VOLUME-8, ISSUE-12, DECEMBER-2019 • PRINT ISSN No. 2277 - 8160 • DOI : 10.36106/gjra

Original Research Paper

Anatomy

INDEXING OF THE NUTRIENT FORAMINA OF FOREARM BONES

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ABSTRACT

INTRODUCTION- Nutrient foramina (NF) are the cavities present on the diaphysis of long bones that conduct the nutrient arteries and peripheral nerves of the bones. The detailed knowledge of position and number of NF is very important during bone transplants and resection. They also provide baseline data to calculate the length of the bones from the given fragments.

OBJECTIVES: To determine the foraminal index of the nutrient foramen in radius and ulna.

METHODS: 50 radii and 50 ulnae were taken. In all the bones nutrient foramina were identified. The total length and distance of the foramen from the proximal end of the bones were measured by using the digital vernier caliper. Mean foraminal index was calculated for both radius and ulna. (Foramen index= distance of the foramen from the proximal end/bone length). Also, the number and the distribution of the foramina concerning specific regions/surfaces of the diaphysis were identified.

RESULTS: All the bones had nutrient foramen directed towards the elbow. The mean foraminal index was found to be different for the different surfaces in radius and ulna respectively. Nutrient foramen was double in 4%radii and 4% ulnae both. Also, majority of the bones had a nutrient foramen on their anterior surface.

CONCLUSION: The foraminal index of radius and ulna can be useful in certain surgical procedures to preserve the circulation. Also, the accurate anatomical description of these foramina would be useful in microvascular bone transfer in the forearm.

KEYWORDS : Nutrient Foramina, Radius, Ulna.

INTRODUCTION

Nutrient foramina (NF) are the cavities present on the diaphysis of long bones that conduct the nutrient arteries and peripheral nerves of the bones.[1] They are fundamentally present at a particular position for each bone and seen on flexor surfaces.[2] The direction of the NF obeys a jingle " towards the elbow we go, from the knee we flee". [3] The direction of the nutrient canal is important to know the growing end of a bone [4]. The nutrient foramen has a particular position for each bone [5]. The detailed knowledge of position and number of NF is very important during bone transplants and resection.[6] The present study was done to determine if the number and position of the NF in the Radii and ulnae, direction and the obliquity of the nutrient canals running from them. Also, the foraminal index of both the radii and ulnae were calculated which would provide a baseline data to calculate the length of the bones from the given fragments and ultimately the stature from the bone length.[7]

MATERIAL AND METHODS

The study comprised of randomly selected 50 radii and 50 ulnae of unknown age and sex, obtained from Government Medical College Patiala. The broken bones and the bones with gross abnormality were excluded from the study. NF's were observed with the naked eyes. Location and directions of foramen were noted in each bone. Patency and direction were checked with the help of 24 hypodermic needles. The smaller foramen were more carefully observed with the help of a hand lens. The smaller foramen(less than the size of 24 hypodermic needles) were considered as the secondary foramen and larger foramen (more or equal to the size of 24 hypodermic needles) as the dominant foramen(1). The number and the distribution of the foramina concerning specific surfaces of the diaphysis were identified. The total length of the bones (in mm) and the distance of the foramen from the proximal end of the bones was measured by using the digital vernier caliper. Mean foraminal indices were calculated for each surface of the radius and ulna of both sides. The total length of the radius was taken as the distance between the most proximal margin of the head of the radius and the tip of the radial styloid process. The distance between the most proximal margin of the olecranon and the tip of the ulnar styloid process was measured to calculate the total length of the ulna.

The position of all nutrient foramina was determined for both types of the foramina by calculating a foraminal index (FI) using the formula:

FI = (DNF/TL) x 100

DNF = Distance the NF from the proximal end.
TL = Total bone length.

RESULTS

Table no-1

No. of nutrient foramen observed in radii and ulnae of both sides

No of nutrient foramina	Bones					
	Radius {N=50}			Ulna {N=50}		
	Rt {N=14}	Lt {N=36}	Total {N=50}	Rt {n=23}	Lt (n=27)	Total (N=50)
1 [n%]	14 (100%)	33 (91.66%)	47 (94%)	22(95.65 %)	25(92.59 %)	47(94%)
2 [n%]	---	3 (8.34%)	3(6%)	1(4.34%)	2(7.41%)	3(6%)

Table no. 1 shows that there was single NF in all the 14 right-sided radii while out of 36 left-sided radii 33 had a single NF and 3 had a double NF. Out of 23 right-sided ulnae, 22 had a single NF while 1 had a double foramen. In case of total 27 left-sided ulnae, 25 had a single NF and 2 had a double NF.

Given below is the graph showing the nutrient foramina for radii and ulnae of both sides.

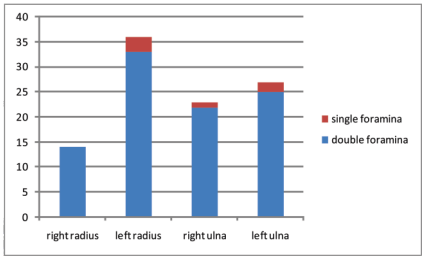

Table no-2

Position and number of dominant (DF) and secondary (SF) nutrient foramina observed in the radii of right side

Position	Total no of foramina	%age	No. of foramina			
			Single		Two	
			DF	SF	DF	SF
Anterior surface (midway between anterior and interosseous border)	7	50	2	5	--	--
Anterior surface (close to interosseous border)	3	21.42	1	2	--	--
Anterior surface (close to anterior border)	2	14.24	--	2	--	--
Posterior surface (close to interosseous border)	2	14.24	1	1	--	--

Table 2 shows that in the right-sided radii 7 bones had NF on their anterior surfaces (AS) midway between anterior and interosseous border (IB). Out of these seven NF, 2 were DF and 5 were SF. 3 of the right-sided radii had single NF on the AS located close to IB out of which 1 was DF and 2 were SF. Two of the radii had a single NF located on the AS close to the anterior border and both of them were SF. Two of the bones were having single NF on the posterior surface close to the IB out of which 1 was a DF and other was SF.

Table no-3

Position and number of dominant (DF) and secondary (SF) nutrient foramina observed in the radii of left side

Position	Total no of foramina	%age	No. of foramina			
			Single		Two	
			DF	SF	DF	SF
Anterior surface (midway between anterior and interosseous border)	27	69.23	5	20	1	1
Anterior surface (close to interosseous border)	5	12.82	1	2	1	1
Anterior surface (close to anterior border)	2	5.12	--	2	--	--
Posterior surface (close to interosseous border)	5	12.82	1	2	1	1

Table 3 shows that in the left-sided radii 26 bones (25 with Single NF and 1 with double NF) had NF on their anterior surfaces (AS) midway between anterior and IB.Out of these twenty seven NF 6 (5+1) were DF and 21(20+1) were SF. 4 of the left-sided radii (3 with single NF and 1 with Double NF) had NF on the AS located close to IB where 2 (1+1) of the NF were DF and 3(2+1) were SF. Two of the radii with single NF had their NF on the AS located close to the anterior border and both of them were SF. Four (3 with single NF and 1 with Double NF) of the bones had their NF on the posterior surface close to the IB out of which 2(1+1) were DF and three(2+1) were with SF.

Table no-4

Position and number of dominant (DF) and secondary (SF) nutrient foramina observed in the ulnae of right side

Position	Total no of foramina	%age	No. of foramina			
			Single		Two	
			DF	SF	DF	SF
Anterior surface (midway between anterior and interosseous border)	17	70.83	4	12	1	--
Anterior surface (close to interosseous border)	3	12.50	1	2	--	--
Anterior surface (close to anterior border)	2	8.33	1	--	--	1
Posterior surface (close to interosseous border)	2	8.33	1	1	--	--

Table 4 shows that in the 17 right-sided ulnae (16 with Single NF and 1 with double NF) had NF on their anterior surfaces (AS) midway between anterior and IB.Out of these seventeen NF, 5 (4+1) were DF and 12(12+0) were SF. 3 of the right-sided ulnae had a single NF on their AS located close to IB where 1 of the bone had DF and 2 of them had SF. Two ulnae (1 with single NF and 1 with double NF) had their NF on the AS located close to the anterior border where the bone with single NF had DF and the bone with double NF had SF located on the anterior surface. Two bones had single NF on the posterior surface close to the IB out of which 1 had a DF and 1 was with SF.

Table no-5

Position and number of dominant (DF) and secondary (SF) nutrient foramina observed in the ulnae of left side

Position	Total no of foramina	%age	No. of foramina			
			Single		Two	
			DF	SF	DF	SF
Anterior surface (midway between anterior and interosseous border)	24	82.75	9	13	1	1
Anterior surface (close to interosseous border)	1	3.4	--	--	--	1
Anterior surface (close to anterior border)	3	10.34	1	1	1	--
Posterior surface (close to interosseous border)	1	3.4	1	--	--	--

Table no. 5 shows that in the 23 left-sided ulnae (22 with Single NF and 1 with double NF) had NF on their anterior surfaces (AS) midway between anterior and IB.Out of these 10 NF (9+1) were DF and 14(13+1) were SF. 1 of the left-sided ulnae (with double NF) had a NF which was a SF on its AS located close to IB. Three of the ulnae (2 with single NF and 1 with double NF) had their NF on the AS located close to the anterior border out of which 2(1+1) were DF and 1(1+0) was SF. One of the bone had single NF on the posterior surface close to the IB out of which was DF.

Table no-6

Direction of nutrient foramina in the radii and ulnae

Bone	Direction
Radii (both right and left)	Proximally
Ulnae (both right and left)	Proximally

Table 6 shows that all the bones obeyed the jingle, towards the elbow we go, from the knee we flee". Both radii and ulnae had a direction of the NF directed proximally i.e. opposite to their growing ends.

Table no-7

Foraminal Indices of Radii

Position	Side	Foraminal Index
Anterior surface (midway between anterior and interosseous border)	R	38.48
	L	36.64
Anterior surface (close to interosseous border)	R	37.68
	L	32.48
Anterior surface (close to anterior border)	R	33.79
	L	36.43
Posterior surface (close to interosseous border)	R	33.04
	L	47.21

Table no. 7 shows the foraminal indexes calculated for the radii of both sides on different surfaces. It was observed that the foraminal index for the different surfaces had a very little

difference as shown above. While on the posterior surface for the left side radii it showed a great difference.

Table no-8
Foraminal Indices of Ulnae

Position	Side	Foraminal Index
Anterior surface (midway between anterior and interosseous border)	R	36.92
	L	38.72
Anterior surface (close to interosseous border)	R	38.08
	L	23.28
Anterior surface (close to anterior border)	R	49.05
	L	38.86
Posterior surface (close to interosseous border)	R	44.59
	L	42.01

Table no 8. shows the foraminal indexes calculated for the ulnae of both sides on different surfaces. It was observed that foraminal index for the right side ulnae varied according to the surface, maximum being for the anterior surface where the NF was located close to the anterior border. On the left side, the foraminal index for the anterior surface where the NF was located close to the IB was minimum.

DISCUSSION

Different arteries (brachial artery, profunda brachii artery, radial and ulnar arteries) supply the forearm bones. The number of branches of arteries determines the quantity of blood supply to the bones. So bones exhibit a difference in its response while healing fractures also survival of grafting procedures based on the arterial supply.

The present study was done on the 100 dry bones(50 radii and 50 ulnae). The results found were compared to the previous studies as discussed in the tables below-

Table 9- Showing comparision according to the no. of foraminae

Studies	Total no of bones		No foramina (%)		1 foramina (%)		2 foramina (%)	
	Radii	Ulnae	Radii	Ulnae	Radii	Ulnae	Radii	Ulnae
Present Study	50	50	0	0	94	94	6	6
Chhatrapati DN (8)	61	68	0	1	100	94	0	5
Mysorekar VR (9)	180	180	2	0	94	96	4	4
Kate BR (10)	50	50	0	0	100	86	0	13
Shamsunder R (2)	-	-	0	0	100	100	0	0
Solanke KS (11)	40	40	5	3.75	92.50	96.25	2.50	0
Roul B (12)	37	37	0	0	97.29	100	2.7	0

RADII-

In 1967, Chhatrapati DN observed NF in 61 radii. He found that 100 percent of the radii had single NF. In 1961 one more study was done by Mysorekar VR on 180 radii. He found that 2% of the bones had a complete absence of NF, 4 % of the bones had a double foramen, 94% of the bones had a single NF which was very similar to the present study. In 1971 Kate BR studied 50 radii and found that all the 50 bones had a single NF. In 2014 Rao VS observed that all the 100% radii and ulnae had single NF. In 2015, Roul B found that out of 37 radii 97.29% had a single foramina and 2.7% had a double foramina.

ULNAE-

NF in 68 ulnae were observed by Chhatrapati DN. He found that 94 percent of the ulnae had single NF, 1% of the radii had a complete absence of NF and 5% of the bones had double NF. Mysorekar VR found that 96% of the bones had single NF, 4% of the bones had a double foramen. In 1971 Kate BR studied 50 radii and found that 86% of bones had a single NF and 13% of the bones had a double NF also 1 % of the bones had three NF. Royal B stated that all the 100% ulnae he studied had a single foramen. The results of the present study were very similar to the study done by Chhatrapati and were very close to study done by Roul B. In the present study 94% of the bones had a single NF and 6% of the NF had a double NF. \

The presence of the nutrient foramina on the different surfaces was compared to the studies of previous workers as described in the tabe below-

Table 10- Showing comparision of positions of NF

Studies	Anterior Surface (%)		Posterior Surface(%)	
	Radii	Ulnae	Radii	Ulnae
Present Study	91.66	96.66	8.33	3.4
Chhatrapati DN	69	80	5	0
Mysorekar VR	75	73	9	0
Kate BR	100	100	0	0

It was observed that incidence of the nutrient foraminae on the different surfaces varied in all the studies.

The foraminal index was also calculated according to the different surfaces for both radii and ulnae. The mean foraminal index was different for the different surfaces.

CONCLUSION-

The present study was conducted on the 100 dry adult forearm bones (50 radii and 50 ulnae). After studying we concluded that the NF varied both with respect to the number and position in the bones. Majority of the NF were located on the anterior surface (flexor surface). The incidence of the single and double nutrient foraminae were calculated for both the radii and ulae.

The study would surely help the orthopaedicians, surgeons and forensic experts in the bone related surgeries like bonegrafting and microvascular bone transfer. The study would also be helpful in medico-legal aspects like estimating the stature of a person from the foraminal index.

ABBREVIATIONS- NF- nutrient foramina, FI-foraminal index, DNF- the distance the NF from the proximal end, TL- total bone length, AS- anterior surface, IB- interosseous border.

Figure 1- Showing measurement of radius

Figure 2- Showing length of Ulna

Figure3- Radius showing double foramen

Figure 4- Ulna showing double foramina

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