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Original Research Article

Study on the morphology of nutrient foramens in humerus and its surgical implications

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ABSTRACT

Background: Long bones have large or small foramina for the entry of the blood-vessels. Such foramens are known as the nutrient foramina which are large in the shafts of the largest long bones. Such foramina lead to nutrient canals through which the blood vessels enters the bone supplying the medullary cavity. The site of entry and the direction of the nutrient foramina are almost constant and are directed away from the growing ends. The nutrient artery that passes through these foramina are the main source of blood supply to humerus and is particularly important during growth period in the embryo and foetus and also during the early stage of ossification.
Aim: a. To determine the direction of nutrient foramen in humerus. b. To determine the number of nutrient foramen of humerus. c. To determine the location of nutrient foramen of humerus.
Materials and Methods: The study was conducted on 120 adult humeri that were obtained from the Department of Anatomy, Sri Devaraj Urs medical college, Kolar, karnataka. Bones were segregated into right and left and observed for the direction, number and location of nutrient foramens in humerus
Results: In the present study, the percentage of humerus bones with one nutrient foramen was 87% and two foramina was 9% and absent in 4%. Single nutrient foramen on right humerus bones was 92% and left side was 4% and absent in 4%. Single nutrient foramen on left humerus bones was 83% and left side was 13% and absent in 4%. 59% of the bones had nutrient foramen that were located on the medial border. Following which, the order was Anteromedial surface in (25%), Lateral border in (5%), Posterior surface in (3%) and anterior border in (3%). 81% had the nutrient foramen that was located in the middle 1/3rd, 11% at the junction between middle 1/3rd and lower 1/3rd and 3% in the lower 1/3rd of humerus. All the nutrient foramina were directed towards the elbow joint and was away from the growing end as per the law of ossification.
Conclusion: Nutrient artery is the main source of blood supply to long bones that enters through the nutrient foramen. The surgical and anatomical knowledge of nutrient foramen in humerus or any long bone is important for orthopaedic surgeons and general surgeons during surgical procedures on the humerus such as vascular surgeries, bone grafting and transplantation.

1. Introduction

Long bones have foramina large or small for the entry of the blood-vessels.

Such nutrient foramina are particularly large in the shafts of the long bones. They lead to nutrient canals through which vessels enter the bone supplying the medullary cavity. The sites of entry and their direction are directed away from the dominant growing ends. The nutrient artery is a main source of blood supply to humerus and is important during

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their growth period in the embryo and foetus and stage of ossification.[1] Nutrient foramen (NF), is directed obliquely and edges are elevated for entry of the nutrient artery. NF is directed away from the growing end that is 'seek the elbow and flee from the knee'.

Lack of an adequate blood supply can delay fracture healing. Nutrient artery is the major source of blood supply to the long bone and hence plays an important role in fracture healing. Thorough knowledge about direction and location of nutrient artery of humerus with its common variations is of prime importance during surgical or orthopaedic procedures involving limbs, such as bone grafts and vascular bone transplantations.[2]

2. Materials and Methods

The study was done on 110 adult humeri (50 right and 60 left humeri) that were collected from Department of Anatomy, Sri Devaraj Urs Medical College, Kolar, Karnataka.

Damaged and deformed bones were omitted from the study. Length of the humerus was measured with the help of an osteometric board. Bones were then divided into three zones as Zone I upper 1/3rd, Zone II Middle 1/3rd and Zone III lower 1/3rd. The surfaces of the bones were examined for the direction number, and location of the nutrient foramen based on surface and borders.

3. Results

Out of 110 bones, 60 of them were left sided and 50 of them were right sided.

Asharani et al. studied 120 humerii and the percentage of the humerus having single nutrient foramen as 87% and double foramina as 11%. There were no dominant foramen in both sides of the humerus bones.

In the present study, the percentage of the humerus bones with single nutrient foramen was 87% and two foramina was 9% and absent in 4%. Single nutrient foramen on right humerus bones was 92% and left side was 4% and absent in 4%. Single nutrient foramen on left humerus bones was 83% and left side was 13% and absent in 4%.(Table 1)

Aashish e al 5 studied 68 humeri and found the single nutrient foramen in 97.05% that is 33 of right humerus and 91.12% that is 31 of left humerus, double nutrient foramina in 3.95% that is 01 of right humerus and 6.39% that is 03 of left humerus, triple nutrient foramina was not found in any humerus.

According to Asharani et al, 57% of the humerus bones have nutrient foramens that were located on the medial border. In sequence, the next in order were Anteromedial surface in (43%), Lateral border in (3%), Posterior surface in (3%) and anterior border in (2%).

In the present study, 59% of the bones had nutrient foramen that were located on the medial border. After that, the next in order were Anteromedial surface in 25%, Lateral border in 5%, Posterior surface in 3% and anterior border in 3% (Table 2).

Fig. 1: Double nutrient foramens in the middle 1/3rd (Zone II)

Fig. 2: Single nutrient foramen in the middle 1/3rd (Zone II)

Mysorekar et al[3] studied that Out of 179 humeri, seventy-five (42%) had more than one foramen. Of the 263

Table 1: Number of nutrient foramens inhumerus

Number of nutrient foramens in humerus	Right		Left		Both %	
	Number of nutrient foramens in humerus	Percentage of nutrient foramens in humerus	Number of nutrient foramens in humerus	Percentage of nutrient foramens in humerus	Number of nutrient foramens in humerus	Percentage of nutrient foramens in humerus
1	46	92	50	83	96	87
2	2	4	8	13	10	9
Absent	2	4	2	4	4	4

Table 2: Location of the nutrient foramens inhumerus

Location of nutrient foramens in humerus	Right		Left		Both %	
	Number of nutrient foramens in humerus	Percentage of nutrient foramens in humerus	Number of nutrient foramens in humerus	Percentage of nutrient foramens in humerus	Number of nutrient foramens in humerus	Percentage of nutrient foramens in humerus
Medial border	30	60	35	58	65	59
Anteromedial surface	15	30	12	20	27	25
Lateral border	5	10	1	2	6	5
Anterior border	-	-	3	5	3	3
Posterior surface	-	-	3	5	3	3

Table 3: Location of the nutrient foramens with respect to zones ofhumerus

Zones/Regions	Right	Left	Both	Percentage
Junction between middle 1/3rd and lower 1/3rd (Zone I)	5	7	12	11
Middle 1/3rd (Zone II)	42	47	89	81
Lower 1/3rd (Zone III)	3	-	3	3

foramina, 185 (70%) were in the fourth sixth and sixty-seven (25 5%) in the third sixth. Of the 263 foramina, 106 (40%) were on the antero-medial surface, 101 (40%) on medial border, and fifty (19%) in spiral groove. In specimens (seventy-five) having multiple foramina, thirty-eight (51%) had one in the spiral groove and on the anteromedial surface or on the medial border. In one specimen there were as many as three foramina in the spiral groove.[3]

It has been suggested that the direction of nutrient foramina was determined by the growing end of the long bone. The growing end is the one that is supposed to grow at least twice as fast as the other end of the bone.[3]

According to Bharathi et al, out of 100 humeri, in most of the humerii (94%), the nutrient foramen was located in middle 1/3rd of humerus bone and in 6% of the bones, it was located in the lower 1/3rd of the bone. The location of the nutrient foramen of humerus in the anteromedial surface was 92%, in the posterior surface was 6% and in the anterolateral surface, it was 2%.[4]

Majority of the bones studied by Asharani et al. mentioned that 87% had the nutrient foramen located in middle 1/3rd, then 22% was at the junction of middle 1/3rd and lower $1/3^{rd}$ and 2% in lower $1/3^{rd}$ of humerus. Direction of the nutrient foramen was observed that all the nutrient foramen were directed towards the elbow joint and were away from the growing end.[3]

In the present study on 110 humeri, 81% have the nutrient foramen located in the middle 1/3rd, 11% at the junction of middle 1/3rd and lower 1/3rd and 3% was in the lower 1/3rd of humerus. All nutrient foramina were directed to the elbow joint and were away from the growing end as per the law of ossification (Table 3).

4. Discussion

Constant blood or vascular supply is very important for healing of any fractured bone. NF is one of the external opening of the nutrient canal in long bones. The vessels that initially pierces the ossifying cartilage at the centre of ossification acts as nutrient artery and lies in the nutrient canal within NF.[5]

Chandrasekaran et al[6] studied a total of 258 adult dry humeri. In most of the humeri (86.43%), the nutrient foramen were located in the middle 1/3rd of the humerus bone and in 13.57% of the bones, it was located in the lower 1/3rd of the humerus bone. The location of the nutrient foramen in the antero-medial surface was as 89.92% and that in the posterior surface was 8.53% and that in the antero-lateral surface was 1.55%.

Mysorekar has reported NF of the humerus in the medial border or in antero-medial surface in 80% of the cases.[3]

The location of the nutrient foramen were more in the middle l/3rd of antero- medial surface. Most of the humeri showed one nutrient foramen, whereas there were 2 to 3 foramina in few humeri.[7]

In the study in Nigerian population,[5] 66% of the humeri had one foramen, 18% had two foramina and 26% had no foramen at all.

The constancy of the nutrient artery to the diaphysis of humerus is significant. The risk of damaging this artery is highest in open reduction of the fracture involving the mid-shaft region of the bone.[8]

Khan AS et al. studied 75 humerus, out of which 90% of humeri had one nutrient foramen.

Among them, 96% were located on the middle 1/3rd of antero-medial surface, 2.67% on the posterior surface and 1.33% on the antero-lateral surface.[9]

Nutrient artery is the main source of blood supply to the long bone and therefore plays an important role in healing of fractures. Orthopedic surgical procedures like bone microsurgery requires the enormous knowledge of the blood supply. In vascular bone grafting, the blood supply by nutrient artery is very important and must be conserved in order to help fracture healing.[10,11]

In a study of 200 humerii by Joshi H et al 63% had one nutrient foramen which suggests that the major blood supply to humeral shaft will enter at a particular point.[12]

Fracture of the upper or lower third of the humerus, which is more common than the middle third, is less likely to endanger its blood supply, as NF is present most commonly in its middle third and is distal to insertion of deltoid. Nutrient artery of most bones enters through its middle third for the humerus in its medial border or anteromedial surface. Hence, information can be used to exactly locate the nutrient artery in the majority but not all the bones, for procedures such as fracture repair, joint replacement therapy, bone grafts reconstruction procedures and bone microsurgery.[2]

In the present study, the percentage of humerus bones with one nutrient foramen was 87% and two foramina was 9% and absent in 4%. Single nutrient foramen on right humerus bones was 92% and left side was 4% and absent in 4%. Single nutrient foramen on left humerus bones was 83% and left side was 13% and absent in 4%. 59% of the bones have nutrient foramen located on the medial border. Next order are Antero-medial surface in (25%), Lateral border in (5%), Posterior surface in (3%) and anterior border in (3%). 81% have the nutrient foramen located in the middle 1/3rd, 11% at the junction of middle 1/3rd and lower 1/3rd and 3% in the lower 1/3rd of humerus. All the nutrient foramina were directed towards the elbow joint and were away from the growing end as per the law of ossification.

5. Conclusion

Majority of dry humerus bones that we studied had one NF, absence or replication of nutrient foramen. Nutrient artery is the main source of blood supply to long bones which enters through the nutrient foramen. The surgical and anatomical knowledge of nutrient foramen in humerus or any long bone is therefore more important for surgeons and orthopaedic surgeons during surgical procedures on the humerus namely bone grafting and transplantation.

6. Source of Funding

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7. Conflict of Interest

None.

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