Clinical and Medicolegal Significance of Variations in the Nutrient Foramen of the Adult Dry Human Tibia

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Abstract

Background: The long bones receive their blood supply through the nutrient artery. The nutrient foramina of the tibia are commonly located on the posterior surface, near the soleal (popliteal) line, in the proximal third of the bone. However, variations in their number and position have been observed, which hold clinical and medicolegal significance. In the medical profession, anatomical knowledge and variations of the nutrient foramen is crucial, particularly for forensic and bone transplant applications.

Material and Methods: A total of 180 fully ossified dry tibiae were obtained from the bone bank of the Anatomy Department, Khyber Girls Medical College, for this study. Bones without any pathological abnormalities, such as fractures or structural deformities were selected.

Results: Out of a total of 180 tibiae studied, 58 had a length of ≥1.27 mm, while 55 measured at least 1.27 mm. The average length of the left tibia was 37 cm, and the right tibia measured 36.2 cm. The mean distances of the nutrient foramina were 13.6 cm in the left tibia and 13.4 cm in the right tibia. Additionally, eight tibiae exhibited double the usual number of nutrient foramina. In the upper third region of the tibia, 72 foramina were observed on the left side and 76 on the right side.

Conclusion: The study's findings are helpful in both surgical operations and the resolution of medical malpractice claims. The study's findings add to the body of knowledge regarding the changes in the nutrient foramen of the arid human tibia and their potential therapeutic consequences. The surgeons can better grasp the variances with the use of this data, leading to improved surgical treatment outcomes.

Key Words: Tibia, Diaphysis, Forensic medicine, Nutrient foramen.

Introduction

The main blood supply to the long bone is through the nutrient artery. Anatomically,the nutrient artery of the tibia is most commonly a branch of the posterior tibial artery however it may occasionally arise from the peroneal artery. The most significant artery supplying the cortical bone is the nutrition artery.[1] The nutritive artery has a vital function, particularly fetal development and the onset of bone ossification, since it is the only source of blood supply to the tibia.[2]

The nutrient foramen serves as an entry point for the nutrient artery into the long bone. The top portion of the shaft of long bones is where the nutrient artery enters. In clinical anatomy, this is significant. The lower parts of the shaft will receive less nourishment since the most common point of entry of the artery is through the upper one third of the shaft, the lower end gets less blood supply particularly in cases of bone fractures.[2]. Given that anatomy is the foundation of all surgeries, it is imperative that a clinician must have a thorough knowledge about the potential sites and variations of the nutrient artery in the long bones. This makes it possible for surgical treatments involving long bones, particularly those involving bone fractures, to have a higher success rate.[3-6] The clinicians will benefit from having more information about the number and location of the nutrient arteries throughout the transplant procedure.[7] It is also beneficial in handling medico legal situations as in medicolegal cases, identifying variations in the nutrient foramen can assist forensic experts in determining the cause of bone damage, differentiating between ante-mortem and post-mortem fractures, and providing critical evidence in trauma or assault cases.

Therefore, one of the main areas of interest for medical professionals is understanding the shape and variability of the nutrient foramen. The current study sought to determine the quantity, location, and variations of the tibia's nutrient foramen, as well as its orientation, which was assessed based on the obliquity of the foramen in relation to the longitudinal axis of the bone.

Material and Methods

180 fully ossified, dry tibia obtained from the bone bank of Anatomy Department Khyber Girls Medical College Peshawar. Bones with normal anatomical features were selected that showed no signs of pathology, including fractures or bone deformities. The size, length, quantity, orientation, position, and changes in the tibia's nutrient foramen were among the observations made in the chosen bones. To prevent observer bias, two different observers made each observation.

Size of the foramen: The foramen's size was measured using a hypodermic needle.[8] The foramen was separated into main and secondary foramen based on size. According to the criteria listed in the literature, a foramen was classified as secondary nutrient foramen if its size was below needle 24, and as primary or dominating foramen if it was more.[9.]

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Number of foramen: The bones were divided into single and multiple nutrient foramen based on the number of foramen that were observed. A single foramen was referred to as a single nutrition foramen bone. Numerous foramena are referred to as numerous nutrient foramen bones. In order to identify the bones lacking the nutrition foramen, observation was also carried out.

Size of foramen: syringe needle of various gauges was used to measure the foramen size.

Location of the foramen: by using the conventional foraminal index as described in the literature, the location of the nutrient foramen was evaluated in relation to the soleal line .[10]

Other observations: According to the usual technique described in the literature, the direction and variances were noted.[11] The orientation of the nutrient foramen was vertically downhill across Tibia.

Results

There are 180 bones in all, with 90 left and 90 right. Table 1 displays the foramen (right) size (N = 90). Out of 90 bones, 58 measured ≥1.27 mm. Table 2 displays the foramen size on the left side for N = 90 people. 55 of the 90 bones on the left side measured ≥1.27 mm. Table 3 shows the tibia's entire length as well as the distance between the nutrient foramina and the upper end of the tibia. The average tibial length is 37 cm on the left and 36.2 cm on the right. The left and right NFs (nutrient foramina) are 13.6 and 13.4 cm apart from the top end.Tibia's anterior edge has a single foramina. (Figure 1). Eight tibiae were discovered to have doubled the typical amount of nutrient foramen. Nutrient foramina are absent in two Tibiae (Fig. 2). The nutrient foramina were most commonly located along the posterior surface of the tibia, near the soleal line. In the upper third of the tibia, 72 foramina were observed on the left and 76 on the right, while in the middle third, 14 foramina were found on the right and 18 on the left. (Fig. 3).

Foramen index (FI) Calculations

Foramen index FI = (DNF/TL) x100

DNF = the distance of the nutrient foramina to the upper end of tibia.

TL = total length of bone.

	Table 1: showing Size of the right foramen (N=90)	
	foramen size	No of Bones
1	(≥1.27 mm)	58
2	(≥ 0.90mm to < 1.27mm)	21
3	(≥ 0.71mm to < 0.90 mm)	6
4	(≥ 0.55mm to < 0.71 m)	0

	Table 2: showing Size of the left foramen (N=90)	
	foramen size	No of Bones
1	(≥1.27 mm)	55
2	(≥ 0.90mm to < 1.27mm)	15
3	(≥ 0.71mm to < 0.90 mm)	7
4	(≥ 0.55mm to < 0.71 m)	10

	Table 3: Tibia's length and the distance between its upper end and the NF			
		Right	Left	Foramen (FI) index
1	Tibia's Length	36.2 cm	37 cm	37.32
2	Distance between the upper end and NF	13.4 cm	13.6cm	37.26

Table 4: Distribution of Nutrient Foramina in the Tibia: Location and Direction			
Parameter	Right Tibia (N=90)	Left Tibia (N=90)	Total (N=180)
Foramen Location (Upper Third)	76	72	148
Foramen Location (Middle Third)	14	18	32
Foramen Direction (Downward Oblique)	90	90	180

Discussion

The nutrient artery provides the majority of the long bone's nutrition. The posterior tibial artery gave rise to this nutrient artery that supplies the long bones. There are 180 bones in all. of which 90 were left and 90 were right. On the right 58 bones were ≥1.27 mm. On the left side 55 bones had size of ≥1.27 mm. The left and right NFs (nutrient foramina) are separated by 13.6 and 13.4 cm, respectively, from the top end. One or two foramen were found in earlier research, but a different study by Mazengenya et al. described a bone with six foramen.[12]

Our findings are in line with the study performed by Roy PP et.al. On Indian population who has reported similar results.[11]

The bulk of research on the placement of NF indicated that it is located in the middle one third of the tibial shaft. [12,13] The current study supports previous research. According to a research, radiographs may appear to show bone fractures due to the linear appearance of the nutrient foramen. Examining the anterior nutritive foramen should also be done with caution since osseous disease may be misinterpreted by it.[14]

This information is crucial for managing surgically the long bones that have undergone surgery. All of the nutrient arteries run caudally during development, and their continued path is determined by how both ends of the long bones get matured. [15] Further researches, meantime, suggested that this theory might not always apply to people.[16–17] Remarkably, a different study found that the foramen of nutrients is located far from the knee joint.[18–20]

Clinical significance Maintenance of blood flow to the bones is crucial while doing the procedures needed to treat bone fractures. Similarly, this is used when performing grafting and joints replacements. Maintenance of blood supply is crucial, since it speeds up the healing process. Therefore, the current work contributes to the body of literature about our understanding of nutrient foramen.

Forensic implications In terms of the forensic implications, there could be situations in which a forensic physician must distinguish between human and non-human bone, even in cases when a little piece of long bone may be present. In these situations, macroscopical and computed tomography (CT) examination of the nutrition foramina is essential. [21–22.]

Forensic implications can be helpful in creating biological profiles and enabling individual identification. The potential for these findings to contribute to the development of forensic osteological databases enhancing identification capabilities, supporting research, and improving the overall efficiency of forensic investigations.[23]

Conclusions

The results of the study are useful for both surgical procedures and the settlement of medical malpractice lawsuits. The results of the study broaden our understanding of the modifications to the nutrient foramen of the arid human tibia and the possible therapeutic implications of these changes. With the use of this data, the surgeons can better understand the variances, improving the results of surgical therapy.

The variability of the tibial nutrient foramen holds significance in both clinical and forensic applications. Understanding its anatomical variations may enhance forensic identification techniques and improve surgical precision.

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FIG 1: Foramen in anterior border of tibia

FIG 2: Double nutrient foramina

FIG 3: Absent nutrient foramen

Discussion

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1. Shahabuddin: Conception and study design, analysis, and interpretation of data, drafting the manuscript.
2. Naheed Siddiqui: Conception and study design, critical review.
3. Ghulam Muhiyuddin: Acquisition and drafting of data, drafting the manuscript.
4. Syeda Hina Zehra: Analysis and interpretation of data, critical reveiw.
5. Rabia Khan: Acquisition, analysis, and interpretation of data.
6. Anwar Ul Haq: Drafting the manuscript, critical review, approval of final version to be published.