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A morphometric study of nutrient foramina in adult human femur in western Rajasthan

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Abstract
Aim and Objective: Aim of this study to observe presence, number, location and direction of nutrient foramen. The knowledge of presence, number, location and direction of nutrient foramen has clinical significance in orthopedic procedures.
Material & Method: The present study was conducted on 100 dry femur bones of unknown sex and origin from the department of anatomy Dr. S.N Medical College Jodhpur Rajasthan. The lengths of femur were measured using an osteometric board. For the purpose of study the femur was divided into three equal segments. The presence, number, location & direction of nutrient foramen were noted.
Result: In the present study single Nutrient foramen was located on middle third of the shaft was observed. Study provides data on the morphology of diaphyseal nutrient foramina in human femur which in turn will give information to preserve circulation during surgeries.
Conclusion: The nutrient artery is the major source of blood supply of the long bones The study will provide essential data for nutrient foramen which will be helpful in surgical orthopedic procedures and interpretation of radiological images.

Keywords: Dry adult femur, osteomatric board, nutrient foramen

1. Introduction
The knowledge of the nutrient foramina is valuable in certain operative procedures to preserve the vascularization of bone. The nutrient foramen is defined as the largest of the foramen present on the shaft of femur and it distinguish from any other foramen by the presence of distinct vascular groove outside the foramen [1]. Nutrient foramen is the peripheral opening of the nutrient canal in a bone. It allows the passage of the blood vessels to the medullary cavity of a bone [2]. The Nutrient canal which is primarily horizontal gets slanted during the growth. This is due to differential growth of the both sides of epiphysis of long bone [3].
Diaphyseal nutrient artery enters the shaft obliquely through nutrient foramina leading in to nutrient canal [1]. Nutrient artery does not branch in their canal but divides in to ascending and descending branch in medullary cavity which anastomose with epiphyseal and metaphyseal arteries [4]. The diaphyseal nutrient artery usually originates as a branch of 2nd perforating artery. The diaphyseal nutrient foramen is located away from the growing end of the bone .their direction follow the jingle rule – "to the elbow I go from the knee I flee." [5] The DNF is usually located around the center of the linea aspera [6].
Aim of this study to observe presence, number, location and direction of nutrient foramen. For the purpose of study the femur was divided in to 3 segments. An understanding of location, number, and direction of diaphyseal nutrient foramina in long bone is very important clinically, especially in orthopedic surgical procedure such as a joint replacement, fracture repair, bone grafting, vascularized bone microsurgery, non-unions and resection technique.

2. Materials and Method
The study was conducted on 100 dried human femurs of unknown sex and age collected from the Department of Anatomy, Dr. S.N. Medical College Jodhpur, Rajasthan.

After determining the sides of all the bone following parameters were studied

1) Total length of femur
2) Number of nutrient foramen
3) Location and Direction of nutrient foramen.

Instruments used

1) Hand lens: To locate the nutrient foramen
2) Osteomatric board: To measure the length of femur as a distance between the proximal ends of the head to the distal most part of the medial condyle.
   Then it divided into equal 3 segments. In each segment nutrient foramen was searched with hand lens
3) A 24 gauge needle was passed through each foramen to conform the patency. Foramina smaller than a size of 24 gauge needle were not taken in consideration in this study.

Fig 1: Showing femurs

Fig 2: Showing measurements of femur with osteomatric board

Fig 3: Showing nutrient foramina

3. Result

Table 1: Observation of bone length (in cm)

Side	Total no of Bone	Range of Total length (in cm)
Right	48	39.5- 47.8
Left	52	37-48.3
Both	100	37- 48.3

Total no. of femur bones examined was 100 of which 48 Right and 52 Left side .in table no 1 total length of bone were examined.
Shows maximum length in femur 48.3 cm and least length is 37 cm.
For the purpose of study, length divides into 3 segments.

Table 2: Observation of nutrient foramen in relation to segment and direction of nutrient foramen

Side	Upper	Middle	Lower	Direction of Nutrient foramen
Right	18	39	0	Upward
Left	14	42	0	Upward
Both	32	81	0	Upward

According to table no. 2 - 81 nutrient foramen located on middle segment, 32 nutrient foramen located on upper segment.
All the nutrient foramen directed upward

Table 3: Observation about the nutrient foramen regarding number

Side	No of bones : Zero NF	No of bones : Single NF	No of bones : Double NF	No of bones : Triple NF
Right	0	35	14	1
Left	1	33	16	0
Both	1	68	30	1

According table no 3 - Single NF was observed in 68 femora, Double NF was observed in 30 femora, Triple NF was observed in 1 Right femur and 1 Left femur observed with 0 NF.

Table 4: Observation about the Nutrient foramen regarding location

Side	LA	ML	LL	PS	MS	LS	AS
Right	26	13	3	8	9	3	0
Left	20	5	5	12	22	5	0
Both	46	18	8	20	31	8	0

According to table no 4 – 46 NF were located on LA, 31 NF were located on MS, 20 NF were located on PS, 18 NF were located on ML, 8 NF were located on LL & LS.
So most commonly NF located on LA.

Table 5: Frequency of double NF regarding surface and linea aspera

Location	Frequency
ML, LA	3
PS, LA	2
LA, LS	3
LA, LA	2
PS, LS	2
LL, MS	2
ML, MS	3
MS, LA	2
MS, MS	1
MS, PS	4
LA, LL	2
ML, ML	2

According to table no 5 – Most commonly double NF located on MS, PS.

4. Discussion

In the present study femora had variable no. of nutrient foramina. Single nutrient foramen reported in 68 (68%) femora and double nutrient foramen reported in 30 (30%) femora.
This study compare with previous study we find that majority (68%) of femora have single nutrient foramen is similar to Kizilkanat *et al*. (75%) and Laing (60%) [7, 8].
The femoral nutrient artery usually arises from 2nd perforating branch of profunda femoris artery.
In case of double nutrient foramen nutrient artery usually come from 1st and 3rd perforating artery [2].
The difference in the occurrence of nutrient foramen in the different populations may be related to variation in genetic constitution.
1% bone reported absence of nutrient foramen in this study, previous study reported absence of nutrient foramen in 3.3% by Mysorekar and Kizilkanat *et al*. and Laing not found any bone without a nutrient foramen [7-9].
In the absence of nutrient foramen, the shaft of the femur receives irrigation from the periosteal vessels [10].
Three foramina were observed in 1% femora and frequently on the right femur (MS, PS) acc. to this study.
The least occurrence of the nutrient foramen on the lateral surface of the femur in the present study and the absence on the anterior surface make these two sites the safest for orthopedic manipulation.

Table 6: Comparison of number of nutrient foramen with previous study

Author	No. of bone studied	% with 0 NF	% with 1 NF	% with 2 NF	% with 3 NF
Kizilkanat *et al*	100	0	75%	25%	0
Mysorekar	180	3.3%	45%	50%	1.6%
Laing	10	0	60%	40%	0
Present study	100	1%	68%	30%	1%

5. Conclusion

The occurrence of nutrient foramen is frequent on linea aspera and medial surface, less frequent on the lateral surface and rare on the anterior surface of the shaft.
The topographical knowledge of these foramina is useful in certain operative procedures to preserve the circulation
Therefore it is important that the arterial supply is preserved in free vascularized bone graft so that the osteocyte and osteoblast survive.
When a bone graft is taken the vascularization of the remaining bones has to be considered with the vascularity of this area allowing various options in grafting.
The bony defect which is left behind following traumatic injuries, tumor resection procedure and pseudoarthrosis can all be reconstructed by bone grafting procedures and preferred modality in free vascularized bone graft.
It is well known that one of the courses of delayed union or non –union of a fracture is lack of arterial supply.
The morphological knowledge of nutrient foramina is significantly important for orthopedic surgeons undertaking an open reduction of a fracture to avoid injuring the nutrient artery and thus lessening the chances of delayed or non-union of the fracture.

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