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A study of Diaphyseal Nutrient Foramina in human lower limb long bones and its clinical importance

Vijayalakshmi SB[1], Sneha Guruprasad Kalthur[2], Antony Sylvan D' Souza[2]

[1]Department of Anatomy, RAK College of Medical Sciences, RAK Medical and Health Sciences University, Ras Al Khaimah, UAE

[2]Department of Anatomy, Kasturba Medical College, Manipal University, Manipal, Karnataka, India

*Corresponding author: *drvijishetty@gmail.com*

Abstract

The diaphyseal nutrient artery, main source of blood to a long bones. A natural opening in the shaft of the long bones, Nutrient foramen allows these arteries into the medullary cavity. The objective of this study is to investigate the location, number and direction of the nutrient foramen in long bones of adult lower limbs. The study was conducted on 150 human lower limb long bones. Non-metrical and metrical measurements were investigated Femora had foramen on the middle one-third between 25% and 63%, on the linea aspera. Majority of them had single dominant foramen of large size caliber directed towards the proximal end. However, in Tibia, upper one-third (between 27% and 44%) was the most common location of nutrient foramen. Most of the nutrient foramen were large in diameter and were directed towards the distal end of the bone. In fibula, the most common position of the nutrient foramen was between 31% and 75%, that is, middle one-third. Majority of the dominant foramina were of medium size caliber. However, in 6 fibulae the nutrient foramina were directed proximally which violated the law. An accurate knowledge of the location of the nutrient foramina in long bones can be useful in certain surgical procedures like bone grafting, microsurgical vascularized bone transplantation and in many fractures.

Keywords: Nutrient foramina, diaphyseal nutrient artery, dominant foramina.

Introduction

Clinical fracture of a long bone is usually accompanied by rupture of the nutrient artery and periosteal vessels, following, together with those in the adjacent soft tissue, start local bleeding (Trueta J, 1974). Long bones are generally supplied with blood, via periosteal, diaphyseal, metaphyseal and epiphyseal arteries. The diaphyseal nutrient artery is the main source of blood to entire osteal tissue and bone marrow of a long bone, especially during its active growth period and the early stages of ossification (Nagel A, 1993). Therefore, they play a very significant role in healing of fractures and prevention of avascular bone necrosis. Even though metaphyseal and epiphyseal vessels, together with the periosteum, can maintain the blood supply of bones after an interruption of nutrient arteries, it cannot support the complete healing of the fractured bones. Injury to the nutrient artery at the time of fracture, or during subsequent manipulation and surgery may be a significant predisposing factor to faulty union of long bones (Craig JG et al., 2003). The site of entry and the angle with which the nutrient artery enters the bone creates a distinct groove proximal to foramen and characteristically directed away from the dominant growing epiphysis (Branemark PI, 1959).

In long bones of lower limb, nutrient foramen in femur is directed proximally usually towards the linea aspera. The main nutrient artery is usually derived from the second perforating artery, branch of profunda femoris artery. If two nutrient arteries occur, they may branch from the first and third perforators (Oyedun OS, 2014). In the tibia, nutrient foramen is generally present on posterior surface where there is a large vascular groove near the end of the vertical line, which is a faint line descending from the center of the soleal line and directed distally. The foramen transmits a branch of the posterior tibial artery; or a branch may arise at the level of the popliteal bifurcation or as a branch from the anterior tibial artery (Collipol E et al., 2007). In the fibula a little proximal to the midpoint of the posterior surface, the shaft is characterized by a nutrient foramen, directed distally, which receives a branch of the fibular artery branch of posterior tibial artery (Standring S, 2008)

Longitudinal stress fractures are more commonly associated with the lower limb bones. These longitudinal stress fractures arise either from the nutrient foramen or its superomedial aspect hence location, number and direction of nutrient foramina is important (Craig JG et al., 2003). An understanding of the location and number of nutrient foramina in long bones is, therefore important in orthopaedic surgical procedures such as joint replacement therapy, fracture repair, bone grafts and vascularized bone microsurgery, as well as in medicolegal cases (Trueta J, 1974; Nagel A, 1993; Longia GS et al., 1980; Campos F et al., 1987; Sendemir E et al., 1991; Gumusburun E et al., 1994).

The objective of the investigation was to contribute details of the diaphyseal nutrient foramina of the femur, tibia and fibula bones, specifically in terms of location, number and direction.

Materials and Methods

The study was conducted on 150 human adult (>25 years) lower limb long bones of unknown sex preserved in Department of Anatomy, Kasturba Medical College, Manipal, Manipal University. The bones assessed were 50 femora (29 right, 21 left), 50 tibiae (27 right, 23 left) and 50 fibulae (25 right, 25 left). A prior approval was obtained from the Institutional Ethics Committee to conduct the study.

Only well-defined foramina on the diaphysis were accepted. Foramina at the ends of the bones, worn out and damaged bones were ignored. For each bone the number, direction, location and caliber of nutrient foramina were noted. The location of NF was described into horizontal and vertical zones. Horizontal zone was with respect to surface and border. Any foramen lying within 1mm from any border was taken to be lying on that border (Gumusburun E et al., 1994). Vertical zones was with respect to length of the bone, which was divided into three zones that is upper one-third, middle one-third and lower one-third. To determine caliber three hypodermic needle of 20G (Large), 24G (Medium) and 26G (Small) were used.

The location of all nutrient foramina was determined by calculating a foraminal index (I) using the formula: $I = DNF/TL \times 100$, where DNF is the distance from the proximal end of the bone to the nutrient foramina and TL the total bone length. Determination of the length of the individual bones was taken as follows: for the femur, the straight distance between the highest point of the head and the deepest point on the lateral condyle; for the tibia from the most projecting point of the inter-condylar eminence to tip of the medial (tibial) malleolus; and for the fibula between the apex of the head of the fibula and the distal aspect of the lateral malleolus. Circumference of the bone at the level of nutrient foramen was noted with a help of a wire and measured using Vernier caliper.

All measurements were taken to the nearest 0.1mm using an INOX sliding caliper (China) 6. The data were analyzed using SPSS (Statistical Package for the Social Sciences–USA). Data are expressed as means and standard deviations for continuous variables, and percentage for categorical variables

Results

In the present study, variations in number, size of the foramen, direction of foramen and their location in adult long bones of lower limb were recorded.

A. Variation in the number of nutrient foramina of lower limbs (Table 1).

Table 1: Variations in number of nutrient foramina observed in long bones of the lower limbs

Bone	Number of foramen	Right side	Left side	Total Number
Femur (n=50)	0	0	0	0
	1	14	17	31
	2	12	3	15
	3	2	1	3
	4	1	0	1
Tobia (n=50)	0	0	0	0
	1	27	22	49
	2	0	1	1
Fibula (n=50)	0	5	4	9
	1	20	19	39
	2	0	2	2

Femora: The number of nutrient foramen ranged from one to four in femur. Majority of the femora (62%) had a single nutrient foramen while 30% of femora had two nutrient foramina, 6% had three nutrient foramina and 2% of femora had four nutrient foramina in them. However, femora with two nutrient foramina were more common on the right side than the left side (12 and 3 respectively). Three nutrient foramina were observed in two of the three femora while there was only one femur with four nutrient foramina which was of right side (Figure 1).

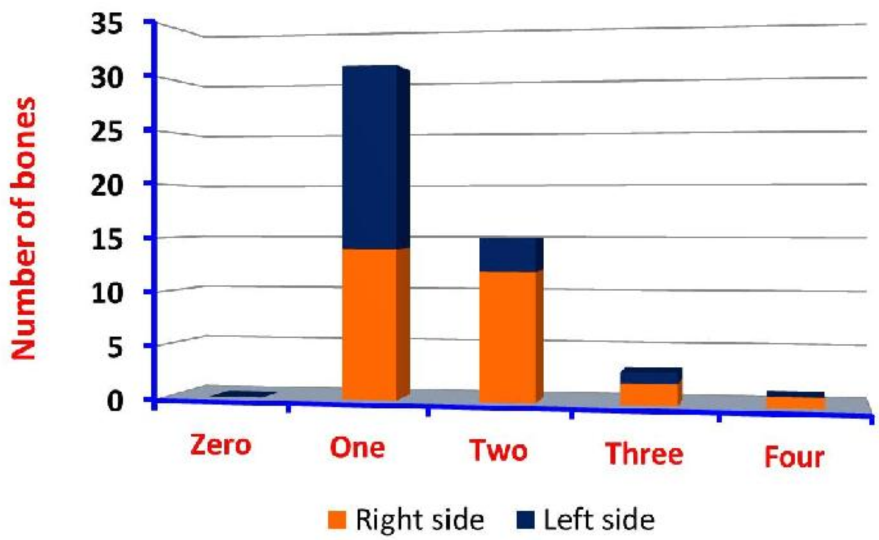

Figure 1: Frequency of variation in the number of nutrient foramen in femora of right and left sides (n=50)

Tibiae: In the tibia, 98% of the bones (49 tibiae) had single nutrient foramen whereas two nutrient foramina were found in one tibia (2%) which was of left side (Figure 2).

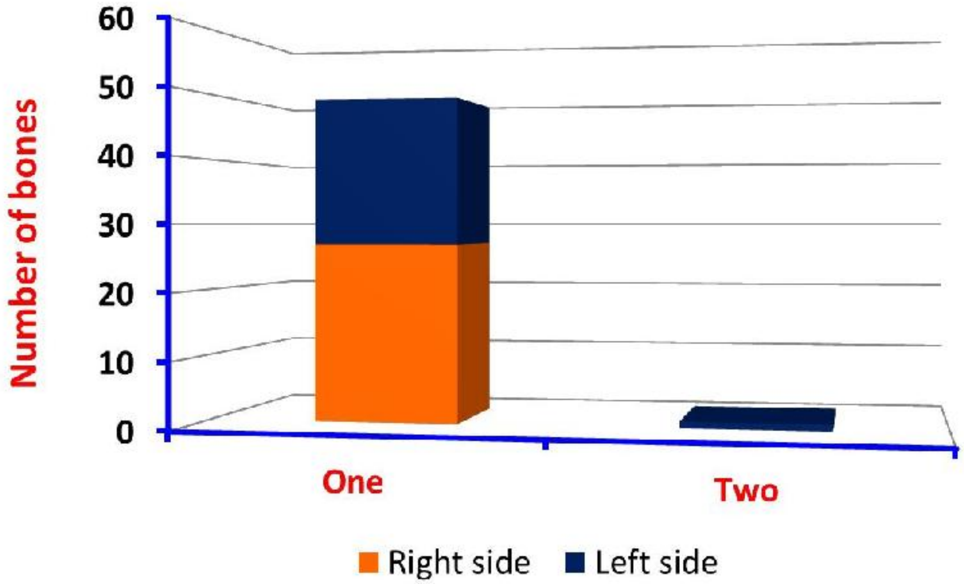

Figure 2: Frequency of variation in the number of nutrient foramen in tibiae of right and left sides (n=50)

Fibulae: In the fibula, 78% of the bones had single nutrient foramen while in 4% of fibulae there were two nutrient foramina which were of left side. In addition, 18% of the fibulae did not have any nutrient foramen in them (Figure 3).

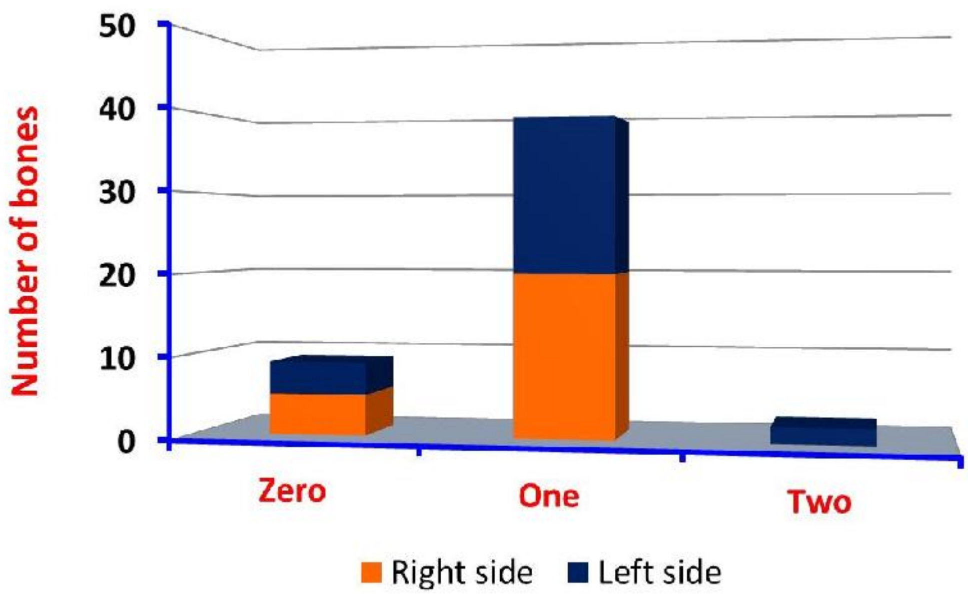

Figure 3: Frequency of variation in the number of nutrient foramen in fibulae of right and left sides (n=50)

B. Directions of nutrient canal in long bones of lower limbs:

The direction of nutrient canal was observed in 150 long bones of lower limb (Table 2).

In 50 femora analyzed, there were 74 nutrient foramina in total. All the foramina were directed towards the proximal end. Similarly in tibia, 50 tibiae had 51 nutrient foramina in total all of which were directed towards the distal end. However, in fibulae (n=50) there were a total of 43 nutrient foramina out of which 6 were directed towards proximal end and the remaining 37 were directed towards distal end.

Table 2: Various directions of the nutrient canal observed in the long bones of lower limbs

Bones	Total No,of foramina	Towards proximal end	Towards distal end
Femur (n=50)	74	74	0
Tibia (n=50)	51	0	51
Fibula (n=50)	43	6	37

C. Location of nutrient foramen in long bones of lower limbs (Table 3):

Femora (n=50): In 50 femora of both right and left sides a total of 74 nutrient foramina were observed in the present study. In 34 (68%) bones a total of 45 (60.8%) foramina were present on linea aspera (LA) out of which 37 were dominant and 8 were secondary foramina. In 7 bones (14%) there were 15 nutrient foramina (20.3%) located on the medial surface (MS) out of which 10 were dominant and the remaining 5 were secondary. In 4 bones (8%) the lateral surface had 7 nutrient foramina (9.5%) among which 5 were dominant and 2 were secondary. On the posterior surface of 3 bones (6%) a total of 5 nutrient foramina (6.8%) were observed in which 3 were dominant and 2 were secondary. On the spiral line (SL) and on lateral lip of gluteal tuberosity a single nutrient foramen (1.4%) was observed in each bone (2%).

Tibiae (n=50): In 50 tibiae of both the sides a total of 51 nutrient foramina were observed. The anterior border, medial border, medial surface and lateral surface did not have any nutrient foramen in any of the bones studied. In 48 (96%) tibiae a total of 49 nutrient foramina (96.1%) were observed on the posterior surface of the bones. Among these 49 foramina, 48 were dominant and one was secondary. In relation to the posterior surface the nutrient foramen was observed related to vertical line and soleal line. Among 48 nutrient foramina, 30 were lateral to the vertical line, 9 were medial to the vertical line, and 8 on the vertical line and 1 foramen were on the soleal line. In remaining two bones (4%), the interosseous border had 2 (3.9%) nutrient foramina in them both of which were dominant.

Fibulae (n=50): Out of 50 fibulae, 41 bones (82%) had foramina located on posterior surface and remaining 9 (18%) bones had no foramen. There were 43 nutrient foramina in total all of which were located on the posterior surface (100%) in which 41 were dominant and 2 secondary. Among these, 20 nutrient foramina were between medial crest and posterior border, 17 were on the medial crest and 6 were between interosseous border and medial crest. On the anterior border, posterior border, interosseous border, medial surface and lateral surface there were no nutrient foramina.

Table 3: Location and number of dominant (DF) and secondary (SF) nutrient foramina observed in lower limb long bones (right & left)

Bone	No.of bones (%)	Location	Number of foramina (%)	Number of foramina	
				Dominant foramen (DF)	Secondary foramen (SF)
Femora (n=50) TF=74	34(68%)	LA	45(60.8%)	37	8
	7(14%)	MS	15(20.3%)	10	5
	4(8%)	LS	7(9.5%)	5	2
	3(6%)	PS	5(6.8%)	3	2
	1(2%)	SL	1(1.4%)	1	0
	1(2%)	LGT	1(1.4%)	1	0
Tibiae (n=50) TF=51	-	AB	-	0	0
	-	MB	-	0	0
	2(4%)	IB	2(3.9%)	2	0
	-	MS	-	0	0
	-	LS	-	0	0
	48(96%)	PS	49 (96.1)	48	1
Fibulae (n=50) TF=43)	-	AB	-	0	0
	-	PB	-	0	0
	-	IB	-	0	0
	-	MS	-	0	0
	-	LS	-	0	0
	41(82%)	PS	43(100%)	41	2

LA= Linea aspera; MS= Medial surface; LS= Lateral surface; PS= Posterior surface; SL= Spiral line; GT= Gluteal tuberosity; AB= Anterior border; MB= Medial border; IB= Interosseous border; PB= Posterior border

D. Position of nutrient foramen in long bones of lower limbs divided into vertical zones

The long bones of the lower limbs were divided in to three equal halves and designated as upper $1/3^{rd}$, middle $1/3^{rd}$ and lower $1/3^{rd}$.

Femora: In 50 femora of both right and left sides a total of 74 nutrient foramina were observed in which 10 nutrient foramina (6 on the right and 4 on the left) were found in the upper $1/3^{rd}$ of the bone. Majority of the nutrient foramina (64 out of 74) occupied the middle $1/3^{rd}$ of the bone. Lower $1/3^{rd}$ of the femur did not have any nutrient foramen in it.

Tibiae: In 50 tibiae analyzed in the study, there were 51 nutrient foramina totally, out of which 30 nutrient foramina (12 on right and 18 on left side) were observed in the upper $1/3^{rd}$ of the bone. In the middle $1/3^{rd}$ of the bone there were 21 nutrient foramina (15 on right and 6 on left). Lower $1/3^{rd}$ of tibia did not have any nutrient foramen.

Fibulae: Out of 50 fibulae of both right and left hand side, there were 43 nutrient foramina. In upper $1/3^{rd}$ of the bone, only on right side of fibula, there was single nutrient foramen on the posterior surface. On the left side there was no nutrient foramen lying in this segment. However, in the middle $1/3^{rd}$ of the bone, there were 41 nutrient foramina (19 on right and 22 on left) all of which were located on the posterior surface of the bone. In lower $1/3^{rd}$ of the bone no nutrient foramen was observed on the right side while on the left side there was one nutrient foramen located on the posterior surface of the bone.

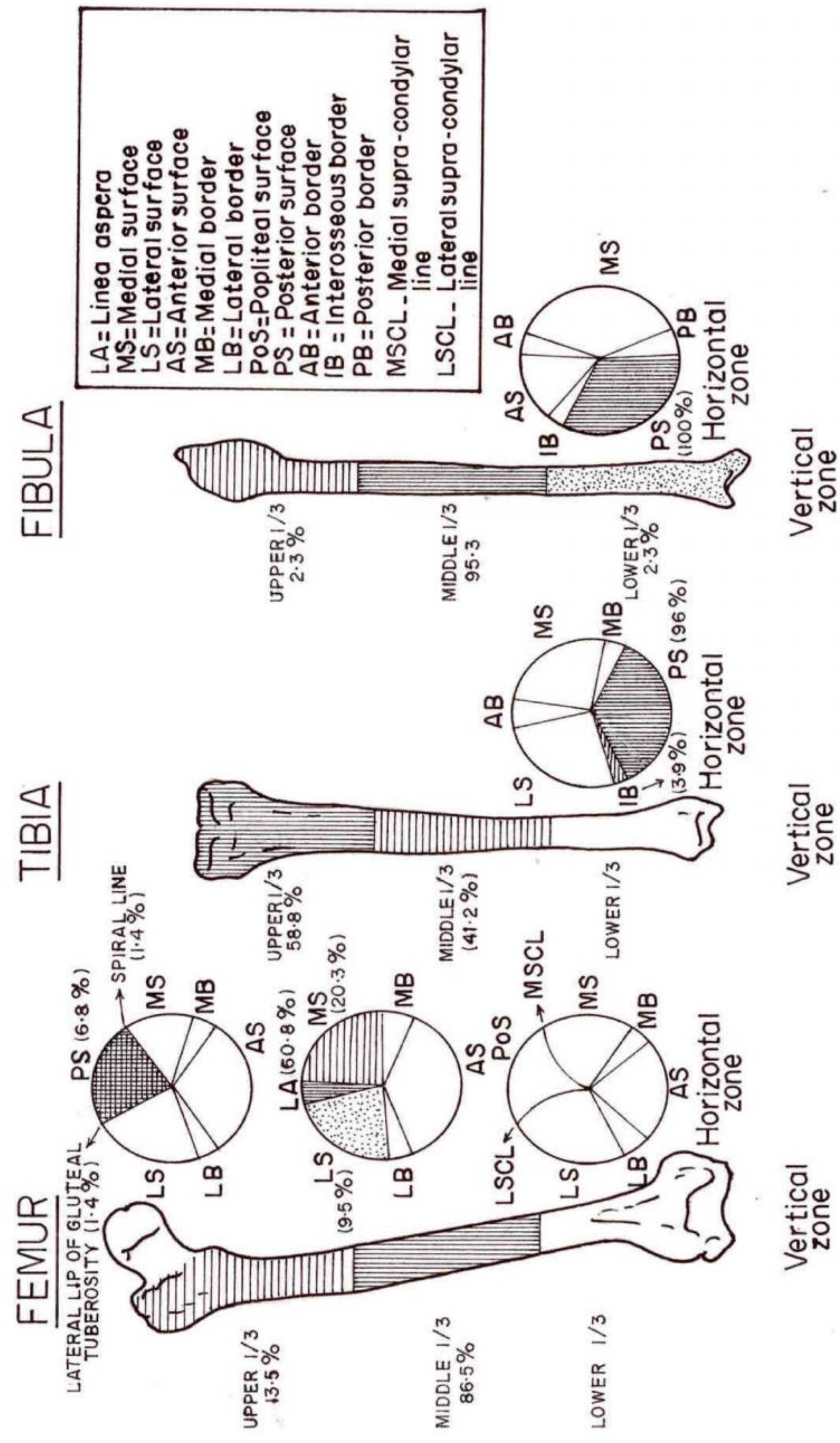

Figure 4: Position of Nutrient foramina in lower limb long bones

E. Variations in the size of nutrient foramina in long bones of lower limbs:

Different sizes of nutrient foramina ranging from very small to very large were observed in the lower limbs. Only dominant foramina caliber was noted.

Femora: Among 50 femora, 48 femora had dominant nutrient foramina of large sized caliber, only one femur each had small and very small caliber. Out of 57 dominant foramina, 55 (96 %) were having large sized caliber, 1 (2 %) each was small and very small caliber. None of the dominant foramina had medium sized caliber.

Tibiae: In 50 tibiae, there were 51 nutrient foramina among which 50 were dominant. In 50 dominant foramina, 12 nutrient foramen (24%) were having very large caliber, 30 (60%) were with large caliber, 5 nutrient foramen (10%) were with medium caliber and 3 (6%) foramina of small sized caliber.

Fibulae: In 50 fibulae there were total of 43 nutrient foramina among which 41 (95.3%) were dominant. In 41 dominant foramina, 10 (24.4%) were of large caliber, 19 (46.3%) were of medium caliber, 5 (12.2%) were small and 7 (17.1%) were of very small caliber (Figure 10). Out of 50 fibulae, 10 bones had large caliber followed by 19 of medium, 5 of small and 7 bones of very small calibered nutrient foramina.

F. Metrical parameters of long bones of lower limbs (Table 4)

Table 4: Metrical parameters of long bones of upper and lower limbs

Bone	**Metrical parameters in cm (Mean SE)**					
	Length	**DNF(p)**	**FI**	**DNF(d)**	**Mid-shaft**	**Mean Circum**
Femur	44.40±2.72	17.40±4.51	39.40±1.02	25.03±4.90	4.90±2.39	8.50±0.55
Tibia	37.40±2.61	12.60±1.47	33.70±3.32	24.60±2.12	5.90±1.26	8.60±0.83
Fibula	35.20±2.45	17.10±3.78	48.30±1.02	18.50±3.57	2.80±1.59	4.40±0.36

Femur had a mean length of 44.4 cm. The distance of NF from proximal end was 17.4 cm, from distal end was 25.03 cm. About 4.9 cm above the mid length was the presence of NF on an average. The mean FI- 39.3 and mean circumference was 8.5 cm.

Mean length in tibia was 37.4 cm. The presence of NF from the proximal end was 12.6 cm and 24.65 cm from distal end. About 5.85 cm above or below the mid length was the presence of NF on an average. The mean FI- 33.7 and mean circumference was 8.55 cm.

In fibula, the mean length was 35.2 cm. The distance of NF from proximal end was 17.1 cm, from distal end was 18.5 cm and from mid shaft was about 2.8 cm above or below. The mean FI- 48.3 and mean circumference was 4.4 cm.

Discussion

Femora:

In the present study, the mean length of the femur was 44.4 ± 2.72 cm which agrees with earlier reports done by Sendemir E et al (1991), Gumusburun E et al (1994), Kizilkanat E et al (2007) and Collipol E et al (2007).

The FI in the present study observed to range from 25.38 to 63.15%. The lowest FI of this study are similar to that reported by Campos F et al (1987) and Kizilkanat E et al (2007). On the contrary, the previous study conducted by Mysorekar VR (1967) reported that the FI ranges from as low as 16.55 to 67.5%.

Majority (62%) of the femora in the present study had single nutrient foramen. This is in agreement with the few previous studies by Longia GS et al (1980); Kizilkanat E et al (2007). On contrary the earlier reports by Collipol E et al (2007), Campos F et al (1987), Sendemir E et al (1991), Gumusburun E et al (1994) and Mysorekar VR (1967) reported majority of the femora had double NF with a incidence from 42.8 to 60%. But in the present study about 30% of the femora had double NF.

Sendemir E et al (1991) observed up to nine NF in the femur which was observed in Turkish population. Absence of NF in femur was also reported by Gumusburun E et al (1994) and Mysorekar VR (1967) which was not observed in the present study.

Considering the size of the nutrient foramina, majority of them (74.3%) were of large caliber which was not coinciding with few earlier reports (Longia GS et al., 1980 and Kizilkanat E et al., 2007). Medium size caliber was highest in the previous studies.

The location of the nutrient foramen in femur of the present study was similar to those studies reported previously (Longia GS et al., 1980; Sendemir E et al., 1991; Gumusburun E et al., 1994 and Mysorekar VR, 1967). Majority of the NF was found on the middle one-third of the bone followed by upper one-third. In lower one-third of the bone there was not a single NF observed in this study. However, earlier studies have observed that few NF occupy the lower one-third of the bone (Longia GS et al., 1980; Sendemir E et al., 1991; Gumusburun E et al., 1994 and Mysorekar VR, 1967). When the location of the nutrient foramen on the horizontal zone was analyzed, the most common position was on the linea aspera followed by medial surface and lateral surface which agrees with the earlier reports (Collipol E et al., 2007; Longia GS et al., 1980; Campos F et al., 1987; Sendemir E et al., 1991; Gumusburun E et al., 1994 and Mysorekar VR, 1967). 6.8% of the NF was observed on the posterior surface in the present study which agrees with few previous studies (Longia GS et al., 1980; Sendemir E et al., 1991; Kizilkanat E et al., 2007). In the present study 1.4% each of NF was observed on the spiral line and lateral lip of gluteal tuberosity in the upper one-third of the bone which was not reported in the earlier reports. No nutrient foramen was observed on the anterior surface in the present study but Sendemir E et al., (1991) observed 17 NF on the anterior surface.

Tibia:

The mean length of 50 tibiae was around 37.4 ± 2.61 cm in the present study and almost in agreement with the previous studies (Collipol E et al., 2007; Sendemir E et al., 1991; Gumusburun E et al., 1994 and Kizilkanat E et al., 2007).

The FI was calculated which was ranging from 27.22 to 43.54% in the present study. On contrary, the study done by Sendemir E et al., (1991) and Gumusburun et al., (1994) reported FI as low as 11 and 14.82% respectively.

In the present investigation majority that is 98% of the tibiae were found to have single NF. Presence of double NF has been observed by previous authors (Collipol E et al., 2007; Longia GS et al., 1980; Campos F et al., 1987; Sendemir E et al., 1991; Gumusburun E et al., 1994; Kizilkanat E et al., 2007 and Mysorekar VR, 1967). Presence of double NF in the present study was 2% which was in agreement with all above authors except Gumusburun et al., (1994) where he got 11%. Also he reported 2.8% having three NF and 0.9% with no NF. But this was not seen in present study.

Majority of the NF (82.4%) in tibiae were of large sized caliber which was not agreeing with earlier reports. Majority of the NF in earlier reports (Longia GS et al., 1980 and Kizilkanat E et al., 2007) were of medium size caliber which was only 9.8% in the present study. Also no NF in the Kizilkanat et al., (2007) study was of large sized caliber.

Highest percentages of nutrient foramina were found within the upper one-third of the bone followed by middle one-third in present study. This is in agreement with previous studies (Longia GS et al., 1980; Gumusburun E et al., 1994 and Mysorekar VR, 1967). No NF was seen on lower one-third. In addition, when the location of the NF on the horizontal zone was analyzed, the most common position was on the posterior surface which agrees with earlier reports (Collipol E et al., 2007; Longia GS et al., 1980; Campos F et al., 1987; Sendemir E et al., 1991; Gumusburun E et al., 1994; Kizilkanat E et al., 2007 and Mysorekar VR, 1967). Few NF (3.9%) were observed on the interosseous border which was also observed by previous authors (Collipol E et al., 2007; Longia GS et al., 1980; Sendemir E et al., 1991; Gumusburun E et al., 1994 and Mysorekar VR, 1967). Few nutrient foramina were also observed on the other areas like anterior border, medial border, medial and lateral surfaces in previous studies done by Longia GS et al., (1980); Sendemir E et al., (1991); Gumusburun E et al., (1994); Kizilkanat E et al., (2007) and Mysorekar VR, (1967), which was not observed in the present study.

Fibula:

The mean length of fibula was 35.25 ±2.45 cm in the present study which was in agreement with the previous studies (Sendemir E et al., 1991; Gumusburun E et al., 1994; Kizilkanat E et al., 2007).

The FI of fibula was observed to range from 31.6 to 74.33% in the present study. The result of this study are almost similar to that reported by Campos et al., (1987); Sendemir et al., (1991); Gumusburun et al., (1994); Kizilkanat et al., (2007) and Mysorekar VR, (1967).

Single nutrient foramen was in majority on the 78% of fibulae in the present investigation. This result was corresponding with previous reports done by Collipol et al., (2007); Longia et al., (1980); Campos et al., (1987); Sendemir et al., (1991); Gumusburun et al., (1994); Kizilkanat et al., (2007); Mysorekar VR (1967) and McKee et al., (1984) with an incidence from 73.9 to 93.2%. Absence of NF in the fibula were reported by previous authors (Sendemir et al., 1991; Gumusburun et al., 1994; Kizilkanat et al., 2007; Mysorekar VR, 1967 and McKee et al., 1984) and in the present study it was about 18%. A study by Mc Kee et al., (1984) reported a fibula having three foramina which was not observed in the present study and also the study done by other authors.

Size of the nutrient foramen was studied and about 44.2% of the foramina were of medium sized caliber which was in agreement with a study by Kizilkanat et al., (2007). A study by Mc Kee et al., (1984), majority of the NF were of small sized caliber and it was only 11.6% in the present study. About 16.3% of NF were very small. No NF were of large caliber in the study done by Kizilkanat et al., (2007) but in the present study, 23.3% of NF were of large size and even McKee et al., (1984) observed about 12.9% of NF with large sized caliber.

Majority of the nutrient foramina (95.3%) in the fibulae were located on the middle one-third of the bone. This result agrees with previous studies (Longia GS et al., 1980; Campos F et al., 1987; Gumusburun E et al., 1994; Mysorekar VR, 1967 and McKee et al., 1984). 2.3% each of NF were observed on the upper one-third and lower one-third in the present report which agrees with few previous reports (Mysorekar VR, 1967 and McKee et al., 1984). No NF were observed on the upper one-third of the bone in the study done by Gumusburun et al., (1994). Considering the location of the nutrient foramen on the horizontal zone, all the NF were on the posterior surface in the present study which was also reported by previous studies (Collipol E et al., 2007; Campos F et al., 1987; Gumusburun E et al., 1994; Mysorekar VR, 1967 and McKee et al., 1984). Sendemir et al., (1991) observed that the majority of the NF were on the medial surface. Previous authors observed few NF in other areas of the bone like anterior border, medial border, interosseous border, medial surface and lateral surface (Collipol E et al., 2007; Campos F et al., 1987; Sendemir E et al., 1991; Gumusburun E et al., 1994; Kizilkanat et al., 2007; Mysorekar VR, 1967 and McKee et al., 1984). But in the present study no single NF was observed on other areas of the bone.

The nutrient foramina in long bones as a rule are directed towards the elbow and away from the knee. All the foramina of long bones in the present study were following the rule except about 13.95% of fibulae were violating the rule. This result agrees with the study done by Mysorekar VR (1967) where he observed in 5% of the fibulae, the NF was directed upwards.

Longia et al., (1980) observed that in 0.5% femur, 3.5% tibiae and 9.5% fibulae, the NF was directed upwards

Conclusion

The present study was conducted on 150 long bones of the lower limb to study the variation in nutrient foramen with respect to their number, location, direction and size of the diaphyseal nutrient foramina.

In femur the most common position of the foramen was on the middle one-third between 25% and 63%, on the linea aspera. Majority of them had single dominant foramen of large size caliber directed towards the proximal end. However, in Tibia, upper one-third (between 27% and 44%) was the most common location of nutrient foramen found on the vertical zone, whereas, in the horizontal zone majority of nutrient foramina were located on the posterior surface of the bone. Most of the nutrient foramen were large in diameter and were directed towards the distal end of the bone. In fibula, the most common position of the nutrient foramen was between 31% and 75%, that is, middle one-third. All the foramina were found on the posterior surface. Majority of the dominant foramina were of medium size caliber. However, in 6 fibulae the nutrient foramina were directed proximally which violated the law.

In conclusion, the nutrient foramen with respect to the location in the femur no foramen was observed on the lower one-third of the total length of the bone. In fibula, no foramina were observed on any borders or surfaces, all were limited on the posterior surface. Majority of the nutrient foramina in the femur and tibia were of large size caliber.

An accurate knowledge of the location of the nutrient foramina in long bones can be useful in certain surgical procedures: in bone grafting, in microsurgical vascularized bone transplantation and in many fractures. It helps to prevent intraoperative injuries in orthopedic, as well as in plastic and reconstructive surgery. Delayed or nonunion following trauma may be directly related to the absence of nutrient arteries entering the bones.

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