

A Morphological Study of Position of Nutrient Foramen in Dry Human Femur

Nand Kishor Karmali¹, S K Chouhan²

¹Tutor, Department of Anatomy, Mahatma Gandhi Memorial Medical College, Jamshedpur, Jharkhand, India, ²Associate Professor, Department of Anatomy, Mahatma Gandhi Memorial Medical College, Jamshedpur, Jharkhand, India

Abstract

Aim: The aim of the study is to determine the variations in diaphyseal nutrient foramen(NF) of femur with respect to their number, location, direction and size in Jharkhand state population.

Materials and Methods: 70 dry adult femora(38 Right side and 32 Left side) were collected from the department of Anatomy, Mahatma Gandhi Memorial Medical College, Jamshedpur, Jharkhand. Femora were examined for mean length of femur, number, position including foraminal index, direction and size of nutrient foramina.

Result:- Mean length of femur was 42.27cm. According to Foraminal Index the location of nutrient foramina were 72.34% in right side and 86.84% were located in left side in middle 1/3 of bone. Most common position was between two lips of Linea aspera(42.35%). Single nutrient foramen was 64.70%.

Conclusion:- The knowledge of anatomical variation in diaphyseal nutrient foramen of femur is important for bone ossification, bone healing and it also give additional information to orthopedicians for microvascular bone grafting.

Key words: Femur, Nutrient artery, Nutrient foramen, Foraminal index

INTRODUCTION

The nutrient foramina are cavities that conduct the nutrient arteries and the peripheral nerves on the shaft of long bones. The femur is supplied principally by the diaphyseal nutrient artery (DNA) which enters the bone through the diaphyseal nutrient foramen (DNF) with little contribution from the metaphyseal and epiphyseal arteries. Adequate knowledge of the location of nutrient foramen (NF) is important for the process of bone ossification, growth, and healing. Surgically aided bone defect repair such as microvascular bone graft relies greatly on the vascularity of the femur for survival of donor and recipient bones. Knowledge of location and relevant anatomy of nutrient foramina is important in surgical procedures to preserve circulation. The DNA usually originates from profunda femoris artery

as a branch of the second perforating artery, enters the DNF to run through the nutrient canal characteristically directed away from the growing epiphysis. At the medullary end of the nutrient canal, the nutrient artery divides into ascending and descending branches which anastomose with epiphyseal and metaphyseal arteries.

MATERIALS AND METHODS

A total of 70 dried, adult human femora of unknown sex (38 of right and 32 of left side) were taken for morphological study of nutrient foramina from the Department of Anatomy, Mahatma Gandhi Memorial Medical College, Jamshedpur, Jharkhand, India. Bones with gross structural abnormalities were excluded from the study. The instruments used were osteometric board, 18, 20, 22, and 24 gauge hypodermic needles, magnifying hand lens, measuring tape, Vernier digital scale, and divider. Photographs were taken with the digital camera. With the help of osteometric board, determination of the total length of the individual bones was done by taking the measurement between the superior aspect of the head of the femur and the most distal aspect of the medial condyle. The value was recorded in centimeter.

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Corresponding Author: Dr. Nand Kishor Karmali, Tutor, Department of Anatomy, Mahatma Gandhi Memorial Medical College, Jamshedpur, Jharkhand, India. E-mail-dr_karmali@yahoo.com

The nutrient foramina were observed in all the bones carefully with the help of hand lens and the total number of foramina present on any surface was recorded. After side determination, the NF was studied with regard to number of foramen on bone shaft; location of foramen in relation to segment was studied using foraminal index formula:

$$\text{Foraminal index} = (\text{DNF}/\text{TL}) \times 100$$

Where, DNF = The distance from the proximal end of the bone to the NF.

TL = Total bone length.

Subdivisions of foraminal position according to the foraminal index can be grouped into three types.

- Type 1: From 1 up to 33.33: The foramen is in the proximal third of the bone.
- Type 2: From 33.34 up to 66.66: The foramen is in the middle third of the bone.
- Type 3: Above 66.67: The foramen is in the distal third of the bone. Caliber of NF was measured using 18–24 gauge hypodermic needles and direction of foramen was also noted.

RESULTS

A total of 70 femora were examined, of which 38 were of the right side and 32 were of the left side. A total range of length of femur of the right side was from 36.3 cm to 46.9 cm and femur of the left side ranged from 35.6 cm to 47.9 cm.

DISCUSSION

Anatomical characteristics of the NF, such as its number, position, size, and direction, are important factors considered in orthopedic surgeries including bone grafting and fracture repair. These characteristics also contribute to the prognosis after a fracture because they are essential to blood flow. Gray’s anatomy textbook describes that the

foramina for the nutrient arteries are situated close to the linea aspera (LA).^[1] They vary in number and position. One is usually at the upper end of the LA, and a second, which is not always present, near its lower end [Figure 1]. The foramina are directed upward through the compact bone. The nutrient artery of the femur usually comes from the second perforating artery, which is one of the three perforating branches from the profunda femoris artery. When two nutrient foramina exist [Figure 3], they usually come from the first and third perforating branches of above artery. Kizilkanat *et al.*^[2] stated that the position of the nutrient foramina was directly related to the requirements of a continuous blood supply to specific aspects of each bone, for example, areas of some major attachments such as flexors require more blood supply as compared to extensors due to more activity. Many theories have been put forward to account for the direction of foramina and also the anomalously directed ones. The present study of femur obeys the growing end theory of Mysorekar^[3] that opined the direction of 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. The nutrient artery runs away from the growing end as the growing bone might pull and rupture the artery. Hence, the nutrient foramina are directed away from the growing end. Laing examined 10 femora, Murlimanju BV,^[4] Kizilkent *et al* studied in 100 femora, Gupta AK *et al*^[5] studied 100 femora, Sendemir^[6] examined 102 femora, Bridgmen *et al* used 108 femora, Motabagani studied 130 femora, Gupta Pk *et al* studied



Figure 1: Nutrient foramen on linea aspera

Table 1: Mean length of femur

Total number of femur	Side	Total length (range) (cm)	Mean length (cm)	Mean length of femur (cm)
38	Right	36.3–46.9	41.85	42.27
32	Left	35.6–47.9	42.69	

Table 2: Total number of nutrient foramina present [Figure 1]

Total number of femur	Side	Number of nutrient foramina present in one femur				Total number of foramina
		Absent	One	Two	Three	
38	Right	0	29	9	0	47
32	Left	0	26	6	0	38

with 312 femora, Present study was done in 70 femora under following parameters.

Length of Femur

In the present study, the average mean length of both sides of femur was 42.27 cm [Table 1], which resembles with the previous study done by Kizilkanat *et al.*;^[2] Roopam *et al.*;^[7] Kirshner *et al.*;^[8] Gupta *et al.*;^[5] and Nagel.^[9]

Author	Mean total length of femur (cm)
Kizilkanat <i>et al.</i>	42.58
Roopam <i>et al.</i>	43.23
Kirschner <i>et al.</i>	40.8
Gupta <i>et al.</i>	41.22
Nagel	40.10
Present study	42.27

Number of Nutrient Foramina

The present study shows 64.70% single NF and 35.29% having double nutrient foramina [Tables 2-4]. This study is almost similar with the previous study done by Kizilkanat *et al.* and Collipal E^[10] and Oladayo^[11] and Laing^[12] and and Gupta *et al.*, but the result is more than Roopam *et al.*^[7] and Bridgement *et al.* This study indicates that majority of femur is supplied by single source of nutrition.

Position of Nutrient Foramina

According to present study, position of nutrient foramina was present predominantly on middle 1/3 of femur (78.82%) [Table 5] which is almost similar with the authors Mysorekar;^[3] Kizilkanat *et al.*;^[2] Longia *et al.*;^[13] Nagel^[9], Kirschner *et al.*, Kumar *et al.*^[14] and Gupta *et al.* reported that the nutrient foramina are mostly located in the middle one-third of the diaphysis. Forriol

Table 3: Position and number of nutrient foramina observed in femur [Figure 2-6]

Position of nutrient foramina	Number of nutrient foramina	Percentage of nutrient foramina
Medial lip of LA	22	25.88
Lateral lip of LA	08	09.41
Medial surface	15	17.64
LA	04	04.70
Between two lips of LA	36	42.35
Upper posterior surface	00	00

LA: Linea aspera

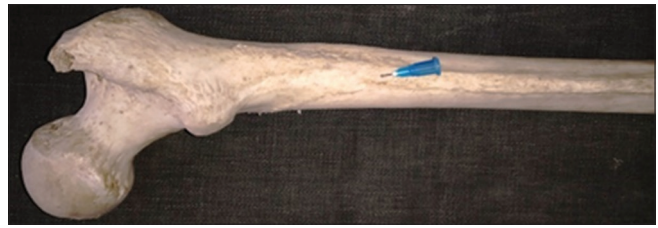


Figure 2: Nutrient foramen in between lips of linea aspera



Figure 3: Single and double foramina



Figure 4: Nutrient foramen on medial and lateral lip of linea aspera



Figure 5: Nutrient foramen on distal 1/3



Figure 6: Nutrient foramen on medial surface

Table 4: Comparative study of Number of nutrient foramina in %

Author	Number of bone	Bone % with 0 NF	Bone % with 1 NF	Bone % with 2 NF	Bone % with 3 NF	% of Dominant NF
Kizilkanat <i>et al.</i>	100	0	75	25	0	80.64
Motavagani	130	3.07	48.46	48.46	0	
Roopam <i>et al.</i>	312	0	44.60	49.40	6.10	77.10
Laing	10	0	60	40	0	
Gupta <i>et al.</i>	100	3	71	25	1	64.50
Bridgeman <i>et al.</i>	109	2.75	44.03	53.21	0	
Present study	70	0	64.70	35.29	0	68.27

NF: Nutrient foramen

Table 5: Observation about the location of nutrient foramina in relation to segment according to foraminal index formula

Total number of bones	Side	Proximal 1/3 (%)	Middle 1/3 (%)	Distal 1/3 (%)	Total number of foramina
38	Right	12 (25.53)	34 (72.34)	01 (2.12)	47
32	Left	05 (13.15)	33 (86.84)	00	38

Table 6: Comparative study of Position of nutrient foramina in %

Author	Total bones	Total nutrient foramina	Medial surface	Between two lips of LA	Lateral lip	Medial lip	LA	Upper posterior surface
Mysorekar <i>et al.</i>	180	270	14.4%		-	-	-	-
Roopam <i>et al.</i>	312	511	16.6%	-	12.1%	40.9%	53%	-
Kizilkanat <i>et al.</i>	100	124	39.8%	-	-	-	44.3%	-
Gupta <i>et al.</i>	100	124	26.6%	-	12.95	1.65	00	-
Present study	70	85	17.64%	42.35%	9.41%	25.88%	4.70%	00

LA: Linea aspera

Table 7: The size of the foramina observed with gauge needle

Total number of foramina	SIDE	Small (24 gauge) (%)	Medium (20 and 22 gauge) (%)	Large (18 gauge) (%)
47	Right	18 (38.29)	23 (48.93)	06 (12.76)
32	Left	12 (31.57)	22 (57.89)	04 (10.52)

All nutrient foramina (100%) in the femur were directed proximally (upper end) away from the growing end

Campos F *et al.*^{15]} studied the diaphysial nutrient foramina in the femur at between 25 and 58%. According to our present study 82.34% [Table 6] of nutrient foramina was located on whole posterior surface including linea aspera and its two lips (42.35% between two lips, 25.88% on medial lip, 9.41% on lateral lip, 4.70% on linea aspera), which is again similar with the Mysorekar *et al.*, Roopam *et al.* and Kizilkanat *et al.* while Gupta *et al.* reported more frequency on lateral surface. 48.93% of right side and 57.89% of left side foramina observed by gauge needle was medium size [Table 7].

CONCLUSION

Knowledge of anatomical variation in detail for DNF of femur with respect to their number, location, direction, and size is important. The single foramina were more common as compared to double. All the foramina were located on or near the LA, especially in middle one-third. Adequate knowledge of the location of dominant NF is important for bone ossification, bone healing, and microvascular bone grafting.

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