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A Morphometric Study of Nutrient Foramina in Dry Femur Bones

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Abstract

Background: The nutrient artery of femur usually arises from the second perforating branch of profunda femoris artery. Adequate bone blood flow is an important clinical consideration, particularly during fracture healing, distraction osteogenesis and osteoporosis.

Aim: The objective of the present study was to study the number, location and direction of nutrient foramen in the femur and also to determine the foraminal index of femur.

Material and Methods: The study included 100 femur bones (46 right and 54 left) which were obtained from the department of Anatomy of a private medical institution. The number, location and direction of the nutrient foramina were examined in all the femur bones. The foramen index (FI) was calculated by dividing the distance of the foramen from the proximal end (D) by the total length of the bone (L) and then multiplied by hundred.

Results: Majority of the femur bones had singlenutrient foramen (56%) followed by double (44%). Nutrient foramina in all the femur bones were directed upwards. The foraminal index observed in the study is 40.16±9.12.

Conclusion: Single nutrient foramen is more commonly seen along the linea aspera of femur bone. Nutrient foramen is more commonly located in middle third of the femur.

Keywords: Nutrient foramen; Femur; Linea Aspera; Foraminal Index.

Introduction

The nutrient artery of femur usually arises from the second perforating branch of profunda femoris artery. When two nutrient arteries are present, they are derived from first and third perforating branches.[1] Further, a nutrient artery for femur may also arise from fourth perforating artery.[2] The nutrient foramina of femur are directed proximally. They are located on the linea aspera and they vary in number and site.[3] 70% of the total bone blood flow is carried by the nutrient arteries to the diaphyseal cortex and marrow.[4]

Adequate bone blood flow is an important clinical consideration, particularly during fracture healing, distraction osteogenesis, osteoporosis, disuse osteopenia, and bone grafting.[5] This study was undertaken to determine the morphometry and topography of nutrient foramina of femurin the South Indian population.

Aim

The objectives of the present study was

1. To study the number, location and direction of nutrient foramen in the femur.
2. To determine the foraminal index of femur.

Materials and Methods

The study included 100 femur bones (46 right and 54 left) which were obtained from the department

of Anatomy of a private medical institution.

Inclusion criteria: Intact, completely ossified femur bones were included in the study.

Exclusion criteria: Damaged, deformed bones, bones with gross pathological deformities were excluded from the study.

The number, location and direction of the nutrient foramina were examined in all the bones. The foramina were studies with a magnifying lens. A 24 guage needle was used to confirm the patency of the formina. Only diaphyseal nutrient foramina were studied. The number and location of the nutrient foramina with respect to the borders and surfaces were studied. The foramina which were located within 1mm of the border were taken to be lying along the border.

The Femur was divided into 3 equal parts and topographical location of the foramen, whether the foramen was located in upper 1/3rd, middle 1/3rd, lower1/3rd was noted.

The foramen index (FI) was calculated by dividing the distance of the foramen from the proximal end (D) by the total length of the bone (L) and then multiplied by hundred. If more than one foramen is present, the larger foramen was taken into consideration to calculate the Foramen Index. The direction of the nutrient foramen was determined by passing the needle through the foramina.

Results

In the study majority of the femur had single nutrient foramen (56%) followed by double (44%) foraminas as shown in Table 1. Direction of the nutrient foramen in all the femur bones were directed upwards and the foraminal index observed is 40.16±9.12.

Table 1: The distribution of number and location of the nutrient foramina of femur observed in the study.

Number of nutrient foraminas	Number of femur bones		Total
	Right (46)	Left (54)	
Nutrient foramen	25	31	56
Nutrient foramina	21	23	44

Table 2: Location of the nutrient foramen of femur with respect to borders and surfaces observed in the study.

Position of nutrient foramen	Right (n=46)	Left (n=54)	Total
Linea aspera	41	46	87
Posterior surface	5	8	13
Medial surface	-	-	-
Lateral surface	-	-	-

Table 3: Location of the nutrient foramina of femur observed in the study.

Location of foramina in the femur	Present study
Upper 1/3rd	28(28%)
Middle 1/3rd	72(72%)
Lower 1/3rd	0

Fig. 1: Femur with single nutrient Foramen on the linea aspera located in upper 1/3rd of the length.Enlarged view of the nutrient foramen is shown in the circled part.

Discussion

The nutrient foramina in the femur bone is directed away from the knee which is the growing end. This is said to be due to one end of limb bones growing faster than the other.[6] The arrangement of the diaphyseal nutrient foramina in the long bones usually follows a definite pattern. There are often two nutrient foramina in the femur. In the femur the nutrient foramina are restricted to the linea aspera or to its immeiate neighborhood in the middle third of the bone.[6]

Table 4: Comparision of the number of nutrient foramina observed in the study with other studies.

Number	Author	N	Right N (%)	Left N (%)	Total N (%)
Single	Murlimanju et al[7]	86	-	-	47.7%
	Shreshta P et al[8]	151	57 (80.29%)	62 (77.50%)	119 (78.81%)
	Joshi et al[9]	50	-	-	34(68%)
	Abhijit et al[10]	50	10 (40%)	13 (52%)	23 (46%)
	Poornima et al[11]	100	-	-	62(62%)
	Present study	100	25(54%)	31(57%)	56(56%)
Double	Murlimanju et al[7]	86	-	-	44.2%
	Shreshta P et al[8]	151	13 (18.30%)	18 (22.50%)	31 (20.52%)
	Joshi et al[9]	50	-	-	16(32%)
	Abhijit et al [10]	50	15(60%)	11(44%)	26(52%)
	Poornima et al [11]	100	-	-	37(37%)
	Present study	100	21(45.65%)	23(42.59%)	44(44%)

In the study, we observed single nutrient foramen in 56 bones, double nutrient foramen in 44 bones. Our findings are similar to other studies which show that the frequency of occurrence of single nutrient foramen is more than double nutrient foramen as shown in Table 3. In bones having duplicated foramina, both should be treated as main ones, the presence of which is not surprising in view of the length of the bone.[6]

Table 5: Comparision of location of nutrient foramen observed in the present study with other studies.

Location of foramina in the femur	Authors			
	Joshi et al[9]	Roy et al[12]	Abhijit et al[10]	Present study
Upper 1/3rd	9 (18%)	17	12 (16%)	28 (28%)
Middle 1/3rd	41 (82%)	19	63 (84%)	72(72%)
Lower 1/3rd	-	1	0 (0%)	0

Table 6: Comparision of Foraminal Index with other studies.

Authors	Foraminal Index
Murlimanju et al[7]	38.9
Joshi et al[9]	45.58
Abhijit et al[10]	44.13±10.89
Parmar et al[13]	39.3 (± 8.22)
Present study	40.16±9.12

In our study, we noted that the nutrient foramens were located in the middle third of the femur in 72% of the cases and in upper third of the femur in 28% of the cases. Our findings are in concurrence with the results of other studies which show that presence of nutrient foramen in the middle one third of the femur in majority of the cases as shown in Table 5. Table 6 shows the foramen index obtained in our study in comparision with previous studies. The foramen index noted in our study is similar to the findings of previous studies which indicate that the nutrient foramina are more frequent in middle third of the femur.

Several studies have explored the number, course, location of nutrient artery supplying the femur in dry bones, cadavers, plain radiographs, MDCT. Imre et al studied the nutrient canals of the femur using multidetector computed tomography and observed negative correlation between the number of nutrient canals and the canal diameters. Most of the nutrient artery foramina were located in middle third of diaphysis. Imre et al also observed that majority (95%) of the nutrient artery canals were directed upward,some of them directed transversely (3%) and few of them directed downwards (2%).[14]

Henderson et al investigated the change in position of nutrient foramen of femur with age in rats. He observed that femoral nutrient foramen remained constant in position with increasing age, whereas the tibial nutrient foramen moved relatively nearer to the distal end of the shaft. This is due to differences in growth rates at the epiphyseal plates of the femur compensating for the disproportion in the distances of the foramen from the two plates.[15] Unilateral ligation of nutrient artery of the femur provokes an abnormal centripetal blood flow into the compact bone from the vessels in the periosteum.[4]

It has been suggested that the direction of the 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.[6] Bettina et al studied the cadaveric specimens while trying to determine the safe zones for avoiding perforators in proximal thigh studied. He observed that perforating arteries passed to the back of the thigh at every level between 14.0 and 36.5 cm from the anterior superior iliac spine (16-39% of the leg length). He also observed the high variability in the number and course of the perforating arteries.[16]

Yun et al studied plain radiographs to distinguish nutrient artery canals from fracture lines. They observed that when compared to fracture lines, nutrient artery canals have less radiolucency, small diameter and blunted ends.[17]

Conclusion

In the present study, we observed single nutrient foramen in 56 femur bones, double nutrient foramen in 44 bones. We noted the location of nutrient foramen in the middle third of the femur in 72% of the cases and in upper third of the femur in 28% of the cases. In our study, the foraminal index observed is 40.16±9.12. It was observed that nutrient foramen in all the bones were directed upwards.

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