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Original Research Article

DIAPHYSEAL NUTRIENT FORAMEN OF LOWER LIMB LONG BONES: VARIATIONS AND IMPORTANCE

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ABSTRACT

Background: The nutrient foramen (NF) is the largest of the foramen present on the shaft of long bone allowing nutrient artery to enter the bone. These arteries are important during active growth period of embryo and fetus and during the early phases of ossification. They provide 70–80% of the interosseous blood to long bones.

The context and purpose of the study: The study was conducted on 156 long bones of lower limb available in the department of anatomy, Government medical college, Aurangabad.

The aim of the study was to note the morphology and variations of nutrient foramen in human adult lower limb long bones and to discuss its clinical importance. We observed only diaphyseal nutrient foramens of these bones for size and number. Size of foramens were measured using hypodermic needle and foramen were classified as secondary (SF) or dominant (DF). Number of foramens or their absence was noted. Distance of nutrient foramen (DNF) was measured using Vernier caliper from highest point of head of femur and fibula to foramen and from center of tibial condyles on posterior aspect of tibia. Total length of bone (TL) was measured using standard osteometric board. The location of all nutrient foramen in upper, middle or lower third of bone was determined by calculating a foraminal index using Hughes formula.

Results: We observed that maximum tibia had single foramen followed by fibula and femur. We found maximum five foramens on two left femurs. One femur had secondary foramen on anterior surface. Nutrient foramens were totally absent in six fibulas. According to foraminal index, tibia had maximum nutrient foramen in upper third of shaft while femur and fibula had them on lower third.

Potential implications: On radiograph, nutrient foramen mimics longitudinal stress fracture or may be misdiagnosed as lytic bone lesions like osteoid osteoma. Precise knowledge of nutrient foramen and its variations is necessary for doctors to predict prognosis of grafts, tumors, fractures of bones and also useful for anthropologist during interpretation of height from a fragment of bone.

Conclusions: The maximally observed position of nutrient foramen is in middle third of the shaft of femur and fibula while upper third of shaft in tibia. Knowledge of which is important clinically for proper diagnosis and planning of surgery and also to predict the prognosis.

KEY WORDS: Secondary Or Dominant Foramen, Foraminal Index, Longitudinal Stress Fracture.

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INTRODUCTION

The nutrient foramen (NF) is defined as the largest of the foramen present on the shaft of long bone allowing nutrient artery to enter the bone, the role of which is important in providing nutrition and growth of the long bones. One or two main diaphyseal nutrient arteries enter the shaft obliquely through nutrient foramen leading into nutrient canals. Their sites of entry and angulation are almost constant and characteristically directed away from the growing epiphysis [1].

The nutrient artery is the main source of blood supply to the long bone especially during active growth period of embryo and fetus and during the early phases of ossification. During childhood, the nutrient arteries provide 70–80% of the interosseous blood to long bones. These arteries enter the long bones through the nutrient foramen which is mostly located away from the growing end [2]. Precise knowledge of nutrient foramen and its variations is necessary for doctors to predict prognosis of grafts, tumors [3], fractures of bones [4] also useful for anthropologist during interpretation of height from a fragment of bone in medico-legal cases [5]. On radiograph, nutrient foramen mimics longitudinal stress fracture [6,7] or may be misdiagnosed as lytic bone lesions like osteoid osteoma [8]

Considering all the above facts, aim of the present study was to note the morphology and variations of the nutrient foramen in human adult lower limb long bones, available at our institution and to highlight its clinical importance and also to add our data to literature for further studies.

MATERIALS AND METHODS

The study was conducted on 156 long bones of lower limb of unknown age and sex available in the department of anatomy, Government medical college, Aurangabad. All selected bones were complete and fully ossified. Incomplete bones and bones with pathological changes were not included in the study. Only diaphyseal nutrient foramens were observed in all the bones. For each bone examined, size and number of nutrient foramen were noted. Size of foramen was measured using hypodermic needle. Nutrient foramen smaller than a size 24 needle were considered as being secondary nutrient foramen (SF), while 24 and larger foramen were accepted as being dominant (DF). Single and multiple NF on the bones were noted. Single NF were further grouped as SF or DF. Bones without any diaphyseal NF were also noted. Distance of nutrient foramen (DNF) was measured using Vernier caliper from highest point of head of femur and fibula to foramen and from center of tibial condyles on posterior aspect of tibia. In case of more nutrient foramens, mean of all foramens was used as DNF .Total length of bone (TL) was measured using standard osteometric board (Fig. 1) [3,9].

Fig. 1: Osteometric board.

Table 1: The Findings Of Our Study With Measurements & Number Of Foramen In Percentage.

Bones	Number Of Foramens in percentage							Measurements			Position of Foramen according to FI
	1	2	3	4	5	Only Secondary	Absent	Mean Length (mm)	DNF (mm)	FI	
FEMUR	46.2	19.2	26.9	1.9	3.9	1.9	NA	407.9	184.3	45.1	Middle1/3
TIBIA	94.3	1.9	3.8	NA	NA	NA	NA	361.9	105.2	29	Upper1/3
FIBULA	63.5	7.7	1.9	NA	NA	15.4	11.5	353.5	159.5	45.1	Middle1/3

NA – not available

The location of all nutrient foramen in upper, middle or lower third of bone was determined by calculating a foraminal index (I) using Hughes formula [9,10] : foraminal index (I)=DNF/TLX100

Subdivisions of location of foramen according to FI:

The location of the foramen was divided into three types according to FI as follow:

Type 1: FI up to 33.33, the foramen was in the proximal third of the bone.

Type 2: FI from 33.33 up to 66.66, the foramen was in the middle third of the bone.

Type 3: FI above 66.66, the foramen was in the distal third of the bone.

All information was tabulated using Microsoft excel sheet

OBSERVATIONS (Table 1, Fig. 2)

In femur, single foramen was observed in 48.1% bones which included 46.2% dominant and 1.9% secondary foramen. In fibula, single foramen was observed in 78.9% bones which included 63.5% dominant and 15.4% secondary foramen. Single foramen on the bone was maximally observed in tibia (94.3%) followed by fibula (78.9%) and femur (48.1%). Maximum number of foramens observed on a single bone was five. It was noted for two left femur. One femur having five foramens had one foramen on anterior surface. All tibias had at least one dominant foramen. Presence of secondary foramen without dominant foramen was observed maximum in fibula (15.4%) followed by femur (1.9%). Nutrient foramens were totally absent in six fibulas (11.5%). According to foraminal index, tibia had maximum nutrient foramen in upper third of shaft while femur and fibula had it more on lower third of shaft.

Fig. 2: Various arrangements of nutrient foramens on bones.

1,2 - showing femur with 5 foramen and anterior foramen

3,4 – Tibia – multiple nutrient foramen above and below soleal line

5 – fibula showing distal primary and 2 proximal secondary foramens

DISCUSSION

Table 2: Comparison Of Various Studies For Femur With Present Study.

Studies (Femur)	Mean length (mm)	Position of max.NF (1/3)	% of Nutrient foramen						
			1	2	3	4	5	6	Absent
Kazilkant etal [9]	426	Middle	75	25	NA	NA	NA	NA	NA
Sharma etal [2]	NA	middle	54	42	2	NA	NA	NA	2
Mazengenya etal black African [11]	443.4	middle	64.4	34.4	NA	NA	NA	NA	0.6
Mazengenya etal White African[11]	449.6	middle	45	52.2	0.6	0.6	NA	0.6	1
Present study (Table 1)	407.9	middle	46.2	19.2	26.9	1.9	3.9	NA	NA

Kizilkanat etal [9] in his study found that femur had either single or double foramen while Mazengenya etal [11] in his study found as high as six foramens on a single bone, we found five foramens on two left femurs. Mazengenya etal [11] in his study of White African observed percentage of femur having double foramen was more than femur having single and in femur of black Africans the ratio was opposite. Though we observed maximum femur with single foramen (46.2%), we noted that the percentage of three foramens (26.9%) was more than two (19.2%). Other researchers found percentage of double foramen more than any other type of multiple foramens. The mean length of femur observed in our study was less as compared to other studies (table 2 femur). Position of maximum nutrient foramens is on the middle third of shaft and our findings match with other researchers.

Table 3: Comparison Of Various Studies For Tibia With Present Study.

Studies (Tibia)	Mean length (mm)	Position of maximum NF(1/3)	% of Nutrient foramen				
			1	2	3	More than 3	Absent
Kazilkant et al [9]	358	middle	98	2	NA	NA	NA
Udhya et al [3]	355.5	Upper	96.3	3.7	NA	NA	NA
Sharma et al [2]	NA	NA	96	4	NA	NA	NA
Mazengenya et al black Africans [11]	384.4	Upper	99.4	0.6	NA	NA	NA
Mazengenya et al White Africans [11]	371.2	Upper	98.3	1.7	NA	NA	NA
Present study	361.9	Upper	94.3	1.9	3.8	NA	NA

In all the studies (Table 3 tibia), more than 96% of tibia had single nutrient foramen while remaining had double foramen (refer). In our study we noted that though maximum tibia had single foramen, the percentage of tibia having three foramens (3.8%) was more than having two (1.9%). Our study match with other researchers for location of maximum foramens

on upper third of tibia except Kazilkant etal [9] had reported that maximum foramens were on middle third of tibia. The mean length of tibia varied between 355.5 mm to 384.4 mm in all studies.

Table 4: Comparison Of Various Studies For Fibula With Present Study.

Studies (Fibula)	Mean length (mm)	Position of maximum NF (1/3)	% of Nutrient foramen					
			1	2	3	More than 3	Only secondary	Absent
Kazilkant etal [9]	340.2	26% to 83%	93.1	5.5	NA	NA	NA	1.4
Sharma etal [2]	NA	NA	92	NA	NA	NA	NA	8
Mazengenya etal black Africans [11]	367.6	Middle	87	5	1	NA	NA	7
Mazengenya etal White Africans [11]	360.7	Middle	86.1	8.9	NA	NA	NA	5
Present study	353.5	Middle	63.5	7.7	1.9	NA	15.4	11.5

In our study, (table 4 fibula) nutrient foramens on fibula were present maximally in middle third of shaft. Our findings match with other researchers[2,9,11]. Kazilkant etal [9] has observed maximum foramens in a range of 26% to 83% on shaft of fibula which includes upper, middle as well as lower third of shaft. We observed 79.9% fibula had single foramen of which 15.4% fibula had only secondary foramen. Other researchers did not find only secondary foramen on fibula. We also noted 3 foramens on a single bone which is also reported by Mazengenya etal[11] in the study of Black Africans. We observed complete absence of diaphyseal nutrient foramen only in fibula. Though the absence of foramen is observed usually in fibula, Sharma etal [2] and Mazengenya etal [11] had reported its absence in femur. Usually diaphysis receives its blood supply from the nutrient arteries, and in their absence, the vascularization occurs through the periosteal vessels [3].

We observed one anterior nutrient foramen (picture 2) in femur on lower one third of shaft which is a rare finding. Rawson etal [8] had reported a case of a rare anterior tibial nutrient foramen in an adolescent patient with anterior shin pain. During our study, we did not find any anterior foramen in tibia or fibula.

Study of nutrient foramen is clinically very important as the position of nutrient foramen may differ in its growing and non-growing end; knowledge of which is mandatory to preserve the circulation for better prognosis. The Preserved circulation directly affects survival of the osteoblasts and osteocytes in cases of tumour resection and traumas [3]. Any accidental ligation of the nutrient artery leads to an immediate decrease in the bone blood flow leading to malunion or nonunion. Location of nutrient foramen in upper one third of tibia explains the fact of non-unions more common on the lower part of shaft [12]. Nutrient foramen typically appears linear on radiographs and can therefore mimic fractures. Anterior nutrient foramen can be misdiagnosed as osseous pathology, such as fractures or lytic bone lesions and can be the cause of shin pain[8]. From the length of the long bones, height of an individual can be calculated. The Knowledge of distance of nutrient foramen from either end is useful in calculating whole the length of long bone from a given fragment which is important in medico-legal and anthropological work [2,5].

The foramen may be a potential area of weakness in some patients [7]. Longitudinal stress fractures may be associated with nutrient foramen and are commonly seen in the tibia, but occasionally occur in the femur, fibula and patella [4]. These fractures may be underapprec-iated if an x-ray beam encounters a radial longitudinal fracture line at any angle other than perfect en face alignment. In such situation, even if the fracture is seen, it may be mistaken for a normal nutrient foramen [6]. Saad etal [7] had presented two cases of longitudinal stress fractures started at the nutrient foramen. According to them, when under stress because of increased physical activity or decreased quality of the bone, the foramen may allow development of a vertical fracture and the round shape of the foramen and absence of an endosteal and periosteal edema along the nutrient vessel course can rule out a stress fracture.

CONCLUSION

The maximally observed position of nutrient foramen is in middle third of the shaft of femur and fibula while upper third of shaft in tibia. Knowledge of which is important clinically for

proper diagnosis and planning of surgery and also to predict the prognosis.

ABBREVIATIONS

NF - Nutrient foramen

SF - secondary nutrient foramen

DF - dominant foramen

DNF - Distance of nutrient foramen from the highest point of bone

TL - Total length of bone

Conflicts of Interests: None

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