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Original Research Article

The Indore population's morphometric study of the nutrient foramina of the dried radius

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ABSTRACT

Background: Bone formation, growth and its vitality necessitates blood supply. Nutrient artery is the key source of blood supply to the long bone apart from the other important sources like periosteal, metaphyseal and epiphyseal arteries. Nutrient foramina allow nutrient artery. Typically, the direction of the nutrient foramina is towards the elbow joint in radius, away from its growing end. Knowledge of foramen index, number, direction and size of the nutrient foramina assists the surgeon to take and exact section of bone in case of bone resection and transplantation techniques. The aim of the present study is to determine the number, position, size direction of the nutrient foramina and the Foramen Index of the human dry radius bones.
Methods: In the present study, 100 radius bones of unknown age and sex were taken into consideration from the department of anatomy Index Medical College, Indore (MP), India.
Results: Most of the foramen was observed on the anterior surface of the bone. Nutrient foramina was found to be absent in 4 right sided and 3 left sided bones. The foramen index on right side was 34.92±4.97 cm whereas on the left side 34.79±4.43 cm. The nutrient foramen was directed towards the proximal end of radius in all the bones studied.
Conclusions: In the present study the average length of the bone and foramina of the size larger are more on the right side when compared to the left side. The foramina are located mostly in the middle third of the bone of the anterior surface. This study may add to the present statistical data available on foramen index number of foramen and their location in the population of Indore region, during recent orthopaedic techniques like bone resection and transplantation.

Keywords: Nutrient foramina, Radius, Foramen index, Nutrient artery

INTRODUCTION

Bone formation, growth and its vitality necessitates blood supply. Nutrient artery is the key source of blood supply to the long bone apartfrom the other important sources like periosteal, metaphyseal and epiphyseal arteries. According to Trueta, nutrient artery supplies about 80% of blood to the growing long bone, in whose absence the periosteal arteries take active role to nourish the bone.[1] Nutrient foramina allows nutrient artery along with the corresponding peripheral nerve to enter the bone at an angulations typically.[2-5] The direction of the nutrient foramina is towards the elbow joint in radius, away from its growing end.[6] The location direction and number of nutrient foramina usually do not change with age or length of the bone however, variations in the location, direction and number of nutrient foramina has been reported.[7-9] Knowledge of foremen index, number, direction and size of the nutrient foramina assists the surgeon to take and exact section of bone in case of bone resection and transplantation techniques.

Aim

The aim of the present study is to determine the number, position, size, direction of the nutrient foramina and the foramen index of the human dry radius bones.

METHODS

The present study was conducted in the Department of Anatomy, Index Medical College, Indore (MP), India. This study was approved by the Institutional Research and Ethics Committee (NO. MU/Research/EC/PhD/2021/161, date 23 November 2021), Malwanchal University, Indore. In the present study, 100 (50 right side and 50 left sided) radius bones of unknown age and sex were taken into consideration. All selected bones were normal with no appearance of pathological changes length of the bone was calculated by an osteometric board. Total length was calculated as the distance between the proximal aspect of the head of the radius and the most distal aspect of the styloid process. Foramen index (FI) was calculated using the formula, where DNF=the distance from the proximal end of the bone to the nutrient foramen, and TL=total bone length. Hand lens was used to observe the nutrient foramina.[7,10]

$$FI = (DNF/TL) \times 100$$

Size of foramina (SF) was measured using hypodermic syringe needles of various gauzes. Foramina of size less than 24 gauze were not taken into account.

SF-1 (large)

The size of the 18 gauze hypodermic needle was estimated to be 1.27 mm or greater.

SF-2 (medium)

The size of the 20 gauze hypodermic needle was estimated to be between 0.90 mm and 1.27 mm.

SF-3 (small)

Size of the 22 gauze hypodermic needle was estimated to be between 0.71 mm and 0.90 mm.

SF-4 (extra small)

Size of the 24 gauze hypodermic needle was estimated to be between 0.55 mm and 0.71 mm.

RESULTS

Direction of the nutrient of foramina

In all the bones of both right and left side, the nutrient foramen was directed proximally.

Incidence of nutrient foramen

Out of 100 radius, single nutrient foramen was observed in 93% of the bones and double nutrient foramina were observed in 3% of the bones, 3% absent foramina observed (Table 2). Out of 50 right sided bones, the nutrient foramina were not at all found in the shaft of two radius bones. Only one bone showed two foramina, all the other bones have single nutrient foramina. Whereas on the left side, out of 50 bone, 1 bone is found without nutrient foramina, three bones showed tow foramen and the remaining bones showed single nutrient foramina. (Table 2).

Total length of the bone

Distance from the upper end to proximal nutrient foramina and foramina index are shown in the Table 1. Segmental position and location of nutrient foramen of the bone and the size for foramina are shown in the Table 3-5 and Figure 1-4.

Figure 1: Nutrient foramen on the anterior surface of radius.

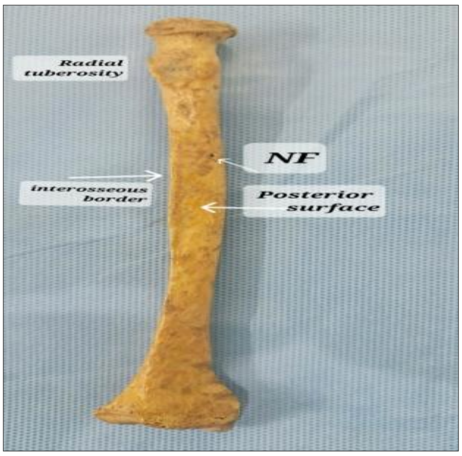

Figure 2: Nutrient foramen on the posterior surface of radius.

Figure 3: Nutrient foramen on the anterior boarder of radius.

Figure 4: Nutrient foramen on the interosseous boarder of radius.

Table 1: The length of the bone, distance of the proximal nutrient foramina from the upper end and foramen index.

Parameters	Total length of the bone		Distance from upper end to NF		Foramen index	
	Median	Mean with SD	Median	Mean with SD	Median	Mean with SD
Right (n=50)	24	23.72±1.93	8	8.26±1.18	33.91	34.92±4.97
Left (n=50)	23.75	23.35±1.75	8.1	8.12±1.18	34.39	34.79±4.43

N=Total number of bones, SD=standard deviation, NF=nutrient foramina

Table 2: Incidence of nutrient foramen.

No. of foramina	Right (n=50)		Left (n=50)		Total radius (n=100)	
Zero NF	2	4%	1	2%	3	3%
One NF	47	94%	46	92%	93	93%
Two NF	1	2%	3	6%	3	3%

Table 3: Segmental position of nutrient foramen.

Situation	Right radius (n=50)		Left radius (n=50)		Total radius (n=100)	
	No. of NF	(%)	No. of NF	(%)-	No. of NF	(%)
Proximal 1/3	19	39.58	15	30.61	34	35.05
Middle 1/3	29	60.42	34	69.39	63	64.95
Distal 1/3	-	-	-	-	-	-
Total no. of NF	48	100	49	100	97	100

Table 4: Location of nutrient foramen on the bone.

Side of radius bone	Total no. (n) of bone	Total no. of NF	Surface of radius bone									
			Anterior		Posterior		Lateral		Interosseous border		Anterior border	
Right	50	48	36	75%	1	2.08%	0		10	20.83%	1	2.08%
Left	50	49	37	75.51%	1	2.04%	1	2.04%	7	14.29%	3	6.12%
Total	100	97	73	75.26	2	2.06%	1	1.03%	17	17.53%	4	4.12%

Table 5: Size of the nutrient foramen.

No. of NF	Size of the nutrient foramina							
	SF1		SF2		SF3		SF4	
Right (n=48)	8	16.67%	11	22.92%	19	39.58%	10	20.83%
Left (n=49)	4	8.16%	9	18.37%	9	18.37%	27	55.10%
Total 97	12	12.37%	20	20.62%	28	28.87%	37	38.14%

Size of nutrient foramina

Observed extra small size nutrient foramina was observed 38.17%, small size was observed 28.87%, medium sized was observed 20.62% and large size was observed 12.37% (Table 5).

DISCUSSION

In embryonic period all the nutrient arteries course caudally**.** This is true in hemodynamic point of view to force the blood from cephalic to caudal side.[11] This agrees with adult rules "towards the knee and away from elbow". This is said to be to unequal growth of the ends of the long bones.

Developmentally, a perisosteal bud excavates the newly formed bone to allow the nutrient artery to enter the calcified matrix, whose opening later remains as nutrient canal.[12] Nutrient artery is the chief source of blood to long bones, about seventy to eighty percent during growth and development, along with the perisosteal, diaphyseal and epiphyseal arteries.[13]

Direction of nutrient foramina

Growing end of a long bone can be determined by the direction of nutrient foramina. The hemodynamic flow of blood from cephalic to caudal direction forces the nutrient foramina. The hemodynamic flow of blood from cephalic to caudal direction forces the nutrient artery to course caudally. Due to differential growth of the two ends of a long bone, the nutrient artery is directed away from the growing end.[14] However, a few studies have shown that the direction of the nutrient foramina is at variance in mammals.[15] In the present study all the nutrient foramina are directed away from the growing end, towards proximal.

Positions of nutrient foramina

The position of the foramina was observed consistently on anterior (flexor) surfaces as it is true even in case of the present study.[15,16] The results in the present study (right radius:75%, left radius: 75.51%) (Table 4) are in consistent with the results of the other authors such as Kizilanat et al (96.8%), Pereira et al (73.2%), Arora (77.98%), Murlimanju et al (72.23%), Anusha et al (72.2%), Ukoha et al (91.4%), Sharma et al (72.75%) Pramod et al (91.3%), Solankeet al (73.75%), Patel et al (87.5%) Meenakshiet al (72.23%), Anjana et al (88%), and Udayasree et al (100%).[17-25,27-30]

As it is shown in the Tables 1, 3 and 6 most of the foramina on radius are located in the middle third of the bone. In the present study the foramen index is 34.86±4.7 cm, with the average length of bones as 23.48±2.8 cm, indicating the location of the foramina in middle third of the bone. However, Ukoha et al, Pramod et al and Anjana et al observed that the nutrient foramina in radius are mostly located in the upper one third of the bone.[22,24,29] No foramina are found in the lower one third.

Size of foramina

In the present study, the size of the majority of nutrient foramina was small in radius (Table 5). However, Pramod et al observed that the size of nutrient foramina in radius majority was medium.[24]

Number of nutrient foramina

As stated in the table no. 7 the present study showed single nutrient foramen in more than 93% of the bones similar to the other previous studies. Present study did not show any nutrient foramina in 3% of bones corresponding to the results of Anusha et al, Murlimaju et al, Sharma et al, Solanke et al, and Meenakshi et al but as study by Ukoha et al in 50 radii of Nigeria population reported that only 68% bones have single nutrient foramina and 32% of bones are without any nutrient foramina.[19,20,22,23,25,28]

The knowledge of position of nutrient foramina is important in case of orthopaedic techniques like fracture repair, bone graft transplantation and resection. This knowledge also serves the surgeon to be careful enough during surgical procedures to prevent post – surgical fracture non-union. The foramen may be a possible location of weakness in some people, and when stressed due to increased physical activity or poor bone quality, the foramen could lead to the onset of a fracture. The position of the fracture relative to the nutrient foramen of the long bone and the patterns of edoema are secondary indicators in the key to the diagnosis of this type of fracture.[31]

Table 6: Comparison of segmental position of nutrient foramen by various authors.

Author	Year	Upper 1/3rd (%)	Middle 1/3rd (%)	Lower 1/3rd (%)
Anusha et al[21]	2013	38.5	61.50	-
Ukoha et al[22]	2013	57.10	42.90	-
Pramod et al[24]	2013	66	34	-
Solanke et al[25]	2014	22.50	72.50	-
Bichitranan-da et al[26]	2015	24.32	75.67	-
Patel et al[27]	2015	42.50	57.50	-
Anjana et al[29]	2016	76	24	-
Udayasree et al[30]	2018	15.38	84.61	-
Naveen et al[31]	2018	36.16	63.82	-
Present study	2023	35.08	64.95	-

Table 7: Comparison of number of nutrient foramen observed by various authors.

Author	Year	0- NF (%)	1 NF (%)	2 NF (%)
Emine et al.[17]	2007		98.92	1.07
Periera et al.[18]	2011		99.36	0.63
Mani arora et al.[19]	2011		98.20	1.80
Murlimanju et al.[20]	2011	4.16	94.44	1.39
Anusha et al.[21]	2013	2	92	6
Ukoha et al.[22]	2013	32	68	-
Sharma et al.[23]	2013	5	80	15
Pramod et al.[24]	2014		97	3
Solanke et al.[25]	2014	5	92.50	2.50
Bichitrananda et al.[26]	2015	-	97.29	2.70
Patel et al.[27]	2015		100	
Meenakshi et al.[28]	2016	4.16	94.44	1.39
Present study	2023	03	93	03

CONCLUSION

In the present study the average length of the bone and foramina of the size larger are more on the right side when compared to the left side. The foramina are located mostly in the middle third of the bone of the anterior surface. The study supported prior findings about the number and location of nutrient foramina in the long bones of the limbs. It also provided significant information about the clinical significance of the nutrient foramina. As micro vascular bone transfer becomes more widespread, the anatomical data of this subject may add to the current statistical data available, particularly in the Indore region.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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