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Morphological and Topographical Study of Nutrient Foramina in Adult Humerii

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Abstract:
Fracture of long bones is very common and major complications of these fractures are non-union and delayed union. There are various reasons for these complications and blood supply to the bone plays an important role in it. Blood supply of long bones is mainly by nutrient artery. This study was done to analyse the nutrient foramina in dry adult human humerii. The study was aimed to note the number of nutrient foramina, their size and location with respect to surface and zones on the shaft of humerus.
Total 100 dry adult humerii were studied and maximum bones had 1 nutrient foramen located on anteromedial surface in middle 1/3rd of shaft. Maximum number of foramen found in this study was 3. Nutrient foramina were also located on anterolateral and posterior surface. None was located in upper 1/3rd; few bones showed nutrient foramen in lower 1/3rd.
This study helps in enhancing the knowledge about the anatomy of nutrient foramina and is important for orthopaedic surgeons to plan the reduction of fractures and reduce the chances of post reduction complications.

Key words*: nutrient foramina, fracture humerus, non-union, delayed union, vascular bone grafting*

1. Aims and Objectives

The aim of the study was to determine the morphology and topography of nutrient foramina of adult humerus.

2. Materials and Methods

In this study 100 dry normal humerus bones of unknown sex were collected from anatomy department and museum of Shadan Institute of Medical Sciences. Bones which were damaged or with pathological abnormalities were not included in the study. The Humerii were numbered using a marker pen. Length of each bone was measured from superior aspect of lesser tubercle to the inferior surface of medial epicondyle of humerus by using an osteometric board. The humerus bone was divided into three equal zones. Upper 1/3rd was zone I, middle 1/3rd was zone II and lower 1/3rd was zone III. With the help of a hand lens nutrient foramina were observed and their location was noted with respect to the surface – Anteromedial, Anterolateral and Posterior, and zones of the shaft. The size of nutrient foramina was determined by using hypodermic needles of various sizes. The Foramina which accepted 20 gauge needles was placed under large size, 22 for medium size foramina and 24 for small sized foramina. When more than one foramen was founded, the larger nutrient foramen was considered as the dominant and its size was noted. The direction of nutrient foramina leading to nutrient canal was also noted. All the data thus collected was compiled, tabulated and statistically analysed by calculating percentage and mean.

3. Introduction

The humerus is the largest bone in the upper limb. Most injuries of the proximal end of humerus are fractures of surgical neck. These injuries are especially common in elderly people with osteoporosis. An avulsion fracture of greater tubercle of the humerus is seen most commonly in middle aged and elderly people. A transverse fracture of shaft of humerus is commonly encountered by orthopedicians which results from direct blow to the arm. The proximal fragment is carried laterally due to pull of deltoid muscle. Indirect injury like fall on outstretched hand may produce spiral fracture of humeral shaft. Overriding of the oblique ends of fractured

bones may result in foreshortening. As humerus is surrounded by muscles and has well developed periostium, the bone fragments usually untie well (1). The healing of fracture is dependent upon blood supply of the bone. As other long bones, humerus is also supplied by four sets of arterial system – Nutrient artery, Epiphyseal, Metaphyseal and Periosteal Arteries. Nutrient Artery is the major source of blood supply to the bone and hence plays an important role in healing of fracture. Usually, Nutrient Artery to humerus is a branch of brachial artery. It enters into the bone from anteromedial surface at middle 1/3rd of shaft (2). Nutrient artery is usually ruptured during the fracture of shaft along with variable disruption of peripheral vessels associated with periosteal detachment (3, 4). Injury to the nutrient artery also occurs during open or closed reduction of the fracture. So it is very important to have a detailed knowledge of nutrient foramina in orthopaedic surgical procedures such as reduction of fractures, vascularised bone microsurgery etc. In free vascular bone grafting, the blood supply by nutrient artery is extremely important and must be preserved in order to promote fracture repair, as good blood supply is necessary for osteoblast and osteocyte cell survival as well as facilitating graft healing in the recipient (5).

By defining the restricted area of entry of nutrient artery into the nutrient canal through nutrient foramen, injury to nutrient artery can be avoided and thereby minimizing the risk of non-union or delayed union of fractured shaft humerus (6). This study was undertaken to determine the number and size of nutrient foramina, its position with respect to humeral surface and zones. Also, direction of nutrient canal was noted to determine whether the nutrient foramina obey the rule that it is directed away from growing end.

4. Result

Among 100 bones studied, 58 bones were left sided and 42 were right sided. The length of humerii ranged from 26.5 cm to 32.7 cms and mean length was 28.57 cm.

No of nutrient foramina: Majority of humerii had 1 foramen. 79% humerii had 1 foramen while 19% humerii had 2 foramina and only 2% bones had 3 foramina.(table 1)

No of foramina	Right sided humerus		Left sided humerus		Combined %
	Number	%	Number	%	
1	34	81	45	77.5	79
2	8	19	11	19	19
3	0	0	2	3.5	2

Table 1: shows the number of nutrient foramina on right and left sided humerus along with combined %

Size of dominant nutrient foramina: Small sized nutrient foramina were found only in 4% humerii while medium sized foramina were found in 38% humerii and large sized foramina were present in 58% humerii. Higher proportion of large dominant foraminawas present on right sided humerii while higher proportion of medium sized and small sized dominant foramina was found on left sided humerii. (Table 2)

Size of foramina	Right sided humerus		Left sided humerus		Combined %
	Number	%	Number	%	
Small	1	2	3	5	4
Medium	14	33	24	41	38
Large	27	64	31	54	58

Table 2: Shows size of nutrient foramina on right and left sided humerus along with combined %

Location of nutrient foramina in relation to surface of shaft of humerus: Total number of nutrient foramina found in 100 humerii was 139, out of which 88.5% were present on anteromedial surface, 8% on posterior surface and 3.5% on anterolateral surface (table 3).

Surface	No of humerus	Percentage%
Anteromedial	123	88.5
Anterolateral	5	3.5
Posterior	11	11

Table 3: Shows location of nutrient foramina in relation to the surface of humeral shaft

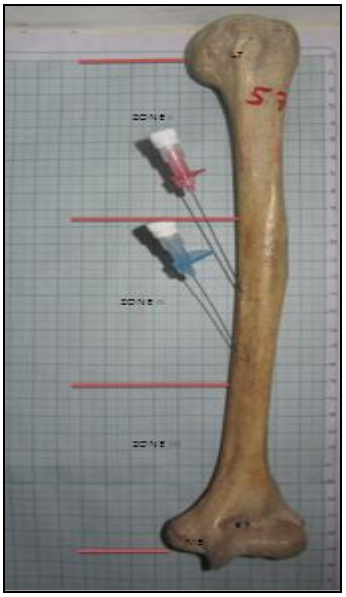

Figure 1: Showing three zones of humerus with 1 large sized and 1 medium sized nutrient foramen present on anteromedial surface of shaft in Zone II. LT = Lesser Tubercle, ME= Medial Epicondyle

Location of nutrient foramina in relation to the zones of humerus: According to the zone, number of nutrient foramina located in middle 1/3rd(zone II) of humerus were 124 (89%), nutrient foramina in lower 1/3rd(zoneIII) were 15 (11%) . No nutrient foramen was found in upper 1/3rd (zone I) (table 4).

ZONE	No of humerus	Percentage%
I	0	0
II	124	89
III	15	11

Table 4: Shows location of nutrient foramina in relation to zone of humeral shaft

Direction of nutrient foramina: Out of all nutrient foramina observed, 138(99.2%) were directed obliquely towards the lower end of humerus. Only 1 (0.8%) nutrient foramen was directed horizontally and none was directed towards the upper end.

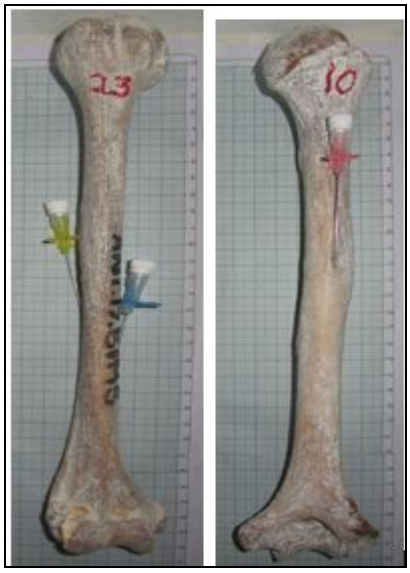

Figure 2: Showing Two nutrient foramina, medium sized on anteromedial surface and small sized on anterolateral surface of shaft
Figure 3: Showing one nutrient foramen of large size present on posterior surface of shaft

5. Discussion

Humerus is the largest bone of upper limb so it also enjoys highest vascularity among the bones of upper limb. Blood supply is mainly by brachial artery and also by axillary, radial and ulnar arteries. The periosteal and metaphyseal arteries supply the outer cortex and metaphysis of bone and the inner half of cortex and medulla depend upon nutrient artery for blood supply. Vascularity of humerus was studied by Laing and he stated that nutrient artery of humerus must be protected during operations done on shaft of humerus(7).

In a study done by ShantaChandrasekaran et al on 258 humerii, 198 (76.74%) humerii had single nutrient foramen while 53 (20.54%) had two nutrient foramina and only 7 (2.71%) humerii had three nutrient foramina (8). Manjunath SH et al studied 200 humerii and reported 161 (80%) single nutrient foramen, 35 (18%) double nutrient foramina and 4 (2%) showed triple nutrient foramina (2). While in a study conducted by P. Anusha et al on 50 humerii, one nutrient foramen was found in 36 (72%) humerii, two in 12 (24%) humerii. In this study 2 (4%) humerii were found to have no nutrient foramina at all and none was reported to have three nutrient foramina (4). Laing PG et al reported 28 (93%) humerii with one nutrient foramina and 2 (7%) humerii with two nutrient foramina out of 30 humerii studied (7). In present study all humerii studied showed either 1, 2 or 3 foramina which related to past studies. No humerus was observed with no nutrient foramen or more than 3 foramina. However, few workers have reported even four foramina but its very rare (9). In our study majority of humerii (79%) showed one nutrient foramen while 19% humerii had two nutrient foramina and only 2 humerii showed three nutrient foramina. Observations were made that number of nutrient foramina did not show any relationship to the length of the humerus. Chhatrapati et al concluded in his study done on 125 humerii that position and number of nutrient foramina on shafts of long bones are variable. It is not possible to find the total length of a long bone in relation to the nutrient foramen (11). Manjunath et al shared same point of view (2).

In a study done by Manjunath SH et al it was reported that 19% humerii had medium sized nutrient foramina and 81% humerii had large sized foramina (2). Carroll SE et al reported that 7% of humerii has small sized nutrient foramina, 41% had medium sized foramina and 52% had large sized foramina (6). In present study also large sized foramina were found to be maximum and small sized foramina were least.

Manjunathconcluded in his study that nutrient artery to the humerus enters through a restricted surface area on the anteromedial surface of middle $1/3^{rd}$ of shaft. He found 87% of nutrient foramina on anteromedial surface and 84% on middle $1/3^{rd}$ of humerus (6). As reported by Hemang J et al 77% foramina were in medial zone which included anteromedial surface and medial border and most of them lying in middle of shaft (10). Observations made in present study are in acceptance with those of previous studies stated above that maximum number of nutrient foramina is present on anteromedial surface of shaft in middle $1/3^{rd}$.

Nutrient artery enters the bone during early stages of development and as growth takes place external end of nutrient canal is usually directed away from the growing end. So the nutrient foramen in humreus lies obliquely towards elbow. We observed that out of 139 foramina in 100 humerii, 138 were oblique towards lower end of humerus but 1 was directed horizontally.

6. Conclusion

This study provides an information on morphology and topography of nutrient foramina in humerus which is of great use to orthopaedic surgeons to treat fractures of humerus and also to minimise complications of this treatment. This study will also help to enlighten the clinicians dealing with microvascular bone transfer. Observations made in this study make it quite evident that entry of nutrient artery is restricted to anteromedial surface on middle $1/3^{rd}$ of humerus. So one has to be careful to guard nutrient artery against any injury, especially in this area during surgeries on humerus.

7. References

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