tibial tuberosity is more than the length of the proximal tibial tuberosity and breadth of distal tibial tuberosity is more than the breadth of proximal tibial tuberosity. On right side it is more than on left side. Sojka JH, Everhart JS, Kirven JC, Beal MD, Flanigan DC et.al, discovered that the mean tuberosity distance from the joint surface was 29.2mm (SD 3.5, range 16.6-38.6mm) and was greater in males than in females (30.7mm (SD 2.9) vs. 27.6mm (SD 3.3); $p<0.001$). They also observed that the tuberosity distance from the joint surface increased by an average of 0.18mm per 1.0cm increase in height ($p<0.001$).[5]

In our study, we found that the mean distance between the tibial tuberosity and the upper tibial joint surface is 2.33cm. In males, the distance between the tibial tuberosity and the upper tibial joint surface is 2.5cm (2.2cm on the left side and 2.8cm on the right side) (SD = 3.5, range 1.9cm-3.7cm, $p<.001$). In females, the distance between the tibial tuberosity and the upper tibial joint surface is 2.3cm (2.5cm on the left side and 2.2cm on the right side) (SD=5.9, range 1.9cm-3.5cm, $p<.001$).

Consequently, avulsion fractures of the tibial tuberosity are more common on the right side in males, while in females, they are more frequently found on the left side, as indicated by the distance between the tibial tuberosity and the upper tibial joint surface.. In a study conducted by Ortug, A; Ormeci, T, Yuzbasioglu et.al, it was found that the total mean TTTG was 10.02 ± 1.51 mm (minimum 7.00 mm and maximum 14.90 mm), with no statistically significant difference between males and females. The mean TTTG for males was found to be 10.07 ± 1.60 mm and for females 9.96 ± 1.41 mm ($P > 0.05$). However, when comparing TTTG between the left and right knee, the mean TTTG for the right knee was 9.81 ± 1.49 mm (n = 105) and 10.24 ± 1.50 mm for the left knee. This difference was found to be statistically significant ($P < 0.05$) [6].

Furthermore, Dong C, Zhao C, and Li M et.al, suggested that an increased tibial tubercle-trochlear groove distance (TT-TG) of 2 cm was one of the main risk factors for patel

lofemoral instability (PFI).[7]. The study by Mahmoud J, Alrashedan BS, Allimmia KM, Alanazi B, Alshehri TA highlighted that tibial tubercle avulsion fractures are frequently observed in athletic males, with basketball players being the most commonly affected. The primary reported causes of injury were linked to jumping activities, direct falls on the knee, and twisting injuries. The researchers found that using five 4.5 mm partially threaded cancellous screws led to a successful outcome in definitive fixation. In our case, we opted for a different surgical approach, achieving reduction with three 3.5 mm partially threaded cancellous screws for the tibial tuberosity fracture. Additionally, we utilized a proximal tibial plate to support the lateral tibial column. [10]

CONCLUSION

With the dimensions of tibial tuberosity one can find the proper screw size for fixation of tibial tuberosity in avulsion fracture.

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