A Study Of Diaphyseal Nutrient Foramina In Human Lower Limb Long Bones.

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Abstracts: Background & Objectives: Nutrient foramen is a natural opening into the shaft of a bone, allowing for passage of blood vessels into the medullary cavity. This study aims to determine the number, location, size and direction of nutrient foramina of long bones of the lower limb. Which information is very important in orthopedic surgical procedures. Methodology: This study consisted of 120 adult human cleaned and dried bones of the lower limbs. They were divided into three groups 40 bones of each. Were studied above mentioned. Measurements were taken with Vernier Caliper. Results: Number: 40% of the femurs had a single foramen, 60% had double foramina. For the tibia, 100% had a single nutrient foramen. 80% of the fibula had a single nutrient foramen and 20% had double nutrient foramen. Position: femur: Of the total 48 foramina, 8(16.6%) were in the proximal third (Type-1) and 40(83.3%) in the middle third (Type-2). Tibia: Of the total 30 foramina, 27(90%) were in the proximal third (Type-1) and 3(10%) were in the middle third (Type-2). There were no foramina in the distal third (Type- 3).Fibula: Of the total 36 foramina, 35(97.2%) existed in the middle third (Type-2) and 1(2.7%) were in the distal third (Type-3). There were no foramina in the proximal third (Type-1).In femur all foramina directed proximally & in tibia all are directed distally while in fibula total 36 nutrient foramina observed out of them, 28 (77.71%) was directed distally; while 8(22.2%) was proximally. Conclusion: The study confirmed previous reports regarding the number and position of the nutrient foramina in the long bones of the lower limbs. Information and details about these foramina is of clinical importance, especially in surgical procedures like bone grafting and microsurgical vascularized bone transplantation. [Patel S NJIRM 2015; 6(3):14-18]

Key Words: Nutrient foramen, long bones, foraminal index.

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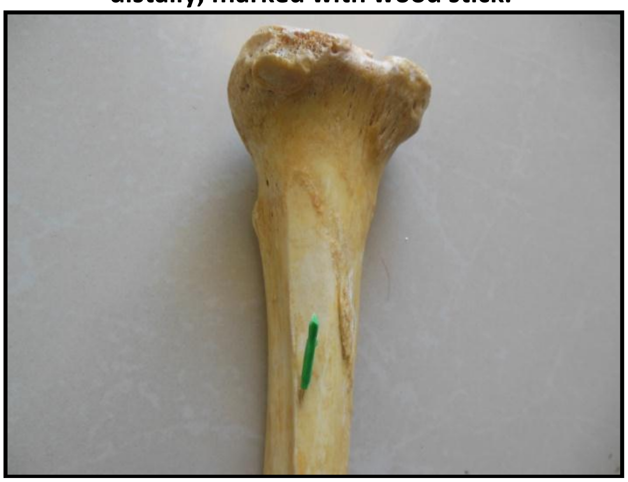
Introduction: Nutrient foramen is an opening into the bone shaft which gives passage to the blood vessels of the medullary cavity of a bone, for its nourishment and growth [1]. The nutrient artery is the principal source of blood supply to a long bone and is particularly important during its active growth period in the embryo and fetus, as well as during the early phase of ossification [2].Bones are structures that adapt to their mechanical environment, and from a fetal age adapt to the presence of naturally occurring holes which allow blood vessels to pass through the bone cortex [3]. When compromised occurs with less vascularization of the metaphysis and growth plate [4]. It has been suggested that the direction of the nutrient foramina is determined by the growing end of the bone,which is supposed to grow at least twice as fast as the non-growing end. As a result, the nutrient vessels move away from the growing end of the bone [1]. As is popularly stated, they 'seek the elbow and flee from the knee' [5], showing their varying directions in both limbs. Variations have been described in the direction of nutrient foramina in the lower limb bones [6]. However, only a few studies have reported variation in direction of the nutrient foramina in the upper limb bones [7].The study of nutrient foramina is important in both morphological and clinical aspects. Some pathological bone conditions such as fracture healing or acute a hematogenic osteomyelitis are closely related to the vascular system of the bone [8]. Detailed data on the blood supply to the long bones is invariably crucial in the development of new transplantation and resection techniques in orthopaedics [2, 9].Studies on the vascularization of long bones of various populations have been conducted to analyze the nutrient foramina morphometry [2, 10], the nutrient blood supply [11, 12], the vascular anatomy in reconstructive surgeries[13, 14] and the micro surgically vascularised bone transplant [15], [16].However, there is still a need for a greater Understanding of nutrient foramina in bones such as the humerus, radius and ulna. The aim of this study is to record the location, number and direction of nutrient foramina in long bones of the lower limbs.

Material and Methods: The study was conducted in the Department of Anatomy, medical college valsad. The materials for the present study consisted of 120 adult human cleaned and dried bones of the lower limbs. They were divided into three groups: 40 bones of femur and 40 bones each of tibia and fibula. All selected bones were normal with no appearance of pathological changes. The specific age and sex characteristics of the bones studied were unknown.The nutrient foramina were observed in all bones with the help of a hand lens. They were identified by their elevated margins and by the presence of a distinct groove proximal to them. Only well-defined foramina on the diaphysis were accepted. Foramina at the ends of the bones were ignored.

Direction: A fine stiff broomstick was used to confirm the direction and obliquity of the foramen.

Figure 1: Large nutrient foramina on tibia directed distally, marked with wood stick.



Position: The position of all nutrient foramina was Determined by calculating the foraminal index (FI) using the formula:

FI = (DNF/TL) x 100

Where DNF=the distance from the proximal end of the bone to the nutrient foramen; TL=Total bone length 17. The position of the foramina was divided into three types according to FI as follows:

Type 1: FI below 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.

Figure 2: Level of nutrient foramina in different fibula bone

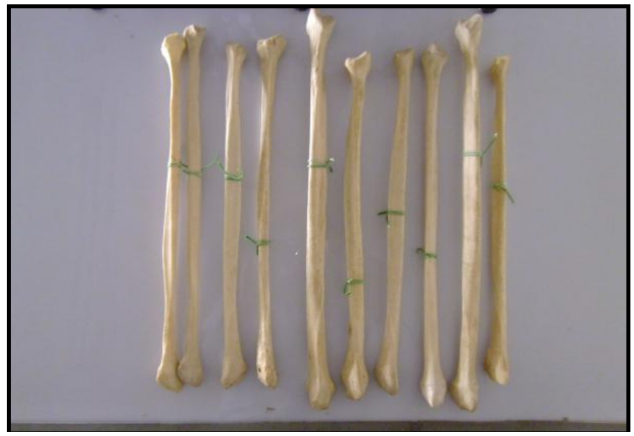
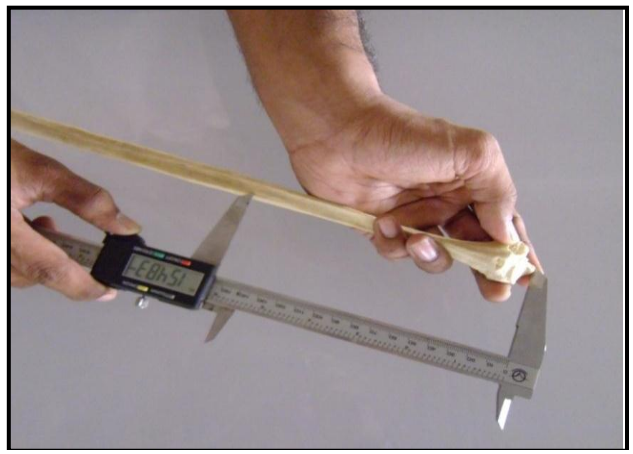


Figure 3: Measurements of distance between head of fibula to level of nutrient foramina.



All measurements were taken to the nearest 0.1 mm using an INOX sliding calliper 2. Photographs were taken by a Casio digital camera (12 mega pixels). Each photograph had a definition of 16x12 cm.

Results: Total 16(40%) femurs had a single foramen and 24(60%) had double foramina, for the tibia all had a single foramina 40(100%), and for the fibula 32(80%) had a single and 8(20%) had a double foramina. (Table-1). Tables 1 to 8 give the details of the results in terms of nutrient foramina number, position, size and directions.

Discussion: Number of Nutrient Foramina: In this study, 60% of the femora examined possessed double nutrient foramina, while 40% had only one nutrient foramen. In the previous literatures, a discrepancy was noticed regarding the number of nutrient foramina in the femora. Many authors stated that the majority of femora studied had double nutrient foramina[4, 19,20], while others reported the presence of a single foramen in most specimens [2,6,21].

Table 1: Number of nutrient foramina observed in the long bones of the lower limb.

Bone	Number of bone	Number of foramina	Percentage
Femur (n=40)	16 24	1 2	40% 60%
Tibia (n=40)	40	1	100%
Fibula (n=40)	32 8	1 2	80% 20%

Table 2: Position and number of dominant (DF) and secondary (SF) nutrient foramina observed in the femur.

Position	Total FM (nos)	%	Number of FM			
			Single		Two	
			DF	SF	DF	SF
Between the two lips of linea Aspera	9	18.6	4	_	5	_
Medial lip of linea aspera	16	3.33	4	_	6	6
Lateral lip of linea aspera	12	2.5	5	_	7	_
Posteromedial Surface	11	22.8	2	_	4	5
Posterolateral Surface	3	6.24	_	_	3	_
Medial to spiral line	5	10.3	1	_	1	3
Gluteal tuberosity	8	16.6	2	_	4	2

*** Foramina – FM**

Table 3: Position and number of dominant (DF) and secondary (SF) nutrient foramina in tibia.

Position	Total FM (Nos)	%	Number of FM			
			Single		Two	
			DF	SF	DF	SF
Posterior surface (midway between interosseous border and soleal line)	12	30	3	9	_	_
Posterior surface (closer to the interosseous Border	25	62.5	11	14	_	_
Posterior surface (Closer to soleal line).	3	7.5	1	2	_	_

Table 4: Position and number of dominant (DF) and secondary (SF) nutrient foramina observed in the fibula.

Position	Total FM (Nos.)	%	Number of FM			
			Single		Two	
			DF	SF	DF	SF
Posterior surface (on the medial crest)	32	66.6	1	25	3	3
Posterior surface (between medial crest and Interosseous border)	15	31.2	_	6	_	9
Lateral surface	1	2.0	_	_	1	_

Table 5: Position and direction of nutrient foramina in the long bones of the lower limb.

Bone	Position			Direc-tion
	Type-1	Type-2	Type-3	
Femur	11 (17.18%)	53 (82.8%)	_	Proxi-mal
Tibia	36(90%)	4 (10%)	_	Dista-lly
Fibula	_	46 (95.8%)	2 (4.1%0)	38 distaly 10 proxi-mal

Table 6: The range, mean ± standard deviation (SD) of foraminal indices of the femur.

Position	Side	Range	Mean ± SD
Between the two lips of linea aspera	L R	37.09 – 38.49 36.06 – 62.65	37.63 ± 00.75 46.00 ± 11.55
Medial lip of linea aspera	L R	44.05 – 59.17 37.37 – 60.38	54.93 ± 7.27 52.54 ± 9.48
Lateral lip of linea aspera	L R	35.87 – 51.53 35.30 – 61.14	41.70 ± 8.55 46.25 ± 10.16

Posteromedial Surface	L R	55.11 – 60.67 45.20 – 59.06	57.18 ± 3.03 55.47 ± 5.81
Medial to spiral line	L R	- 29.81 – 31.90	- 31.12 ± 00.91
Gluteal tuberosity	L R	31.87 – 37.31 31.73 – 34.25	34.06 ± 2.87 33.07 ± 1.26

L=Left, R=Right

Table 7: The range, mean ± standard deviation (SD) of foraminal indices of the tibia.

Position	Size	Range	Mean ± SD
Posterior surface (Midway between interosseous border and soleal line)	L R	27.82 – 34.17 27.95 – 31.52	31.24 ± 2.62 29.47 ± 1.43
Posterior surface (closer to interosseous border)	L R	26.49 – 35.54 28.53 – 32.17	30.56 ± 3.06 30.25 ± 1.45

Table 8: The range,mean ± standard deviation (SD) of foraminal indices of the fibula.

Position	Side	Range	Mean ± SD
Posterior surface (on the medial crest)	L R	36.18 - 50.15 35.23 – 61.45	43.85 ± 4.09 45.52 ± 6.68
Posterior surface (between medial crest and interosseous border)	L R	40.25 - 67.69 36.39 - 65.33	47.53 ± 6.26 45.66± 6.61

In this study, the whole series of tibiae examined had a single nutrient foramen. Previous studies reported the presence of a single nutrient foramen in at least 90% of the tibiae. But, in contradiction with the present results, they also reported the presence of double nutrient foramina in some of the tibiae [6,18,19,20.]

In the fibulae studied, 80% of the bones presented a single nutrient foramen, while 20% of the bones possessed double nutrient foramina. Similar data had been reported in previous study.[4,6,18], while Mckee reported fibulae with three nutrient foramina[22]. On the other hand fibulae with no nutrient foramina reported by other auther[18,19,20].

<u>Position of nutrient foramina:</u> In the present study, most of the nutrient foramina (83.33%) were located along the middle third of the femur; the rest were in the proximal third, with no foramina detected in the distal third of the femur. These results were in accordance with other author's study [2,4,6,18,19]. However, these findings did not coincide with those of other authors study who stated that the nutrient foramina were closer to the hip joint[4,21].

In the present series, all nutrient foramina studied were located on the posterior surface of the tibiae. Similar results were reported by other author's study[2, 4,6,18.]

In this study, 66.66% of the fibular foramina were located on the medial crest and 30.55% on the posterior surface. Similarly, other author reported that 56% of nutrient foramina were located on the medial crest while 33% lied on the posterior surface of fibula[18].

However, some authors observed more nutrient foramina on the posterior surface compared to those on the medial crest [2, 4,19,20.]

Conclusion: The study confirmed previous reports regarding the number and position of the nutrient foramina in the long bones of the limbs. It also provided important information to the clinical significance of the nutrient foramina.

Accordingly, a well understanding of the characteristic morphological features of the nutrient foramina by orthopaedic surgeons is recommended. Exact position and distribution of the nutrient foramina in bone diaphysis is important to avoid damage to the nutrient vessels during surgical procedures.

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