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Original Research Article

The Study on the Incidence and Direction of Nutrient Foramina in the Diaphysis of Radius Bone of South Indian Origin and Their Clinical Importance

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ABSTRACT

Objective: The study on the incidence and direction of nutrient foramina in the diaphysis of radius bone of south Indian origin and their clinical importance.
The study of nutrient foramina is having academic, clinical and medico-legal importance. The nutrient foramen is a surface opening on the shaft of bone through which the diaphyseal nutrient artery enters to supply the shaft. The present study was conducted on 110 dissected adult human radii of south Indian origin of unknown sex and age. In each radius nutrient foramen was identified and studied regarding- direction, size, number and distribution. Totally 116 nutrient foramina were observed in different vertical and horizontal zones. The majority of foramina were single, which were located on the anterior surface of middle 1/3rd of the shaft. The present study result correlates well with the of previous study findings by various scholars. The knowledge on incidence of the nutrient foramen will help the surgeons in avoiding vascular injury, to assess the prognosis of surgery and to get better result in bone graft and fracture healing. Hence the study was undertaken.

Key words: Diaphysis, radius, nutrient foramen.

INTRODUCTION

Nutrient foramen is a surface opening of nutrient canal passing obliquely through the compact bone of the shaft of long bone to enter the marrow cavity. It is directed away from the growing end in a typical long bone (Fig-1). The diaphyseal nutrient artery enters through nutrient foramen into canal. It divides into an ascending and descending branch on reaching the medullary cavity. It will supply the shaft. The nutrient artery supplying the radius arises from the anterior or posterior Interosseous artery. Any damage to the precise area of nutrient foramen, nutrient canal or nutrient artery by traumatic or iatrogenic reasons may result with delayed union, non union of the bone following fractures or bone graft, because healing of fracture, or bone graft is dependent on blood supply. [(1-3)] The knowledge on incidence of the nutrient foramen will help the orthopedic surgeon to overcome the vascular injury during surgery and to assess the prognosis. Hence, the study on incidence of the nutrient foramen of the radius was undertaken.

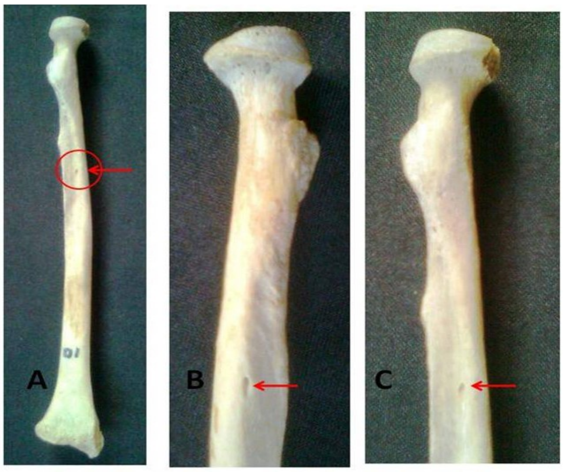

Fig-1. Nutrient foramina in Radial diaphysis.
A-Nutrient foramen, B-Nutrient foramen in posterior surface, C-Nutrient foramen in anterior surface.

MATERIALS AND METHODS

The study was conducted on 110 dissected adult human radii of south Indian origin of unknown sex and age in the department of anatomy, Malabar medical college and research centre, Modakkallur, Calicut, Kerala, India. The radii were randomly selected at the anatomy department. The damaged bones and those having pathological abnormalities were excluded. The side determination was done for all the radii. In each radii nutrient foramen was identified and studied carefully under proper illumination regarding-

1. Number of nutrient foramen and its incidence on the right and left side,
2. Distribution of nutrient foramen in the vertical and horizontal zones of radial diaphysis,
3. Direction and size of nutrient foramen.

The nutrient foramen was identified by recognizing the presence of a well marked grove and slightly elevated edge of the foramen at the beginning of the nutrient canal. In doubtful cases hand lens was used. The size of foramen was determined by using hypodermic needle no-24. Calibrated foramina were categorized into main and secondary foramen.

1. Main foramen-accepting the needle no-24 Gauge (0.55mm),
2. Secondary foramen-which do not accept the needle no-24 Gauge (0.55mm).

The patency and direction of foramina was confirmed by passing fine copper wire.
The total length of the radius was determined by measuring the distance between the most proximal margin of the head of the radius and the tip of the radial styloid process. The midpoint was calculated by dividing the length by two and it was marked on the bone. The length of radius was divided horizontally into three zones namely upper 1/3rd, middle 1/3rd and lower 1/3rd part and analysed topographically. The vertical zones were recognised as- Interosseous border, anterior surface, anterior border and Posterior surface, as described in the gray's anatomy, 40th edition.[3] The foramina within 1mm area from the respective border were considered to be lying on that border itself (Fig-1). The findings were noted. The result was analyzed and tabulated.

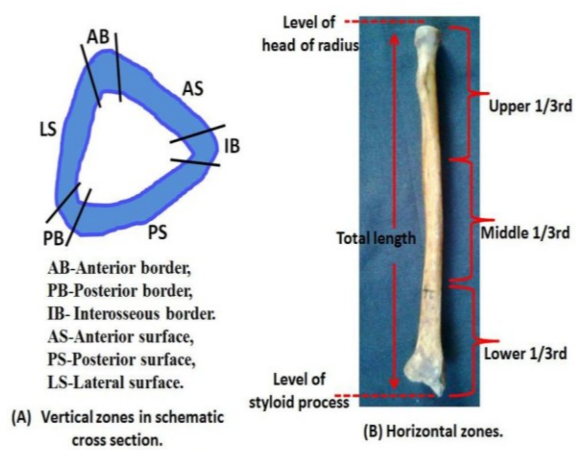

Fig-2. Different zones of Radius bone.

RESULT

In the present study totally 116 nutrient foramina were observed in the 110 radius bones, of which single nutrient foramina was found in 104 radius (94.55%) and double nutrient foramina was found in 06 radius (5.45%). All the nutrient foramina were directed towards the proximal end of the radius (away from the growing end).

The incidence, size, and distribution of nutrient foramina on the horizontal and vertical zones of radial diaphysis were presented in Tables 1 to 3.

Table-1. General findings of present study on radius bone.

	Findings	Description	Numbers	Percent	Total
1	Sample size	Right	55	50	110
		Left	55	50	
2	Total number of nutrient foramina	Right	62	53.45%	116
		Left	54	46.55%	
3	Incidence of number of nutrient foramen observed	One per bone	104	94.55%	110
		Two per bone	06	5.45%	
4	Incidence of nutrient foramen on horizontal zones of bone	Upper $1/3^{rd}$	43	37.07%	116
		Middle $1/3^{rd}$	73	62.93%	
		Lower $1/3^{rd}$	0	0%	
5	Number of nutrient foramen per bone	Mean	1.05	-	-
		Range	1-2	-	-
6	Direction of nutrient foramen	Towards growing end	0	0%	116
		Away from growing end	116	100%	
7	Size of nutrient foramen	Main ≥0.55mm	104	89.66%	116
		Secondary <0.55mm	12	10.34%	

Proportionately higher incidence of single, main nutrient foramen was observed in the middle $1/3^{rd}$ of radial diaphysis (Table-1).

Table-2. Distribution of nutrient foramen on radial diaphysis in the vertical zones and horizontal zones. (Fig-2 A and B)

Zones		<------ Vertical zones ----> Fig-2:A				Total	
		IB	AS	AB	PS	Nutrient foramen	Percent
Horizontal zones Fig-2:B	Upper $1/3^{rd}$	11	25	04	03	43	37%
	Middle $1/3^{rd}$	05	62	01	05	73	63%
	Lower $1/3^{rd}$	0	0	0	0	0	0%
Total Number of nutrient foramen		16	87	05	08	116	-
Percent		13.79%	75.0%	4.30%	6.90%	100%	-

IB- Interosseous border, AS-Anterior surface, AB-Anterior border, PS-Posterior surface.

The incidences of 100% of nutrient foramina were found on the upper $2/3^{rd}$ of shaft of radius (on middle $1/3^{rd}$ 63.0% and on upper $1/3^{rd}$ 37.0%). Among them majority of foramina were on Anterior surface (75.0%), followed by on Interosseous border (13.79%) and posterior surface (6.90%). Hence these parts are precious regarding vascular supply to radial shaft.

Table-3. Incidence of nutrient foramen on right and left side on radial diaphysis.

Incidence	Right side	Left side	Total bones	Percent
One per bone	56	48	104	94.55%
Two per bone	03	03	06	5.45%
Total bones	59	51	110	100%
Percent per bone	53.64%	46.36%	100%	-
Total Nutrient foramen	62	54	116	-

IB-Interosseous border, AS-Anterior surface, AB-Anterior border, PS-Posterior surface.

Comparatively 94.55% of radii had one nutrient foramen per bone (Fig-1). It shows that major blood to radial diaphysis will enter at one point. Hence clinically it is significant.

DISCUSSION

In the present study on 110 radius bone [Right-55, left-55], totally 116 [Right-62, left-54] nutrient foramina were observed. The comparisons of study results were presented (in Tables-4 to 6).

Table-4. Comparison of study results regarding number of nutrient foramina per radius.

Studies by	Sample size	Incidence of nutrient foramen in number of radius: One per bone (%)	Two per bone (%)	Three per bone	Not found	Total Nutrient foramen
Present study	110	94.55%	5.45%	0	0	116
V.R.Mysorekar. [4]	180	91.3%	4.35%	0	2.17%	184
BV.Muralimanju et al [5]	72	94.4%	1.4%	0	4.2%	
Vinay G et al. [6]	32	93.94%	3.03%	0	0	33
Sharma et al. [7]	40	80%	15%	0	5.0%	44
P.Anusha et al. [8]	50	92%	6%	0	2%	52
Pereira,G.A.M. et al. [9]	157	99.4%	0.6%	0	0	158

Number of Nutrient Foramina: (Table-4). In the present study, a single nutrient foramen had a higher percentage 94.55%, compared to that of double 5.45%.The present results correlated well with the previous studies by VR Mysorekar [4], BV Muralimanju et al[5], Vinay G et al[6], and P Anusha et al.[8]

The absence of nutrient foramina was also found in the studies by Vinay G et al.[6] and Pereira G A M et al.[9] It was opined by Patake SM et al[10] and Dr.Ojaswini Malukar et al [11] that, in such cases the periosteal arteries or epiphyseal arteries will supply blood to the bone respectively. Further, the study by Patake SM et al[10] was also mentioned that number of nutrient foramina is not related with number of ossification centers. The shaft of clavicle with two primary ossification centers has one nutrient foramen,[12] and the diaphysis of the femur with one primary ossification centre has two nutrient foramina, (one each foramen- near the proximal and distal ends) in the linea aspera.[13]

Table-5. Comparison of study results on the incidence of nutrient foramina in the horizontal zones of radial diaphysis.

Studies by	Sample size	Incidence of number of nutrient foramen in: Proximal 1/3rd	Middle 1/3rd	Distal 1/3rd	Total Nutrient foramen
Present study	110	37.0%	63.0%	0.0%	116
Vinay.G. et al. [6]	32	27.27%	72.33%	0.0%	33
P.Anusha et al. [8]	50	38.5%	61.5%	0.0%	52
V.R.Mysorekar. [4]	180	36%	62%	0.0%	184

Distribution of nutrient foramen in the horizontal zones (Table-5): In the present study, the most of the nutrient foramina (63%) were located on the middle 1/3rd and rest of 37% in the Upper 1/3rd of the radial diaphysis. The result of present study is close to the findings of previous research works by P Anusha et al [8] and V R Mysorekar.[4] Hence, these findings were strongly suggestive of the position of nutrient foramina nearer to the elbow than the wrist in radial diaphysis. The absence of nutrient foramina in the distal third of radial diaphysis was observed in the studies by V R Mysorekar,[4] Vinay G et al[6] and P Anusha et al.[8] Proportionately the proximal

2/3rd of radial diaphysis has more of muscle attachments than the distal 1/3rd part.[(3)] This finding corresponds with the incidence of majority of foramens in upper 2/3rd, to supplying the bone at the sites of muscle attachment.

Table-6. Comparison of study results regarding incidence of nutrient foramina in thevertical zones of radial diaphysis.

Studies by	Sample size	IB (%)	AS (%)	AB (%)	PS (%)	Nutrient foramen
Present study	110	13.79%	75.0%	4.30%	6.90%	100%
P.Anusha et al. [(8)]	50	11.5%	72.2%	11.5%	4.8%	52
BV.Muralimanju et al. [(5)]	72	14.29%	74.29%	5.71%	5.71%	70
Vinay G. et al. [(6)]	32	18.18%	78.79%	3.03%	0.0%	33
V.R.Mysorekar [(4)]	180	15.75%	75.0%	0.0%	9.24%	184

IB- Interosseous border, AS-Anterior surface, AB-Anterior border, PS-Posterior surface.

Distribution of nutrient foramen in the vertical zones (Table-6): In the present study, the majority of the nutrient foramina (75.0%) were observed on the anterior surface of radial diaphysis. Then 13.79% in the Interosseous border, 4.30% in the anterior border, 6.90% in the posterior surface. The present study result correlates well with the previous studies by VR Mysorekar,[(4)] BV Muralimanju et al,[(5)] Vinay G et al[(6)] and P Anusha et al.[(8)] Proportionately the lesser incidence of nutrient foramina in the lateral part and posterior surface is clinically significant and hence the dorsal approach may be preferred during the surgical procedures.

Direction of Nutrient Foramina: In the present study (Table-1), all the nutrient foramina were directed towards the proximal end of the radius (away from the growing end). The study by VR Mysorekar [(4)] observed that direction of nutrient foramen is determined by growing end of bone, which will grow at least twice faster than other end.

Clinical significance: The knowledge on incidence and distribution of the nutrient foramina is useful for surgical procedures (fracture repair, bone grafts and other bone surgeries.) The site of foramen and nutrient canal may be a weak point, which is prone for fracture. Carroll SE[(14)] opined that any damage to the precise area of nutrient foramen or nutrient canal or nutrient artery by traumatic or iatrogenic reasons may result with delayed union, non union of the bone following fractures, because healing process is dependent on blood supply. By avoiding damage to limited area of the cortex of the long bone containing the nutrient foramen, better result and faster healing can be achieved.

CONCLUSION

The present study concludes that even though nutrient foramina were found distributed in different vertical and horizontal zones of radii as single or double per bone, the majority of foramina were on the Anterior surface of middle 1/3rd of the shaft of bone followed by Interosseous border and posterior surface. Hence regarding the vascular supply, the vital part of the cortex begins on anterior surface of middle 1/3rd and it spirals proximally and medially towards the posterior aspect of the upper third of the radial shaft. Avoiding injury to this area will help for effective management, better result and prognosis.

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