Original Research Article

Anatomical study of nutrient foramina in long bones of human upper limbs

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Abstract

Background: An opening into the bone shaft for passage of blood vessels to the medullary cavity of a bone for its nourishment and growth is called as nutrient foramen. There is always a need for a greater understanding of nutrient foramina in upper limb bones such as the humerus, radius and ulna. So the aim of present study was to record the location, number and direction of nutrient foramina in long bones of the upper limb.

Material and methods: A total number of 120 long bones (40 humeri, 40 radii and 40 ulnae) were used for the study.

Results: In the results, 66% of the humeri had a single foramen, 18% had double foramina and 26% had no foramen. For the radii, 68% had a single nutrient foramen and 32% had no nutrient foramen. 78% of the ulnae had a single nutrient foramen and 22% had no nutrient foramen. All the foramina except one (in the radius) were directed away from the growing end, that is, they were directed towards the elbow.

Conclusion: Information and details about nutrient foramina is of clinical importance, especially in surgical procedures like bone grafting and bone transplantation.

Key words

Nutrient foramen, Long bones, Foraminal index, Variation in position, Location, Number.

Introduction

An opening into the bone shaft for passage of blood vessels to the medullary cavity of a bone for its nourishment and growth is called as nutrient foramen [1]. The nutrient artery is the Principal source of blood supply to a long bone is nutrient artery which is important during its active growth period in the embryonic and fetal life, as well as during the early phase of ossification [2]. Reduction of blood flow to bone leads to ischemia of the metaphysis and growth plate [3]. Usually the nutrient vessels move away from the growing end of the bone [1]. Many variations have been described till date in the direction of nutrient foramina [4]. Study of nutrient foramina in upper limb is very important for morphological, clinical, and pathological point of view. Fracture healing or hematogenic osteomyelitis is closely related to the vascular system of the bone [5]. Detailed data on the blood supply to the long bones is crucial for transplantation and resection techniques in orthopaedics [2, 6]. There is always a need for a greater understanding of nutrient foramina in upper limb bones such as the humerus, radius and ulna. So the aim of present study was to record the location, number and direction of nutrient foramina in long bones of the upper limb.

Materials and methods

The study was conducted in the Department of Anatomy, GMERS Medical College Valsad, Gujarat, India. Total 120 adult human cleaned and dried bones of the upper limbs were included in the study. They were divided into three groups: 40 bones of humerus and 40 bones each of ulna and radius. All selected bones were normal with no appearance of pathological changes. The specific age and sex characteristics of the bones studied were unknown. The nutrient foramina were observed in all bones with the help of a hand lens. They were identified by the elevated margins and by the presence of a distinct groove proximal to them. Only well-defined foramina on the diaphysis were accepted for present study. Foramina at the ends of the bones were ignored. **Direction**: A fine stiff broomstick was used to confirm the direction and obliquity of the foramen. **Position**: The position of all nutrient foramina was determined by calculating the foraminal index (FI) using the formula: FI = (DNF/TL) x 100 where DNF is the distance from the proximal end of the bone to the nutrient foramen; TL is total bone length [17]. The position of the foramina was divided into three types according to FI as mentioned below. **Type - 1:** FI below 33.33, the foramen was in the proximal third of the bone. **Type - 2:** FI from 33.33 up to 66.66, the foramen was in the middle third of the bone. **Type - 3:** FI above 66.66, the foramen was in the distal third of the bone. All measurements were taken to the nearest 0.1 mm using vernier caliper 2. Data were expressed as means and standard deviations for continuous variables, and percentage for categorical variables.

Results

Total 60% of the humeri had a single foramen, 35% had double foramina and 5% had three foramina. For the radii, 100% possessed a single nutrient foramen. 92.5% of the ulnae had a single nutrient foramen and 7.5% had double foramen. Table - 1 to 6 give the Details of the results in terms of nutrient foramina number, position and direction were as per **Table – 1** to **Table – 7**.

Table - 1: Position of nutrient foramina observed in the humerus.

Position	**Number of foramina (%)**
Antero-medial surface	34 (58.6%)
Posterior surface (in the middle of surface)	4 (6.8%)
Posterior surface (close to medial border)	3 (5.17%)
Posterior surface (close to lateral border)	8 (13.7%)
Medial border	9 (15.5%)

Table - 2: Position of nutrient foramina observed in the radius.

Position	**Number of foramina (%)**
Anterior surface (midway between interosseous and anterior borders)	13 (32.5%)
Anterior surface (close to interosseous border)	9 (22.5%)
Anterior surface (close to anterior border)	13 (32.5%)
Posterior surface (close to interosseous border)	5 (12.5%)

Table – 3: Position and number of dominant (DF) and secondary (SF) nutrient foramina observed in the ulna.

Position	Number of foramina (%)
Anterior surface (in the middle of surface)	7 (15.9%)
Anterior surface (close to interosseous border)	12 (27.27%)
Anterior surface (close to anterior border)	25 (56.8%)

Discussion

Number of nutrient foramina

In the present study, a single nutrient foramen had a higher percentage (66%) in the humeral bones, compared to that of double (8%). Many studies reported a percentage approximately similar to that of our study [4, 7]. The range of occurrence of double foramina varied from 13% [6], 26% [8], and 42% [7]. Also, some reported the absence of nutrient foramina in some humeri [1, 2]; which is in accordance to the present study as 26% of humeri observed were without nutrient foramen. Total 68% of the radii examined in the present study had a single nutrient foramen. In other studies, the majority of radii (more than 90%) were found to possess a single nutrient foramen [2, 9]. Other authors reported a single nutrient foramen in more than 88% of ulnae [2, 8] which was correlated with our study.

Table – 4: The range, mean ± standard deviation (SD) of foramina indices of the humerus.

Position	Side	Range	Mean ± SD
Anteromedial surface	R L	50.18 – 63.38 49.06 – 67.35	56.72 ± 4.30 57.27 ± 5.13
Posterior surface (in the middle of surface)	R L	36.14 – 42.44 –	39.29 ± 4.45 –
Posterior surface (close to lateral border)	R L	– 38.45 – 44.56	– 41.34 ± 2.34
Medial border	R L	53.59 – 68.68 55.33 – 56.21	59.85 ± 5.85 55.77 ± 0.62

Table – 5: The range, mean ± standard deviation (SD) of foraminal indices of the radius.

Position	Side	Range	Mean ± SD
Anterior surface (in the middle of surface)	R L	29.95 – 43.92 29.68 – 48.57	34.51 ± 5.2 39.13 ± 13.36
Anterior surface (close to interosseous border)	R L	34.45 – 37.10 30.80 – 38.78	35.34 ± 1.51 35.78 ± 3.54
Anterior surface (close to anterior border)	R L	31.81 – 35.94 27.82 – 32.63	34.02 ± 1.47 30.00 ± 1.99
Posterior surface (close to interosseous border)	R L	31.22 – 38.13 _	34.67 ± 4.88 –

Position of nutrient foramina

In our study, most of nutrient foramina were located along the middle third of the humerus which was correlated with other studies [2, 10]. Similar findings had been reported by Kizilkanat, et al. [2], and Kumar, et al. [8].

Table – 6: The range, mean ± standard deviation (SD) of foraminal indices of the ulna.

Position	Side	Range	Mean ± SD
Anterior surface (in the middle of surface)	R L	38.13 – 47.59 35.93 – 46.74	42.54 ± 4.76 41.3 ± 7.6
Anterior surface (close to interosseous border)	R L	27.00 – 45.62 31.31 – 45.05	37.42 ± 6.91 40.38 ± 7.86
Anterior surface (close to anterior border)	R L	27.90 – 40.17 31.39 – 36.12	33.58 ± 3.48 33.59 ± 1.85

Table – 7: Position and direction of nutrient foramina in the long bones of the upper limb.

Bone	Position			Direction
	Type-1	Type-2	Type-3	
Humerus	3 (5.1%)	52 (89.65%)	3 (5.1%)	Distally
Radius	17 (42.5%)	23 (57.5%)	-	Proximally
ulna	16 (36.37%)	28 (63.69%)	-	proximally

Direction of nutrient foramina

In present study, most of the nutrient foramina in humerus were directed distally (away from the growing ends). In the radii examined, the direction of the nutrient foramina was proximal which was similar to the study by Kumar, et al. [8].

Clinical relevance

Position and number of the nutrient foramina in long bones is very important in orthopedic surgical procedures like joint replacement therapy, fracture repair, bone grafts and vascularized bone microsurgery [2]. Injury to the nutrient artery at the time of fracture, or at subsequent manipulation, may be a significant factor predisposing to faulty union. The levels of osseous section are selected according to the localization of the diaphyseal nutrient foramina in order to preserve diaphyseal vascularization of the recipient to support the consolidation with the osseous graft [11].

Conclusion

Our study supported previous reports regarding the number and position of the nutrient foramina in the long bones of the limbs. It also provided important information to the clinical significance of the nutrient foramina.

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