ANATOMICAL STUDY OF NUTRIENT FORAMINA IN DRIED HUMAN UPPER LIMB BONES AND THEIR CLINICAL SIGNIFICANCE

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ABSTRACT

BACKGROUND

Nutrient artery is the major source of blood supply to the long bone, which enters through the nutrient foramen. Lack of adequate vascular supply can significantly delay or prevent fracture healing.

The aim of this study is to study the number, location and direction of nutrient foramina of human upper limb long bones (Humerus, Radius and Ulna).

MATERIALS AND METHODS

The study was conducted on 116 upper limb long bones, which included 39 humeri, 39 radii and 38 ulnae.

RESULTS

The variations found in number and location of nutrient foramina were observed. In humerus single, double and triple nutrient foramina were seen. No nutrient foramen in one radius and double nutrient foramina were observed in case of ulnae.

CONCLUSION

An understanding of the location and the number of the nutrient foramina in long bones is important in orthopaedic surgical procedures such as joint replacement, fracture repair and bone grafts.

KEYWORDS

Nutrient Foramen, Nutrient Artery, Upper Limb Long Bones (Humerus, Radius and Ulna) and Foraminal Index.

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BACKGROUND

An opening into the bone shaft for the passage of blood vessels to the medullary cavity of a bone for its nourishment and growth is called as nutrient foramen. Nutrient artery is important during its active growth period in embryonic and foetal life. All long bones have one or more nutrient arteries, which enter through a nutrient foramen without branching in the foramen and that are accompanied by several thin walled veins and a myelinated nerve.[1] The nutrient artery and its ascending and descending medullary branches form the important source of blood supply to the bone marrow and inner 2/3rds of the compact part of the diaphysis.[2] Usually nutrient arteries move away from the growing ends of the long bones.[3] Detailed study of blood vessels and intact vascularity is required for fracture healing, bone grafts and other Orthopaedic procedures.[4] During pregnancy intake of some of the drugs like thalidomide interferes with vascularisation and leads to death of mesenchymal cells in the early limb bud causing phocomelia.[5] The detailed study of number, location and direction of nutrient foramina in upper limb long bones is useful for the Orthopaedic surgeons to do surgical procedures on the bones.

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MATERIALS AND METHODS

For this study, total 116 long bones of upper limb (Humeri-39, Radii-39 and Ulnae-38) were taken from the Department of Anatomy, NRI Institute of Medical Sciences, Sangivalasa, Visakhapatnam. Each bone was examined with the help of hand lens and hypodermic needle to identify the position, number and the direction of nutrient foramen. The nutrient foramen was identified by the presence of a well-marked groove and raised edge at the commencement of the canal. The exact position of the nutrient foramen was made out whether it was present on the upper, middle or lower one-third of the body of the long bone. The total length of long bones and distance of nutrient foramen from the upper end were also measured by vernier calipers and osteometric board. The position of nutrient foramen was determined by calculating the Foraminal Index (FI) using the formula: FI = DNF/TL*100. [DNF = Distance of Nutrient Foramen from the upper end of the bone, TL = Total Length of the bone]. The position of the foramina was divided into 3 types according to FI.[6]

Type 1 - FI below 33.33, the foramen was in the proximal 1/3rd of the bone.

Type 2 - FI ranges between 33.33 and 66.66, the foramen was in the middle 1/3rd of the bone.

Type 3 - FI more than 66.66, the foramen was in the lower 1/3rd of the bone.

Broken ends of long bones were excluded due to lack of total length of the bone for measurement. Age and sex of the bones were not considered in the present study.

RESULTS

Humerus

Out of 39 bones, 30 (77%) bones had single nutrient foramen, two foramina were present in 7 (18%) bones and three foramina were found in 2 (5%) bones. The mean foraminal index was 54.98. In 38 bones, foramen was present in middle 1/3rd and 1 bone had foramen in the lower 1/3rd of shaft. It was present on anteromedial surface in 34 bones, anterolateral surface in 3 bones and was present on posterior surface in 2 bones. All foramina were directed downwards towards elbow (Figure 1, 2).

No. of Bones		One Nutrient Foramen		Two Nutrient Foramina		Three Nutrient Foramina		None	
		No.	%	No.	%	No.	%	No.	%
Humeri	39	30	77	7	18	2	5	--	--
Radii	39	37	95	--	--	--	--	2	5
Ulnae	38	37	97	1	3	--	--	--	--

Table I. Showing the Number and Percentage of Nutrient Foramina

Radii

Out of 39 radii, (37) 95% of bones had single nutrient foramen, (2) 5% of bones had no foramen at all. Its foraminal index was 34.14. All foramina were present on anterior surface of radius; 33 bones had foramen in the middle 1/3rd and 6 had in the upper 1/3rd of the shaft (Figure 3).

Name of the Bone	Mean of Total Length cm	Mean Distance of NF from Upper End of the Bone cm	Foraminal Index (FI)
Humeri	30.20	16.73	54.98
Radii	23.84	8.13	34.14
Ulnae	25.85	9.01	34.91

Table II. Showing the Mean calculation of FI (Foraminal Index)

Ulnae

Out of 38 bones, 37 (97%) had single nutrient foramen and in one (3%) bone two nutrient foramina were present. In 33 bones, nutrient foramen was present in middle 1/3rd and in 5 it was in upper 1/3rd. In 37 bones, foramen was found on anterior surface and in one it was present on interosseous border. The mean foraminal index was 34.91. In ulnae and radii, all the nutrient foramina were directed proximally (Figure 4).

No. of Bones		Upper 1/3rd (Type 1)	Middle 1/3rd (Type 2)	Lower 1/3rd (Type 3)	Expected	Variant
Humeri	39	--	38	1	Antero-Medial-34	Antero-Lateral-3, Posterior-2
Radii	39	6	33	--	Antero-Surface-37	No Foramen-2
Ulnae	38	5	33	--	Anterior Surface-37	Interosseous Border–1

Table III. Showing the Position of the Nutrient Foramina

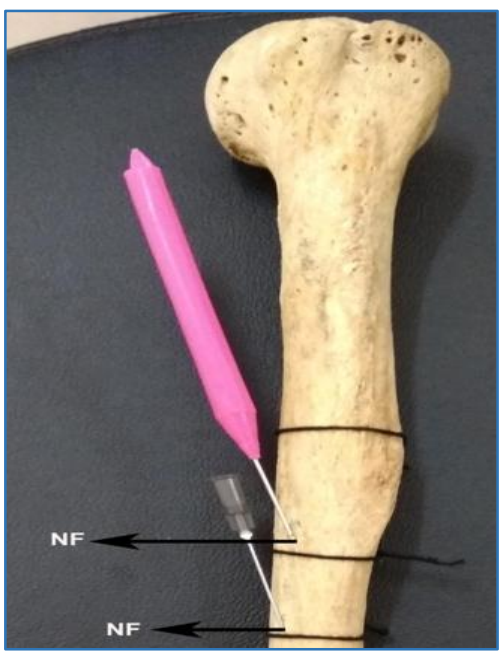

Figure 1. Shaft of Humerus showing Three Nutrient Foramina (NF), 2 with Needles on Anteromedial Surface and One on Posterior Surface. All are Located in the Middle 1/3rd (Type 2) of Shaft and are Directed Downward

Figure 2. Shaft of Humeri showing Nutrient Foramina (NF) on Anteromedial Surface, Located in the Middle 1/3rd (Type 2) of Shaft and are Directed Downward

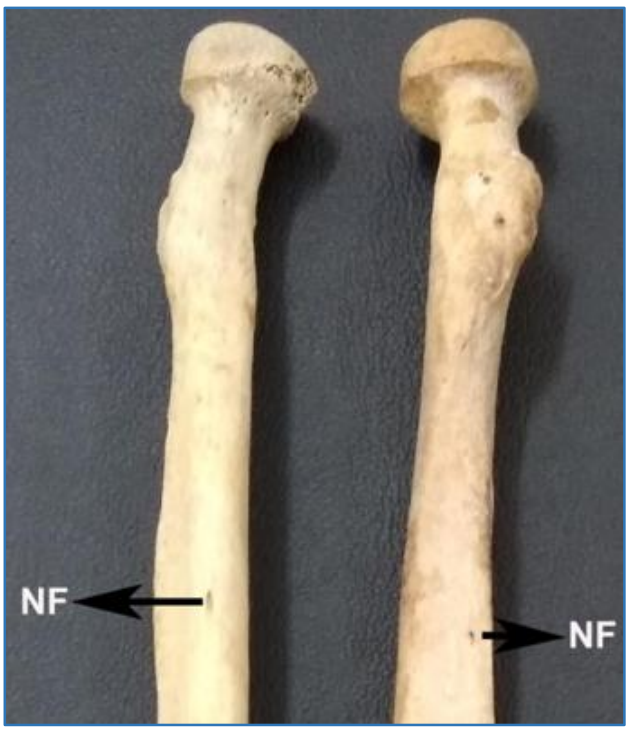

Figure 3. Shaft of Radii showing Nutrient Foramina (NF) on Anterior Surface, are Located in the Middle 1/3rd (Type 2) of Shaft and are Directed Upward

Figure 4. Shaft of Ulnae showing Nutrient Foramina (NF) on Anterior Surface, are Located in the Middle 1/3rd (Type 2) of Shaft and are Directed Upward

DISCUSSION

Embryogenesis

The osteogenic layer of periosteum forms the periosteal bud which contains osteoclasts, osteoblasts and blood vessels. The bud excavates passages through the newly formed bones and passes into the calcified matrix as the primary centre of ossification. The perforation of the bud persists as the nutrient canal.[7]

In the present study out of 39 humeri 77% (30) had one nutrient foramen, 18% (7) had two nutrient foramina and three foramina were found in 2 (5%) of bones (Figure 1 and Table 1). According to Asharani SK and Ajay Ningaiah,[8] 87% of bone had one nutrient foramen, 11% had two foramina. Anusha P and Naidu MP[9] reported that 2 bones (4%) had no foramen and Sabah Y et al[10] observed that 2% of bones had three foramina.

In the present study out of 39 humeri, 87.2% of bones had nutrient foramen on anteromedial surface (Figure 1 and 2), 7.7% on anterolateral surface and in 5.1% of bones it is present on posterior surface. According to Abdul SK et al[11] 96% foramina were located on anteromedial surface, 2.66% on the posterior surface and 1.33% on anterolateral surface. In 97.4% of humeri, all the foramina were present in the middle 1/3rd and 2.6% foramina were present in lower 1/3rd of humerus. According to Sabah Y et al,[10] 89% had foramina in middle 1/3rd and 11% had foramina in the lower 1/3rd of humerus. All are directed towards elbow joint. The mean blood supply to the shaft of the humerus is through a restricted area and one must be careful to guard against injuring this vessel in operations on the shaft of humerus.[12] A posterolateral approach is therefore recommended to minimise damage to the blood supply of the humerus and limiting the chances of delayed or non-union in fracture shaft of the humerus.

In the present study out of 39 radii, 95% had single nutrient foramen and 5% had no foramen (Figure 3). Mani A[13] observed that single nutrient foramen was present in 98.17% and Anusha P and Naidu MP[9] observed that 92% of radii had single nutrient foramen, 6% had two foramina and 1% had no foramen. In the present study, 33 bones had foramen in middle 1/3rd and are present on anterior surface; 6 bones had foramen in upper 1/3rd of shaft of radius. All are directed towards elbow joint.

In the present study out of 38 ulnae, 97% had single and 3% had two nutrient foramina. In 33 bones, it was present in middle 1/3rd and in 5 bones it was present in upper 1/3rd of ulna (Figure 4); 37 bones had foramen on anterior surface and one had foramen on interosseous border. According to the study done by Prasad Rao KRS and Janaki V[14] on 98 ulnae, 66 bones had single foramen, 20 had double, triple in 4 bones, four foramina in 6 bones and five foramina in 2 bones; 74 foramina were present in middle 1/3rd, 50 in upper 1/3rd and 28 are found in lower 1/3rd of ulnae. They found most of the foramina on anterior surface.

Knowledge of the number and position of the nutrient foramen in long bones was important in orthopaedic surgical procedures such as joint replacement therapy, fracture repair, bone grafting and vascularised bone microsurgery. The foramen might be a potential area of weakness in some patients and when under stress because of increased physical activity or decreased quality of the bone, the foramen might allow the development of a fracture. Position of the fracture relative to the nutrient foramen of the long bone and the pattern of oedema were the key features in the diagnosis of this type of fracture.[15]

CONCLUSION

In the present study of upper limb long bones, mostly single nutrient foramen was present and in few two or three were present on humeri and ulnae. Almost all foramina were present in middle 1/3rd and on anteromedial and anterior surfaces. The knowledge of this position and number of nutrient foramina in long bones was useful for orthopaedic surgeons to treat fractures and other interventional surgeries and non-union of fracture ends.

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