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AN OSTEOLOGICAL STUDY ON NUTRIENT FORAMINA OF HUMAN DRY ADULT ULNA BONES

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ABSTRACT

Background: Nutrient artery is the major source of blood supply to long bones. This artery enters the shaft of the long bone through nutrient foramen. Vascular insults to the Ulna during fracture dislocation or during surgical correction of fracture may result in delayed healing or non-union of fracture.

Materials and Methods: The present study was undertaken on 100 dry adult ulna bones of unknown sex (50 each of right and left sides) from Department of Anatomy, Gadag Institute of Medical Sciences, Gadag, Karnataka. The ulna bones were numbered using a marker pen. Using Hepburn's osteometric board, length of the bone was measured. The size and direction of the nutrient foramina was assessed using 19, 22 and 25 gauge hypodermic needles.

Results: Among the total 100 ulna studied, 86 had single nutrient foramina, 13 had two nutrient foramina and 1 had three nutrient foramina. 59.13% of nutrient foramina were of medium sized and 20% were of large size. 85.22% of nutrient foramina were located in upper third of shaft of ulna; 12.17% in middle third and 2.61% in lower third. 1% of NF were directed horizontally, 2% lower oblique and remaining upper oblique. No correlation could be demonstrated between the length of ulna and number of nutrient foramina in the present study.

Conclusion: The present study conducted on nutrient foramina of 100 dry adult ulna arrived at a conclusion that majority of nutrient foramina were located in the upper third of the shaft in anterior surface. The results of the present study are consistent with most similar studies. The knowledge of location, direction and number of nutrient foramen on shaft of ulna is of utmost importance to the Orthopaedicians and Oncologists.

KEY WORDS: Ulna, Nutrient Foramina, Diaphysis, Fracture, Bone graft.

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INTRODUCTION

The bones of the forearm are the radius and ulna, the former being developmentally the preaxial bone and therefore corresponding to the tibia of the leg, the latter corresponding to the fibula, the postaxial bone [1].

Similar to a typical long bone Ulna is fed by four groups of arterial systems, which are – a nutrient artery, epiphyseal, diaphyseal and periosteal arteries. The arteries supplying these long bones pervade into it via numerous foramina located over its different segments, being named as vascular foramina. Among these vascular foramina, nutrient foramen is an important one which gives way to the nutrient artery [2].

Fractures of shaft of Ulna are quite common and are more prone for delayed union. Fractures of distal one third of ulna have got greater incidence of delayed union than those of upper end, because the upper end has got more blood vessels passing into the bone then the lower end [3]. Healing of fracture depends on its blood supply. Injury to the nutrient artery at the time of fracture or at subsequent manipulation is an important cause for faulty union. As most cases of fractures of shaft of ulna require operative treatment, in order to prevent damage to supplying vessels, the position, direction and penetration of the arteries of ulna are to be known.

The nutrient arteries enter Ulna in the second proximal quarter of diaphysis, from anterior to anterolateral. If surgeons could avoid these areas particularly during open reduction than post-operative complications like delayed union, malunion and avascular necrosis can be avoided [4].

It is worth to find the number and size of nutrient foramina. There is not much available data concerning the exact location and entrance of vessels through nutrient foramina. The knowledge regarding the nutrient foramina helps to protect them during conservative operative procedures of the bone, such as bone grafts, microsurgical vascularised bone transplantation, tumour resections, etc.

MATERIALS AND METHODS

The present study was undertaken on 100 dry adult ulna bones of unknown sex (50 each of right and left sides) from Department of Anatomy, Gadag Institute of Medical Sciences, Gadag, Karnataka. The ulna bones were numbered using a marker pen. Using Hepburn's osteometric board, length of the bone was measured. The size and direction of the nutrient foramina was assessed using 19, 22 and 25 gauge hypodermic needles (Fig. 1).

Shaft of Ulna was divided into following segments – upper 1/3, middle – 1/3 and lower 1/3. Each third of the shaft was further observed The direction of nutrient foramina was also noted and categorized into three types: horizontal (H), upper oblique (UO) and lower oblique (LO). Its location on the surface of ulna was also observed. Statistical methods (SPSS) were used to analyze these observations.

Fig.1: Materials used in the study. A. Hepburn's osteometric board. B. Marker pen and hypodermic needles of different gauges.

RESULTS

The results are shown in Tables 1 to 5. Among the total 100 ulna studied, 86 had single nutrient foramina, 13 had two nutrient foramina and 1 had three nutrient foramina. 59.13% of nutrient foramina were of medium sized and 20% were of large size. 85.22% of nutrient foramina were located in upper third of shaft of ulna; 12.17% in middle third and 2.61% in lower third. In the upper third, 97.96% of nutrient foramina were located in anterior surface and 2.04% in medial surface. In middle third 92.86% of nutrient foramina were located in anterior surface and 7.14% in posterior surface. In lower third all nutrient foramina were located in anterior surface. 1% of NF were directed horizontally, 2% lower oblique and remaining upper oblique. No correlation could be demonstrated between the length of ulna and number of nutrient foramina in the present study (Table 6).

Table 1: Number of Nutrient foramina.

Number of Nutrient Foramina	Total number of Ulna	Total number of Nutrient Foramina
0	0	0
1	86	86
2	13	26
3	1	3
Total	100	115

Table 2: Size of Nutrient foramina.

Size of Nutrient Foramina (in mm)	Number of Nutrient Foramina	Percentage
Small (>0.5 <0.71)	24	20.87
Medium (>0.71 <1.1)	68	59.13
Large (>1.1)	23	20

Table 3: Location of Nutrient foramina in different surfaces of shaft.

Location of Nutrient Foramina	Number of Nutrient Foramina	Percentage
Anterior surface	112	97.39
Posterior surface	1	0.87
Medial surface	2	1.74

Table 4: Location of Nutrient foramina in different segments of shaft.

Location of Nutrient Foramina	Number of Nutrient Foramina	Percentage
Upper 1/3	98	85.22
Middle 1/3	14	12.17
Lower 1/3	3	2.61

Table 5: Direction of Nutrient foramina in different segments of shaft.

Location of Nutrient Foramina	Number of Nutrient Foramina	Percentage
Horizontal	1	0.87
Upper oblique	112	97.39
Lower oblique	2	1.74

Table 6: Length of Ulna v/s number of Nutrient foramina.

Length of Ulna	Number of Ulna of this length studied	Nutrient Foramina	
		Total number	Average
19.1 – 20	2	2	1
20.1 – 21	3	4	1.33
21.1 – 22	9	11	1.22
22.1 – 23	26	29	1.11
23.1 – 24	21	28	1.33
24.1 – 25	18	18	1
25.1 – 26	17	19	1.11
26.1 – 27	3	3	1
27.1 – 28	1	1	1
Total	100	**115**	

DISCUSSION

The ulna being the medial bone of forearm derives its nutrition from different arterial sources of upper limb. Blood supply is accomplished via various branches of brachial artery, profunda brachii artery, radial and ulnar arteries. The quantity of blood supply provided by each of these sources is determined by the number and caliber of branches of these arteries. The bone exhibits difference in its response to healing of fractures and survival of grafting procedure based on difference in arterial inputs. A study of the blood supply by Robert WJ concluded that, inner half of the cortex and the medulla are vascularized by the nutrient artery, and it should be intact for the active repair of injuries. Outer half of the cortex is nourished by the periosteal vessels, and these vessels, do not provide an effective collateral supply to the medulla of the diaphysis. The periosteal repair was relatively poor in the healing of cortical defects. As far as shaft is concerned, nutrient vessels are the most important, followed by metaphyseal and then the periosteal vessels. The anatomical and physiological study of blood supply of diaphysis will aid in dealing with problems like non-union, delayed union, bone transplants, etc [5].

Hughes H stated that variations in the direction of the nutrient foramina have been observed in many tetrapods and there is some similarity in the nutrient foraminal pattern in mammals and birds. According to him, anomalous canals are found most frequently in the femur, but rarely occur in the radius and seldom in other bones, and he provides an explanation of unequal arterial growth, according to which, if unit lengths of an artery lying close to a long bonedo not grow at equal rates anomalous canals can occur [6].

Table 7: Observations on the number of Nutrient Foramina (NF) of ulna in the present study have been tabulated with similar studies.

Studies	Total no. of bones studied	Total no. of NF	Percentage of bones with					
			No NF	1 NF	2 NF	3 NF	4 NF	5 NF
Present study	100	115	0	86	13	1	0	0
Mysorekar VR [7]	180	188	1	94	5	0	0	0
Chhatrapati DN [8]	68	71	0	96	4	0	0	0
Kate BR [9]	50	50	0	100	0	0	0	0
G Vinay [10]	32	36	0	87.5	12.5	0	0	0
Spatika Ashwini [11]	84	102	0	78.6	21.4	0	0	0
Veeramuthu M [12]	59	59	2	96	2	0	0	0
Sharma M [13]	40	42	0	95	5	0	0	0
Prasad KRS [14]	98	152	0	68	20	4	6	2

The arteries which supply the shaft are mainly the nutrient arteries. In the present study, the density of nutrient foramina was observed in the upper third of the anterior surface of the shaft. The size of the majority of nutrient foramina in the present study was medium ranging from 0.71 to 1.1 mm. This suggests the importance and critical role of nutrient artery in vascularization of long bones. The direction of nutrient foramina was towards the elbow (97%), which is in accordance with the general rule of direction of nutrient foramina.

Fig.2: Ulna showing two NF.

Table 8: Observations on the location of Nutrient Foramina (NF) in different segments of the shaft of the ulna have been tabulated with similar studies.

Studies	Location of NF			
	Upper third (%)	Middle third (%)	Lower third (%)	Junction of upper & middle third
Present study	85	12	3	0
Mysorekar VR [7]	35	62	0	3
Kate BR [9]	100	0	0	0
G Vinay [10]	44.4	55.6	0	0
Spatika Ashwini [11]	39.3	60.7	0	0
Prasad KRS [14]	48.7	32.9	18.4	0

These tables 7 to 9 show that the arrangement of the diaphyseal nutrient foramina in the ulna usually follows a definite pattern. The foramina are located at the upper third and middle third of the shaft and most frequently occur on the anterior surface.

In our study we found 13% of the ulnae had 2 NF and 1% had 3 NF. In Mysorekar VR study 5% of the ulnae had 2 NF and 4% in Chhatrapati DN study. In G Vinay study 12.5% of the ulnae had 2 NF and 21.4% in Spatika Ashwini study (Table 7).

Majority (85%) of the NF were located in the upper third of the shaft of ulna in our study, which is in agreement with Kate BR study. However Mysorekar VR (62%), G Vinay (55.6) and Spatika Ashwini (60.7) study concludes majority were located in middle third (Table 8). The presence of the nutrient foramina at different levels could be due to differential growth and the length of the bones in different ethnic groups.

The number of nutrient foramina did not show any relationship to the length of the ulna in our study. It is because the nutrient arteries are concerned with intraosseous plexus within the medullary cavity for regeneration of the blood and formation of bone marrow. This is in full agreement to the similar observations made by Harrison TJ [15]. It is not possible to find the total length of a long bone in relation to the position of nutrient foramen. The present study is in full agreement to that of Chhatrapati's study, as correlation was not observed between number and location of nutrient foramen and the length of ulna.

Table 9: Observations on the location of Nutrient Foramina (NF) on different surfaces and borders of the shaft of the ulna have been tabulated with similar studies.

Studies	Anterior surface (%)	Posterior surface (%)	Lateral surface (%)	Interosseous border (%)	Anterior border (%)	Medial border (%)
Present study	97	1	2	0	0	0
Mysorekar VR [7]	73	0	0	10	17	0
Chhatrapati DN [8]	80	0	0	10	10	0
Kate BR [9]	100	0	0	0	0	0
G Vinay [10]	29	0	0	5	0	2
Spatika Ashwini [11]	77	-	-	-	-	-
Veeramuthu M [12]	76	2	5	0	15	0
Sharma M [13]	52	0	0	5	43	0
Prasad KRS [14]	90.8	5.3	0	2.6	1.3	0

Blood supply to the bones varies according to their shape. Long bones tend to have a chief artery to the shaft, called the nutrient artery. The nutrient artery enters the bone during early development and as the bone grows, the nutrient canal in which it lies usually has its external end carried toward the faster growing end. In most long bones, growth in length of the bone occurs much more at one end than at the other; thus, the slant of the canal from surface to marrow cavity is commonly towards the end that has grown less rapidly [16]. The direction of nutrient foramen in this study was consistent towards the upper end i.e. upper oblique.

CONCLUSION

The present study conducted on nutrient foramina of 100 dry adult ulna arrived at a conclusion that majority of nutrient foramina were located in the upper third of the shafts in anterior surface. The results of the present study are consistent with most similar studies. The location of nutrient foramen is highlighting as the nutrient artery may be involved in iatrogenic or traumatic injuries. As the nutrient artery is the major source for the medullary wall and bone marrow, its zone over the shaft should be tackled with utmost care during surgical interventions for fractures in the upper third of ulna. In the present study there was no increase in number of nutrient foramina with increase in length of ulna. The location of nutrient foramina is also inconsistent to arrive at particular relation between length of ulna and location of nutrient foramen. The knowledge of location, direction and number of nutrient foramen on shaft of ulna is of utmost importance to the Orthopaedicians and Oncologists.

Conflicts of Interests: None

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