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Morphometric study of nutrient foramina of humerus in North Indian population

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Abstract

Introduction: Knowledge of location and relevant anatomy of nutrient foramina is important in surgical procedures to preserve circulation. Non- union of fracture shaft of humerus one common complication and a great challenge to surgeons. Nutrient artery along with others play important role in treatment and healing of such problems. Therefore precise location and morphometry of nutrient foramina of humerus should be known. The role of nutrient artery in healing of fractures is well known. It is also important in medico-legal practices. Three hundred fifty human humerii were studied to determine the number, size, direction, site and location of nutrient foramina.

Materials and Method: The present study was conducted on 350 dried adult humerii of both sexes of North Indian origin, obtained from the Department of Anatomy, King George's Medical University, Lucknow, Uttar Pradesh, India. With the help of osteometric board all type of measurement were taken and observation were recorded. The number, size, site, direction and location of nutrient foramina were observed macroscopically.

Results: The nutrient foramen was absent in 5.43% of humerus single in 80.86%, double in 13.42% and three foramen was noted in0.29% on left side only. Majority of humerii showed medium size (1-2 mm) of nutrient foramina both on right and left sides. The maximum number of foramina was present on the antero-medial surface followed by posterior surface. Majority of foramen was present on the middle third region of the diaphysis of humerus. The direction of nutrient foramina in all the humerii was downward.

Conclusions: Knowledge of number, size, site, direction and location of nutrient foramina could be of interest to surgeons and clinicians who are involved in procedures such as bone grafting and surgical approach for internal fixation.

Keywords: Humerus, Diaphysis, Nutrient artery, Nutrient foramina.

Introduction

In modern era due to change of life style and dependency over and machines, injury and fracture of bones not uncommon. For the healing of wound and fractures blood supply play a major role.[1,2] The blood supply of long bone is derived from nutrient, periosteal, metaphyseal, and epiphyseal arteries. Diaphyseal nutrient artery of long bones is the main blood supply not only for osteal tissue but also for the bone marrow and is particularly important during its growth.[3] One or two main diaphyseal nutrient arteries enter the shaft obliquely through nutrient foramina leading into nutrient canals. Their sites of entry are almost constant and characteristically directed away from the dominant growing epiphysis.[4]

Position of nutrient foramina (NF) in mammalian bones are variable and may alter during the growth.[5] The topographical knowledge of these foramina is useful in certain operative procedures to preserve the circulation.[6-8] Knowledge of position, number and variation of nutrient foramina is an important tool which can be used in medico legal practices. The aim of this study was to record the number, size, position and situation of nutrient foramina in humerii of adults in North Indian population.

Materials and Method

Total 350 dried, macerated, adult, North Indian human humerii of both sexes (200 of right and 150 of left side) were taken for morphometric study of nutrient foramina from the Department of Anatomy, King George's Medical University Lucknow, Uttar Pradesh, India. The instruments used were osteometric board, metallic calibrated wires of 0.5 mm, 1 mm, 1.5 mm, 2 mm and 2.5 mm diameter, magnifying hand lens, measuring tape, scale and divider. Photographs were taken with the digital camera. All bones were closely observed for identifying nutrient foramina with the help of hand-lens, so that small foramina would not be missed. The identification of nutrient foramen was confirmed with the help of fine wire. On the surface of bone, a groove was present adjacent to the nutrient foramen which appeared to continue into it. Size of each foramen was measured with the help of small metallic wires of different diameters. These were grouped as small (diameter less than 1mm), medium (diameter between 1-2 mm) and large (diameter more than 2 mm). The number and location of foramina were measured and recorded.

Observations and Results

The incidence of the number of nutrient foramina was observed and classified according to its presence or absence. The frequency of number of foramina were observed from one to three. The nutrient foramina were absent in 19 (5.43%) humerus. The incidence of single nutrient foramen was highest which was seen in 283 (80.86%) bones (Fig, 1a). Two nutrient foramina were

observed in 47 (13.42%) cases (Fig. 1b). The number of nutrient foramina was three only in 1 (0.29%) boneon left side while none of the humerus of right side showed 3 nutrient foramina (Table 1).

Table 1: Incidence of no. of nutrient foramina in humerus

Side & no.(n) of bones	Incidence of no. of nutrient foramina (%)			
	Absent (0)	One (1)	Two (2)	Three (3)
Right (n=200)	13 (6.5%)	155 (77.5%)	32 (16%)	0 (0%)
Left (n=150)	6 (4%)	128 (85.33%)	15 (10%)	1 (0.67%)
Total (350)	19 (5.43%)	283 (80.86%)	47 (13.42%)	01 (0.29%)

Fig. 1

The incidence of various sizes of nutrient foramina was classified according to their diameter under three groups i.e. small (<1mm), medium (1-2mm) and large (>2mm). Out of total 380 nutrient foramina (219 right and 161 left sided), incidence of small size foramina was 21.84% (n=83), medium size 74.21% (n=282) and only 3.95% (n=15) foramina were of large size (Table 2).

Table 2: Incidence of size of nutrient foramina in humerus

Side of bone & total no. of foramina (n)	Incidence of size of nutrient foramina (%)		
	Small (<1mm)	Medium (1-2mm)	Large (>2mm)
Right (n=219)	44 (20.09%)	167 (76.25%)	8 (3.65%)
Left (n=161)	39 (24.22%)	115 (71.43%)	7 (4.35%)
Total (380)	83 (21.84%)	282 (74.21%)	15 (3.95%)

The site of nutrient foramina in relation to different surfaces of humerus (200 right and 150 left) was observed and it was seen that they were present on the antero-medial, antero-lateral and posterior surface. Out of total 380 nutrient foramina (219 right and 161 left sided), incidence of 84.74% (n=322) was seen on antero-medial surface followed by 12.11% (n=46) on posterior surface and 3.16% (n=12) on antero-lateral surface(Table 3).

Table 3: Situation of nutrient foramina in relation to different surfaces of humerus

Side of bone	Total no. of bones	Total no. of foramina	Position of foramina		
			Antero-medial Surface	Posterior Surface	Antero-lateral Surface
Right	200	219	188 (85.84%)	26 (11.87%)	5 (2.28%)
Left	150	161	134 (83.23%)	20 (12.42%)	7 (4.34%)
Total	350	380	322 (84.74%)	46 (12.11%)	12 (3.16%)

The site of nutrient foramina in relation to different parts of shaft of humerus was also describe die on proximal one-third, middle one-third and distal one-third. Out of total 380 nutrient foramina (219 right and 161 left sided), maximum number (n=371) was observed in middle one-third of shaft i.e. 97.63%, followed by 1.84% (n=7) on distal one-third and only 0.53% (n=2) foramina were present in proximal one third part (Table 4).

Table 4: Site of nutrient foramina in relation to different parts of humerus

Side of bone	Total no. of bones	Total no. of foramina	Situation of foramen		
			Proximal 1/3rd of bone	Middle 1/3rd of bone	Distal 1/3rd of bone
Right	200	219	2 (0.91%)	212 (96.80%)	5 (2.28%)
Left	150	161	0 (0%)	159 (98.76%)	2 (1.24%)
Total	350	380	2 (0.53%)	371 (97.63%)	7 (1.84%)

Discussion

During the active growth of long bones the nutrient artery is a principle source of blood. Berard(1835) was the first to correlate the direction of nutrient canal with the mode of ossification and growth of bone.[9] The humerus also received blood supply from other sources like metaphyseal and periosteal arteries which are branches of axillary and brachial artery. The periosteal and the metaphyseal arteries supply the outer cortex and the metaphysis of the bone, but the inner half of the cortex and the medulla of the shaft are predominantly dependent on the nutrient artery. The study on the blood supply of the shaft will help in knowing about the healing of fractures, delayed unions and non-unions of the bone following fractures and bone transplants.[10]

The incidence of single nutrient foramen ranged from 63% to 93% in different studies.[2,6,11-20] Our finding of 80.86% is approximately same as that of Manjunath & Pramod (2011) who reported in 80.5% cases.[19] The range of occurrence of double foramen

was found to be 7% to 42%.[2,6,11,17-20] It was 13.42% in the present study which correlated well again with the study of Manjunath & Pramod (2011) who reported in 17.5% cases.[19] According to Kizilkanat,[16] frequency of three foramina in the humerus did not more than 1-7%.[11,17-20] But in our study this was observed only in 0.29% specimen. On the other hand Kizilkanat (2007) also reported the presence of four nutrient foramina in 1% of the humerii studied.[16] This was not observed in the present study. Moreover, the absence of nutrient foramina was also reported in 5.43% humerii in the present study which correlated well with other studies.[12,14,16,21] In these cases bone received blood supply from periosteal vessels.

The size of nutrient foramen was categorized into small (<1mm), medium (1-2mm) and large (>2mm). 21.84% of humerii showed small, 74.21% exhibited medium while only 3.95% have large foramen in the present study. The sizes of the foramina ranged from 0.45 to 1.2 mm with average of 0.828 mm 0.26 in a study conducted in Tamilnadu (South India) by Chandrasekaran and Shanthi (2013).[18] These results are nearly similar with the present study. These findings are important for the clinicians who are involved in bone graft surgical procedures.

The situation of nutrient foramen in relation to different surfaces of humerus was also noted. The maximum number of foramen was found on antero-medial surface (84.74%) followed by posterior surface and antero-lateral surface. The findings of present study are in consensus with those of Chandrasekaran and Shanthi (2013).[18] Predominant location of nutrient foramen on the anteromedial surface was also stated by many previous studies.[2,11,13,16,17,22]

Nutrient foramina were also classified according to their situation in relation to different parts of humerus. Maximum number were located on the middle 1/3rd of humerus (97.63%) followed by distal 1/3rd and proximal 1/3rd. The findings are in agreement with that of Chandrasekaran and Shanthi (2013)[18] but they didn't found any foramen in the proximal 1/3rd part. In some previous studies position of nutrient foramina found in the middle third of the bone.[18] Carroll stated that the nutrient artery enters through the restricted antero-medial surface, in the middle 1/3rd of the humerus and that the surgeries which are done on the middle 1/3rd of the shaft of the humerus should be handled well without causing damage to the nutrient foramen, in order to prevent delayed unions or non-unions of the fractures.[17]

Location of nutrient foramen is important for surgeons, as injury to nutrient artery in growing bones can lead to necrosis of bone and delay inn growth. The data obtained from the present study would be of interest to clinicians who are involved in procedures such as bone grafting and surgical approach for internal fixation. For the healing of any wound or fracture blood supply play a major role.[1,23] Any damage to the nutrient artery during surgical procedures or subsequent manipulations is a significant factor which may lead to delayed unions or non-unions.[9,10]

In general it was described that the vessel which invades ossifying cartilage are nutrient vessels and site is nutrient foramen, so nutrient foramen is actual site of ossification centre.[24]

The direction of nutrient foramina were determined by growing end of in a typical long bone and it was supposed that growth of growing end about twice fast than other end.[6] The growth of two ends and remodeling may affect position of nutrient foramina.[5] Nagel (1993) described the risks for intra-operative injury to the nutrient artery during its exposure. It was described that the knowledge about these foramina is useful in the surgical procedures to preserve the circulation.[15]

Conclusion

The nutrient foramina of the humerii were maximally located in the middle third followed by distal and proximal third of shaft. The location of foramen was noted on the antero-medial, antero-lateral and posterior surfaces. Most of humerii had one NF though it was observed that some cases had more than one foramina. These finding are very important for orthopedic surgeons who are involve in various surgical procedures like treatment fracture and bone grafting and equally important to clinical anatomists and morphologist.

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