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Original Research Article

MORPHOMETRIC AND TOPOGRAPHICAL STUDY OF THE NUTRIENT FORAMINA IN FEMUR– OF CENTRAL INDIAN POPULATION

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ABSTRACT

Background: The nutrient foramina are cavities contain nutrient arteries and peripheral nerves. The present study was done in Department of Anatomy, L.N. Medical College and Research Centre, Bhopal with 100 dry human femurs. there were 149 foramina in 100 femurs. Mean length of femur 435mm, most frequently seen on Linea aspera of femur foramina index mean was 44.3403 for femur. Right side femur foramina index range 28.52-63.86, left side bone foramina index range 30.65-61.42. Information about number, location, position and direction of nutrient foramina important clinically in orthopedic procedures such as joint replacement therapy, fracture repair and preserving blood supply of graft during vascularized bone grafting.

Keywords: Nutrient foramina, Femur, Nutrient artery, long bone.

INTRODUCTION

The skeletal system is composed of highly specialised forms of supporting/connective tissue, based on collagen and acellular matrix Bone is a complex tissue whose character is dominated by the inorganic salts that give it rigidity.[2] All bones are derived from mesenchyma. Bones are structures that adapt to their mechanical environment and from a fetal age adapt to the presence of naturally occuring holes. These holes or nutrient foramina, allow blood vessels to pass through the bone cortex. In long bones, there are generally three sets of arteries the diaphyseal, metaphyseal and epiphyseal arteries.

The diaphyseal nutrient artery is the main source of blood supply to the long bones. The external opening of the nutrient canal, usually referred to as the nutrient foramen.[32] The nutrient foramina is distinguished from any other foramen by the presence of distinct vascular groove outside the nutrient foramina. The nutrient foramen was at the site of original centre of ossification. [32, longia]

The major blood supply for long bones originates from the nutrient arteries, mainly during the growing period and during the early phases of ossification.[30,17,36,22] Nutrient artery arises from adjacent arteries outside the periosteum. supplying bone marrow, spongy bone and deeper portion of the compact bone. vascularization of the long bones generally is given by one or two diaphyseal nutrient arteries. End of the bones are supplied by metaphysial and epiphysial arteries. [Kith and moore] In cases where the nutrient arteries are absent, periosteal vessels become the sole source of blood to the diaphysis of the long bones.[36,6]

Nutrient arteries do not branch in their canals but divide into ascending and descending branches in the medullary cavity. [gray] The direction of the nutrient foramina is determined by the growing end of the bone. Most of the nutrient arteries follow the rule "to the elbow I go, from the knee I flee" but they are variable in position this is because one end of the limb bone grows faster than the other.[8]

The growing end is supposed to grow at least twice as fast as the other end. As a characteristic, the diaphyseal nutrient vessels move away from the growth extremity dominant in the bone.[6] Nutrient foramina in long bones occupy their flexor surface.[4] Loss of arterial supply to an epiphysis or other parts of a bone results in the death of bone tissue this is avascular necrosis. [kith and moor] 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 (Longia et al., 1980;).

Investigations on the vascular anatomy of long bones tended in the past to be confined to rabbits, rats and dogs. This study is of utmost importance to human because it is relevant to fracture treatment. Combined periosteal and medullary blood supply to the bone cortex helps to explain the success of nailing of long bone fractures particularly in the weight bearing femur.[2] A considerable interest in studying nutrient foramina resulted not only from morphological, but also from clinical aspects. Knowledge about location of these foramina is usefull in certain operative procedure to preserve the circulation.[6] Variations have been described in the direction of nutrient foramina only in the lower limb bones (Longia et al., 1980). there is a need for a greater understanding of the direction, location and number of nutrient foramina in femur bone.

MATERIAL AND METHODS

In this study 100 adult clean and dried Femur bones belonging to central Indian were taken. The bones were obtained from osteology section of Department of Anatomy, L.N. Medical College and Research Center, Bhopal.

The bones were randomly selected without taking age and sex into consideration. All bones were macroscopically observed for nutrient foramina with the help of a hand-lens. Only well-defined foramina on the diaphysis were accepted. Foramina at the ends of the bone were ignore.[6]

The bones having regular shape and devoid of deformities and any pathological changes were selected. The bone that were damaged fractured or had some degenerative changes were excluded. Foramina within 1mm from any border were taken to be lying on the border.[8,6]

The number and topography of the foramina in relation to specific borders or surfaces of the diaphysis were analyzed. In bones where there was doubt as to the nature of a foramen, a fine wire was passed through it to confirm that it did enter the medullary cavity. To describe the position of the foramina bones were divided into three parts each.[6]

Instruments1.Osteometric board, 2. Magnification hand lens, 3. Digital venier caliper, 4. Hypodermic needles 18G (1.2 mm) 20G (0.9 mm) 22G(0.70mm) 24G (0.55 mm) 26G (0. mm).

Parameters

Metrical:

1. Total length of the bone.
2. Distance between upper end to nutrient foramen
3. Foramina index.

Non-metrical

1. Number of nutrient foramina
2. Direction and obliquity was noted. Position of nutrient foramina
3. Size

Methodology The following data were studied on the diaphyseal nutrient foramina of bone

A. Number of nutrient foramina: - Bone was examined for the number of nutrient foramina.

B. Position of nutrient foramina: - Determination of the total length of the femur bone Determination of the total length of bone: Determination of the total length of the individual bone was taken as follows: Femur: the distance between the proximal aspect of the head of the femur and the most distal aspect of the medial condyle.

Calculation of the Foramina index

Foramina index =FI[17] FI = DNF / TL × 100(Hughes, 1952)

-Total length of bone =TL

-Distance from the proximal end of the bone to nutrient foramina =DNF

C. Subdivisions of position of foramina according to FI

The position of the foramina 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.

D. Size of nutrient foramen Hypodermic needles with the caliber of 18G (1.2 mm),20G (0.9 mm), 22G (0.70mm),24G (0.55 mm),26G (0. mm) sizes passed through each foramen to confirm their patency and nutrient foramen Caliber. Nutrient foramina smaller than a size 24 hypodermic needles were considered as being secondary nutrient foramina.[17,31] while those equal or larger were accepted as being dominant nutrient foramina.[17] Nutrient foramina divided into three sizes by using Caliber of needles Large size foramen: diameter ≥ 0.91mm,

Medium size foramen: 0.91mm > diameter ≥ 0.55mm, Small size foramen: > 0.55mm.

E. Directionof nutrient foramina: - Direction of nutrient foramina also noted it's may be directed towered the growing end or away from the growing end.

F. Obliquity of nutrient foramina: - The obliquity of nutrient foramina was also noted and categorized into:1. Horizontal direction 2. Upper oblique direction 3. Lower oblique direction.

RESULTS

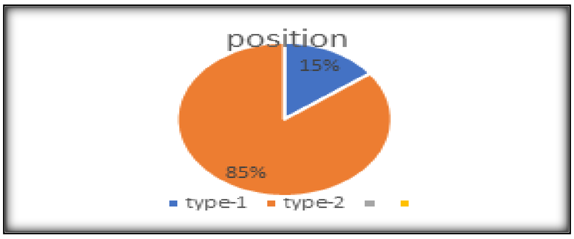

Figure 1: Pie Chart Showing Foramina Mostly Present in Proximal Part of Femur Bone.

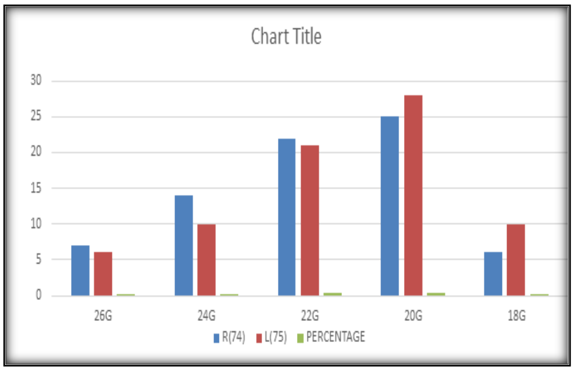

Figure 2: Column Chart Showing Different Size of Foramina Present in Femur Bone

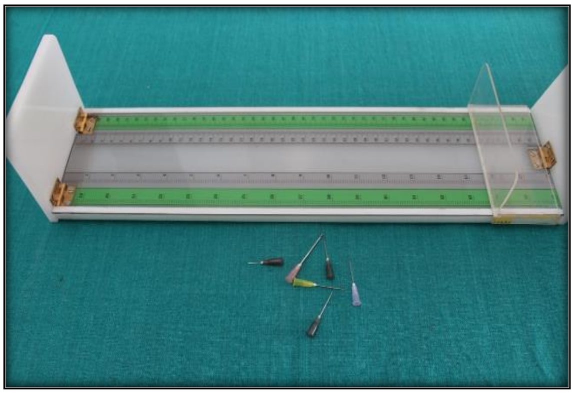

Figure 3: A photograph of Osteometric board instrument used for measuring the length of the bone

Figure 4: Lower limb bones showing direction of nutrient foramina

Figure 5: Upward direction of foramen toward the hip joint

Figure 6: Digital vernier caliper

Figure 7: A photograph of femur showing double nutrient foramina on the posterior Surface

Figure 8: Femur bone showing two nutrient foramens close to each other

In 100 femur bone have 149 foramina ,127 (85.23%) foramina seen middle third of bone and 22 (14.76%) seen on proximal third of bone127 (85.23%) take TYPE-2 position and 22 (14.76%) are TYPE-1 position. There were no foramina in the distal third (Type-3). Mean length of the bone=435, 50 bones had single NF ,48 double NF, only 2 bone show absent of foramen and 1 had 3 NF.

Femur bone foramina index rang, mean and standard deviation calculating according to surface and border. Femur 100bones have 149 foramens, 136 are dominant foramina and 13 secondary foramina. The nutrient foramina were located along the middle third of the femur with the foramen index ranging between 29.81 and 62.65% of the bone length. Of all femoral foramina, 12(25%) were on the medial lip of the linea aspera, 9(18.75%) on the lateral lip of linea aspera, 8(16.6%) on Nutrient foramina of most commonly present on the medial-to-medial lip of linea aspra 34 (28 were dominant foramen,6 secondary foramen) and between the two lips of linea aspera 31were second most common position (30 were dominant foramen,1 secondary foramen)gluteal tuberosity 4(2.68%) medial to spiral line and 13(8.7%) on the posterolateral surface 34 (22.81%) medial to medial lip of linea aspre 28 (18.7%)

The nutrient foramina in all femora examined, were directed proximally There was no change in the obliquity of the foramina, whether they were in the centre of the bone or nearer to the ends.

Statistical Analysis

The collected data was summarized by using frequency, percentage, mean & S.D. To compare the qualitative outcome measures Chi-square test or Fisher's exact test was used. To compare the quantitative outcome measures independent t test was used. The t-value is 0.53825, p-value is 0.295611.the result is not significant at p<.05 right FI mean ± SD 44.67 ± 10.96 and left FI mean ± SD 43.72 ± 9.86 p value was marginal significant on the right side of bone and not significant on the left side of bone. Right side femur foramina index range 28.52-63.86and P value < 0.0000 was significant for location and foramina index left side bone foramina index range30.65-61.42. If data was not following normal distribution, Mann Whitney U test was used. SPSS version 22 software was used to analyse the collected data. p value of <0.05 was statistically significant.

Table 1: Number of Nutrient Foramina Observed in Femur Bone

Bone	Number of bone	Number of foramina	Percentage
Femur(n=100)	2 50 48 1	0 1 2 3	2% 50% 48% 1%

Table 2: Position of Foramen

Bone	No of Bone	Foramen	Position			Direction	P-Value
			TYPE-1	TYPE-2	TYPE-3		
Femur	R (50) L (50)	74 75	13 9	61 66	- -	Proximally	0.67123269
Total	100	149	22 (14.76%)	127 (85.23%)	-		

Table 3: Range, Mean and Standard Direction of Nutrient Foramina

Position	Side	Range	Mean±SD	P-value
Between the two lips of linea aspera	R L	34.33-59.01 32.124-57.34	41.078±6.359 39.062±5.365	0.0001
Medial lip of linea aspra	R L	34.62-63.86 38.513-60.40	53.836±10.432 52.44±6.66	
Lateral lip of linea aspra	R L	36.185-55.464 36.244-39.29	40.857±8.23 37.77±1.253	
Medial to medial lip of linea aspra	R L	34.709-61.392 36.649-61.427	53.137±6.866 53.908±7.047	
Posterior surface	R L	29.88-34.351 30.65-35.40	32.236±1.553 33.52±1.459	
Gluteal tuberosity	R L	30.120-32.013 35.636-36.676	31.0667±1.3385 36.156±0.735	
Medial to spiral line	R L	28.527-35.433 32.48-36.275	32.168±1.899 34.012±1.606	
Lateral to lateral lip of linea aspra	R L	43.058-59.78 50.66-58.890	50.211±5.648 54.32±4.188	

Table 4: Size of Nutrient Foramen on Femur Bone

No. of foramen	Small		medium	Large	
	26 G	24 G	22G	20 G	18 G
R (74)	7	14	22	25	6
L (75)	6	10	21	28	10
Percentage	8.7%	16.10%	28.85%	35.57%	10.7%

Table 5: Position and Number of Dominant and Secondary Foramine Seen on Femur

Position	Side	Total number of foramina	%	Number of foramina						
				Single		Two		Three		
				DF	SF	DF	SF	DF	SF	
Between the two lips of linea aspera	R (12) L (19)	31	20.8	14	-	6	1	-	-	p-value 0.484 t-test 1.76
Medial lip of linea aspra	R (10) L (18)	28	18.7	7	-	19	1	1	-	
Lateral lip of linea aspra	R (5)	9	6.04	3	-	4	1	1	-	

	L (4)									
Medial to medial lip of linea aspra	R (22) L (12)	34	22.8	6	1	21	5	1	-	
Posterior surface	R (8) L (13)	21	14.09	8	-	13	-	-	-	
Gluteal tuberosity	R (2) L (2)	4	2.68	1	-	3	-	-	-	
Medial to spiral line	R (9) L (4)	13	8.7	5	2	4	2	-	-	
Lateral to lateral lip of linea aspra	R (6) L (3)	9	6.04	3	-	6	-	-	-	

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 (Mysorekar,1967; Forriol Campos et al., 1987; Nagel, 1993; Gumusburun et al., 1994; Collipal,2007), while others reported the presence of a single foramen in most specimens (Lutken, 1950; Laing, 1953; Longia et al., 1980; Sendemir and Cimen, 1991; Motabagani, 2002; Kizilkanat et al., 2007). Three nutrient foramina were observed in a small number of femora (2.19% - 10.7%) by many authors (Lutken, 1950; Longia et al., 1980; Forriol Campos et al., 1987; Nagel, 1993; Gumusburun et al., 1994;56Collipal, 2007). It was interesting to find studies reporting a number of nutrient foramina as high as six (Gumusburun et al., 1994) and up to nine (Sendemit and cimen, 1991), while others confirmed the absence of nutrient foramina in some femora (Mysorekar, 1967; Gumusburun et al., 1994; Motabagoni, 2002). In this study, the whole series of tibiae examined had a single nutrient foramen

Position of nutrient foramina: In this study, 58.33% of the nutrient foramina of the femora were located mainly around the linea aspera and along a narrow strip on either side of it. These results were similar to those of Lutken (1950), Laing (1953), Longia et al. (1980), Sendemir and Cimen (1991) and Gumusburun et al. (1994) who stated that most of nutrient foramina where concentrated along the linea aspera.

Size of nutrient foramina: Sendemir and Cimen (1991) stated that there was no femur without a dominant nutrient foramen. Such statement was applicable in the present study, only in case of femora with a single nutrient foramen. Direction of nutrient foramina Hughes (1952) stated that anomalous canals were found frequently in the femur, which might be the cause of the latter findings.

Obliquity of nutrient foramina; Femur examined, there were no changes in the obliquity of the foramen whether it was in the centre of the bone or nearer the ends. Such results were in agreement with those of Mysorekar (1967).149 foramina on femur dominating foramen seen mostly seen on medial to medial lip of linea aspra means nutrient foramen related with linea aspra on femur bone.

CONCLUSION

Femur showed single and double nutrient foramen with almost equal frequency located around the linea aspra. The foramens were mainly medium size and directed upward toward the hip joint.

Declarations

Funding: None **Conflicts of interest/Competing interests:** None Availability of data and material: Department of Anatomy, L.N. Medical College Bhopal (M.P.) **Code availability:** Not applicable **Consent to participate:** Consent taken Ethical **Consideration:** There are no ethical conflicts related to this study. **Consent for publication: Consent taken.**

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