Original Article

Morphometric Analysis of Tibial Tuberosity in Dry Adult Human Tibiae: An Institutional Study

Rabia Farooq[1], Mohd Saleem Itoo[2], Ghulam Mohammad Bhat[2]

[1]Resident, Department of Anatomy, Government Medical College Srinagar, Postgraduate Department of Anatomy, Government Medical College, Srinagar, Jammu and Kashmir, India. [2]Professor, Department of Anatomy, Government Medical College Srinagar, Postgraduate Department of Anatomy, Government Medical College, Srinagar, Jammu and Kashmir, India

Abstract

Background: The tibial tuberosity, a bony projection on the anterior proximal tibia, serves as the attachment for the patellar ligament and is critical for knee biomechanics. Accurate morphometric data are essential for clinical and surgical applications. This study aimed to assess the morphological characteristics of the tibial tuberosity in right and left tibiae to understand its anatomical variations and clinical relevance. **Material and Methods:** A total of 110 tibiae (55 right and 55 left) were analyzed for the distance of the tibial tuberosity from the anterior border of the intercondylar area, as well as the length and breadth of its upper smooth and lower rough parts. Measurements were categorized, and mean ± SD values were calculated for each parameter. Side-to-side comparisons were performed, and p-values <0.05 were considered statistically significant. **Results:** The distance of the tibial tuberosity from the anterior border of the intercondylar area was most commonly within 12–15 mm (58.2% overall). The mean distance was 13.71 ± 1.48 mm in right tibiae and 14.12 ± 1.68 mm in left tibiae, with no significant difference between sides (p = 0.167). For the length of the tibial tuberosity, the upper smooth part predominantly measured 15–19 mm (62.7% overall), with mean lengths of 18.46 ± 3.69 mm (right) and 17.97 ± 3.52 mm (left), whereas the lower rough part mostly measured 28–32 mm (66.4% overall), with mean lengths of 31.07 ± 4.63 mm (right) and 30.07 ± 4.37 mm (left); differences between sides were not statistically significant (upper smooth p = 0.477; lower rough p = 0.246). Regarding breadth, the upper smooth part was commonly measured to be 15–18 mm (64.5%), and the lower rough part was 16–19 mm (64.5%). Mean breadths were comparable between right and left tibiae (upper smooth: 16.69 ± 3.25 mm vs. 16.32 ± 2.97 mm, p = 0.534; lower rough: 17.14 ± 3.11 mm vs. 17.28 ± 2.85 mm, p = 0.806). **Conclusion:** No significant differences were observed between right and left tibiae. Most tibial tuberosities had moderate distances, lengths, and breadths. These morphometric data provide valuable guidance for surgical planning, prosthetic design, and understanding knee pathologies such as Osgood-Schlatter syndrome.

Keywords: Tibial tuberosity, Morphometry, Upper smooth part, Lower rough part, Intercondylar area, Knee anatomy, Side-to-side comparison, Human tibia.

Received: 14 August 2025 **Revised: 16 September 2025** **Accepted: 22 October 2025** **Published: 02 December 2025**

Introduction

The tibial tuberosity (TT) is a prominent bony projection located on the anterior surface of the proximal tibia, just below the condylar region. It serves as the insertion site for the patellar ligament, which transmits the powerful contraction forces generated by the quadriceps femoris muscle to the tibia, thereby facilitating knee extension. [1,2] This structural configuration constitutes a vital component of the extensor mechanism of the lower limb, playing an indispensable role in maintaining gait, posture, and performing activities such as squatting, jumping, and running. Developmentally, the TT is an apophysis that forms under tractional forces.[3] Its formation progresses through four stages: cartilaginous, apophyseal, epiphyseal, and bony. Ossification of the tuberosity typically begins between seven and nine years of age, arising as a distal ossification focus that gradually enlarges proximally and anteriorly. Concurrently, the proximal tibial epiphysis expands downward, contributing to the development of the tuberosity.[4] Anatomically, the TT projects only modestly and is divided into two regions: a proximal smooth region, which serves as the attachment site of the patellar tendon, and a distal rough region, which remains palpable on clinical examination.[5] The morphology of the tibial tuberosity shows considerable variation among individuals, influenced by genetic, developmental, and functional factors.[6] These variations are not only of anatomical and anthropological interest but also bear direct clinical and surgical relevance. Accurate morphometric knowledge of the tibial tuberosity is essential for procedures involving the proximal tibia, including anterior cruciate ligament

Address for correspondence: Dr. Rabia Farooq,
Resident, Department of Anatomy, Government Medical College Srinagar,
Postgraduate Department of Anatomy, Government Medical College, Srinagar,
Jammu and Kashmir, India
E-mail: rabiafarooqi76@gmail.com

DOI:
10.21276/amit.2025.v12.i3.215

How to cite this article: Farooq R, Itoo MS, Bhat GM. Morphometric Analysis of Tibial Tuberosity in Dry Adult Human Tibiae: An Institutional Study. Acta Med Int. 2025;12(3):994-998.

(ACL) reconstruction, tibial tuberosity osteotomy, corrective osteotomies for patellar maltracking, and the design of tibial implants in knee arthroplasty. Inadequate understanding of its dimensions may lead to improper fixation, altered biomechanics, or complications such as anterior knee pain and patellofemoral instability. Pathological alterations involving the tibial tuberosity further highlight its clinical importance. In adolescents, repeated stress and traction at the tibial tuberosity can result in Osgood–Schlatter disease, characterized by pain, swelling, and prominence of the tuberosity.[7-9] In adults, abnormal positioning or excessive lateralization of the tibial tuberosity is a known factor in recurrent patellar dislocation and anterior knee pain syndrome.[10-12] Additionally, traumatic injuries and degenerative changes involving this region often complicate surgical approaches, necessitating a detailed understanding of its morphometry.

From both anthropological and forensic perspectives, the tibial tuberosity serves as a useful marker for skeletal identification and population-based studies. Its morphology and dimensions may reflect mechanical loading patterns, lifestyle adaptations, and genetic influences across different groups. Despite its clinical significance, detailed morphometric studies on the tibial tuberosity, particularly in dry adult human tibiae, remain relatively limited. Establishing baseline data on its dimensions and morphological characteristics is important for improving the accuracy of surgical planning, prosthetic design, and anthropological research. The present study aims to provide a comprehensive morphometric analysis of the tibial tuberosity in dry adult human tibiae, thereby contributing to the anatomical literature and enhancing the understanding of its clinical relevance.

Materials and Methods

This descriptive cross-sectional study was conducted in the Department of Anatomy at Government Medical College, Srinagar, over six months to evaluate morphometric parameters of the tibial tuberosity in dry human tibiae. A total of 110 tibiae, comprising 55 right and 55 left bones, were included. The specimens were obtained from the departmental osteological collection, and details such as age and sex were not available. Only bones that were intact and free from deformities, fractures, or pathological changes affecting the proximal tibia and tibial tuberosity were included, while damaged or deformed specimens were excluded to ensure measurement accuracy.

All measurements were taken using a digital Vernier calliper with an accuracy of 0.01 mm under standardized conditions. The morphometric parameters studied included the height of the tibial tuberosity, measured from the base to its most prominent superior point; the width, taken as the maximum transverse dimension across the tuberosity; and the prominence, recorded as the anteroposterior projection from the anterior tibial surface to the most prominent point of the tuberosity. Each measurement was performed three times by the same observer, and the mean of the three readings was used as the final value to minimize observational bias.

Data were tabulated using Microsoft Excel and analyzed with SPSS software (version 20, IBM Corp., USA). Descriptive statistics, including mean, standard deviation, and range, were calculated for each parameter, and an independent samples t-test was applied to compare morphometric values between right- and left-sided tibiae. A p-value of less than 0.05 was considered statistically significant. To ensure the reliability of measurements, a subset of 10% of specimens was randomly selected for repeat measurements at different intervals to assess intra-observer consistency. The digital caliper was calibrated before each measurement session. The study was conducted in accordance with institutional ethical standards. Since the bones were anonymized dry specimens of unknown age and sex, individual consent was not required; however, permission for the use of osteological material was obtained from the Institutional Ethics Committee of Government Medical College, Srinagar.

Results

[Table 1] Presents the categorical distribution of morphometric parameters of the tibial tuberosity in right and left tibiae. The distance of the tibial tuberosity from the anterior border of the intercondylar area was most commonly within the range of 12–15 mm, observed in 60.0% of right tibiae and 56.4% of left tibiae, comprising 58.2% of the total sample. Distances less than 12 mm were recorded in 18.2% of right and 20.0% of left tibiae, while distances ≥15 mm were noted in 21.8% and 23.6%, respectively. For the length of the upper smooth part of the tibial tuberosity, the majority of specimens fell in the 15–19 mm category, accounting for 61.8% of right tibiae and 63.6% of left tibiae. Shorter lengths (<15 mm) were seen in 16.4% of right and 14.5% of left tibiae, whereas lengths ≥19 mm were recorded in 21.8% of both sides. The length of the lower rough part of the tibial tuberosity predominantly measured 28–32 mm, with 65.5% of right and 67.3% of left tibiae in this category. Measurements <28 mm were observed in 14.5% of right and 12.7% of left tibiae, while ≥32 mm lengths were noted in 20.0% of both sides. Regarding the breadth of the upper smooth part, most tibiae (65.5% right and 63.6% left) measured between 15 and 18 mm. Narrower breadths (<15 mm) were seen in 12.7% of right and 14.5% of left tibiae, while ≥18 mm was recorded in 21.8% of both sides. Similarly, the breadth of the lower rough part is most frequently measured between 16 and 19 mm, found in 63.6% of right and 65.5% of left tibiae. Breadths <16 mm were noted in 16.4% of right and 14.5% of left tibiae, whereas ≥19 mm was observed in 20.0% of both sides.

Table 1: Categorical Distribution of Morphometric Parameters of Tibial Tuberosity in Right and Left Tibiae

Parameter	Range (mm)	Right Tibiae (n=55)	Left Tibiae (n=55)	Total (n=110)
Distance of tibial tuberosity from anterior border of intercondylar area	<12	10 (18.2%)	11 (20.0%)	21 (19.1%)
	12–15	33 (60.0%)	31 (56.4%)	64 (58.2%)
	≥15	12 (21.8%)	13 (23.6%)	25 (22.7%)

Length of upper smooth part of tibial tuberosity	<15	9 (16.4%)	8 (14.5%)	17 (15.5%)
	15–19	34 (61.8%)	35 (63.6%)	69 (62.7%)
	≥19	12 (21.8%)	12 (21.8%)	24 (21.8%)
Length of lower rough part of tibial tuberosity	<28	8 (14.5%)	7 (12.7%)	15 (13.6%)
	28–32	36 (65.5%)	37 (67.3%)	73 (66.4%)
	≥32	11 (20.0%)	11 (20.0%)	22 (20.0%)
Breadth of upper smooth part of tibial tuberosity	<15	7 (12.7%)	8 (14.5%)	15 (13.6%)
	15–18	36 (65.5%)	35 (63.6%)	71 (64.5%)
	≥18	12 (21.8%)	12 (21.8%)	24 (21.8%)
Breadth of lower rough part of tibial tuberosity	<16	9 (16.4%)	8 (14.5%)	17 (15.5%)
	16–19	35 (63.6%)	36 (65.5%)	71 (64.5%)
	≥19	11 (20.0%)	11 (20.0%)	22 (20.0%)

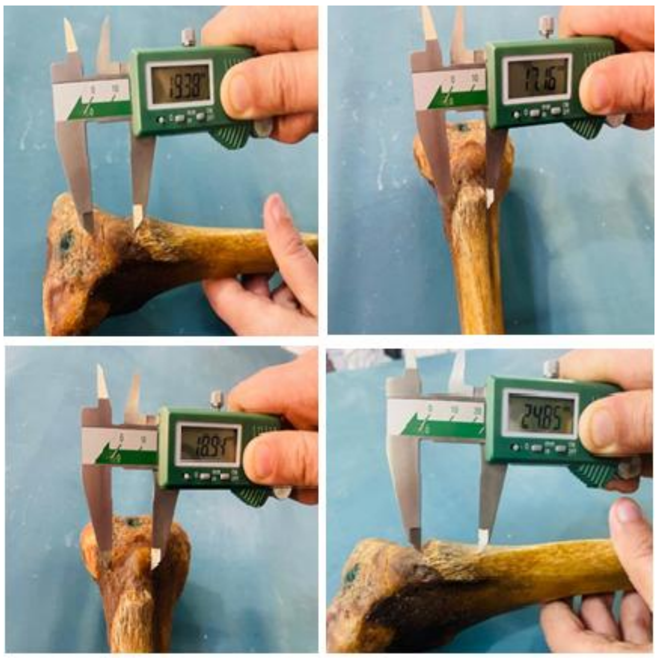


Figure 1: Morphometric Measurements of Tibial Tuberosity using Vernier's calipers

[Table 2] Presents the comparison of the distance of the tibial tuberosity from the anterior border of the intercondylar area between right and left tibiae. The mean distance in the right tibiae was 13.71 ± 1.48 mm, ranging from 10.2 to 16.08 mm, whereas in the left tibiae it was slightly higher at 14.12 ± 1.68 mm, with a range of 11.64 to 17.04 mm. When combined, the overall mean distance for both sides was 13.91 ± 1.58 mm, with values ranging between 10.2 and 17.04 mm. The observed difference between right and left tibiae was statistically not significant (p = 0.167).

[Table 3] Shows the comparison of the length of the tibial tuberosity, subdivided into its upper smooth and lower rough parts, between right and left tibiae. The mean length of the upper smooth part was 18.46 ± 3.69 mm in right tibiae (range: 13.5–23.40 mm) and 17.97 ± 3.52 mm in left tibiae (range: 13.2–22.74 mm). The combined mean length was 18.22 ± 3.60 mm (range: 13.2–23.40 mm). The difference between sides was not statistically significant (p = 0.477). For the lower rough part, the mean length in right tibiae was 31.07 ± 4.63 mm (range: 28.6–33.54 mm), while in left tibiae it was 30.07 ± 4.37 mm (range: 27.3–32.84 mm). The pooled mean length was 30.57 ± 4.50 mm (range: 27.3–33.54 mm). Again, the side-to-side difference was not statistically significant (p = 0.246).

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

Parameter	Right Tibiae (n=55)	Left Tibiae (n=55)	Total (n=110)	p-value
Mean± SD (mm) Range (mm)	13.71 ± 1.48 10.2–16.08	14.12 ± 1.68 11.64–17.04	13.91 ± 1.58 10.2–17.04	0.167

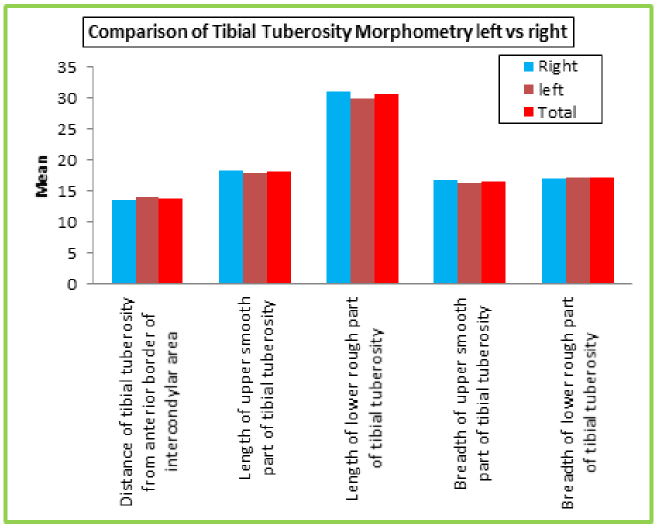
Table 3: Comparison of Length of Tibial Tuberosity (Upper Smooth and Lower Rough Parts) in Right and Left Tibiae

Parameter	Right Tibiae (n=55)	Left Tibiae (n=55)	Total (n=110)	p-value
Length of upper smooth part (mm) Range (mm)	18.46 ± 3.69 13.5–23.40	17.97 ± 3.52 13.2–22.74	18.22 ± 3.60 13.2–23.40	0.477
Length of lower rough part (mm) Range (mm)	31.07 ± 4.63 28.6–33.54	30.07 ± 4.37 27.3–32.84	30.57 ± 4.50 27.3–33.54	0.246

Table 4: Comparison of Breadth of Tibial Tuberosity (Upper Smooth and Lower Rough Parts) in Right and Left Tibiae

Parameter	Right Tibiae (n=55)	Left Tibiae (n=55)	Total (n=110)	p-value
Breadth of upper smooth part (mm) Range (mm)	16.69 ± 3.25 14.5–18.88	16.32 ± 2.97 14.2–18.88	16.51 ± 3.11 14.2–18.88	0.534 0.806
Breadth of lower rough part (mm) Range (mm)	17.14 ± 3.11 15.2–19.08	17.28 ± 2.85 15.6–18.96	17.21 ± 2.98 15.2–19.08	

[Table 4] presents the comparison of the breadth of the tibial tuberosity. The upper smooth part measured 16.69 ± 3.25 mm in right tibiae and 16.32 ± 2.97 mm in left tibiae, with a combined mean of 16.51 ± 3.11 mm; the difference was not statistically significant (p = 0.534). The lower rough part measured 17.14 ± 3.11 mm (right) and 17.28 ± 2.85 mm (left), with a combined mean of 17.21 ± 2.98 mm, also showing no significant difference (p = 0.806).



Discussion

In the present study, the mean distance of the tibial tuberosity from the anterior border of the intercondylar area was found to be 13.71 ± 1.48 mm on the right side and 14.12 ± 1.68 mm on the left side, with an overall mean of 13.91 ± 1.58 mm. Although the left side demonstrated a slightly greater value, the difference was statistically not significant (p = 0.167). These findings are consistent with previous literature, which has similarly reported no significant laterality differences. Simriti et al. (2019) documented mean distances of 11.86 ± 3.01 mm on the right and 12.92 ± 2.28 mm on the left in a North Indian population, also finding the left side to be slightly higher, although the difference was not statistically significant.[13] More recently, Asad et al. (2025) reported higher mean values of 15.33 ± 3.32 mm on the right and 15.75 ± 3.32 mm on the left, with a combined mean of 15.54 ± 2.10 mm, again showing no significant side variation.[1] In comparison, Hughes and Sunderland (1946) documented a mean distance of 20 mm in the Australian population. However, they did not differentiate between right and left sides, highlighting possible ethnic and methodological variations.[14] The findings of the present study are also in close agreement with those of Randev et al., who reported mean values of 14.34 ± 2.33 mm on the right and 14.76 ± 2.33 mm on the left, with a total mean of 14.55 ± 2.11 mm.[15] Similar to the current study, they observed a slightly greater distance on the left side, though the difference was statistically insignificant (p = 0.574). This consistency across studies suggests that while minor variations in the mean distance may exist due to population-specific anatomical differences, gender distribution, or sample size, the lack of significant laterality differences appears to be a reliable observation across populations.

In the present study, the mean length of the upper smooth part was slightly greater in right tibiae (18.46 ± 3.69 mm) than in left tibiae (17.97 ± 3.52 mm), whereas the lower rough part was also found to be marginally longer on the right side (31.07 ± 4.63 mm) compared to the left (30.07 ± 4.37 mm). However, these side-to-side differences were statistically not significant, indicating overall symmetry between the right and left tibiae. When compared with previous literature, the values observed in our study are lower than those reported by Simriti et al. (2019), who documented mean lengths of 22.31 ± 4.06 mm (right) and 22.03 ± 4.71 mm (left) for the upper smooth part, and 48.68 ± 6.96 mm (right) and 48.56 ± 7.13 mm (left) for the lower rough part.13 Similarly, Asad et al. (2025) found even higher values, with upper smooth part lengths of 24.59 ± 4.88 mm (right) and 24.53 ± 4.24 mm (left), and lower rough part lengths of 46.83 ± 6.12 mm (right) and 47.77 ± 6.08 mm (left), however likewise to our study the side-to-side differences for mean length of upper and lower smooth parts were statistically not significant.[1]1 Randev et al. (2021) also reported larger mean values, with the upper smooth part measuring 23.60 ± 3.89 mm (right) and 23.54 ± 3.25 mm (left), while the lower rough part measured 45.84 ± 5.13 mm (right) and 46.78 ± 5.09 mm (left).[15] All these studies, however, consistently demonstrated no statistically significant side differences, similar to the present findings. The consistently higher values in earlier studies compared to our results may be attributed to population variability, sample size, and methodological differences. Variations in ethnicity and skeletal build are well documented to influence morphometric parameters, while the use of different reference landmarks or measuring instruments may further contribute to the observed heterogeneity. Nevertheless, the repeated observation across studies of a lack of significant bilateral differences highlights the symmetrical development of the tibial tuberosity. This symmetry can be ascribed to the balanced mechanical loading exerted by the patellar tendon during growth and locomotor activities, which promotes uniform modeling of the bony attachment site.

In the present study, the breadth of the tibial tuberosity showed remarkable bilateral symmetry. The upper smooth part measured 16.69 ± 3.25 mm on the right and 16.32 ± 2.97 mm on the left, with a combined mean of 16.51 ± 3.11 mm (p = 0.534). Similarly, the lower rough part measured 17.14 ± 3.11 mm on the right and 17.28 ± 2.85 mm on the left, with an overall mean of 17.21 ± 2.98 mm (p = 0.806). These findings are consistent with prior morphometric studies, which have likewise identified no significant laterality differences. Simriti et al. (2019) reported higher breadth measurements in a North Indian sample, with the upper smooth part averaging 20.04 ± 1.68 mm (right) and 20.50 ± 1.56 mm (left), and the lower rough part averaging 20.51 ± 2.26 mm (right) and 19.82 ± 2.72 mm (left).[13] Despite the higher absolute values, their results also displayed symmetrical breadths across both sides, reinforcing the anatomical consistency observed in our study. Similarly, in the likewise study by Asad et al. (2025), the upper smooth part had a mean breadth of 21.28 ± 1.53 mm (right) and 21.01 ± 1.53 mm (left), while the lower rough part measured 22.04 ± 3.26 mm (right) and 22.88 ± 1.91 mm (left), again showing no significant lateral variation.1 Randev et al. (2021) similarly reported mean breadths of approximately 20.29 ± 1.54 mm (right) and 20.02 ± 1.52 mm (left) for the upper smooth part, and 21.05 ± 2.27 mm (right) versus 21.89 ± 1.90 mm (left) for the lower rough part, findings that also confirmed bilateral symmetry.[15] The relatively smaller breadth measurements in the present study may be attributable to regional anatomical variability and differences in skeletal build across populations, as well as potential variations in the age distribution or preservation status of specimens examined.

Despite these differences in absolute values, the consistent finding across multiple investigations is the absence of lateral asymmetry in tibial tuberosity breadth, further reinforcing the notion that this structure develops symmetrically under the influence of balanced biomechanical forces.

Conclusion

The present study demonstrated that the morphometric parameters of the tibial tuberosity, including the length and breadth of the upper smooth and lower rough parts as well as the distance of the tibial tuberosity from the anterior border of the intercondylar area, showed no significant variation between the right and left sides, reflecting the inherent bilateral symmetry of this bony landmark. Such symmetry is crucial for maintaining the balanced functioning of the extensor mechanism of the knee, where the tibial tuberosity forms the key attachment site for the patellar tendon. The anatomical data generated in this study offer a comprehensive understanding of the morphometry of the dry adult tibial tuberosity, providing a valuable reference point for clinical practice. In particular, identifying the most prominent point of the tibial tuberosity in relation to the anterior border of the intercondylar area carries significant implications for orthopaedic surgeons, radiologists, rehabilitation specialists, and sports medicine practitioners, thereby enhancing diagnostic precision, surgical accuracy, and rehabilitative strategies.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Asad MR. A Morphometric Examination of Tibial Tuberosity in the North Indian Population. J Pharm Bioallied Sci. 2025 May;17(Suppl 1): S869-S872. Doi: 10.4103/jpbs.jpbs_1798_24. Epub 2025 Mar 19. PMID: 40510968; PMCID: PMC12156564.
2. Deopujari S, Kiel J. Knee Extensor Mechanism Injuries. [Updated 2023 Apr 10]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK554587//
3. Ehrenborg G, Engfeldt B. The insertion of the ligamentum patellae on the tibial tuberosity. Some views related to the Osgood–Schlatter lesion. Acta Chir Scand 1961; 121:491–499.
4. Ogden JA. Radiology of postnatal skeletal development. X. Patella and tibial tuberosity. Skeletal Radiol 1984; 11(4): 246-57.
5. Standring S, Borley NR, Collins P, Crossman AR, Gatzoulis MA, Healy JC, et al, editors. Gray's anatomy: The Anatomical basis of clinical practice. 40th ed. UK, Elsevier Ltd; 2008. p. 1412-15.
6. Sojka JH, Everhart JS, Kirven JC, Beal MD, Flanigan DC. Variation in tibial tuberosity lateralization and distance from the tibiofemoral joint line: An anatomic study. Knee. 2018 Jun;25(3):367-373. doi: 10.1016/j.knee.2018.03.006. Epub 2018 Apr 19. PMID: 29681529.
7. Carius BM, Long B. Osgood-Schlatter disease as a possible cause of tibial tuberosity avulsion. Cureus. 2021 Feb 10;13(2).
8. Grimm NL, Weiss JM, Kessler JI, Aoki SK. Osteochondritis dissecans of the knee: pathoanatomy, epidemiology, and diagnosis. Clinics in sports medicine. 2014 Apr 1;33(2):181-8. Sanchis-Alfonso V, McConnell J, Monllau JC, Fulkerson JP. Diagnosis and treatment of anterior knee pain. Journal of ISAKOS. 2016 May 1;1(3):161-73.
9. Nowinski RJ, Mehlman CT. Hyphenated history: Osgood-Schlatter disease. American Journal of Orthopedics-belle mead-. 1998 Aug 1; 27:584-5.
10. Sanchis-Alfonso V, McConnell J, Monllau JC, Fulkerson JP. Diagnosis and treatment of anterior knee pain. Journal of ISAKOS. 2016 May 1;1(3):161-73.
11. Smith JM, Varacallo MA. Osgood-Schlatter Disease. [Updated 2023 Aug 4]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK441995/
12. Watts RE, Gorbachova T, Fritz RC, Saad SS, Lutz AM, Kim J, Chaudhari AS, Shea KG, Sherman SL, Boutin RD. Patellar Tracking: An Old Problem with New Insights. Radiographics. 2023 Jun;43(6):e220177. Doi: 10.1148/rg. 220177. PMID: 37261964; PMCID: PMC10262599.
13. Simriti B, Raina S, Arban K. Study of various dimensions of tibial tuberosity in dry human tibia. Paripex Indian J Res. 2019;8(4):69–70.
14. Hughes ESR, Sunderland S. The tibial tuberosity and the insertion of the ligamentum patellae. Anat Rec 1946; 96:439 44.
15. Randev A, Ghosh B, Parashar V. Morphometric study of the tibial tuberosity in the North Indian population. J Cardiovasc Dis Res. 2024;15(1):829–36.