ORIGINAL RESEARCH

Assessment of nutrient foramen of the humerus in the North Indian subjects

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ABSTRACT

Background: The largest and longest bone in the upper limb is the humerus. The nutrient foramen is an aperture in the bone's shaft that permits blood vessels to get to the bone's medullary cavity for nutrient and growth. The long bones' nutrient foramina have been the subject of numerous published research. Since the literature has not yet established a palpable landmark for the nutrient foramina, the purpose of this study was to characterize the nutrient foramen in dry adult humeri in terms of their numbers and location.

Methods: The study comprised all the humerii (not necessarily paired and those of unknown age and sex) from the university of the Aam Admi Party's medical colleges. The length of the humerus, the number of nutrient foramen, the size of the nutrient foramen, the location of the nutrient foramen in regard to the surfaces and the zones, and the distance of the nutrient foramen from the midpoint of the humerus were all observed. All the data were recorded, and the percentage, mean, range, and standard deviation were computed as part of the statistical analysis.

Results: In our study we examined 147 humeri. Among 147 examined humeri there were 82 right humerus and 65 left humeri. The number of single nutrient foramen was most commonly recorded among examined humerus (78.91%). The examination of humerus for location of nutrient foramen based on surface showed that more than four fifth of nutrient foramen were located on anteromedial surface (83.67%). The mean total length of humerus examined was 269.75±22.53 mm and the mean distance from of nutrient foramen from proximal end of humerus was 151.93±17.57 and calculated foraminal Index (FI) was 55.36%.

Conclusion: When performing various surgical procedures on the humerus, such as treating fractures, bone repair, bone grafting, micro-surgical bone transplantation, in numerous fractures, and during extensive periosteal stripping, orthopaedic surgeons must have a thorough understanding of the anatomy of the number, location, and direction of the nutrient foramina of the humerus in order to minimise damage to the nutrient artery of the humerus.

Keywords: Nutrient foramen, humerus, upper limb, medullary cavity, bone grafts

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INTRODUCTION

The largest and longest bone in the upper limb is the humerus. The nutrient foramen is an aperture in the bone's shaft that permits blood vessels to get to the bone's medullary cavity for nutrient and growth. Devascularization may result from an injury to the nutrient foramen caused on by trauma or surgical dissection [1,2]. Long bone fractures are becoming more common as a result of sports injuries, osteoporotic patients' pathological fractures, industrial and transportation accidents, and other causes. Orthopedic surgeons that perform treatments involving bone transplants, fracture repair, joint replacement, and vascularized bone microsurgery found this understanding of nutritional foramen to be of utmost importance. Limb bones grow more rapidly on one end than the other.The direction of the nutritional foramen is oriented towards the elbow in the upper limb as a result [3,4].

When the blood supply is not properly established, problems including a delayed union or a non-union of the fracture may occur. The necrosing cortex and the uniting callus of the fracture site are revascularized in part via the medullary arterial system. Understanding the location of the nutrient foramen and the relevant anatomy can help to reduce these issues. With this knowledge, the surgeon can limit complications from a delayed or incomplete healing of the fracture and prevent injury to the nutritional artery [5,6]. The long bones' nutrient foramina have been the subject of numerous published research. Few of this research have been carried out recently, and the majority date back many years. The humerus length was not given in great detail.Only the number, direction, and location of the nutrient foramina were discussed. In clinical practise, palpable landmarks can be used to identify anatomical structures. There hasn't been any mention of a palpable landmark for the nutritional foramina in the literature [2,7].

Our study provides novel data, including the diameter and symmetry analysis of the nutrient foramen through which we can also comprehend variation in length. Our study also aimed to analyse the nutrient foramen in dry adult humeri, with respect to the number, location of the nutrient foramen with respect to the surfaces and zones, and its distance from the mid-point of the humerus.

MATERIALS and METHODS

The study included all of the humerii from the university of the Aam Admi Party's medical colleges. Excluded from the study were bones with pathological abnormalities and damaged bones. We looked at every adult humerii, even those that weren't always paired and those with undetermined ages and sexes.

The length of the humerus, the number of nutrient foramen, the size of the nutritional foramen, the location of the nutrient foramen in relation to the surfaces and the zones, and the separation of the nutrient foramen from the midpoint of the humerus were all observed.

Using an osteometric board, the length of each humerus bone was measured from the superior part of the lesser tubercle to the inferior surface of the medial epicondyle [7]. Zone I (the upper 1/3rd), Zone II (the middle 1/3rd), and Zone III (the lower 1/3rd) were further divisions of the humerus bone. By dividing the humerus' length in half, the midpoint was determined. The osteometric board was used to locate the midpoint and mark it on the humerus.

The anteromedial, anterolateral, and posterior surfaces as well as the three zones—zone I, zone II, and zone III—were taken into consideration while determining the location of the nutrient foramen. With the aid of a vernier calliper, the distance between the nutrient foramen and the humeral midpoint was calculated. Hypodermic needles of known diameters in sizes ranging from 18 gauge to 26 gauge were used to measure the size of the nutrient foramen (18 gauge = 1.2 mm, 20 gauge = 0.9 mm, 24 gauge = 0.55 mm, and 26 gauge = 0.45 mm). The larger nutrient foramen was regarded as the dominant foramen and its size was evaluated when multiple foramens were observed.

Clinicians can detect the nutritional artery with the aid of the foraminal index, which was determined. The Hughes method was used to calculate a Foraminal Index (FI), [FI= (DNF\TL) x 100], where DNF stands for the distance from the proximal end of the bone to the nutrient foramina and TL stands for the total length of the bone in millimetres.

STATISTICAL ANALYSIS

After recording all the data, a statistical analysis was performed by computing the percentage, mean, range, and standard deviation.

RESULTS

In our study we examined 147 humeri. Among 147 examined humeri there were 82 right humerus and 65 left humeri. The number of single nutrient foramen was most commonly recorded among examined humerus (78.91%). Also, among 3.40% of examined humerus there were not even single nutrient foramen observed. Similarly, more than two nutrient foramens were observed among3.40% of examined humerus.

Table 1: Distribution of number of nutrient foramina in humeri studied (N=147).

Number of the nutrient foramina	Number (%)		
	Right humerus (n=82)	Left humerus (n=65)	Total (n=147)
0	3 (3.66)	2 (3.08)	5 (3.40)
1	66 (80.49)	50 (76.92)	116 (78.91)
2	11 (13.41)	10 (15.38)	21 (14.29)
3	2 (2.44)	3 (4.62)	5 (3.40)

The examination of humerus for location of nutrient foramen based on surface showed that more than four fifth of nutrient foramen were located on anteromedial surface (83.67%), whereas the distribution of nutrient foramen on posterior surface (8.84%) and anterolateral surface (7.49%) were nearly similar. The examination of humerus for location of nutrient foramen based on zone showed that more than four fifth of nutrient foramen were located on Zone II (85.03%).The present study showed that the direction of all the nutrient foramina of humeri was directed towards the distal part of humeri.

Table 2: Distribution of location and direction of nutrient foramina in humeri studied (N=147).

Description of the nutrient foramina	Number (%)		
	Right humerus (n=82)	Left humerus (n=65)	Total (n=147)
Location (surface)			
Anteromedial surface	67 (81.71)	56 (86.16)	123 (83.67)
Posterior surface	8 (9.75)	5 (7.69)	13 (8.84)
Anterolateral surface	7 (8.54)	4 (6.15)	11 (7.49)
Location (zone)			
Zone I	7 (8.54)	6 (9.23)	13 (8.84)
Zone II	70 (85.36)	55 (84.62)	125 (85.03)
Zone III	5 (6.10)	4 (6.15)	9 (6.13)
Direction			
Distal	82 (100.00)	65 (100.00)	147 (100.00)
Proximal	0 (0.00)	0 (0.00)	0 (0.00)

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The mean total length of humerus examined was 269.75±22.53 mm and the mean distance from of nutrient foramen from proximal end of humerus was 151.93±17.57 and calculated foraminal Index (FI) was 55.36%.

Table 3.Mean values of statistical measurements of the humeri studied (N=147).

Parameters	Mean ± SD or %		
	Right (n = 82)	**Left (n = 65)**	**Total (n = 147)**
Mean Total Length (in mm)	270.43±19.54	269.28±19.90	269.75±22.53
Distance from proximal end of the nutrient foramina (in mm)	152.35±16.98	151.96±17.15	151.93±17.57
Foraminal Index (FI) (in %)	55.57	54.94	55.36

DISCUSSION

Even with the best care, some fractures either heal slowly or not at all. Lack of artery supply is one of the main factors in non-healing or delayed healing. Through the nutrient foramen, the nutrient artery, which is the blood supply's richest source, enters the medullary cavity. The ability to recognise different nutrient foramina will enable orthopaedic surgeons execute open reductions of fractures without damaging the nutrient artery, reducing the possibility of delayed or non-union of the fracture.

From this study it is observed that 78.91% of humeri have single nutrient foramen. A study conducted by Forriol Campos et al., in 36 humeri collected from Medical School of Alcala de Henares University found that 75% of humeri had single nutrient foramen as compared to the present study [8]. A similar study done by Carroll et al., in 71 humeri collected from University of Western Ontario, London observed that 67.61% of humeri had a single nutrient foramen [7].A lower incidence of single nutrient foramenwas observed among the studies by Mansur et al., (60.87%)Shaheen et al., (60.0%) Mysorekar et al.,(58.0%) and Joshi et al., (63.0%) [4,5,9,10]. Many studies reported high percentage of incidence of single nutrient foramen. A study done by Khan et al., on 75 humerus reported that 90% of humeri had single nutrient foramen [11]. Similarly, a study conducted by Pereira et al., reported the incidence of 88.5% of humeri having single nutrient foramen in Southern Brazil and Bhatnagar et al., reported the incidence of 90% in Uttar Pradesh, India [12,13].

The present study showed that 14.29% of humeri have double nutrient foramen which was similar to the findings observed byHalagatti et al., (17.5 %) [14].Many studies reported high percentage of incidence of double nutrient foramen. Mansur et al., in Nepal reported incidence of double nutrient foramen as 28.85%, Carroll et al., in London reported incidence of double nutrient foramen among 28.16% of humeri, Joshi et al.,incidence of double nutrient foramen as 33.0% and Shaheen et al.,incidence of double nutrient foramen as 33.3% [4,7,910]. A lower incidence of double nutrient foramen was observed among the studies conducted by Bhatnagar et al.,where 7.14% of humeri were having double nutrient foramen, and Solanke et al., reported incidence of double nutrient foramen as4% [13,15].

The present study observed 3.40 % of humeri were having triple nutrient foramina which were was lower to the studies conducted by Shaheen et al., (6.7 %) in Saudi Arabia and Mansuret al., (6.32 %) in Nepal [4,9]. The findings reported by Bhatnagar et al. (1.42 %), Halagattiet al.,(2 %) and Yaseen et al., (2 %) were having comparatively lower incidence of triple nutrient foramina than the finding observed in the present study [13,14,16].

On the anteromedial surface, towards the medial border of the humeri, just below its midpoint, are the nutrient foramina. Foramina, though, can be found in different places. In the current study, 83.67% of the foramina were found on the anteromedial surface of the humeri. The majority of nutrient foramina (85.03%) were found in zone II (the middle one-third) of the shaft of the humerus, according to the current study, which is consistent with a study by Halagatti et al., that found an incidence of nutrient foramina in the middle one-third of of the

shaft of the humerus of 84.0% [14].But the studies conducted by Mansur et al.,and Khan et al.,who reported 94.84% and 96.20% of nutrient foramina were present in zone II diaphysis of the shaft of the humeri respectivelywhich was higher than the present study findings [4,11]. The studies conducted by Ukoha et al., and Kumar et al., showed that 100.0% of the nutrient foramina were located on the middle one-third of the humeri [17].
Prior to birth, the direction of the nutrient foramina is horizontal; however, as the growth process progressed, the direction of the nutrient foramina is shifted away from the growing end of the humeri. Other investigations that proved that the direction of nutrient foramina remained continuous and adhered to the law of ossification supported the current study's finding that all of the humeri's foramina of nutrient were directed towards the lower end of the humeri. However, according to the study by Kumar et al., all of the nutritional foramina in the humeri were directed away from the growing end of the humeri, with the exception of one that was directed towards the upper end, and in contrast to the incidence seen in the current investigation, a study by Khan et al., revealed that 98.67% of the nutritional foramina were directed distally towards the lower end of the humeri [11,18].

CONCLUSION

When performing various surgical procedures on the humerus, such as treating fractures, bone repair, bone grafting, micro-surgical bone transplantation, in numerous fractures, and during extensive periosteal stripping, orthopaedic surgeons must have a thorough understanding of the anatomy of the number, location, and direction of the nutrient foramina of the humerus in order to minimise damage to the nutrient artery of the humerus. In orthopaedic surgery as well as plastic and reconstructive surgery, it aids in the prevention of intraoperative damage. When placing internal fixation devices during open or closed operations to prevent delayed or non-union following humeral shaft fracture, knowledge of the location and changes in the position of the nutrient foramina may also be helpful.

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