A STUDY OF ADULT HUMAN FEMORAL DIAPHYSEAL NUTRIENT FORAMINA

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ABSTRACT

BACKGROUND

Long bones receive majority of its nourishment through nutrient arteries. These arteries enter long bones through nutrient foramina. It is important to have an understanding of diaphyseal nutrient foramina in femur, especially in orthopaedic surgical procedures. The aim of the study is to evaluate the common number, location & direction of nutrient foramina of femur.

MATERIALS AND METHODS

This is a descriptive study of 100 cleaned and dried human adult femora which were taken from Department of Anatomy, Guntur Medical College, Guntur and Osmania Medical College, Hyderabad and each femur was studied for location, direction & number of nutrient foramina.

RESULTS

The mean number of nutrient foramina per femur bone was 1.43 and mean distance of nutrient foramen from upper end was 20.5 cm. The foraminal index obtained was 49%. The commonest location of the nutrient foramen was on linea aspera {55.2%}. 52% of femora had only one nutrient foramen, while 44% had two nutrient foramina. 82.5 % of nutrient foramina were observed in the middle third of femur. All femora observed have the nutrient foramen directing upwards.

CONCLUSION

The study on nutrient foramina of long bones has clinical significance in interventional procedures like orthopaedic transplant techniques & microvascular bone transfer procedures.

KEY WORDS

Femur, Foraminal Index, Diaphyseal Nutrient Foramen, Nutrient Artery, Linea Aspera

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BACKGROUND

Bones are dynamic structures that undergo constant change & remodelling in response to ever-changing environment. They have the ability to regenerate without scarring. Adequate blood supply is necessary for growth of the bones and their mutability in response to changing environment. Antonie Van Leeuwenhoek,[1] observed many little holes on tibia extending from cortex to medulla like as small pipes going long ways. For a bone the blood supply is mainly through periosteal vessels, nutrient arteries and their interosseous medullary branches.[2] The nutrient artery enters the bone through an opening called nutrient foramen and travels via nutrient canal into the marrow cavity where it ramifies. Due to the rapid growth of one end of bone than the other the nutrient canal becomes oblique with respect to long axis of the bone. This was first reported by Berard.[3] He stated that nutrient foramina were directed towards elbow in upper limb and away from the knee in lower limb.

Femur is the proximal weight bearing bone of the lower limb. Stress fractures are relatively common in the area of nutrient foramen.

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As femur is a weight bearing bone fracture of its shaft ends in severe deformity, so careful evaluation and correct treatment needed.[4] The details of nutrient foramen help the surgeons to avoid damage to nutrient vessels during operations.

MATERIALS AND METHODS

This Descriptive study of the present study consists of 100 cleaned and dried human adult femora, Hepburn Osteometric board, sliding calipers, hand lens, stiff wire and 21-gauge needle. They were obtained from the Department of Anatomy, Guntur Medical College, Guntur and Osmania Medical College, Hyderabad.

Bones without any abnormalities were selected for the present study. Parameters like age & sex were not considered.

Each femur was observed by using a magnifying lens for nutrient foramen on the shaft. Nutrient foramen was identified by its specific features like elevated margins and distinct groove proximal to it. Only well-defined foramina on the diaphysis were accepted. Foramina at the ends of the bone were ignored.

Parameters Observed in Each Femur-

1. Total Length of Bone

The maximum length of each bone was measured using Hepburn Osteometric board. The total length of femur was determined by measuring the distance between the most proximal part of the head to the distal most part of the medial condyle.

2. Number of Nutrient Foramina
All femora were observed for the number of nutrient foramina in each bone.

3. Location of Nutrient Foramina
The shaft of a long bone consists of three surfaces separated by three borders. The borders are medial, lateral and posterior. The surface between medial and lateral borders is anterior surface, between medial and posterior borders is medial surface and between lateral and posterior borders is lateral surface. The posterior border in the middle third of the shaft is represented by a prominent crest, the linea aspera. The two lips of the linea aspera diverge to enclose posterior surface in the upper third and popliteal surface in the lower third of the shaft.

4. Distance of Nutrient Foramina From Upper End of Bone
It is measured from the most proximal part of the head of the femur to the nutrient foramen by sliding calipers.

5. Position

a. Calculation of Foraminal Index:

- Position of nutrient foramen was determined by calculating Foraminal Index (FI)
- FI = (DU/TL) x 100 (Hughes[5]).
- DU= distance from upper end of head of the femur to the nutrient foramen
- TL = total length of the bone.

b. Subdivisions of Position of Foramina Based on FI:

- Proximal Third- FI up to 33.33.
- Middle Third- FI from 33.34 to 66.66.
- Distal Third- FI more than 66.66.

6. Direction and Obliquity
A fine stiff wire was used to observe the direction of the nutrient foramen and obliquity of the nutrient canal.

RESULTS
This study was conducted in 100 human femora.

Observation	Range	Mean
Total Length in Centimeters	36.1-48	42.28
Distance from Upper End of Femur to Nutrient Foramen in Centimeters	14-31.5	20.5
Foraminal Index	31-66.6	49

Table 1. General Observations About the Nutrient Foramen in 100 Femora

Number of Nutrient Foramen	Number of Bones	%
Absent	3	3%
One	52	52%
Two	44	44%
Three	1	1%

Table 2. Observations About the Number of Nutrient Foramina in 100 Femora

Location of Nutrient Foramen	Number of Bones	%
Linea Aspera	79	55.2%
Medial Surface	32	22.4%
Lateral Surface	31	21.7%
Medial Supracondylar Ridge	1	0.7%

Table 3. Observations About the Location of Nutrient Foramen in 100 Femora

Position of Nutrient Foramen According to FI	Number of Bones	Percentage
Proximal 1/3rd	25	17.5%
Middle 1/3rd	118	82.5%
Distal 1/3rd	0	0%

Table 4. Observations About the Position of Nutrient Foramen in 100 Femora According to Foraminal Index {FI}.

In all femora observed, the direction of nutrient foramina is upwards, i.e. away from the knee. No difference in the obliquity of the nutrient canal, whether in the center of the bone or nearer to the ends.

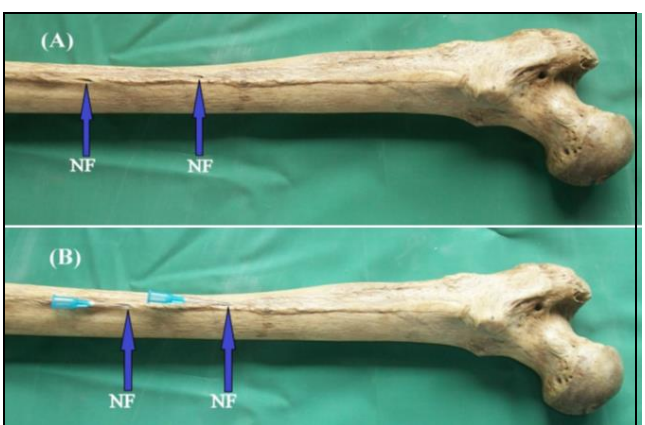

Figure 1. [A] Femur Showing Double Nutrient Foramina, both on Linea Aspera of The Shaft, [B] Both Foramina are Directing Upwards

DISCUSSION
In the present study, femur found to have variable number of nutrient foramina ranging from one to three. 52% of the femora have single, 44% have double and 1% have 3 nutrient foramina. Absence of nutrient foramen was observed in 3% of femora. These results are similar to the study of Lutken P[6], Sharma M et al,[7] Bhatnager S et al.[8] Some authors like Kizilkanat E et al[9] {75%}, Gupta AK et al[10] {71%}, Vinay G et al[11] {66.7%} observed higher percentage of single nutrient foramen than that of present study. Few authors like Mysorekar VR,[12] Gupta RK et al,[13] Bridgeman G et al[14] observed a little higher percentage of femora with double nutrient foramina than femora with single nutrient foramen. Gumusburun E et al,[15] Sendemir E et al[16] observed femur with 6 to 9 nutrient foramina. Mysorekar VR,[12] Bridgeman G et al,[14] Motabagani,[17] Gupta RK et al,[13] Sharma M et al[7] reported femur having no nutrient foramen.

Author	No. of Femora Observed	% of Femora without NF	% of Femora with Single NF	% of Femora with Double NF	% of Femora with 3 or more NF	Mean No. of NF
Lutken P[6]	410	--	53.4	44.4	2.2	1.49
Gupta RK et al[13]	312	0	44.6	49.4	6.1	1.64
Kizilkanat E et al[9]	100	0	75	25	0	1.24
Vinay G et al[11]	90	0	66.7	33.3	0	1.33
Gupta AK et al[10]	100	3	71	25	1	1.24
Mysorekar VR[12]	180	3.3	45	50	1.6	1.5
Bridgeman G et al[14]	109	2.75	44.03	53.21	0	1.5
Sharma M et al[7]	50	2	54	42	2	1.44
Present study	100	3	52	44	1	1.43

Table 5. Showing Comparison of Number of Nutrient Foramina {NF} in Femora

Observed by Different Authors

In this study 55.2% of the nutrient foramina were observed on linea aspera and its lips, 22.4% on medial surface. It correlates with the study of Gupta RK et al.[13] But Gupta RK et al[13] also observed 25.6% of nutrient foramina on posterior surface, which is not seen in this study. Many authors reported that there is no nutrient foramen on anterior surface. But Sendemir E et al[16] examined 7.1% on the anterior surface. Malukar O et al[18] examined 4.5% on the anterior surface. Sendemir E et al[16] and Deepa Bhat,[19] Lutken P[6], Longia GS et al[20] observed a higher percentage of nutrient foramina on linea aspera and its lips. Gupta AK et al[10] observed 58.8% of nutrient foramina on lateral surface.

In this study most of the nutrient foramina were observed in middle third of the shaft similar to most of the other studies. No femur with nutrient foramen in distal third was observed. Mysorekar VR[12], Gupta RK et al[13] observed most of the NF in 3/5th and 4/5th of the shaft of femora. Lutken P[6] and Forriol CF et al[21] stated nutrient foramina were close to hip joint. Kumar, R. et al[22] reported 48% of nutrient foramina in proximal third and 52% in middle third. Most of the authors do not found nutrient foramen on distal third. Bhatnager S et al[8] found 1.17% of femur with nutrient foramen on distal third. Mysorekar VR[12] found 1.4% on distal 1/5Th.

In the present study all nutrient foramina were directed proximally away from the knee. Similar observations were reported by many authors. Lutken P[6] - 1%, Longia GS et al[20] - 0.5%, Vinay G et al[11] -1.3% reported nutrient foramina directed distally. Hughes H[5] stated that anomalous canals were found frequently in the femur which might be the cause of later findings.

CONCLUSION

In femur, single nutrient foramen was little more commonly observed than double nutrient foramina. Most nutrient foramina were observed in middle third of the bone that too on linea aspera. All foramina are directed proximally.

Detailed study of nutrient foramen is important clinically, especially in orthopaedic surgical procedures like vascularized bone microsurgery, non-unions, bone grafting, intramedullary reaming and plating. Appropriate understanding of extraosseous vascular supply of bones along with careful planning before surgeries is important for successful outcome.

The findings of the present study on nutrient foramen add to the information from the studies in the past.

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