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Original Research Article

Variations of Nutrient Foramen of Femur and its Clinical Implications

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ABSTRACT:

Introduction: Nutrient foramen is the largest opening on the shaft of the femur that conveys nutrient artery into the marrow cavity. Knowledge on locations of nutrient foramina is essential during surgical procedures as well as to rule out if the fracture line passes through the foramina. The purpose of the study was to determine the number and position of nutrient foramina in relation to length and topography of the femur. **Methods:** The study model was descriptive, cross-sectional study that included 151 femurs (71 right and 80 left side). The total number, location and direction of nutrient foramina were investigated. Total length of femur and distance of foramen from the proximal end was measured with the 500mm 20" Digital Vernier Nib Jaw Caliper Metric/ Imperial Machine-DRO and finally Foraminal Index was calculated. **Results:** The analysis revealed 119(78.81%) of the femurs with single nutrient foramen, 31(20.52%) with double and 1(0.67%) with triple nutrient foramina. Foraminal Index II was found in 74(86.05%) on right side and 90(91.84%) on left side. The most common location of nutrient foramen was the medial lip of linea aspera (n= 77, 41.85%). All of the foramina were directed towards the proximal end. **Conclusion:** The present study has reported the majority of nutrient foramina located in the middle third of femur along the linea aspera. Thus, linea aspera should not be stripped off during surgical procedures to avoid damage to the nutrient arteries.

Keywords: Femur, Foraminal index, Nutrient artery, Nutrient foramina

INTRODUCTION:

Nutrient foramen is the largest opening on the shaft of the long bone.[1] The femur has one or two nutrient foramina along the linea aspera leading to oblique nutrient canal; if two nutrient foramina are present one appears at proximal end and other at distal end of linea aspera both being directed proximally.[1] The nutrient artery enters through nutrient foramen, passes through nutrient

canal and finally opens into marrow cavity. The artery then divides into marrow sinusoids and finally forms numerous small vessels that ramifies through the cortex, supply bone marrow and spongy bone.[2]

The nutrient artery supplies the outer 2/3rd of the cortex of the bone and plays a vital role in bone remodeling as well as regeneration.[3] The precise knowledge on location of nutrient foramen is essential for surgeons to prevent intraoperative damage to the artery.[4] Also, knowledge on location of nutrient foramina is essential to differentiate the fracture line from the nutrient foramen.[5]

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Interestingly, Ambekar et al., have reported the presence of nutrient foramina upto five and Sendemir et al., reported upto nine.[5,6] Researches accomplished in different parts of the world show the variations in the position of nutrient foramina along the length and surfaces of the bone.[7,8]

Many studies have been conducted on nutrient foramina of femur in different parts of world but in the context of Nepal we are unable to find the relevant data. The present study aims to determine the location and number of femoral nutrient foramina which may provide useful data for orthopedic surgeons, anatomists and radiologists.

METHODS:

This was a descriptive, cross-sectional study approved by Institutional Review Committee of Kathmandu University School of Medical Sciences. The study was carried out from April 2017 to February 2018. The study was conducted on the Femur specimens available at the Department of Anatomy, Kathmandu University School of Medical Sciences and other medical colleges of Kathmandu.

In the present study, 151 cleaned and dried femurs were included and the femur with any signs fracture or deformity was excluded. The side determination of the femur was done and following parameters were observed:

Total length: Total length of femur was measured with the help of 500mm 20” Digital Vernier Nib Jaw Caliper Metric/ Imperial Machine-DRO and recorded upto nearest 0.1mm. The total length was measured between the proximal part of the head of the femur and the distal aspect of the medial condyle.

Number of nutrient foramina: The nutrient foramen of femur was identified by the presence of well-marked groove leading to it and well-marked ridge proximal to it. We observed the number of nutrient foramina with the help of hand lens.

Location of nutrient foramen: The location of foramen in relation to specific border and surface was noticed.

The directions of the nutrient foramina: A straight wire was used to find the direction of the nutrient canal. They were recorded as directed towards the proximal or distal ends.

Distance of foramina: The distance of the foramen

from the proximal end was recorded with the digital vernier caliper and recorded to nearest 0.1mm. In femur with double or triple nutrient foramina, the distance of all foramina from the proximal end were measured.

Foraminal Index (FI): The Foraminal Index was calculated to determine the exact location of the foramen in relation to the length of bone using Hughes formula:[9]

$$FI = D/L \times 100$$

Where,

FI = Foraminal Index

L = Total length of the bone

D = Distance of the foramen from the proximal end

Foraminal Index was divided as follows:

Type I: Below 33.33 indicate the location of foramen in proximal third

Type II: FI 33.33 to 66.66 indicate the location of foramen in middle third of bone

Type III: FI above 66.66 indicate the location of foramen in distal third of bone

All the data were entered in Statistical Package for Social Sciences (SPSS™) version 16 and frequency and percentage were calculated.

RESULTS:

The study model included 151 femurs (71 of right side and 80 of left side) that presented with 184 nutrient foramina: 86 on right side and 98 on left side.

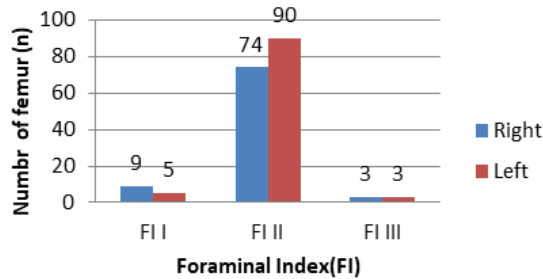
Majority of the femur had single nutrient foramen (78.81%) followed by double (20.52%) and with triple nutrient foramina (0.67%). [Table 1]

Table 1. Nutrient foramina on right and left femurs

Number of nutrient foramen	Right	Left	Total
	n (%)	n (%)	n (%)
Single	57 (80.29)	62 (77.50)	119 (78.81)
Double	13 (18.30)	18 (22.50)	31 (20.52)
Triple	1 (1.41)	0	1 (0.67)

Most of the femurs, 86.05% on the right (n=74) and 91.84% on the left (n= 90) had FI II as shown in the Fig. 1 indicating that majority of foramina were located in the middle third of femur.

Fig. 1. Foraminal Index of the Femur.



The highest percentage of nutrient foramina commenced on the intermediate lip of linea aspera on the right while it commenced on the medial lip of linea aspera on the left. The table 2 shows the arrangement of most of the foramina along linea aspera (intermediate lip, medial lip or lateral lip) while few along the spiral line and gluteal tuberosity.

Table 2. Location of nutrient foramina on the basis of topography

Location of Foramina	Right	Left
	n (%)	n (%)
Intermediate area of linea aspera	31 (36.05%)	24 (24.49%)
Medial lip of linea aspera	27 (31.39%)	50 (51.02%)
Posteromedial surface	9 (10.47%)	11 (11.23%)
Posterolateral surface	7 (8.14%)	3 (3.06%)
Spiral line	1 (1.16%)	1 (1.02%)
Gluteal tuberosity	0	1 (1.02%)

Direction of nutrient foramina:

The analysis revealed the direction of all nutrient foramina towards the proximal end of the femur. The study model did not locate any foramina directed towards the distal end.

DISCUSSION:

The finding of the present study illustrates that nutrient foramina have definite pattern of arrangement in femur, restricted around the linea

aspera in middle third of bone. The knowledge in location of nutrient foramina can give idea to the clinicians about diagnosis, treatment planning and predict its prognosis.[10]

Our study showed that all nutrient foramina presented on posterior surfaces of the femur, which suggest that, the anterior surface is a relatively safer site for surgical procedures. Prior researches by Seema et al., and Oladyo also presented similar outcomes.[8,11] However, the study by Sendemir and Cimen has shown 7.1% of the nutrient foramina located on the anterior surface.[6]

The present study has found the location of 41.85% of nutrient foramina on the medial lip of linea aspera that gives the idea about location of majority of the foramina. In consistence to our finding, Deswal reported the similar position of most of the foramina, thus the knowledge on variation in nutrient foramina position is essential to prevent iatrogenic damage to the artery.[12]

In our study Foraminal index ranged from 17.98% to 91.75% which indicates the occurrence of foramina in any region; proximal, middle or distal third of the shaft. Among them majority had Foraminal Index Type II, indicating the location of foramina in middle third of the bone. Previous investigations by Vinay et al., and Krishna et al., have also concluded the location of the most of the foramina in middle third of thigh.[13,14]

In our investigation 2/3rd of bone had single nutrient foramina which are similar to most of the studies conducted among Indian population by Vinay et al.,[13] and among African population by Pedzisai et al.[15] Additionally our study reported the presence of triple nutrient foramina in 0.7% of the cases which is in consistence with the study of Poornima.[16]

Although Sharma identified 2% femur without nutrient foramina in her study[17] we did not find the femur where nutrient foramen was absent.

The present study falls short of including the representative sample of all the geographic regions of Nepal. The study framework fails to probe into sex specific analysis as the femur that was studied was not labeled with the sex.

CONCLUSION:

The present study has revealed the majority of nutrient foramina located in the middle third of femur along the posterior border or surface. Thus, the research suggests the linea aspera should be taken into consideration during surgical procedures to avoid damage to the nutrient arteries. Double nutrient foramina are also common finding in our study.

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Our study presents the location of foramina along proximal or distal third and along other surfaces as well. This finding advises us the precise knowledge on location of nutrient foramina and the direction of the foramina can serve as guideline to differentiate the foramina from the fracture.

Conflict of Interest:

The authors declare that no competing interest exists.

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No funds were available.