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Original Research Article

A Morphological Study of Nutrient Foramina of Human Ulna and Their Clinical Importance

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ABSTRACT

Background: Major part of a long bone derives nutrition from nutrient arteries, which pass through nutrient foramina seen on shaft of a long bone. Therefore, data regarding distribution of nutrient foramina is crucial to obtain a vascularized bone graft and to avoid damaging blood supply of a bone. Present study focuses on morphological details of nutrient foramina of ulna in South Indian population.
Material and Methods: Present study was conducted on 200 dry, adult ulnae bones, irrespective of age and sex. Bones were obtained from department of Anatomy, Apollo Institute of Medical Sciences and Research, Hyderabad. Laterality of bones was determined. Location and number of nutrient foramina on diaphysis was noted. Total length of the bone and distance of nutrient foramina from proximal end of bone were recorded. Foraminal index of all bones was calculated using Hughes formula. Statistical analysis of data was done applying descriptive statistics.
Results: All bones had at least one nutrient foramen, directed to the proximal end of bone. Double nutrient foramina were observed in 6% of bones. No correlation was found between length of bone and duplication of foramina. Majority of nutrient foramina were found on anterior surface of shaft (74.05%) and in middle third of the bone (60%) with foramen index between 33.34% - 66.66%. Mean foramen index was 35.83 ± 6.12.
Conclusion: The study provides population-specific data on topographical details of nutrient foramina of ulnae bones, which can be of use to orthopedic surgeons to safeguard blood supply of ulna and yield better results.

Key words: Nutrient foramina, Ulna, Foraminal index, South Indian population.

INTRODUCTION

Normal growth and repair of bones is dependent on their blood supply. [(1)] Any long bone is described to have dual blood supply i.e. periosteal vessels supplying the compact bone and nutrient artery supplying the bone marrow. [(2)] Nevertheless, majority of nutrition to long bones is provided by the nutrient arteries. [(3)] Often, one or two diaphyseal/nutrient arteries enter the shaft obliquely through nutrient foramina which lead to nutrient canals. Nutrient foramina are always directed away from the growing end. [(4)] However, the position and direction of nutrient foramina are known to vary in human long bones. [(5,6)] Nutrient arteries do not branch in their canals but divide into ascending and descending branches in the medullary cavity; these approach the epiphyses, dividing repeatedly into smaller helical branches close to the endosteal surface. The endosteal vessels are vulnerable during surgical operations, such as intra medullary nailing, which involve passing metal implants into the medullary canal. [(4)] Fractures affecting area of nutrient foramina, poor surgical technique followed in internal fixation of a fracture are likely to interrupt blood supply and result in delayed union. [(7,3)] Thus, knowledge of usual location of nutrient foramina and variations is essential for a surgeon to safeguard blood supply to the bone and to acquire well vascularized bone grafts so that survival of osteoblasts and osteocytes is ensured. [(8, 9)] Only few studies are available on morphology of nutrient foramina of forearm bones in south Indian population so far. The present study was taken up with an aim to identify location, number and distribution of nutrient foramina on Ulna bones of South Indian population. Foraminal indices were also calculated.

MATERIALS AND METHODS

The present study was conducted at the department of Anatomy, Apollo medical college, Hyderabad. Study sample was collected from the osteology section of our department and comprised of 200 ulna bones, not necessarily of same side. Age and sex of the bones was not determined. Bones with gross pathology, fragmentation, incomplete ossification or distortion were excluded. Laterality of bones was determined. Bones were examined with naked eye for location, number, direction and distribution of nutrient foramina on the diaphysis of bones. Foramina were identified by a groove leading to it, whose margins were often raised forming a canal. 24-gauge needle was passed through it to confirm its patency. Location of foramina on shaft of a bone was described in relation to borders and surfaces of shaft. The foramina which are located within 1 millimeter of any border were considered to be on that border only. Total length of bone, from upper end of olecranon process to the tip of styloid process, and distance of the foramina from proximal end of bone was recorded with the help of Vernier caliper which was accurate to 0.01mm (Figure 1).

Figure 1: Measuring length of ulna with Vernier calipers.

These measurements were used to calculate Foraminal index (FI) using Hughes formula i.e. F.I. = D/L x 100. All measurements were collected by a single author to avoid subjective variability. Data were analyzed using descriptive statistics (mean, range and standard deviation) and P-value (Pearson's correlation coefficient) was calculated to assess statistical correlation between length and duplication of nutrient foramina, at significance level < 0.05. Statistical analysis was carried out using SPSS (Statistical Package for Social Sciences), version 24.0 for Windows.

Figure 2: Single and double nutrient foramina (circled) on the diaphysis of ulna directed upward.

RESULTS

Out of 200 ulna bones, 112 were of left side and 88 were of right side. Nutrient foramina of all bones were directed proximally without any exceptions. 188 (94%) of bones had single foramina and 12 (6%) had double nutrient foramina (Figure 2). Average length of bones was 25.45 ± 1.83 cm. Average length of right side bones was 25.63 ± 1.75 cm and that of left side bones was 25.37 cm ± 1.93 cm. No correlation was found between length and duplication of foramina (r=0.035, P-value = 0.64). Mean distance of nutrient foramina from proximal end was 8.76 cm on right side bones and 9.39 cm on left side bones. Range of Foraminal index of right side bones was 19.84 – 48.75 and that of left side bones was 21.27 – 57.02. Mean Foraminal index (FI) of all bones irrespective of side was 35.83 ± 6.12. Mean FI of right side bones was 34.71 ± 5.79 and that of left side bones were 36.71 ± 6.24. Table I shows average length and FI of bones.

Table 1: Mean length and Foraminal index of bones

Side of the bone	Mean length with SD (cm)	Mean FI with SD
Both sides	25.45 ± 1.83	35.83 ± 6.12
Right	25.63 ± 1.75	34.71 ± 5.79
Left	25.37 ± 1.93	36.71 ± 6.24
FI = Foraminal Index, SD = Standard deviation, cm= Centimeter.		

Based on FI, bones were placed in each of three types. Type I class has bones with FI < 33.33 %, type II class has bones with FI between 33.34% - 66.66% and type III class has bones with FI > 66.67%. 120 bones (60%) were of type II i.e. most of bones had nutrient foramina in middle third of the bone shaft. Foramina were never found on distal third of the bone. Classification of bones based on FI is shown in Table 2.

Table 2: Classification of bones based on Foraminal index

FI	Number of bones	Percentage
Type I (<33.33%)	80	40%
Type II (33.34–66.6%)	120	60%
Type III (>66.67)	0	0%
FI = Foramina index.		

Foramina were, most frequently, found on anterior surface of diaphysis (79%) and anterior border (16.5%). They were never found on posterior surface. Topographical distribution of nutrient foramina, irrespective of side, was shown in Table 3.

Table 3: Topographical distribution of nutrient foramina.

Location of foramina	Number of bones	Percentage
IB	19	9.5%
AB	33	16.5%
AS	158	79%
MS	2	1%
PS	0	0%
IB = Interosseous border, AB = Anterior border, AS = Anterior surface, MS = Medial surface, PS = Posterior surface		

DISCUSSION

Nourishment of majority of long bone i.e. diaphysis and metaphysis is derived from nutrient artery during early phase of ossification. As the bone grows, endochondral bone is progressively removed to form a medullary cavity containing bone marrow and is still supplied by nutrient artery. [10] Thus vessels which occupy nutrient foramina are considered to be the vessels which invaded ossifying cartilage. Thus its point of entry is initially horizontal. [11] Later on, greater longitudinal growth at the growing end of the bone result in deflexion of nutrient artery so that its entry point becomes oblique and directed towards the non growing end of the bone. [11– 14] Hughes "Vascular theory" is widely accepted for explaining normal and abnormal direction of nutrient foramina. [15] Mysorekar and Longia et al observed that anomalous nutrient canals are found only in fibulae. [10, 15] Similarly, current study did not find any anomalously directed canals in ulnae. All of them had proximally directed canals as in previous studies, [16] which support the fact that lower end of ulna is its growing end.

Nutrient artery of ulna is derived from branches of ulnar artery i.e. anterior interosseous artery or ulnar recurrent artery, which follows an ascending course to enter the foramina. [17, 18] In our study, majority of long bones (79%) had their nutrient foramina on the anterior surface of the shaft, followed by anterior border (16.5%) and never found on posterior surface, which can be related to the origin of its nutrient artery as studied by Giebel GD *et al.* [18] Similarly Longia G S et al and several others found the nutrient foramina of forearm bones on flexor/ anterior aspect of diaphysis consistently. [5,15,16,18,19] 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 and the humerus whereas in the other bones they are normally single and also, there is no correlation between number of nutrient foramina and length of bone as well as number of ossification centers. [5] In our study, most of bones (94%) possessed single nutrient foramen and 6% had double foramina similar to studies by Forriol Campos *et al.* [20] Thus diaphysis of ulna is likely to depend on single arterial source, danger of bone ischemia is higher if fracture line goes through area of nutrient foramina and so it is best to avoid this area of bone during surgery. Though foramina are duplicated in few bones, no correlation was found between number of foramina and length of the bone (r=0.035, P-value = 0.64). This phenomenon is probably explained by reciprocity of foramina, which means only one foramen that is larger, conveys main nutrient artery and the smaller foramen is as an accessory foramen carrying an additional source of blood supply. This feature was explained in case of humerus. [5] Mean Foraminal index was found to be 35.83 ± 6.12 and 60% of bones were having nutrient foramina in the middle third of the bone (type II) and rest of them had foramina in the proximal third as found in previous studies by Pereira *et al,* [21] Solanke K S *et al* [16] and Murlimanju B V. [19] Thus, it can be derived that nutrient foramina of ulnae are always directed to the elbow and most often, nutrient artery of ulna is likely to enter the shaft of bone through its anterior surface in the middle or proximal third of the bone shaft. This information can be useful for a surgeon to locate the site of nutrient artery of ulna, while operating on a fracture or taking a vascularized graft. [16, 19, 21, 22]

CONCLUSION

Most of dry bones had single nutrient foramina on the anterior surface of middle third of the bone shaft, directed to the elbow. Thus majority of bones were classified as type II. No correlation was found between duplication of nutrient foramina and length of bone. Findings of current study are in accordance with previous studies except that quite a few bones had nutrient foramina in the proximal third as well. Since these findings are population specific, they can be of use to orthopedic surgeons while operating on forearm bones.

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