

A Study on Variations of Nutrient Foramen of Humerus and Its Clinical Significance

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ABSTRACT

Background: Nutrient foramen is an opening in shaft of humerus which conducts nutrient vessels for medullary cavity. Nutrient artery is the major source of blood supply to long bone. Knowledge of nutrient foramen is important for orthopedic surgeon while doing any procedure on humerus like bone grafting, plating and also plays an important role in fracture healing.

Aims and Objectives: To determine the number, direction and location of nutrient foramen of humerus.

Methods: The present study was conducted on 62 adult humeri (32 of right side and 30 left side) collected from Department of Anatomy, SGT Medical College, Gurugram, Haryana during the period of 15th June to 31st July 2017. Each humerus was observed for number, direction and location of nutrient foramen in relation with surface, border and zone.

Results: In the present study it has been observed that 61% of humeri had a single foramen, 31% double foramen and 8% had triple foramen. Majority of nutrient foramen (54.95 %) present on antero- medial surface, 12.08 % on antero-lateral surface, 12.08 % on posterior surface, 19.78 % on medial border and 1.09 % on lateral border. It was also concluded that most (94.50%) of the foramina present in the zone II followed by zone III (3.30%) then by zone I (2.19%).

Conclusion: Knowledge of number and location of the nutrient foramina in humerus will be helpful in preventing intra-operative injury of nutrient artery during orthopedic, plastic and reconstructive surgery and will also be relevant in medico legal practice.

Key words: Nutrient Foramen, Humerus, Nutrient Artery, Foraminal Index.

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INTRODUCTION

The long bones have four sets arterial system – nutrient artery, epiphyseal, metaphyseal and periosteal arteries. Out of them nutrient artery play an important role during active growth period as well as in healing of fractured bones.¹

All bones possess foramina for the passes of the nourishing blood-vessels; these are known as the nutrient foramina. In long bones it is present on the shaft and in irregular bones it is found in other locations. These foramina lead to nutrient canals through which nutrient vessels entering the medullary cavity and supply bone marrow & inner 2/3rd of cortex. Their sites of entry and direction are almost constant and away from the dominant growing ends.²

Now a days fracture of long bones are increasing in number due to an increase in road traffic accidents, industrial accidents, sports injuries, construction of multistory building and pathological

fractures in osteoporotic patients. There are many complication of fracture, nonunion is one of them.³

One of the very important reasons for nonunion is loss of blood supply to the fractured bone. Damage to nutrient vessels, excessive stripping or injury to periosteum and muscle are few causes for loss of blood supply to the fracture site⁴; hence nutrient artery plays an important role in fracture healing.

Humerus is the largest and longest bone of the upper limb. Nutrient artery supplying the humerus is a branch of brachial artery. Detailed knowledge of the blood supply of bone will be helpful for the orthopedic surgeon during any surgical procedure such as bone repair, bone graft, vascularized bone microsurgery to minimize the damage to nutrient artery of humerus.⁵ The present study was carried out to determine the number, direction and location of nutrient foramen of humerus.

MATERIALS AND METHODS

The present study was conducted on 62 (32 right and 30 left) dried and cleaned humeri collected from Department of Anatomy, SGT Medical College, SGT University Gurugram, Haryana (India) during the period of 15th June to 31st July 2017. All the humeri that were taken for the study were normal. Any damaged or pathologically deformed bones were excluded from the study. All the humeri were examined for side determination. Each humerus was examined in detail for the number, location and direction of nutrient foramen under proper illumination.

Osteometric board with sliding caliper, magnifying lens, scale and alpin were used for measuring these parameters. With the help of magnifying lens the nutrient foramen was identified by the presence of a well-marked groove with slightly raised edge of the foramen at the commencement of the canal. Location of nutrient foramen in relation with surface and borders were identified and recorded. Direction of nutrient foramen in relation with growing end of humerus was observed and recorded by inserting an alpin. Total length of each bone and distance from proximal end of bone to each nutrient foramen was measured with the help of osteometric board and sliding caliper. The position of nutrient foramen in relation to zone was determined by calculating a Foraminal Index (FI) using the Hughes formula.⁶

$$FI = (DNF / TL) \times 100$$

where DNF = distance from the proximal end of the bone to the nutrient foramina.

TL= Total length of the bone in millimeter.

Total length of the each humerus was taken as the distance between the superior aspect of the head and the most distal aspect of the trochlea in millimeter.

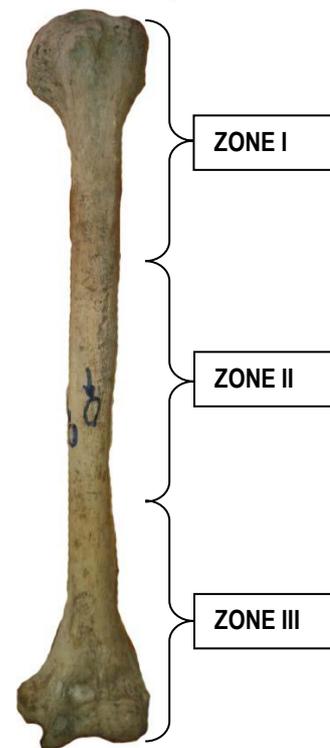
The position of foramina was divided into three zones according to FI as follows:

Zone I: FI up to 33.33%, the foramen was in proximal third of the bone.

Zone II: FI from 33.33% to 66.66%, the foramen was in the middle third of bone.

Zone III: FI above 66.66%, the foramen was in the distal third of bone.

All the numerical data were subjected to statistical analysis using SPSS. The observations and measurements were presented in descriptive statistics.



RESULTS

Out of 62 humeri studied, 32 were of right sided and 30 were of left sided. As shown in Table 1, the single nutrient foramen was present in 65.62% (21) and 56.67% (17), double nutrient foramina were in 34.37% (11) and 26.67% (8) of right and left humeri respectively and the triple nutrient foramina were found in 16.66% (5) of left humeri and no any triple foramina were found in right humeri. From the table it was concluded that the number of nutrient foramen in humerus is variable. The percentage of the bones having one nutrient foramen is 61.29% (38), two foramina are 30.65% (19) and three foramina are 8.06% (5).

Table 1: Showing number of nutrient foramen on humerus.

No. of Nutrient foramen	Right=32		Left=30		Total=62	
	No. of Humerus	%	No. of Humerus	%	No. of Humerus	%
1	21	65.62	17	56.67	38	61.29
2	11	34.37	8	26.67	19	30.65
3	0		5	16.66	5	8.06

Table 2: Showing location of nutrient foramen on humerus.

Location of nutrient foramen	Right=43		Left=48		Total=91	
	No. of nutrient foramen	%	No. of nutrient foramen	%	No. of nutrient foramen	%
Anteromedial surface	24	55.81	26	54.16	50	54.95
Anterolateral surface	4	9.3	7	14.58	11	12.08
Posterior surface	6	13.95	5	10.42	11	12.08
Medial border	8	18.6	10	20.83	18	19.78
Lateral border	1	2.32	0	0	1	1.09

Table 3: Showing location of nutrient foramen with respect to zone of humerus.

Zone	Number of nutrient foramen	%
Zone I	2	2.19
Zone II	86	94.5
Zone III	3	3.3



Figure 2: A photograph showing osteometric board, number, location and direction of nutrient foramen.

From the above table, it was concluded that the majority (54.95%) of the nutrient foramina were located on the antero-medial surface of the shaft of humeri. Next in the order are Medial border (19.78%), anterolateral surface (12.08%), posterior surface (12.08%) and lateral border (1.09%).

Majority of nutrient foramen 94.5%(86) present in middle one-third or zone II of shaft of humeri, followed by lower one-third or zone III 3.3%(3) and by upper one-third or zone I 2.19%(2).

Direction of nutrient foramen: It was observed that all the nutrient foramina were directed towards the elbow joint i.e. away from the growing end.

DISCUSSION

Inspite of giving optimal treatment, some fracture either heal slowly or non-heal.⁵ One of the important causes of non-healing or delayed healing is lack of arterial supply. Nutrient artery which is a richest source of blood supply enters in the medullary cavity through nutrient foramen. The knowledge of variations of nutrient foramina will be helpful for orthopaedic surgeons to avoid injury to the nutrient artery while performing an open reduction of a fracture and thus lessening the chances of delayed or non-union of the fracture.

From this study it is observed that 61.29% of humeri have single nutrient foramen. A similar finding 60.87% was observed by Mansur DI et al. in Nepalese subjects.⁷ Almost similar finding (60%) was observed by Shaheen in Saudi Arabia.⁸ Mysorekar et al. (58%) in Indian population and Joshi et al. (63%) among Gujarati population.^{9,10} Many studies reported high percentage of incidence of single foramina. A study done by Khan AS et al on 75 humerus, and reported that 90% of humeri had single nutrient foramen.¹¹ A similar study done by Carroll et al. in 71 humeri collected from University of Western Ontario, London and observed that 67.61% of humeri had a single nutrient foramen.¹² A study conducted by Forriol et al. in 36 humeri collected from Medical School of Alcalá de Henares University and found that

75% of humeri with single nutrient foramen as compared to the present study.¹³ Similarly, a study conducted by Peirera et al. who reported the incidence 88.5% of humeri have single nutrient foramen in Southern Brazil and Bhatnagar et al. reported the incidence of 90% in Uttar Pradesh (India).^{14,15}

The present study showed that 30.65% of humeri have double nutrient foramen which was similar to the findings observed by Mansur DI in Nepal who reported 28.85%⁷, Carroll in London who reported 28.16% of humeri¹², Joshi et al. reported 33%⁹ and Shaheen reported 33.3%.⁸ Similar studies conducted by Bhatnagar et al. who reported a lower incidence 7.14% of humeri have double nutrient foramen, Halagatti et al. (17.5%) and Solanke et al. (4%).¹⁵⁻¹⁷

Similarly, the present study observed 8.06% of humeri have triple nutrient foramina which were nearly similar to the studies conducted by Shaheen (6.7%) in Saudi Arabia⁸ and Mansur DI et al. (6.32%) in Nepal⁷. Whereas findings reported by Bhatnagar et al.(1.42%), Halagatti (2%) and Yaseen et al. (2%) which was comparatively lesser than the finding observed in the present study.^{15-16,18} The nutrient foramina are situated a little below its midpoint on the antero medial surface close the medial border of humeri. However; the location of foramina may vary in position.² In present study 54.95% of foramina were present on anteromedial surface of humeri

From the present study it is observed that the majority of nutrient foramina (94.50%) were present in zone II (the middle one-third) of the shaft of the humeri which was correlated with the study conducted by Mansur DI et al. who reported 94.84%⁷, Khan et al. who reported 96.20% of nutrient foramina on the middle one-third of humeri of Pakistan cadavers¹¹. A study conducted by Ukoha et al. in humeri of Nigerian population found that 100% of the nutrient foramina were located on the middle one-third of the humeri and a similar trend also reported by Kumar et al. (100%) in Indian population which was higher than the present result.^{19,20} However, Halagatti et al. noticed that lower (84%) incidence of presence of nutrient foramina in the middle one-third of the shaft of humeri.¹⁶

The direction of the nutrient foramina were directed horizontally before birth but as the growth proceeds the direction of nutrient foramina were directed away from the growing end of the humeri.⁷ The present study showed that the direction of all the nutrient foramina of humeri was directed towards the lower end of humeri which was supported by many other studies^{11,16,20}, which revealed that the direction of nutrient foramina were constant and obeys the law of ossification. Similarly, Kumar et al. reported that the direction of all nutrient foramina present in the humeri were directed away from the growing end of humeri except one which was directed towards the upper end²⁰. Similarly, Khan et al. also observed that 98.67% of the nutrient foramina were directed distally towards the lower end of humeri which was accordance with the present result.¹¹

CONCLUSION

It have been concluded that majority of humerus have single nutrient foramen and they are mainly located on antero-medial surface especially in zone II (the middle one- third). The direction of all the foramina is constant and away from the growing end. The knowledge about the location of the nutrient foramen and their variation will be helpful for orthopedic surgeon to decrease the chances of damage to the nutrient artery during open or close

procedures. Damage to the nutrient artery may cause delayed union or non-union of the bone following fracture of shaft of humerus. It will also helpful to avoid this area during any surgical procedures such as bone repair, bone graft, microvascular bone surgery and during extensive stripping of the periosteum so that they can minimize the damage to the nutrient artery of humeri.

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