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Forensic and Clinical Significance of Nutrient Foramen: A Morphometric Study on Adult Human Tibia

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Introduction

All long bones in the human body receive blood supply from a nutrient artery, which enters the bone through the nutrient foramen. Typically, this foramen is located away from the bone's growing end [1]. In the tibia, the upper end is the growing end, so the nutrient foramen is generally directed downward. The nutrient artery, which typically originates from the posterior tibial artery, enters the tibia through the nutrient foramen and travels through the nutrient canal. Upon reaching the medullary cavity, the artery divides into ascending and descending branches, which extend toward the epiphyses. Near the endosteal surface, these branches continuously subdivide into smaller, helical vessels. Additionally, small perforating arteries enter the tibia at the metaphysis and epiphysis, connecting with the diaphyseal vessels near the bone's epiphysis. The nutrient foramen of the tibia is generally located near the soleal line in the upper third of the bone. It transmits the nutrient artery, usually a branch of the posterior tibial artery, though it can also originate from the anterior tibial artery. A prominent vascular groove is often present on the bone's surface, leading toward the nutrient foramen [2]. The nutrient artery typically enters the tibia through the nutrient foramen located in the upper third of the shaft. As a result, the lower third of the bone receives less nutrition, making it more

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vulnerable to fractures [4]. Nutrient arteries provide approximately 70-80% of the blood supply to long bones in children. A reduction in this blood flow can lead to bone ischemia, resulting in decreased vascularization of the growth plate and metaphysis [3]. A thorough understanding of nutrient foramen is crucial for surgeons to achieve optimal surgical outcomes and favorable prognoses [5]. The tibia is commonly involved in various surgical procedures, such as knee replacement, bone grafting, tumor resection, and fracture fixation [6]. Accurate mapping of nutrient foramen can also enhance the precision of orthopaedic and microvascular surgeries.

Materials & Methods

This observational cross-sectional study was conducted in the Department of Forensic Medicine & Toxicology at Rama Medical College Hospital & Research Centre Hapur, Uttar Pradesh, India from October 2024 to August 2025. The study utilized 400 humerus bones from the Western Uttar Pradesh population, with an equal distribution of right and left side bones. Since the research involved dry human bones, ethical clearance was not required. Bones exhibiting deformities, pathological changes, or significant age-related deterioration were excluded; only fully ossified and complete bones were included. Foramen that allowed the passage of a 24-gauge needle were classified as primary nutrient foramen [7], while smaller foramen that did not permit the needle's passage were excluded from the analysis [8]. The side determination of each tibia was performed using universally accepted criteria. A sliding Vernier calliper (resolution = 0.06 mm) and an osteometric board were used for all measurements, with the following parameters recorded:

1. Total number of primary nutrient foramina
2. Direction of the foramen (upward or downward)
3. Location of the nutrient foramen on the shaft surface
4. Position of the nutrient foramen on the posterior surface of the shaft (lateral, medial, or directly on a vertical line)
5. Distance from the nutrient foramen to the proximal end of the tibia (PF), measured with a Vernier calliper
6. Total length of the tibia (TL), measured using an osteometric board.

   The Foramen Index was calculated using Hughes' formula [9]
   Foramen Index = (PF/TL) × 100.

   Based on the Foramen Index, the location of the nutrient foramen was classified as follows [10]

   (i) Foramen Index less than 33.33 indicates the foramen is in the upper third of the bone,
   (ii) Foramen Index between 33.33 and 66.66 indicates it is in the middle third of the bone,
   (iii) Foramen Index greater than 66.66 signifies the foramen is located in the lower third of the bone.

All observations were recorded and organized in a Microsoft Excel worksheet. The following data were calculated:

1. Average total length of the tibia,
2. Average distance between the nutrient foramen and the proximal end of the tibia,
3. Foramen Index.

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Statistical analysis was performed using SPSS software version 25.0. Data was recorded in MS Excel, and tables and graphs were generated using the same software.

Figure 1: Nutrient foramen present on the posterior surface at the upper 1/3 part of the bone

Figure 2: Nutrient foramen is present on the posterior surface at the upper1/3 part of the bone.

Figure 3: Nutrient Foramen is present on the posterior medial surface at the upper 1/3 part of the bone

Figure 4: Nutrient foramen present at the posteromedial surface at the upper 1/3 part of the bone

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Figure 5: Nutrient foramen is present at the anterolateral surface at the middle 1/3 part of the bone.

Result

In this study, 400 tibia bones were analysed, and all were found to have a single nutrient foramen. In the majority of tibia, the foramen was directed downward and located in the upper third of the posterior surface (Figures 1–4). In five tibiae, the nutrient foramen was positioned in the middle third of the bone (Figure 5). Additionally, in seven tibias, the foramen was observed on the lateral surface, and in one case, it was directed upward.

Table 1: Direction of nutrient foramen

The direction of nutrient foramen	***Right***	***Left***	***Total***
Upward	1 (0.5%)	0 (0%)	1 (0.25%)
Downward	199(99.5%)	200 (100%)	399 (99.75%)

Table 2: Surface on which nutrient foramen is present

Surface	***Right***	***Left***	***Total***
Posterior Surface	196 (98%)	197 (98.5%)	393 (98.25%)
Lateral Surface	4 (2%)	3 (1.5%)	7 (1.75%)
Medial Surface	0 (0%)	0 (0%)	0 (0%)
Lateral Border	0 (0%)	0 (0%)	0 (0%)

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Table 3: Surface positioning of nutrient foramen			
Region of tibia	***Right***	***Left***	***Total***
Upper 1/3rd	197 (98.5%)	198 (99%)	395 (98.7%)
Middle 1/3rd	3 (1.5%)	2 (1%)	5 (1.25%)
Lower 1/3rd	0 (0%)	0 (0%)	0 (0%)

Tables 1, 2, and 3 provide detailed information on the direction, surface positioning, and the specific surfaces where the nutrient foramen is located.

The average length of the right tibia was 367.2 mm, while the left tibia measured 370.2 mm, with an overall average of 368.7 mm. The mean distance of the nutrient foramen from the proximal end was 114.56 mm in the right tibia, 114.62 mm in the left tibia, and 114.59 mm overall. The Foramen Index was 30.76 for the right tibia, 31.36 for the left tibia, and 31.06 for all tibiae combined.

Discussion

The nutrient artery is the primary vessel supplying blood to all long bones, including the tibia. Understanding its anatomy is crucial, as any damage to this artery during surgery can lead to ischemia of the tibia, potentially affecting the bone's healing process. Most studies, including ours, have reported the presence of a single nutrient foramen in 100% of tibiae examined. However, some researchers have noted cases with multiple nutrient foramina or, in rare instances, the complete absence of a nutrient foramen in the tibia. Roul B et al. reported double foramina in 16.20% of cases, while Udaya P et al. found them in 10.39% of cases on the left side and 13.51% on the right [11,12]. In their studies, Swapna SA et al. observed three foramina in 3.80% of bones, and Udaya P et al. found the same in 2.70%. In contrast, Joshi P et al. noted the absence of a nutrient foramen in 6% of cases [13,12]. Zahra SU et al. and Prashanth KU et al. also observed the absence of a nutrient foramen in 1.96% and 1.4% of tibiae, respectively [14,15]. Similarly, Gupta RK and Gupta AK reported the absence of a nutrient foramen in 1.86% of right tibiae and 4.34% of left tibiae in their study [16]. Most studies have reported that the nutrient foramen generally runs in a downward direction, consistent with the findings of the present study, where the majority of bones showed a downward orientation of the nutrient foramen, except for one case where it was observed running upward. In a study by Mazengenya P and Faremore MD, the upward direction of the nutrient foramen was observed in 1.7% of tibiae in white South Africans [17] and 0.6% in black South Africans. In the current study, the nutrient foramen was predominantly located on the posterior surface of most tibiae (Figure 1, Figure 2), except in seven cases where it was found on the lateral surface—2% of right tibiae and 1.5% of left tibiae, respectively. Several authors have similarly reported the nutrient foramen's presence on the posterior surface in most bones [2,6,7,12-14,16,18,21,23,24,26,27]. Kamath V et al. noted the foramen on the medial surface in 2.82% of tibiae [6], while Mysorekar VR found it on the posterior surface in 74% of bones [18]. In the current study, the total length (TL) of the tibia was found to be 367.2 mm on the right side and 370.2 mm on the left side [Table/Fig-9]. Similarly, Mazengenya P and Faremore MD reported an average tibial length of 37.12 cm in white South Africans and 38.44 cm in black South Africans [17]. Kizilkanat E et al. found the average tibial length to be 35.8 cm in the Turkish population, while Pereira GAM et al. recorded an average of 37.31 cm [19,20]. In the present study, the average distance of the nutrient foramen from the proximal end of the bone was 114.56 mm in the right tibia and 114.62 mm in the left tibia. Ankolekar VH et al. reported this distance to be 130 mm on the right and 134 mm on the left [21]. In a study on the Rajasthani population, Joshi P and Mathur S found the distance to be 145.3 mm on the right and 140 mm on the left [22]. In the current study, the Foramen Index (FI) was calculated in 395 tibiae, with 98.7% of nutrient foramina located in the upper third of the tibia (FI <33.33). In five tibiae (1.25%), the foramen was located in the middle third (FI between 33.33 and 66.66). In their study on the Gujarati population, Gupta RK and Gupta AK reported similar results [16]. Vadhel CR et al. observed the nutrient foramen in the upper third of the tibia in 99.5% of cases in their study on the Gujarati population, which is slightly higher than the findings of the present study [23]. Mohan K et al. found the foramen in the upper third of the tibia in 42% of cases, while 52% had it located in the middle third [7]. Bhojaraja VS et al. reported that 58.82% of tibiae had the foramen in the upper third, and 41.17% had it in the middle third [24]. Kamath V et al. also noted that 74.65% of tibiae had the foramen in the upper third, while 25.35% were found in the middle third [6]. Pereira GAM, Mazengenya P, and Faremore MD similarly found that the nutrient foramen is most commonly located in the upper third of the tibia [20,17]. No foramina were observed in the lower third of the bone [8].

Author, Population studied, and year of study	**Sample size**	**Mean length (cm)**		**Foramen index (cm)**		**Location of the nutrient foramen (% of bones)**			
						Upper 1/3		**Middle 1/3**	
		Right	**Left**	**right**	**Left**	**right**	**Left**	**right**	**Left**
Kamath V et al., [6]	71 (right-33, left-38)	-		32.08		74.65		25.35	
Mohan K et al., [7]	150	36.58±2.38		34.74±4.08	-	42		58	
Prashanth KU et al., [14]	69 (right-32, left-37)	-		32.5		98.3 (upper 2/5th)	1.7 (3/5th)		
Pereira GAM et al., [20]	142	37.31		32.9±6	32.3±2.8	-	-	-	-
Ankolekar VH et al., [21]	50	37.3	38.7	35.92	34	91.66	88.46	8.33	11.54
Gupta RK et al., [16]	312 (right-161, left-151)	36.1	36.44	32.66	33.09	63.97	58	36.03	42
Kizilkanat E et al., [19]	100	35.8	31.2	-	-	-		-	

Mazengenya P et al., [17]	180 (right-90, left-90)	38.44		31.45±2.52	31.87±3.63	-	-	-	-
Mazengenya P et al., [17]	180 (right-90, left-90)	37.12		31.45±2.52	31.87±3.63	-	-	-	-
Vadhel CR et al., [23]	188 (right-94, left-94)	-	-	-	-	99.5		0.5	
Roul B et al., [11]	37	37.2		33.33	33.33	91.89		8.1	
Swapna SA et al., [13]	-	36.19		-	-	100		-	-
Udaya P et al., [12]	151 (right-74, left-77)	37.26±2.83	37.54±2.30	32.09±3.76	32.12±3.13	73.86	81.18	26.4	18.82
Joshi P et al., [22]	50 (right-21, left-29)	32.84±8.4	34.46±8.1	31.85±1.8	31.67±2.83	88		6	
Zahra SU et al., [15]	91 (right-40, left-51)	35.54±2.53	36.17±2.96	32.39±2.21	32.05 ± 4.6	72		28	
Present Study	400 (right-200, left-200)	36.72	37.02	11.45	11.46	98.5	99	1.5	1

Author, Population studied, and year of study	**Sample size**	**number of the nutrient foramen (% of bones)**							
		One		**two**		**Three**		**Absent**	
		right	**Left**	**right**	**Left**	**right**	**Left**	**right**	**Left**
Sharma M et al., [1]	50 (right-25, left-25)	96		4		-	-	-	-
Kamath V et al., (Mangalore) [6]	71 (right-33, left-38)	100		-		-	-	-	
Mohan K et al., [7]	150	98		2		-	-	-	
Kizilkanat E et al., (Turkish) [19]	100	98		2		-	-	-	-
Pereira GAM et al., (Brazil) [20]	142	98.60		1.40		-	-	-	-
Prashanth KU et al., (Mangalore) [14]	69 (right-32, left-37)	98.6		-		-	-	1.4	
Ankolekar VH et al., (Karnataka) [21]	50	98		0	2	-	-	-	-
Gupta RK et al., (Gujarat) [16]	312 (right-161, left-151)	97.51	94.70	0.62	-	-	-	1.86	4.34
Mazengenya P et al (South African black people) [17]	180 (right-90, left-90)	99.40		0.60		-	-	-	-
Mazengenya P et al., (South African white people) [17]	180 (right-90, left-90)	98.30		1.70		-	-	-	-
Vadhel CR et al., (Gujarat) [23]	188 (right-94, left-94)	100		-	-	-	-	-	-
Roul B et al., (Raipur) [20]	37	83.70		16.20		-	-	-	-
Swapna SA et al., (Aurangabad) [13]	-	94.30		1.90		3.80		-	-
Udaya P et al., (Telangana) [12]	151(right-74, left-77)	83.70	89.61	13.51	10.39	2.70		-	-
Joshi P et al., (Rajasthan) [22]	50 (right-21, left-29)	94		-	-	-	-	6	
Zahra SU et al., (Turkey) [15]	91(right-40, left-51)	97.5	96.07	2.5	1.96	-	-	1.96	
Present Study	400 (right-200, left-200)	100	100	-	-	-	-	-	-

Conclusion

In bones, nutrient foramina hold significant importance in forensic studies as well as in clinical applications. Their size, number, and position help in estimating age, sex, and even suggesting population origin [25]. As the main blood supply channels to long bones, fractures near these sites can delay healing and indicate whether an injury occurred before death [26]. In orthopedic surgery, accidental damage may impair bone repair or cause necrosis, and such findings can be important in medico-legal evaluations [27]. Alterations in the foramina may also point to conditions like malnutrition or osteoporosis, aiding in cause of death assessment [28]. In archaeological or disaster contexts, their study provides insights into health, trauma, and identity of past populations [29]. The nutrient foramen is typically located on the posterior surface of the tibia, allowing the nutrient artery to enter and supply the bone. Surgeons must have a thorough understanding of the nutrient foramen's anatomy to preserve the bone's blood supply during procedures like fracture fixation, knee replacement, Tumor resection, and bone grafting. This knowledge helps prevent complications such as ischemia and improves surgical outcomes.

Bibliography

1. Sharma M, Prashar R, Sharma T, Wadhwa A, Kaur J. Morphological variations of nutrient foramen in lower limb long bones. Int J Med and Dent Sci. 2015;4(2):802-08
2. Standring S. Gray's Anatomy the Anatomical Basis of Clinical Practice. 41st ed. Elsevier Churchill Livingstone. London; 2016. p. 89-90, 1403-5p
3. Truetta J. Blood supply and the rate of healing of the tibial fractures. Clin Orthop Relat Res. 1974; 105:11-26
4. Dickson K1, Katzman S, Delgado E, Contreras D. Delayed unions and nonunions of open tibial fractures. Correlation with arteriography results. Clin Orthop Relat Res. 1994 May;(302):189-93
5. Taylor GI. Fibular transplantation. In: Serafin D, Bunke HJ (eds), Microsurgical composite tissue transplantation, C.V. Mosby Co., St. Louis, 1979:418-23.
6. Kamath V, Asif M, Bhat S, Avadhani R. Primary nutrient foramen of tibia and fibula and their surgical implications. Indian J Clin Anat Physiol. 2016;3(1):41-44
7. Mohan K, Devaraj B, Ramanathan S, Rethinasamy M. Morphometric study of nutrient foramen in the long bones of the lower limb. Int J Anat Res. 2017;5(2.3):3943-48.
8. Lee JH, Ehara S, Tamakawa Y, Horiguchi M. Nutrient canal of the fibula. Skeletal Radiol. 2000; 29:22-26.
9. Hughes H. The factors determining the direction of the canal for the nutrient artery in the long bones of mammals and birds. Acta Anat (Basel). 1952;15(3):261-80.
10.Ukoha UU, Umeasalugo KE, Nzeako HC, Ezejindu DN, Ejimofor OC, Obazie IF. A study of nutrient foramen in long bones of Nigerians. Natl J Med Res.2013; 3:304-08.
11. Roul B, Goyal M. A study of a nutrient foramen in long bones of inferior extremity in human beings. Int. Jour of Adv Res. 2015;3(4):945-48.
12. P Udaya Kumar, Rao JM, V Sirisha, T Kalpana. A study of the nutrient foramen in Dry human tibia bones of the Telangana region. Int J Anat Res. 2017;5(3.1):4152-57.
13. Ambekar SA, Sukre SB. Diaphyseal nutrient Foramen of lower limb long bones: variations and Importance. Int J Anat Res. 2016;4(3):2684-88.
14. Prashanth KU, Murlimanju BV, Prabhu LV, Kumar CG, Pai MM, Dhananjaya KVN. Morphological and topographical anatomy of nutrient foramen in the lower limb

long bones and its clinical importance. AMJ. 2011;4(10):530-37
15. Zahra SU, Kervancio ğlu P, BahŞi i. Morphological and topographical anatomy of nutrient foramen in the lower limb long bones. Eur J Ther. 2018; 24:36-43.
16. Gupta RK, Gupta AK. A study of diaphyseal nutrient foramen in Human tibia. Natl J Med Res. 2014;4(4):310-13.
17. Mazengenya P, Faremore MD. Morphometric studies of the nutrient foramen in lower limb long bones of adult black and white South Africans. Eur J Anat. 2015;19(2):155-63.
18. Mysorekar VR. Diaphyseal nutrient foramen in human long bones. J Anat. 1967;101(4):813-22.
19. Kizilkanat E, Boyan N, Ozashin ET, Soames R, Oguz O. Location, number and clinical significance of nutrient foramen in human long bones. Ann Anat. 2007;189(1):87-95.
20.Pereira GAM, Lopes PTC, Santos AMPV, Silveira FHS. Nutrient foramen in the upper and lower limb long bones. Morphometric study in bones of Southern Brazilian adults. Int J Morphol. 2011;29(2):514-20.
21. Ankolekar VH, Quadros LS, D'souza AS. Nutrient foramen in tibia – A study in coastal region of Karnataka. IOSR-Jour of Dent & Med Sci. 2013;10(3):75-79
22. Joshi P, Mathur S. A comprehensive study of nutrient foramen in human lower limb long bones of the Indian population in Rajasthan state. Galore International Journal of Health Sciences and Research. 2018;3(3),34-42
23. Vadhel CR, Kulkarni MM, Gandotra AR. Anatomy of nutrient foramen of tibia-a study from the Gujarat region. Indian J Clin Anat Physiol. 2015;2(1):6-10.
24. Bhojaraja VS, Kalthur SG, D' Souza AS. A study of Diaphyseal Nutrient Foramen in human lower limb long bones and its clinical importance. Int J Curr Res Med Sci. 2016;2(7):1-12
25. Singh P, Srivastava AK. Morphometric study of nutrient foramina of human tibia and its clinical importance. Int J Anat Res. 2019;7(3.2):6804-09.
26. Sharma A, Rathore MS, Verma R. Nutrient foramina of long bones and their forensic significance in fracture healing. J Forensic Med Toxicol. 2020;37(2):45-49.
27. Patel S, Gupta R. Clinical relevance of nutrient foramina in orthopedic surgeries and its medico-legal implications. Indian J Orthop Surg. 2021;7(1):50-54.
28. Kumar V, Singh A, Thomas R. Nutrient foramen changes in pathological conditions: forensic perspectives. J Clin Diagn Res. 2018;12(6):AC01-AC04.
29. Reddy S, Murty OP. Role of nutrient foramina in bioarchaeological and forensic investigations. Medico-Legal Update. 2017;17(2):123-26.