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Original Research Article

Morphological and topographic study of diaphyseal nutrient foramen of femur and its clinical implications in North Indian population

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ABSTRACT

Background: Nutrient foramen of long bones defines the extent of bone vascularisation. Information regarding nutrient foramen is necessary to conserve circulation during orthopaedic and surgical procedures. The present study was conducted to examine the position, number and calibre of nutrient foramina in 100 dry femora belonging to North Indian population.
Methods: The total length (TL) of each femur was measured by taking the measurement between the most proximal aspect of the head of the femur and the most distal aspect of the medial condyle. Number of nutrient foramina was determined by using a magnifying lens. Distance of nutrient foramen from upper end was measured. Direction and obliquity of nutrient foramina were noted. Position of nutrient foramina was determined in relation to length of femur and linea aspera. Caliber of nutrient foramen was measured using 18, 20, 22 and 24-gauge needles.
Results: Length of femur on right side was 435.2 mm (Range 393-523 mm). Length of femur on left side was 437 mm (range 369-524). 78 (78%) femora had single nutrient foramen, 11 (11%) had double nutrient foramen and 11 (11%) had no nutrient foramen. All foramina were directed upwards. Maximum foramina were located in middle third of femur (84%) followed by upper third of femur (8%). Most common location was on the intermediate area between two lips of linea aspera (42%) followed closely by medial lip of linea aspera (36%).
Conclusions: This study has provided additional data on the subject which will help in resection, surgical procedures and transplantation techniques by orthopedician in North Indian population.

Keywords: Diaphysis, Femur, Linea aspera, Nutrient foramen

INTRODUCTION

The bone marrow, perichondrium, epiphyseal cartilage in young bones and articular cartilage are supplied by the osseous circulation. Points of inflow, feeding complex and sinusoidal networks are important factors that determine vascular supply of long bones. Nutrient foramen which leads to nutrient canals is fed by one or two diaphyseal nutrient arteries. The direction of nutrient canal typically follows the rule “towards the elbow I go away from the knee I flee” and are directed away from the dominant growing epiphysis.[1] Presence of a distinct vascular groove defines a nutrient foramen.[2,3]

The position and direction of nutrient foramina are believed to differ in human long bones.[4] The initial horizontal nutrient canal gets slanted during growth. The difference in the growing rates of the both sides of epiphysis is responsible for slant of direction.[5] The direction of slant is towards the end that had grown least rapidly.[6] Nutrient foramina reflect degree of bone vascularisation. Pathological bone conditions such as developmental abnormalities, fracture healing or acute hematogenic osteomyelitis are closely associated with vascular system of bone.[7]The development of new transplantation and resection techniques in orthopaedics rely heavily upon the data on blood supply of long bones and regions they supply.[8]

Data regarding morphology of nutrient foramen is of utmost importance. It is essential in surgical procedures to preserve circulation.[4] Information is useful for surgical procedures like joint replacement, fracture repair, bone grafting, vascularised bone microsurgery, peripheral vascular disease, long bone growth, non-unions, transplantation and resection techniques, intramedullary nailing, plating as well as in medicolegal cases.[9]

Although an extensive array of studies has been conducted regarding morphology of nutrient foramen of upper and lower limb long bones, but there is insufficient regional data in North Indian population. The aim of this study is to provide referring data that will help in set up and planning of operative methodologies.

METHODS

Study was conducted on 100 (Right =49, Left=51) adult dry human femurs collected from bone bank of department of anatomy, university college of medical science. Unossified, deformed and fractured bones were excluded from the present study. Age and sex of the selected bones were not known.

Determination of total length (TL) of femur

The total length (TL) of each femur was measured by taking the measurement between the most proximal aspect of the head of the femur and the most distal aspect of the medial condyle.

Total number, direction and position of nutrient foramina

Number of nutrient foramina was determined by using a magnifying lens. Nutrient foramen was identified by presence of a conspicuous groove and elevated edge at the beginning of canal. Direction and obliquity of nutrient foramina were noted. Distance of nutrient foramen from upper end was measured using vernier calipers. Position was determined in relation to lips of linea aspera. Position was determined in relation to length of femur whether it was present in upper, middle or lower third of the bone.

Caliber of nutrient foramen

Caliber of nutrient foramen was categorized using 18, 20, 22 and 24-gauge needles. 18 gauze needles were between 1.27 mm or more (1.27 mm). Size of the 20-gauze needle was considered.to be between 0.90 mm and 1.27 mm (0.90 mm to < 1.27mm). Size of the 22-gauze needle was between 0.71 mm and 0.90 mm (0.71mmto < 0.90 mm). Size of the 24-gauze needle was considered to be between 0.55 mm and 0.71mm (0.55mmto < 0.71 mm). Size of 26-gauge needle was considered to be between 0.40 and 0.55 mm.[10]

Calculation of foraminal index (FI)

Foraminal index for each bone was calculated by dividing the distance of foramen from upper end of bone and total length of bone multiplied by 100.

FI = DNF/TL *100[11,12]

DNF: Distance between upper end of long bone and nutrient foramen, TL: Total Length.

Subcategories according to foraminal index[13]

- FI (0-33.33): Nutrient foramen lies in upper third of femur
- FI (33.34-66.66): Nutrient foramen lies in middle third of femur
- FI (66.67-100): Nutrient foramen lies in lower third of femur.

RESULTS

51 femora were right sided and 49 were left sided. 78 (78%) had single nutrient foramen and 11 (11%) had double nutrient foramen and 11 (11%) had no nutrient foramen. (Figure 1, 2, 3) Out of 100 femurs studied average length of femur on right side was 435.2mm (range 393-523 mm). Length of femur on left side was 437 mm (range 369-524).

Figure 1: Femur having no nutrient foramina.

Figure 2: Femur having single nutrient foramina.

Figure 3: Femur having two nutrient foramina.

(Table 1) 78 femora had single nutrient foramen, 11 had double nutrient foramen and 11 had no nutrient foramen (Table 3) (Figure 1, 2, 3).

Out of 100 nutrient foramens observed, none of them were very large sized (18 G needle), large sized (20 G needle) foramen were 20, medium sized (22 G needle) were 18, small sized (24 G needle) were 53 and very small sized foramen (26 G needle) were 19.

(Table 5) All foramina were directed upwards. Maximum foramina were located in middle third of femur (84%) followed by upper third of femur (8%) (Table 2).

Table 1: Length and foraminal index of all nutrient foramina.

Side	Total bones	Total foramina	Mean total length (cms)	Range total length (cms)	Minimum FI	Maximum FI	Mean
Right	51	47	43.52	39.3-52.3	24.2	64.3	44.25
Left	49	53	43.7	36.9-52.4	26.7	64.7	5.7
Both	100	100	43.6	36.9-52.4	25.2	64.5	44.85

Most common location was on the intermediate lip on linea aspera (42%) followed closely by medial lip of linea aspera (36%). Other locations were medial to medial lip (14%), lateral lip of linea aspera (5%) and lateral to lateral lip (3%). (Table 4, Figure 4, 5, 6).

Table 2: Location of nutrient foramen in relation to length of femur (N=100).

Locations	
Upper third	8
Junction (upper and middle third)	5
Middle third	84
Junction (middle and lower third)	3
Lower Third	0

Figure 5: Nutrient foramen located between medial and lateral lips of linea aspera. Purple coloured needle is inserted into nutrient foramen on intermediate area between medial lip and lateral lip of linea aspera.

Figure 4: Nutrient foramina located on medial lip of linea aspera. Purple coloured needle is inserted into nutrient foramen on medial lip of linea aspera.

Figure 6: Nutrient foramen located on lateral lip of linea aspera. Purple coloured needle is inserted into nutrient foramen on lateral lip of linea aspera.

Table 3: Number of nutrient foramina.

No. of foramina	Femur bone		Total	Percentage
	R	L		
0	7	4	11	11
1	41	37	78	78
2	3	8	11	11

Table 4: Analysis of foramina in relation to linea aspera.

	ML	LL	Intermediate area (LA)	MML	LLL	Total
Right	17	2	18	5	1	43
Left	19	3	24	9	2	57
Total	36	5	42	14	3	100
%	36	5	42	14	3	

Table 5: Calibre of nutrient foramen.

Size	Right (N=47)	Percentage (N=53)	Left	Percentage
18G (1.27 mm or more)	0	0	0	0
20G (0.90 mm-1.27mm)	8	8	12	12
22G (0.71mm-0.90mm)	4	4	11	11
24G (0.55-0.71)	35	35	30	30

DISCUSSION

Out of 100 femurs studied average length of femur on right side was 43.52cm (range 39.3-52.3 cms). Length of femur on left side was 43.7 cm (range 36.9-52.4cms). These findings were similar to all studies conducted previously by Gupta et al (43.23 cms), Kizilkanat et al (42.58 cms), Nagel et al (40.1 cms) and Kirschner et al (40.8 cms).[8,9,14,15] This shows that length of femur does not differ according to regions and stays almost the same in different populations. On observation, all foramen in present study were directed upwards which was in accordance with those found in other studies.[4,9-18]

In the present study femur with single nutrient foramen were 78% (Right=41, Left=37) cases. These findings were similar to Saha N et al and Kizilkanat E et al who found single nutrient foramen in71.8% and75% cases respectively.[14,16] However, Gupta et al and Kumar et al found single nutrient foramen of femur in 44.5% and 32% cases respectively.[9,13] Regional variation could be the possible explanation for these findings.

Double nutrient foramen was found in 24.7%, 25%, 49.3%, 44.2% and 68% by Saha N et al, Kizilkanat E et al, Gupta [9] et al, Prashanth et al and Kumar et al, respectively.[9,13,14,16,17] In the current study double nutrient foramen were found in 11% cases only. In this study 11% Femora had no nutrient foramina. This study is similar to the study of Saha N et al and Prashanth et al who found nutrient foramina to be absent in 3.5% and 4.6% cases respectively.[16,17] In contrast, Kizilkanat et al, Gupta et al, Collipal et al and Mysorekar et al, found no femur with absent foramina.[4,9,14,18]

Nutrient foramen was mostly located in the middle third (in 84% cases) in this study. Kumar et al, Gupta et al, Laing, Mysorekar and Collipal et al, also observed nutrient foramen to be present on middle thirds of femur in 70%, 78%, 56% and 68% cases respectively.[4,9,13,18,19] Only Campos F et reported that concentration of nutrient foramina was more towards hip joint.[20] The dissimilarity between their findings and the present study could be due to their study population being Spanish and ours being Indian.

In this study, we found no foramen with calibre ≥1.27 mm in contrast to studies conducted by Poornima Angadi et al and Murlikrishna et al who found it in 7.2% and 40% cases respectively.[10,22] This could be due to the fact that their population was south Indian and ours being North Indian. Foramen with calibre (0.90mm-1.27 mm) in this study were 20% which was similar to the findings by Murlikrishna et al (29.2%) et al.[10] On the contrary the finding were dissimilar from the study conducted by Poornima B et al who found the incidence of this calibre to be 64.7%.[22] In this study the foramen with the calibre of 0.71mm-0.90 mm was found in 15% cases which was quite similar to what was observed by Poornima B et al and Murlikrishna et al who found it to be 16.5% and 19.5% respectively.[10,22] The calibre of most of the foramen found in this study were 0.55-0.71 (65%).This was in contrast to the studies conducted by Poornima B et al and Murlikrishna et al who found it in 11.5% and 10.3% cases respectively.[10,22]

Most of the nutrient foramina in the present study were located on linea aspera (83%) which was similar to the findings of Collipat et a1 (72.5%), Kizilkanat et al (44%), Saha N et al (93.3%), Prashanth et al (76.7%) and Kumar et al (57.33%).[13,14,17-19] Commonest site of the location of nutrient foramen was found to be present between the two lips of linea aspera in the present study (42%). Nutrient foramen was present on the medial lip in 36% cases and lateral lip in 5% cases in this study. This agrees with findings from Collipal et al, Saha N et al, Prashanth et al and Kumar et al.[13,16-18] On the contrary Gupta et al found the commonest location of nutrient foramen to be present on the medial lip of linea aspera in 66.98% cases.

Knowledge regarding blood supply of long bones during growing period is useful in procedures such as bone grafts, tumour resections, traumas, congenital pseudo arthrosis and transplant techniques in orthopaedics.[10] It continues to be a major factor in development of new transplantation and resection techniques in orthopaedics.[8] Morphological knowledge of nutrient foramina is absolutely essential for orthopaedic surgeons operating an open reduction of a fracture so as to avert injuring the nutrient artery and thus reducing the chances of delayed or non-union of the fracture.[18] It is a well-known fact that one of the reasons for delayed union or non-union of fracture of femur is inadequate blood supply.[21]

CONCLUSION

Data recorded in this study will provide the normal spectrum of measurements and expected location and calibre of nutrient foramen of femur. This will help orthopedician and surgeons avert injuries to the nutrient artery during reparative and reconstructive procedures involving femur considering that there is paucity of literature in this area in North Indian population.

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