International Journal of Anatomy and Research,
Int J Anat Res 2015, Vol 3(4):1573-77. ISSN 2321- 4287
DOI: http://dx.doi.org/10.16965/ijar.2015.291

Original Research Article

STUDY OF NUTRIENT FORAMINA OF ADULT FEMORA WITH ITS CORRELATION TO LENGTH OF THE BONE

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ABSTRACT

Introduction: Femur is the most richly vascularised long bone which derives its nourishment from various arteries of the lower limb. The quantum of blood supply is determined by the number and calibre of these arteries. Shaft of this bone is supplied by the vessels from perforators of the thigh which gives nutrient branches to it. Femoral shaft fractures are severe disabling injuries that demand critical evaluation as to the method of treatment. Since the success of these operations depends on a minimal interference with the blood supply of the bone, the knowledge of anatomy of the nutrient vessels is of considerable importance.

Materials and Methods: The study was conducted on 300 adult femora available in the department of Anatomy. The study was undertaken to collect information on the variations in number, location, size of the nutrient foramina and if correlation exists between the length of femur and number of nutrient foramina.

Results: 60% of the bones had double, 39.33% had single and only 0.67% had single nutrient foramina (NF). 52% of them were on medial lip of linea aspera followed by 41%on lateral lip and the rest scattered. 80% of NF was located on upper and middle segments of shaft and very meagre number in lower segment. No correlation was noted between number of NF and length of the bone.

Discussion and Conclusions: The findings in the present study are compared and analyzed with previous researchers. The magnitude of care to be imparted while dealing with fractures of femoral shaft is discussed. The detailed knowledge on vascular anatomy of shaft would allow surgeon to preserve them during procedures.

KEY WORDS: Nutrient foramina, Femur, Linea Aspera, Perforating Arteries.

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Access this Article online

Quick Response code

DOI: 10.16965/ijar.2015.291

Web site: International Journal of Anatomy and Research
ISSN 2321-4287
www.ijmhr.org/ijar.htm

Received: 02 Oct 2015 Accepted: 03 Nov 2015
Peer Review: 02 Oct 2015 Published (O): 30 Nov 2015
Revised: None Published (P): 31 Dec 2015

INTRODUCTION

Femur is the proximal weight bearing bone of lower limb. Femur is the most richly vascularized long bone which derives its nourishment from various arteries of the lower limb. The quantum of blood supply is determined by the number and calibre of these arteries. The major part of a long bone receives its blood supply from numerous points all along its length through the periosteal and nutrient vessels [1]**.** Shaft of this bone is supplied by the vessels from perforators of the thigh which gives nutrient branches to it. Nutrient arteries, the main blood supply to long bones, are particularly important during the active growth period, as well as during the early phases of ossification [2]. The blood supply acts as a most vital factor to deal with problems like non-union, malunion, osteomyelitis and other conditions affecting the diaphysis [3]. Femoral shaft fractures are severe disabling injuries that demand critical evaluation as to the method of treatment [4]. Since the success of these

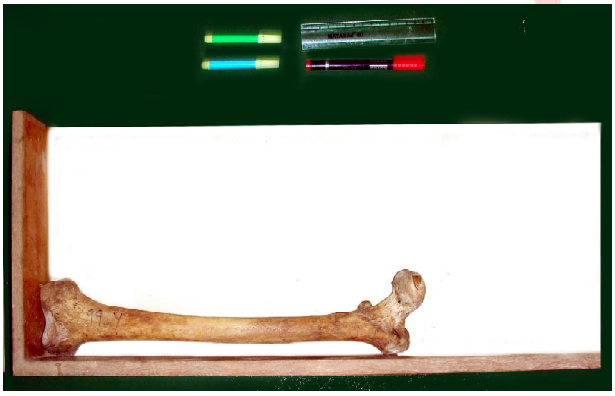
operations depends on a minimal interference with the blood supply of the bone, the knowledge of anatomy of the nutrient vessels is of considerable importance [5]. The detailed knowledge on vascular anatomy would assist the surgeons to preserve them while dealing with vessels during bone resection and graft procedures.

The study was undertaken to gather information on variations in number, location, size of the nutrient foramina. Also attempt is made to establish if a correlation exists between the length of femur and number of nutrient foramina.

MATERIALS AND METHODS

The study was conducted on 300 adult femora (155 of right side and 145 of left side) of South Indian population available in the department of anatomy. The damaged and defective bones were excluded from study. The nutrient foramina were observed in each bone using hand lens. The number, size and location of nutrient foramina in each femur was noted and measured. Wires were chosen of thickness 1mm and 2mm. The foramina were categorised into three groups based on size i.e. A - <0.5mm (did not admit 1mm wire), B – 0.5 – 2mm (admitted 1mm wire), C - > 2mm (easily admitted 2mm wire. The maximum length of femur was measured by using Reid's osteometric board. Femur was placed with dorsal side upwards in such a manner that medial condyle touches the short vertical wall; measuring scale touches the highest point of the head. The length was measured from the distance between highest point of head and the deepest point on the condyle.[Figure 1] The data obtained was statistically analyzed.

Fig. 1: Measurement of length of bone using Reid's Osteometric board.



RESULTS

Number: Among 300 femora studied 60% had two NF, 39% had single NF and 0.67% had three NF (Table 1) (Figure 2 & 3)

Table 1: Number of nutrient foramina observed in femur.

Number of NF	Total number of Femur	Percentage
0	0	0
1	118	39.33
2	180	60
3	2	0.67
Total	**300**	**100**

*NF- Nutrient foramina

Fig. 2: Femur showing 2 nutrient foramina on linea aspera.

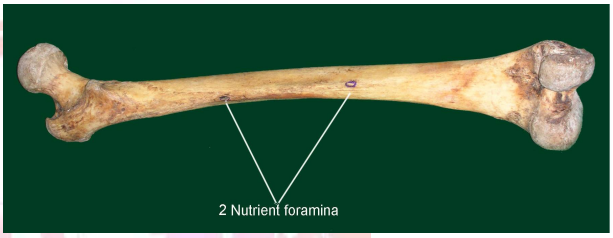
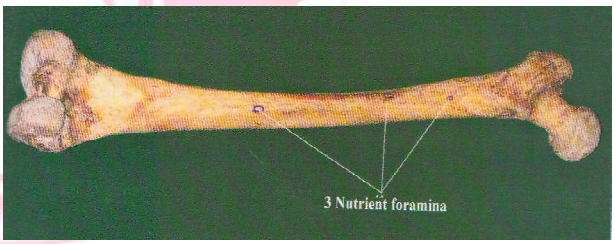


Fig. 3: Femur showing 3 nutrient foramina on linea aspera.



Size: 65% of the NF were large sized, 23% were medium sized, 12% were small sized. (Table 2)

Table 2: Size of nutrient foramina in the femur.

Size of NF*	Number	Percentage
0.5mm	57	11.88
0.5-2mm	110	22.92
2mm	313	65.2

Location: Maximum no of femur had NF in medial lip of linea aspera i.e, 52%, lateral lip of linea aspera had NF in 41%, 7.5% of bones on medial surface and least was observed on upper posterior surface 0.21%.(Table 3)

Table 3: Location of nutrient foramina in various segments of femur.

Location of NF*	Percentage	Number
Medial lip of LA**	51.67	248
Lateral lip of LA	40.62	195
Medial surface	7.5	36
Upper posterior surface	0.21	1
Total	100	480

** LA- Linea aspera

48% of the NF were located at the junction of upper and middle one third of the femur. 38% were at the junction of middle and lower one third of femur. 14% of the total bones had in middle half of the length of the femur. (Table 4) There was no correlation observed between length of femur and the number of nutrient foramina (Table 5).

Table 4: Location of NF in different segments of femur.

Location of NF*	Percentage	Number
Upper & middle 1/3rd of Femur	47.71	229
Middle & lower 1/3rd of femur	37.71	181
.Middle 1/2	13.75	66
Other location	0.83	4
Total	100	480

*NF- Nutrient foramina

Table 5: Length of femur v/s average number of nutrient foramina.

Length of femur	Average no of nutrient foramina
37.1-38cm	1.22
38.1-39cm	1.67
39.1-40cm	1.71
40.1-41cm	1.54
41.1-42cm	1.47
42.1-43cm	1.57
43.1-44cm	1.6
44.1-45cm	1.55
45.1-46cm	1.93
46.1-47cm	1.44

DISCUSSION

Femur is the most richly vascularized long bone which derives its nourishment from various arteries of the lower limb.

Number: Out of 101 bone studied Kumar et al. found 48 (32%) were single foramen,102 (68%) were double foramina and foramen were absent in 2 femora [6]. Out of 180 femurs analyzed, Mysorekar [7] reported 3.3% having none, 45% with one, 50% with two and 1.6% with three foramina. Lutken [8] observed one on 53.4%, two on 44.4% and three foramina on 2.2% of his 410 femurs. And Forriol et al [9] reported that 30% of his 31 femurs had one, 60% had two, and 10% had three foramina.

The number of bones having single and double nutrient foramina was almost similar (60% had two NF and 39% single NF) to other reports but discrepancy was observed in the percentage of bones having 3 foramina (0.67%)

Size: Different investigators have utilized diverse methods to classify the nutrient foramina. Kumar et al [6] classified them into two types; dominant foramina which are more than 0.56 mm in diameter and the rest as secondary foramina which he found 68% & 32% respectively. Poornima B [10] classified them into four categories $\geq$1.27 mm, $\geq$0.90mm to < 1.27 mm, $\geq$0.71mm to < 0.90 mm and $\geq$0.55mm to < 0.71 mm. In the present study the NF were arbitrarily categorized into 3 types; <0.5mm, >2mm and those in between. Majority of NF are of larger size similar to reports from earlier studies irrespective of type of classification. Trias and Ferry (1979) [11] stated that cortices of long bones are dependant for their nourishment from vessels from periosteal and medullary circulatory system, the latter is mainly derived from branches of nutrient artery. He also suggested that periosteal vessels supply outer one third to one fourth of the cortex while medullary arteries supply inner two third to three fourth of the cortex. This indicates the major share of nutrient arteries in providing nutrition to the shaft of the bone. Hence the sole input of blood to cater the demand, to supply the medullary wall and bone marrow is by perforating arteries.

Location: Sendemir E [12] reported 35.3% on the medial lip, 10.1% on the lateral lip and 7.1% on the anterior surface of femoral shaft; the rest were scattered. Malukar O [13] observed that 88.6% were located on medial lip of linea aspera, 6.5% on lateral lip and 4.5% on anterior surface. Kumar et al [6] found 18.66% on the medial lip of the linea aspera, 11.33% on the lateral lip of linea aspera, 27.33% were on posterior surface, 35% the rest. In contradiction to previous reports NF in the present study were observed in posterior surface than anterior. Contrasting variations are observed the location of NF in various studies. Liang [14] in 1953 itself reported that the constancy with which the arteries enter the femoral shaft in the region of the linea aspera needs reiterating. Since most of the authors have report that location of majority of NF medial lip of linea aspera, it will be the entry zone for the vascularity to shaft. As

a structural adaptation, thickening of the medullary wall and the appearance of linea aspera is observed. The shaft of the femur is adapted to the lines of stress and weight transmission. This definitely gains significance from surgical point of view as interference in this region should be done with utmost care.

Maulukar O [13] observed that out Of the total 150 foramina, 48% were in the proximal third and 52% in the middle third and no foramina in the distal third. Poornima B [10] found in her study on 100 bones that density of nutrient foramina was found more close to medial lip of linea aspera and at the junction of upper and middle 1/3rd of the shaft of Femur. Liang G P [14] in his study using contrast dye found no vessel enters from distal one third of femur. A fracture through the upper and middle of the shaft would deprive upper end of lower segment with its blood supply. It is important to note that the passage of a correctly fitting intramedullary nail in adult femora is necessity to avoid damage to medullary branches of all the nutrient vessels.

Correlation with the length: Mysorekar [7] in his study on NF on long bones found no relation between length and number of foramina of bones which supports the finding in present study. Probably the nutrient foramina will remain the same since they are concerned with intraosseous plexuses within the medullary cavity for regeneration of the blood and formation of bone marrow as suggested by Trueta [15].

It is obvious that the linea aspera should never be stripped of muscle attachments at operation. It is important to note that while plating the femur one should never put the plate on the anterior surface of the bone, for then the screws might well penetrate the linea aspera posteriorly and, if the femur in question has only one nutrient artery, could destroy the major source of blood to the shaft.

CONCLUSION

Femur is a highly vascularised bone deriving blood supply from perforating arteries of thigh. Nutrient Foramina are major pathways for entry of blood vessels to shaft. Majority of NF were more than 2mm in size. The study shows similar findings as previous reports regarding the location of nutrient foramina at medial lip of linea aspera. NF was not located in anterior surface in any of the 300 bones studied. Only single foramina were noted on posterior surface in one bone. The most of the nutrient foramina were located at the junction of upper one third and middle one third of the shaft. This area is prone for subtrochanteric fractures which may lead to alarming haemorrhage thus highlighting its applied significance. This study and previous reports largely portrays that size, location of NF exhibit variable finding between investigators. The anticipation on the variations in NF during interventions is mandatory to preserve the vasculature for favourable outcome.

ACKNOWLEDGEMENTS

I thank Dr Pushpalatha K Associate professor of my department for her critical comments in preparation of this manuscript.

Conflicts of Interests: None

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How to cite this article:

Deepa Bhat. STUDY OF NUTRIENT FORAMINA OF ADULT FEMORA WITH ITS CORRELATION TO LENGTH OF THE BONE. Int J Anat Res 2015;3(4):1573-1577. **DOI:** 10.16965/ijar.2015.291