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Original research article

Anatomical study of diaphyseal nutrient foramina in human long bones of upper and lower limb

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Abstract

Background: The nutrient foramina are cavities that conduct the nutrient arteries and the peripheral nerves on the shaft of long bones. Long bones receive most of the blood supply from the nutrient arteries. The knowledge about position and number of the nutrient foramen is helpful for medico legal cases, anthropological study and orthopaedic surgeons during different surgical procedures.

Aims and Objectives: To determine the topography, direction and number of the nutrient foramina in upper and lower limb long bones in Telangana, India.

Materials and Method: This observational cross section study was conducted in the department of anatomy; Medical colleges of Telangana states. The number, direction and site of the foramina were noted in all the long bones. A total of 326 long bones of upper and lower limb were examined.

Results: Out of total 326 long bones 165 were from upper limb and 161 were from lower limb. The single solitary nutrient foramina were noted in most of the bones. The site of the foramina was mainly on middle third of shaft (except tibia, foramina mainly in upper third of shaft). Maximum number of foramina was found on femur (94) followed by Humerus (74).

Conclusion: The present study provides information on the number, position, and direction of nutrient foramina of the long bones. This may help in surgical procedures and in the interpretation of radiological images.

Keywords: Nutrient foramen, nutrient artery, long bone, upper limb, lower limb

Introduction

Nutrient foramen is the largest foramen on the shaft of long bones through which nutrient artery for that bone passes and provides nutrition to the long bones [1]. The nutrient foramen follows the rule "towards the elbow I go, from the knee I flee [2]. The foramen is directed away from the growing end of the bone. The one end of long bone grows higher than the other end [3]. Nutrient artery provides 75-80% of blood supply to the long bones in children and if the blood supply is decreased, it may lead to ischemia of bone resulting into less vascularisation of metaphysis and growth plate [4]. Harris has stated that the position of nutrient foramina is constant during the growth of long bone and Lutken has stated that the position of nutrient foramina is variable and the typical position of nutrient foramina can be determined after a study on human bones [5]. The knowledge of the nutrient foramen number and location could be useful in some surgeries like fracture management. In vascular bone grafts, the arterial supply is essential to the osteoblasts and osteocytes [6]. The nutrient foramen is also important in the development of longitudinal stress fractures, as they either develop from it or from its surrounding areas [7]. Study of length of long bone and distance of nutrient foramen from either ends is beneficial in calculating the length of a long bone from a given piece, which is significant in stature of an individual, medico legal cases and anthropological work [8].

The study of nutrient foramina is important in both morphological and clinical aspects. Some pathological bone conditions such as fracture healing or acute a hematogenic osteomyelitis are closely related to the vascular system of the bone [9].

The objective of the present study was to determine location, number and direction of the nutrient foramen in upper limb and lower limb long bones from south central Indian population.

Materials and Method

This was an observational cross-sectional study conducted in the Department of Anatomy, Kakatiya Medical College, Warangal and Government Medical College, Ramagundam, Telangana. We have

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studied total 326 bones, of which 165 upper limb long bones and 161 lower limb long bones. Among upper limb bones 60 were Humerus, 55 were Radius and 50 were ulna whereas among lower limb bones 65 were femur, 60 were tibia and 40 were fibula bones. The age and gender of all bones were not known. The damaged bones and bones with obvious pathological deformities were not included in the present study. The all bones were observed for the topography, number, direction and location of foramen in relation to a particular surface and border of the lower limb bone. The nutrient foramens were identified by the well-marked groove at the starting of the canal. A needle was passed through each foramen to confirm their patency.
The data was analyzed statistically by using the SPSS software.

Results
A total of 326 long bones examined in the present study, out of which 165 were upper limb bones and 161 were lower limb long bones.

Humerus
Among the 60 Humerus examined 48 (80%) had a single nutrient foramen and 10 (16.6%) had double nutrient foramina, whereas 2 (3.3%) had 3 nutrient foramina.
Total no of nutrient foramina in was 74, most of them (81.1%) was present on middle third. 13.5% on upper third and 4.5% were present on lower third of the Humerus.

Radius
In all the 55 radii examined, 94.5% had a single nutrient foramen and 5.5% were the double nutrient foramen. Total of 58 nutrient foramina 79.3% present on middle third, 13.8% on upper third and 6.9% present on lower third of the radius.

Ulnae
Out of 50 ulnae examined, 46 (92%) had a single nutrient foramen whereas 4(8%) had double nutrient foramina.
A total of 54 nutrient foramina present on Ulna, 77.7% on middle third, 16.7% on upper third and 5.6% present on lower third of the Ulna

Femora
A total of 65 femur bones examined, 48 (80%) had a single nutrient foramen, 10 (16.7%) had double nutrient foramina and 3.3% had 3 nutrient foramen.
Out of total 94 foramina 69 (73.4%) on middle third and 25 (26.6%) present on upper third.

Tibiae
Among the 56 tibiae examined, 96.4% had a single nutrient foramen and 3.6% had double nutrient foramina. A total of 58 nutrient foramina present on tibia, most of them 68.9% on upper third and 31.1% on middle third.

Fibulae
Total of 40 fibulae examined, 39 (97.5%) had a single nutrient foramen, while 1 (2.5%) showed double nutrient foramina.
Out of the 41 nutrient foramina seen in the fibulae, 38 (92.7%) were directed middle third while only 3 (7.3%) were directed on upper third of fibula.
No foramen seen in lower third of the long bones of lower limbs.

Table 1: Number of diaphyseal nutrient foramina seen in long bones of upper limb

Bone	Number of bone	Number of Foramina	Percentage
Humerus (n=60)	48	1	80%
	10	2	16.7%
	2	3	3.3%
Radius (n=55)	52	1	94.5%
	3	2	5.5%
Ulna (n=50)	46	1	92%
	4	2	8%

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Table 2: Number of diaphyseal nutrient foramina seen in long bones of lower limb

bone	Number of Bone	Number of Foramina	Percentage
Femur (n=65)	39	1	60%
	23	2	35.4%
	3	3	4.6%
Tibia (n=56)	54	1	96.4%
	2	2	3.6%
Fibula (n=40)	39	1	97.5%
	1	2	2.5%

Table 3: Location of nutrient foramina by segment of the long bones

Long Bone	No of foramina	Location by segment (numbers and percentage)		
		Upper third	Middle third	Lower third
Humerus	74	10 (13.5%)	60 (81.1%)	4 (5.4%)
Radius	58	8 (13.8%)	46 (79.3%)	4 (6.9%)
Ulna	54	9 (16.7%)	42 (77.7%)	3(5.6%)
Femur	94	25 (26.6%)	69 (73.4%)	0 (0%)
Tibia	58	40 (68.9%)	18 (31.1%)	0 (0%)
Fibula	41	3 (7.3%)	38 (92.7%)	0 (0%)

Discussion

The chief blood supply to long bones occurs through the nutrient arteries, which enter through the nutrient foramina. The supply is crucial during the initial phase of ossification and in techniques such as bone graft, tumor resections, traumas and in transplant procedure in orthopedics [10].

Present study observed single nutrient foramen was in 80% of humerus bone; our finding was comparable with the S Rao *et al.* [11].

Nutrient foramen was predominantly (81.1%) present on middle third of the humerus, similar to the B Khandve *et al.* [12] reported 85% of nutrient foramen in middle third of humerus.

In our study 92% single nutrient foramina in ulna, this was accordance to the E Afzal *et al.* [13] observed 86.6% foramina were single.

In the current study majority of the femora (60%) had single foramina followed by (35.4%) had double nutrient foramina and only 4.6% had three foramina, concordance results also found by Aggarwal P *et al.* [14] and Pereira GAM *et al.* [15]. Majority of the (73.4%) foramen located on middle third of femur, accordance to the Mahat S *et al.* [16]

In the examined tibiae, 96.4% had single foramen; concordance with the study conducted by KU Prashanth *et al.* [17] found 98.6% had single nutrient foramen.

In tibia Most of the nutrient foramen found on upper third (68.9%) which was comparable with the Jayaprakash T *et al.* [18] found 80% foramen on upper 1/3, in contrast to our study *Gupta et al.* [19] reported only 34% nutrient foramen present of upper third and 66% was present on middle third.

Present study observed 97.5% fibula had a single nutrient foramina whereas other study like B Roul *et al.* [20] reported 81% fibula had single foramina.

Common location of nutrient foramina in fibula was middle third (92.7%) which as similar to the study conducted by Parmer *et al.* [21]

Overall 278/326 (85.3%) long bones of upper and lower limb had a single nutrient foramina, comparable to the Zahra *et al.* [22] found 78.8% long bones had single nutrient foramina.

Conclusion

We believe that the present study has provided relevant information about number, size, position, and direction of nutrient foramina of upper limb and lower limb long bones. Most of the long bones that were studied had single nutrient foramen. Majority of the foramina were present on the middle third, except tibia was foramina mainly found on upper third.

These variations observed here can help the surgeons, radiologists and radiotherapists to more precisely localise the nutrient foramina in upper & lower limb long bones in the Telangana population which will help them to deal with the fractures and tumors more accurately. Results of the study are also relevant in medico-legal practice and anthropological surveys

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