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Original Research Article

MORPHOLOGIC AND MORPHOMETRIC STUDY OF THE NUTRIENT FORAMINA IN DRY HUMAN FEMUR BONES OF TELANGANA REGION

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ABSTRACT

Background: Blood supply of living bones comes from many small vessels in the periosteum and from a large nutrient artery that enters the body through nutrient foramina. The nutrient foramen and the artery passing through it plays a major role in bone vascularisation and its growth. A detailed understanding of blood supply to long bones is a necessity in performing the recent orthopaedic techniques like bone resection and transplantation.

Aim: The aim of the present study is to determine the number, position, size, direction of the nutrient foramina and the Foramen Index of the human dry femur bones

Materials and Methods: In the present study, 66 right sided and 56 left sided femur bones of unknown age and sex were taken into consideration from the department of anatomy, Mamata Medical College, Khammam, Telanagana, India.

Results: Average length of the femur on the right side was observed to be 43.48 ± 2.70 cm and on left side 43.71 ± 2.94 cm. The foramen index on right side was 42.01 ± 10.37 cm where as on the left side 39.02 ± 8.56 cm. The nutrient foramen was directed towards the upper end of femur in all the bones studied. Most of the foramen were observed on the linea aspera in the middle third of the bone.

Conclusion: This study may add to the present statistical data available on foramen index, number of foramen and their location in the population of Telangana region, during recent orthopaedic techniques like bone resection and transplantation.

KEY WORDS: Nutrient foramen, Femur, Foramen index.

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INTRODUCTION

Blood supply of living bones comes from many small vessels in the periosteum and from a large nutrient artery that enters the body through nutrient foramina. During early stages of bone formation, the main source of blood supply to long bones is from nutrient artery [1]. The nutrient artery enters the diaphysis of the long bones obliquely. The point of entrance and angulations are relatively constant [2]. The

direction of the nutrient foramina is determined by the growing end of the bone. In long bones, typically, the diaphyseal nutrient vessels move away from the growing end [3]. Variations in the direction of nutrient foramina have been described in the lower limb bones [4]. The nutrient foramen and the artery passing through it play a major role in bone vascularisation and its growth. Some pathological conditions of bone such as developmental anomalies, healing of a fractured bone or acute hematogenic osteomyelities are closely related to the vascular system [5]. A detailed understanding of blood supply to long bones is a necessity in performing the recent orthopaedic techniques like bone resection and transplantation [6,7].

Aim: The aim of the present study is to determine the number, position, size, direction of the nutrient foramina and the Foramen Index of the human dry femur bones

MATERIALS AND METHODS

Clean and dry human femur bones were obtained from the department of Anatomy, Mamata Medical College, Khammam, Telangana. In the present study, 66 right sided and 56 left sided femur bones of unknown age and sex without any pathological changes were taken into consideration.

Length of the bone was calculated by an osteometric board. Total length was calculated as the distance between the proximal aspect of the head of the femur and the most distal aspect of the medial condyle.

Foramen index (FI) was calculated using the formula:

FI = (DNF/TL) x 100 (Hughes [12], Shulman [25]).

DNF = the distance from the proximal end of the bone to the nutrient foramen.

TL = total bone length.

Hand lens was used to observe the nutrient foramina. Size of foramina was measured using syringe needles of various gauzes. Foramina of size less than 24 gauze were not taken into account.

a. Size of the 18 gauze needle was considered to be between 1.27 mm or more (e"1.27 mm).

b. Size of the 20 gauze needle was considered to be between 0.90 mm and 1.27 mm (e" 0.90mm to < 1.27mm).

c. Size of the 22 gauze needle was considered to be between 0.71 mm and 0.90 mm (e" 0.71mm to < 0.90 mm).

d. Size of the 24 gauze needle was considered to be between 0.55 mm and 0.71mm (e" 0.55mm to < 0.71 mm).

RESULTS

Direction of the nutrient foramina: In all the bones of both right and left side, the nutrient foramen were directed upwards (i.e towards head).

Incidence of nutrient foramen: Out of 66 right sided bones, 32 bones have single foramina, 35 bones have two nutrient foramens and in 4 bones showed three nutrient foramen. On the left side, out of 56 bones, in two bones nutrient foramina (of size above 24 gauze) were not at all found in the shaft, whereas twenty bones showed single foramen, twenty seven bones showed two foramen and five bones showed three foramen. In the remaining two of 56 bones showed 4 foramina in each. (Table 2)

Table 1: showing the length of the bone, distance of the proximal nutrient foramina from the upper end and foramen index.

	TOTAL LENGTH OF THE BONE		DISTANCE FROM UPPER END TO NF		FORAMEN INDEX	
	MEDIAN	MEAN WITH SD	MEDIAN	MEAN WITH SD	MEDIAN	MEAN WITH SD
RIGHT (n = 66)	44.15	43.48 ± 2.70	17.8	18.75 ± 4.79	38.2	42.01 ± 10.37
LEFT (n = 56)	44.25	43.71 ± 2.94	15.55	16.98 ± 3.99	36.27	39.02 ± 8.56

n = total number of bones, SD = standard deviation.

Table 2: Showing incidence of nutrient foramen.

	Right (N = 114)				left (N = 98)				
No. of foramina	0	1	2	3	0	1	2	3	4
No.of bones	0	32	35	4	2	20	27	5	2
Percentage	-	48.48%	53.03%	6.06%	3.57%	35.71%	48.21%	8.92%	3.57%

N = total no.of nutrient foramina

Total length of the bone, distance from the upper end to proximal nutrient foramina and formen index are shown in the Table 1. Segmental position and location of nutrient foramen on the bone and the size of foramina are shown in the Table 3, 4 & 5.

Table 3: Showing the segmental position of nutrient foramen.

Right femur (N= 66)	(total no of formanina = 114)		Left femur (N = 56)	(total no of formanina = 98)	
	NF	Percentage		NF	Percentage
Upper 1/3rd	23	20.17%	Upper 1/3rd	14	14.28%
Middle 1/3rd	84	73.69%	Middle 1/3rd	71	72.44%
Lower 1/3rd	7	6.14%	Lower 1/3rd	13	13.26%

N = total no of bones, NF = no. of foramina in each segment

Table 4: Showing the location of nutrient foramen on the bone.

Location of foramina	No. of foramen			
	Right (N=114)	Percentage	Left (N=98)	Percentage
Between the two lips of LA	22	19.29%	41	41.83%
On the Medial lip of LA	43	37.71%	24	24.48%
On the Lateral lip of LA	15	13.15%	6	6.12%
Postero-medial surface	30	26.31%	18	18.36%
Postero-lateral surface	0	-	7	7.14%
Popliteal surface	3	2.63%	2	2.04%
Anterior surface	1	0.87%	0	-

N = total no.of foramen, LA = Linea Aspera

Table 5: Showing the size of the nutrient foramen.

Size of the foramen	Right (N=114)	Percentage	Left (N=98)	Percentage
≥1.27 mm	37	32.45%	47	47.95%
≥ 0.90mm to < 1.27mm	39	34.21%	23	23.46%
≥ 0.71mm to < 0.90 mm	25	21.92%	19	19.38%
≥ 0.55mm to < 0.71 mm	13	11.40%	9	9.18%

N = total no. of foramen

Fig. 1: Showing 4 nutrient foramen.

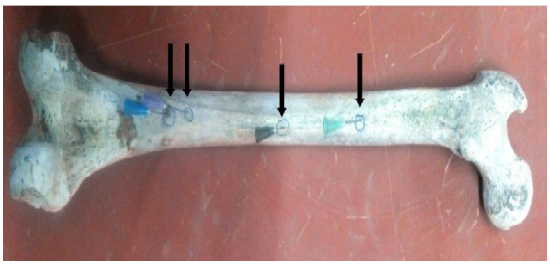

Fig. 2: Showing nutrient foramen on the anterior surface.

Fig. 3: Showing 3 nutrient foramen.

DISCUSSION

Long bones receive blood supply from nutrient artery, periosteal, diaphyseal and epiphyseal arteries. Nutrient artery alone supplies seventy to eighty percent of blood to long bones during childhood [8]. Femur is a highly vascular bone [9]. Usually perforating branches of profunda femoris artery or sometimes direct branch from profunda femoris artery or from femoral artery provide nutrient artery to femur.

Direction of the nutrient foramen: During development, nutrient arteries course caudally due to hemodynamic force of blood from cephalic to caudal side. Mysorekar et al. [10] opined that the direction of the nutrient foramina is directed away from the growing end due to differential growth of the ends of long bones. Henderson [11] observed that the direction of the nutrient foramen is inconsistent in mammals. Hughes [12] reported variant foramen in femur. Raj Kumar et al. [13] reported that, out of 150 femur bones studied, nutrient foramina in 148 bones were directed proximally and 2 were directed distally. In the present study nutrient foramina is directed away from the growing end in all the bones studied.

Position of the nutrient foramen: The arrangement of nutrient foramen in long bones usually follows a definite pattern. Position of the foramina is constant and seen on flexor surfaces [11]. Nutrient foramina of femur are usually located on the linea aspera [14].

Mysorekar et al. [3], Laing et al. [15], and Sendemir & Cimen [16], Gumusburun et al [17] and Kizilkanat et al [7] observed that, most of the bones showed foramina in the middle third of the bone. In the present study also, most of the nutrient foramina are located in middle third of the bone (73.69% on right side and 72.44% on left side) similar to the above studies. Similar to laing's et al [15] observation, present study also, showed nutrient foramina on the flexor surface of the bone except in one bone of right side, which showed a nutrient foramen on the anterior surface in the lower one third (Fig. 2).

Similar to the studies of Lutken [18], Laing [15], Longia et al. [4], Sendemir and Cimen [16] and Gumusburun et al. [17], in the present study (68% right, 72% left) also, most of the nutrient foramina are located along the linea aspera.

Number of nutrient foramen: Mysorekar [3] observed that femur bone is usually pierced by two nutrient foramen. Patake and Mysorekar [19] stated that there is no direct relationship between the length of the bone and the number of nutrient foramen. Sendemir and cimen [16] found that double nutrient foramen were present in 46% of bones. According to Gumusburun [17] 45.3%, Forriol Campos [8] 60%, Laing [15] 55.6%, Prashanth [20] 44.2%, Poornima [21] 37%, Bichitrananda Roul [22] 59.4%, of bones showed double nutrient foramen. Similar to the above observations, in the present study also 53.03% of right side and 48.21% of left side bones showed two nutrient foramen. Poornima et al. [21] observed single nutrient foramina in 62% of bones and Bichitrananda Roul et al [22] 27.2% of femora. Whereas Prashanth et al. [20] observed single nutrient foramina in 47.7% of bones, Gumusburun et al [17] in 41.2% of bones. Erika Collipal [2] observed that 40.7% right sided bones and 47.8% of left sided femora showed single nutrient foramina. Similarly in the present study 48.48% of right side bones and 35.71% of left side bones showed only one nutrient foramina. Gumusburun et al [17] observed three nutrient foramen in 11.3% of bones, Pashanth et al [20] in 3.5% and Poornima [21] in 1%, Bichitrananda Roul [22] 13.51% of bones. In the present study 6.06% of right side bones and 8.92% of left side bones showed three nutrient foramen. According Prashanth et al [20], 4.6% femora did not show any nutrient foramina. Mysorekar [3], Gumusburun [17], Motabagoni [23] and Raj Kumar [13] reported that the shaft of the femur did not show any nutrient foramen. Likewise, two out of 98 left side bones did not show any nutrient foramen in the present study, whereas two other bones showed four nutrient foramen (Fig. 1). Gumusburun et al [17] observed four nutrient foramen in 4 bones, five nutrient foramen in 1 bone and six nutrient foramen in 1 bone and two bones without any nutrient foramina out of total 103 bones. It was interesting to note that Sendemit and cimen [16] observed nine nutrient foramina in a bone.

Length of the bone and foramen index: Erica Collipal [2] observed the average length of the femur as 43. 52 cm on right side and 43.7 cm on left side and the distance of the Nutrient foramina to the upper end as 19.2 ± 4.81 cm, 19.5 ± 4.97 cm respectively. Bichitrananda roul et al. [22] calculated the total length of the femur as 43.6 cm and the average distance of the nutrient foramen from the upper end as 15.25 cm. In the present study also, the average length of femur is in correspondence with the above studies (right side 43.48 ± 2.7 cm and left side 43.71 ± 2.94 cm) with the average distance of the nutrient foramina from the upper end as 18.75 cm ± 4.79 on right side and 16.98 cm ± 3.99 on left side.

The mean foramen index of the femur bones was observed as 48.2 by Gumusburun et al. [17], 38.9 by Prashanth et al. [20], 56.72% in the population of Rohilkhand region of India by Raj Kumar et al. [13].

Oladayo Sunday Oyedun [24] observed that the mean Foramen Index of left femurs (44.40 ±9.34) was significantly higher than that on the right femurs (40.11±8.50) which is in contrast with the present study where the foramen index of the femur on right side was 42.01 ± 10.37, whereas on the left side 39.02 ± 8.56.

Size of nutrient foramina: In the present study the foramina of the size $\geq$ 1.27 mm are more (32.5% on right side and 47.95% on left side) in number than when compared to that of Poornima et al [21] (7.2%).

CONCLUSION

A thorough understanding of nutrient foramina

location, size, and number in relation to the length and foramen index of the bone has crucial role in orthopaedic surgical procedures like bone resection and transplantation. This study may add to the present statistical data available, especially in the population of Telangana region, India.

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Conflicts of Interests: None

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