Diaphyseal Tibial Nutrient Foramen in Goan Population - A Morphometric Study with Clinical Implications

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ABSTRACT

BACKGROUND

Tibia is the weight bearing bone of the leg. Usually it has a single nutrient foramen located posteriorly near the soleal line and transmits a branch of posterior tibial artery. The nutrient artery is the principal source of supply to a long bone. We carried out this study to find out the number, size, location, position and direction of the diaphyseal nutrient foramen in dried human tibia in Goan population.

METHODS

The study was carried out on 66 unpaired dry human tibiae of unknown age, gender and without deformity in the Department of Anatomy, Goa Medical College, using sliding and digital Vernier callipers, 20- and 24-gauge needles. Hughes formula was used to compute foraminal index. The data was statistically analysed with SPSS software version 23.

RESULTS

Most of the tibia in our study had a single nutrient foramen. Majority of the nutrient foramina were medium sized and directed downwards in our study. In 81.42 % tibiae, the nutrient foramina were present in the upper 1 / 3rd of the shaft and in 18.57 % in the middle 1 / 3rd of the shaft of the bone. Almost all nutrient foramina in the upper 1 / 3rd of posterior surface were situated lateral to the soleal line. We computed the mean foraminal index as 30.25 % with standard deviation of 6.14.

CONCLUSIONS

A proper knowledge of morphometry and topography of the nutrient foramen is of utmost importance to orthopaedic surgeons as the nutrient artery may get damaged if fracture line passes through the nutrient canal. Also, it will help the surgeon to conserve vascular supply while performing bone grafting and fracture reduction.

KEYWORDS

Nutrient Foramen, Morphometry, Foraminal Index, Soleal Line

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BACKGROUND

Tibia, the second largest bone in the body,[1] is the weight bearing bone of the leg. It is larger than the fibula and it is medially placed. In Latin, tibia means a flute or pipe.[2] In cross section, the shaft of the tibia is triangular and has three borders; anterior, interosseous and medial and three surfaces; medial, lateral, and posterior surfaces.[3] The bone marrow and inner 2 / 3rd of compact bone of diaphysis are supplied by the nutrient artery. Several nutrient arteries may be present in some bones like femur whereas only a single artery is generally present in tibia.[4] The nutrient foramen is usually located on the posterior aspect of the tibia near the soleal line and generally transmits a branch of the posterior tibial artery.[5] Fracture of tibia involving the nutrient canal would lead to damage of the nutrient artery and predispose to non-union of the bone fragments.[6]

Objectives

We wanted to determine the number, position, direction, size of nutrient foramina in human adult tibia of right and left side and calculate the foraminal index.

METHODS

Sample size was calculated using the formula

$$n = 2\,(Zalpha + Zbeta)^2 \times S^2 / d^2$$

n was found to be 60 where Z alpha 95 % was 1.96, Z beta 80 % was 0.842, mean = 11.33, SD = 2.33, d = 1.2.

The study was a observational type of study and was conducted on 66 unpaired dried human adult tibiae (40 right and 26 left) of unknown age, gender, obtained from the bone bank of Department of Anatomy, Goa Medical College, Bambolim and supplemented by bones procured from the bone sets of first year MBBS students over a period of three months from 6th August 2020 to 6th November 2020. During data collection bones with gross morphological deformities and broken bones were excluded from the study. The total length of tibia was measured with a sliding Vernier caliper. Distance of foramen from proximal end was measured using a digital Vernier caliper with accuracy of 0.01 mm. Location of nutrient foramen with respect to soleal line if the nutrient foramen is in the upper 1 / 3, with respect to the vertical ridge if the nutrient foramen is in the middle 1 / 3 was taken. The standard used to classify the foramina into various sizes was the 20 gauge and 24-gauge hypodermic needle. The rational used to term the foramen as large, medium and small is: 20-gauge needle is equal to 0.9 mm and 24 gauge is equal to 0.55 mm. If the foramen easily admitted a 20 G size needle, we classified the foramen as large sized. If the foramen allowed passage of needle of 24 G size needle but not a 20 G needle, we classified it as medium sized. If the foramen could not admit even a 24 G needle, we considered it to be small sized. Foraminal index (FI) was calculated using Hughes formula[7] (FI = D / L x 100) where D is the distance of foramen from the proximal end of tibia and L is the total length of tibia. Small sized secondary foramina were not considered for computing foraminal index.

Statistical Analysis

The data was statistically analysed using SPSS software version 23

RESULTS

Majority of the tibiae in our study had a single nutrient foramen. Double nutrient foramina were noticed in one right and one left tibia whereas one left tibia had three nutrient foramina. Figure 1 shows a tibia having two nutrient foramina. All the tibiae studied by us had a nutrient foramen present on posterior surface. One right and two left tibiae had additional nutrient foramina present on lateral surface.

The nutrient foramina were present in the upper 1 / 3rd of the shaft in 81.42 % and in the middle 1 / 3rd in 18.57 % of the tibiae. No nutrient foramen was located in the lower 1 / 3rd of the shaft. Almost all nutrient foramina in the upper 1 / 3rd of posterior surface were situated lateral to the soleal line. Majority of the nutrient foramina in our study were medium sized and directed downwards. The mean foraminal index in our study was calculated to be 30.25 with standard deviation of 6.14. The findings of our study are summarised in Table 1, 2, 3 and 4.

Number of Nutrient Foramen	Right (40 Tibiae)	Left (26 Tibiae)	Total (66 Tibiae)
0	0	0	0
1	39 (97.5 %)	24 (92.3 %)	63 (95.45 %)
2	1 (2.5 %)	1 (3.84 %)	2 (3.03 %)
3	0	1 (3.84 %)	1 (1.51 %)
Direction of foramen	Right (41 foramina)	Left (29 foramina)	Total (70 foramina)
Upward	02 (4.87 %)	03 (10.34 %)	05 (7.14 %)
Downward	39 (95.12 %)	26 (89.65 %)	65 (92.85 %)
Location of foramen	Right (41 foramina)	Left (29 foramina)	Total (70 foramina)
Medial surface	0	0	0
Lateral surface	01 (2.43 %)	03 (10.34 %)	04 (5.71 %)
Posterior surface	40 (97.56 %)	26 (89.65 %)	66 (94.28 %)
Position of foramen	Right (41 foramina)	Left (29 foramina)	Total (70 foramina)
Upper 1 / 3	36 (87.8 %)	21 (72.41 %)	57 (81.42 %)
Middle 1 / 3	05 (12.19 %)	08 (27.58 %)	13 (18.57 %)
Lower 1 / 3	0	0	0
Size of foramen	Right (41 foramina)	Left (29 foramina)	Total (70 foramina)
Large (admits 20 G needle)	11 (26.82 %)	06 (20.68 %)	17 (24.28 %)
Medium (admits 24 G needle)	30 (73.17 %)	23 (79.31 %)	53 (75.71 %)
Small	0	0	0

Table 1. Number, Direction, Location, Position and Size of Nutrient Foramen

Relation of foramen to soleal line (in upper 1 / 3)	Right	Left	**Total**
Medial to soleal line	01	0	**01**
Lateral to soleal line	34	18	**52**
Relation of foramen to vertical line (in middle 1 / 3)	Right	Left	**Total**
Medial to vertical line	01	0	**01**
Lateral to vertical line	04	08	**12**

Table 2. Relation of Foramen to Soleal Line in Upper 1 / 3rd and to Vertical Line in the Middle 1 / 3rd of Posterior Surface

Mean distance of foramen from soleal line in mm (in upper 1 / 3)	Right	Left
Medial to soleal line	9.6	0
Lateral to soleal line	11.31	9.07
Mean distance of foramen from vertical line in mm (in middle 1 / 3)	Right	Left
Medial to vertical line	8.1	0
Lateral to vertical line	11.02	9.5

Table 3. Mean Distance of Foramen from Soleal Line in Upper 1 / 3rd and from Vertical Line in the Middle 1 / 3rd of Posterior Surface

	Right			Left			Total (Right+ Left)		
	Mean	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**
Distance of foramen from proximal end (in cm)	11.23	2.12	4.83 - 19.5	11.47	2.62	4.29 - 14.8	11.33	2.33	4.29 - 19.5
Total length of tibia (in cm)	36.92	2.45	32.1 - 41.6	38.20	1.73	34.7 - 41	37.42	2.27	32.1 - 41.6
Foraminal index	30.40	5.62	12.30 - 55.24	30.03	6.90	11.27 - 39.46	30.25	6.14	11.27 - 55.24

Table 4. Distance of Foramen from Proximal End and Foraminal Index

Figure 1. Upper 1 / 3rd of Right Tibia Showing Two Nutrient Foramina

DISCUSSION

Tejaswi H.L. et al.[8] in their study on 150 dried tibiae noticed that the nutrient foramen was located in the upper 3rd in 94.9 % of the tibia and that the foramen was placed on the posterior surface below the soleal line in 91.21 % tibiae. In our study of 66 bones we noticed that the nutrient foramen was located in the upper 3rd in 81.42 % of tibiae.

Joshi P and Mathur S[9] in their study found that 94 % of the tibiae had a single foramen and 6 % had no foramen at all. They noted that 86 % of foramina were located on the posterior surface and 88 % of foramen were observed in the proximal third. They calculated the mean foraminal index for the tibiae to be 31.74 %. In our study the foramen was placed on the posterior surface in 94.28 % tibiae. Gupta R and Gupta A[10] in their study noted that 96.5 % of the tibiae had a single nutrient foramen, 3.2 % had no nutrient foramen and 0.3 % had two foramina. Majority of the bones had the foramen on posterior surface. The foramina were directed downwards in most of the bones except in three bones. The mean foraminal index was 32.86 %. The mean foraminal index in our study was similar at 30.25 %.

Agarwal N et al.[11] observed a single dominant nutrient foramen in all 80 dry tibiae that they studied. They inferred that all the nutrient foramina were located on the posterior aspect of the tibiae inferior to the soleal line, and most of them were placed lateral to the vertical line, running in a downward direction. They inferred that 92.85 % of the nutrient foramina in the tibiae were located in the proximal third. In our study most of the nutrient foramen were located on the upper 1 / 3rd of tibiae lateral to the soleal line.

Roul B and Goyal M[12] in their study noticed that 83.7 % tibiae had a single nutrient foramen whereas 16.2 % had two nutrient foramina. The foramina were present in the upper 1 / 3rd of the shaft in majority of the tibiae and more frequently on the vertical line and less frequently lateral to the vertical line. Only 3.03 % of tibiae in our study had double nutrient foramina located laterally in the upper 1 / 3rd of the shaft.

In a study by Anusha D et al.[13] it was observed that 98 % of tibiae had a single nutrient foramen while 2 % of tibiae had double foramina. The nutrient foramina were seen in the upper third of the shaft in 65 % of the tibiae. Foraminal index of tibia was calculated as 45.05 with standard deviation of 8.29 in the study. The mean foraminal index in our study was 30.25 with a standard deviation of 6.14.

Vadhel Chirag et al.[14] in their study found that a single nutrient foramen was present on the posterior surface of the shaft of all the tibiae they studied. In 92.6 % tibiae, the nutrient foramen was situated in the upper one third of the shaft. In 95.7 % tibiae, the nutrient foramen was situated lateral to the soleal line. All the nutrient foramina were directed downward in their study whereas in our study 7.14 % of the nutrient foramina were directed upwards.

Chavda H and Jethva N[15] observed that a single nutrient foramen was present in all the tibia that they studied. The nutrient foramen was mostly directed downward and situated in the upper 1 / 3rd of posterior surface below the soleal line lateral to the vertical line in majority of the bones. However, in our study only 17.14 % of foramina were situated lateral to the vertical line.

Archana et al.[16] noticed that a single nutrient foramen was present in 93.5 % of the tibiae and double foramina in 6.5 % of the tibiae which they studied. They observed that 59 % of the nutrient foramina were situated on the posterior surface lateral to the vertical line. The foramina were directed downward in all the tibiae studied. While 92.85 % of foramina were directed downward in our study.

Akbari V et al.[17] found that a single nutrient foramen was present in 95.08 % of tibiae, two foramina in 3.28 % of tibiae and absence of foramen in 1.64 % of the tibiae that they studied. Majority (98.33 %) of the nutrient foramina were located on the posterior surface of tibia. The foramen was situated in the upper 1 / 3rd of shaft in 48.33 % of tibiae and in the middle 1 / 3rd of shaft in 51.67 % of tibiae. The foramina were directed towards the lower end in almost all of the tibiae. The mean foraminal index in their study was 34 %. All the tibiae in our study had a nutrient foramen present. Also, in our study we observed that only 18.57 % of foramina were present in the middle 1 / 3rd of the shaft.

Kamath V et al.[18] detected a single nutrient foramen in all the tibiae which they studied. The foramen was present on the posterior surface in 97.18 % of tibiae and on the medial surface in 2.82 % of tibiae. In our study 5.71 % of nutrient foramina were present on the lateral surface of tibia and 94.28 % were on the posterior surface.

Ghosh T and Ray M[19] in their study observed a single nutrient foramen in all the tibia. The nutrient foramen was located mostly in the upper 1 / 3rd of posterior surface of tibia lateral to the soleal line. Majority of the foramina were directed downwards. The location and direction of nutrient foramen is almost similar to our study.

Kumar S, et al.[20] ascertained that a single nutrient foramen was present in 95 % and two nutrient foramina in 5 % of the tibiae that they studied. The nutrient foramen was located in the upper 1 / 3rd region of the posterior surface in all the bones. Majority of the foramina were situated lateral to the vertical line in their study. Foraminal index was calculated to be 32.48 on the right and 32.36 on the left tibiae. Foraminal index in our study was computed to be 30.40 on the right and 30.03 on the left tibiae.

Bohara KC et al.[21] determined that a single nutrient foramen was present in all the tibiae which they studied. They discerned that majority of the foramina were located on the posterior surface of the bone. They computed the foraminal index as 12.80 in their study which is significantly lower than our findings. In summary, our study revealed that 95.45 % of tibiae had a single nutrient foramen which is similar to findings of Gupta R and Gupta A,[10] Anusha D et al.[13] Archana et al.[16] and Akbari V et al.[17]

Majority of the foramina in our study were positioned in the upper 1 / 3rd of posterior surface of shaft similar to studies done by Joshi P and Mathur S,[9] Agarwal N et al.[11] Roul B and Goyal M,[12] Vadhel Chirag et al.[14] and Kamath V et al.[18] Most of the nutrient foramina in upper 1 / 3rd of posterior surface were located lateral to the soleal line similar to studies done by Vadhel Chirag et al.[14] Ghosh T and Ray M[19] and Ankolekar et al.[22]

Most of the foramina in our study were medium sized unlike the study done by Gupta R and Gupta A [10] where most of the foramina were large sized.

Majority of the foramina in our study were directed downwards which is consistent with most of the textbook findings and studies done by various authors. The mean foraminal index in our study was calculated as 30.25 % which is almost similar to studies done by Joshi P and Mathur S,[9] Gupta R and Gupta A,[10] Agarwal N et al.[11] and Kamath V et al.[18]

CONCLUSIONS

A sound understanding of the topography and morphometry of the nutrient foramen is of paramount importance to orthopaedic surgeons while operating on tibia. Knowledge of location and position of the foramen will help to reduce damage to the vessel during surgical procedures and also help to promote healing after fracture reduction. The present study will also help surgeons in planning successful bone grafting procedures keeping the nutrient blood supply intact.

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REFERENCES

[1] Vishram S. Textbook of Anatomy - abdomen and lower limb. 2nd edn. New Delhi: Reed Elsevier India Private Limited 2014: p. 312.
[2] Ralph G, Peter A. Essentials of clinical anatomy. London: Pitman Publishing Limited 1986: p. 12.
[3] Richard D, Vogl A, Adam M. Gray's Anatomy for students. 3rd edn. Philadelphia, Churchill Livingstone/ Elsevier 2015: p. 618.
[4] Kumar DA. Principles of General Anatomy. 6th edn. Kolkata: K.P. Basu Publishing Co., 2004: p. 76.
[5] Susan S. Gray's Anatomy. The anatomical basis of clinical practice. 41st edn. United Kingdom: Elsevier 2015: p. 1404.
[6] Keith M, Arthur D, Anne A. Clinically oriented anatomy. 8th edn. Philadelphia: Wolters & Kluwer 2018: p. 1573.
[7] 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):261-280.
[8] Tejaswi HL, Krishnand S, Dakshayani KR. Anatomic study of nutrient foramina in the human tibiae and their clinical importance. International Journal of Recent Trends in Science and Technology 2014;9(3):334-336.
[9] Joshi P, Mathur S. A comprehensive study of nutrient foramina in human lower limb long bones of Indian population in Rajasthan State. Galore International Journal of Health Sciences and Research 2018;3(3):34-42.
[10] Gupta RK, Gupta AK. A study of diaphyseal nutrient foramina in human tibia. National Journal of Medical Research 2014;4(4):310-313.
[11] Agarwal N, Tiwari A, Parmar AS. Topography and indexing of nutrient foramina of tibia—a study in Vindhya region. Int J Med Sci Public Health 2016;5(5):1000-1004.
[12] Roul B, Goyal M. A study of nutrient foramen in long bones of inferior extremity in human being. International Journal of Advanced Research 2015;3(4):945-948.
[13] Anusha D, Madhavi D, Kondepudi S. Anatomical and morphological study of nutrient foramen in leg bones. Acad Anat Int 2019;5(2):8-10.
[14] Vadhel C, Kulkarni M, Gandotra A. Anatomy of nutrient foramen of tibia – a study from Gujarat region. Indian Journal of Clinical Anatomy and Physiology 2015;2(1):6-10.
[15] Chavda H, Jethva N. Morphometric study of nutrient foramen of adult human tibia bone. International Journal of Anatomy, Radiology and Surgery 2019;8(2):5-8.
[16] Archana NK, Aparna VPK, Hima BN. Morphometric study of nutrient foramen of the dried human tibiae. Int J Anat Res 2019;7(2.1):6468-6473.

[17] Akbari V, Rathwa A, Sanjay CS. Study of nutrient foramina of human tibia of Saurashtra region. Indian J Anat Surg Head Neck Brain 2018;4(3):86-88.
[18] Kamath V, Asif M, Bhat S, et al. Primary nutrient foramina of tibia and fibula and their surgical implications. Indian Journal of Clinical Anatomy and Physiology 2016;3(1):41-44.
[19] Ghosh T, Ray MK. Anthropometric analysis of nutrient foramen of tibia - a study in Eastern India. International Journal of Research and Review 2020;7(2):100-103.
[20] Kumar S, Kumar A, Ratnesh R, et al. Morphometric study of nutrient foramen of tibia in population of Bihar. Journal of Medical Science and Clinical Research 2018;6(3):1186-1190.
[21] Bohara KC, Katara P, Prabha T, et al. A study of diaphyseal nutrient foramina and estimation of foraminal index in the adult dried long bones of upper and lower limb. Int Arch BioMed Clin Res 2020;6(1):HA1-HA4.
[22] Ankolekar V, Quadros L, D'Souza A. Nutrient foramen in tibia – a study in coastal region of Karnataka. IOSR Journal of Dental and Medical Sciences 2013;10(3):75-79.