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ANALYTICAL AND MORPHOMETRIC STUDY OF NUTRIENT FORAMINA OF FEMUR IN ROHILKHAND REGION

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ABSTRACT

The major blood supply to long bones occurs through the nutrient arteries, which enter through the nutrient foramina. This supply is essential during the growing period, during the early phases of ossification, and in procedures such as bone grafts, tumor resections, traumas, congenital pseudoarthrosis, and in transplant techniques in orthopaedics. The present study analyzed the position and the number of nutrient foramina in the diaphysis of 101 adult femur bones. The majority of nutrient foramina in femur are double in number and dominant in size, which may represent a double source of blood supply. The location of the nutrient foramina is predominant on middle third of diaphysis. 57.32% of the nutrient foramina of the femur are located mainly around the linea aspera. The mean foraminal index is 56.72%. This study recorded data related to the population of Rohilkhand region (U.P.), India, providing ethnic data to be used for comparison and that may help in surgical procedures and in the interpretation of radiological images.

INTRODUCTION

Bones are structures that adapt to their mechanical environment, and from a fetal age adapt to the presence of naturally occurring holes. These holes or nutrient foramina, allow blood vessels to pass through the bone cortex [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 foetus as well as during the early phase of ossification [2]. During childhood, the nutrient arteries provide 70-80% of the interosseous blood supply to long bones, when this supply is compromised, medullary bone ischemia occurs with less vascularization of the metaphysis and growth plate [3]. The diaphyseal nutrient arteries obliquely penetrate in the diaphysis of the long bones, their entrance point and angulations being relatively constant, dividing in ascending and descending branches, once they reach the medullary cavity [4].

It has been suggested that the direction of the nutrient foramina is determined by the growing end of the bone. 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 [5]. Variations have been described in the direction of nutrient foramina only in the lower limb bones [6]. However, variations in the direction of nutrient foramina in long bones of the upper limb have never been reported.

A considerable interest in studying nutrient foramina resulted not only from morphological, but also from clinical aspects. Nutrient foramina reflect to a certain degree the bone vascularization. Some pathological bone conditions such as developmental abnormalities, fracture healing or acute hematogenic osteomyelitis are closely related to the vascular system of the bone [7]. Detailed data on the blood supply to the long bones and the association with the areas of bone supplied has been continued to be a major factor in the development of new transplantation and resection techniques in orthopaedics [8],[9].

However, there is still a need for a greater understanding of the direction, location and number of nutrient foramina of femur.

EXPERIMENTALWORK

The material of the present study consist of 101 adult human cleaned and dried bones of the femur. They were obtained from the osteology collection held in the Department of Anatomy, TMMC&RC, TMU, Moradabad (U.P.) and Rohilkhand Medical College, Bareilly (U.P.). They were arranged as follows:

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 bone were ignored. The following data were studied on the diaphyseal nutrient foramina of each bone:

Number:

Out of 101 bones, 51 right & 50 left femur were examined for the number of nutrient foramina.

Location:

Calculation of the foraminal index:

The Location of all nutrient foramina was determined by calculating a foraminal index (FI) using the formula:

FI = (DNF/TL) x 100 [14, 15].

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

TL = total bone length.

Determination of the total length of bone:

Determination of the total length of the individual bone was taken as follows:

The distance between the proximal aspect of the head of the femur and the most distal aspect of the medial condyle.

Subdivisions of location of foramina according to FI:

The location of the foramina was divided into three types according toFI 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 measurements were taken to the nearest 0.1 mm using an INOX sliding calliper [9].

Size:

Nutrient foramina smaller than the size of 24 hypodermic needle (0.56 mm in diameter) were considered as being secondary nutrient foramina (S.F) while those equal or larger were accepted as being dominant nutrient foramina (D.F) [9].

Direction and Obliquity:

A fine stiff wire was used to confirm the direction and obliquity of the foramen.

Statistical analysis:

The results were analyzed and tabulated using the Statistical Package of Social Sciences (SPSS) 8.0 windows. The range, mean and standard deviation of FI were determined.

RESULTS

Number:

In the whole series of 101 femora examined, 48 (32%) were single foramen,102 (68%) were double foramina and foramen were absent in 2 femora. (Table – I; Fig. 1, 2 & 3).

Location:

The nutrient foramina were located along the middle third of the femur with the foramen index ranging between 28.50 and 44.20% of the bone length (Table - II; Fig. 2). Of the total 150 foramina, 72 (48%) were in the proximal third (Type-1)and 78 (52%) in the middle third (Type-2). There were no foramina in the distal third (Type-3) (Table-I). Of all femoral foramina, 41(27.33%) were between the two lips of linea aspera, 28(18.66%) on the medial lip of the linea aspera, 17(11.33%) on the lateral lip of linea aspera, 37(24.66%) on the posteromedial surface, 8(5.33%) on the posterolateral surface, 8(5.33%) medial to spiral line and 11(7.33%) on the gluteal tuberosity (Table-I).

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

Location	Total no of foramina	%	No. of Foramina				Absent (2)
			Single Foramen		Two Foramina		
			DF	SF	DF	SF	
Between the two lips of linea aspera	41	27.33	17	1	15	8	-
Medial lip of linea aspera	28	18.66	3	-	9	16	-
Lateral lip of linea aspera	17	11.33	11	-	4	2	-
Posteromedial Surface	37	24.66	10	-	16	11	-
Posterolateral Surface	8	5.33	1	-	3	4	-
Medial to spiral line	8	5.33	3	-	2	3	-
Gluteal tuberosity	11	7.33	2	-	6	3	-
Total	150	100	47	1	55	47	-

Fig 1 –Showing single nutrient foramen in middle third of diaphysis of femur

Fig 2- Showing double nutrient foramina in middle third of diaphysis of femur

Fig.3 – Showing Absent foramen on diaphysis of femur

Table II - The range, Mean ± Standard deviation (SD) of foramina indices of Femur:

Location	*Side*	*Range*	*Mean ± SD*
Between the two lips of linea aspera	R	28.50- 42.50	37.64 ± 2.98
	L	29.00 – 44.20	39.72 ± 3.31
Medial lip of linea aspera	R	28.50 – 41.50	38.58 ± 3.12
	L	37.60 – 42.00	39.98 ± 1.29
Lateral lip of linea aspera	R	36.50 – 39.40	37.97 ± 0.99
	L	34.00 – 38.40	36.80 ± 1.54

Posteromedial Surface	R	33.00 – 39.50	37.47 ± 1.88
	L	33.00 – 40.30	37.59 ± 2.02
Posterolateral Surface	R	36.40 – 37.90	37.05 ± 0.55
	L	34.00 – 38.30	36.43 ±1.56
Medial to spiral line	*R*	38.60 -40.60	39.40 ± 0.76
	L	30.60 – 32.10	31.35 ± 1.10
Gluteal tuberosity	*R*	37.60 – 40.50	39.22 ± 0.88
	L	31.87- 37.31	34.06 ± 2.87

Size: Of the 150 foramina, 102(68%) were dominant and 48(32%) were secondary foramina (Table - I).

Direction: The nutrient foramina in all femora examined, 148 were directed proximally and 2 were directed distally (Table - III; Fig. 4).

Table III - Showing the direction of Foramina:

Femur	*Direction*	*Single Foramen*	*Double Foramen*		*Absent Foramina (2)*
			DF	*SF*	
RIGHT	Proximally	28	24	18	-
	Distally	-	-	2	-
LEFT	Proximally	20	36	22	-
	Distally	-	--	-	-

Fig. 4 – Showing distally and proximally directed double nutrient foramina of femur

Obliquity: There was no change in the obliquity of the foramina, whether they were in the centre of the bone or nearer to the ends.

DISCUSSION

In the present study, most of the nutrient foramina 78 (52%) 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 those of Laing [10], Mysorekar [5], Sendemir and Cimen [11], Gumusburun et al. [12] and Kizilkanat et al. [9]. However, these findings did not coincide with those of Lutken [13] and Ferriol Campos et al. [3] who stated that the nutrient foramina were closer to the hip joint. Laing [10] attributed the lack of the nutrient foramina in the lower third of the femur to the absence of vessels entering this part of bone.

In this study, 57.32% 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 [13], Laing [10], Longia et al. [6], Sendemir and Cimen [11] and Gumusburun et al. [12] who stated that most of nutrient foramina where concentrated along the linea aspera.

CONCLUSION

The study confirmed previous reports regarding the number and location of the nutrient foramina in the Femur. 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 location 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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