

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 8, August 2018

The Number and Location of the Diaphyseal Nutrient Foramen on Human Dry Long Bones of the Upper Limb in Uttarakhand Region

Sunita^{*1}, Shikha Malik², Dr. Anurag³, Omkar⁴

Tutor, Department of Anatomy, Glocal Medical College Super Speciality Hospital and Research Centre, Mirzapurpole,
Saharanpur, India^{*1, 2}

Professor and Head, Department of Anatomy, Sri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun,
Uttarakhand, India³

Tutor, Department of Anatomy, Sri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun,
Uttarakhand, India⁴

*Corresponding author

ABSTRACT: Aims and Objectives: The present study was done on the human dry long bones of the upper limb in Uttarakhand region, India to know the number and location of the diaphyseal nutrient foramen following its general rule, directed away from the growing end. Nutrient foramina play an important role in nutrition and growth of the bones. The knowledge of nutrient foramen is important in surgical procedures like bone grafting and in microsurgical vascularised bone transplantation.

Materials and Methods: The present study consists of 75 human dry long bones of upper limb (25 humeri, 25 radii, 25 ulnae), taken from the department of Anatomy, Sri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun, Uttarakhand, India. The foraminal indices (by Hughes formula) and mean value were calculated for each bone. Digital calliper was used for the measurements of the nutrient foramen from the higher point of the proximal end of the bone.

Results: The neurovascular foramen was present in all observed bones (100%). Middle third of the humerus had maximum, 22NF (66.66%) were on the anteromedial surface, 6(18.18%) on the medial border, 3(9.09%) on the posterior surface and 2(6.06%) on the antero-lateral surface on humeri with FI 29.87 and 68.63% of the bone length. On radii 8NF(30.76%) on the anterior surface closer to anterior border, 10(38.46%) on the anterior surface closer to the interosseous border, 4(15.38%) were on the anterior surface midway between the interosseous and anterior borders, 2(7.69%) on the posterior surface closer to the interosseous border and 2NF(7.69%) at interosseous border with the FI 28.39 and 44.41% of the bone length. On ulnae 11NF (35.48%) were on the anterior surface closer to the anterior border, 6(19.35%) on the anterior surface closer to the lateral border, 11(35.48%) on the middle of the anterior surface, 2(6.45%) at the anterior borders and 1(3.22%) at the ridge of the upper 1/3rd of the anterior surface with the foramen index ranging between 22.38 and 49.33% of the bone length. In radii and ulnae the NF were located closer to the elbow than to the wrist.

Conclusion: This study provides the ethnic data on upper limb long bones of Uttarakhand region to compare with bones of various populations. It is helpful for interpretation of radiological images and various surgical procedures also.

KEYWORDS: Humeri, Radii, Ulnae, Nutrient foramen, proximal end, distal end, Foraminal index.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 8, August 2018

I. INTRODUCTION

Bone is a living tissue and similar to any other living tissue in the body, it requires the nutrition for its growth and development. Its strength provides support and protection to the body. Unlike cartilage, bone adapts to changing mechanical demands, and to regenerate following injury. From a foetal age they adapt to the presence of naturally occurring holes. These holes or nutrient foramina, allow blood vessels to pass through the bone cortex.^(1, 2) The nutrient foramina are cavities that conduct the nutrient arteries and the peripheral nerves towards elbow in upper limb (directed towards lower end of humerus, upper ends of radius and ulna) away from the growth extremity is dominant in the bone. The position, obliquity of the nutrient foramen and the nutrient artery are very variable in position.³ For considerable time after birth diaphysis and the epiphysis are separated by plate of cartilage called the epiphyseal cartilage, or epiphyseal plate. This plate plays a vital role in growth of the bone. The metaphysis is the most actively growing area of a long bone. Before the fusion, metaphysis is profusely supplied by blood from nutrient, periosteal and juxta-epiphyseal (metaphyseal) arteries. After the epiphyseal fusion the communications are established between the epiphyseal and metaphyseal arteries, as result metaphysis contains no more end arteries, therefore osteomyelitis is rare in adults. The role of the nutrient foramina in the nutrition and growth of the bones is evident from the term 'Nutrient' itself. Their positions in mammalian bones are variable and may alter during the growth phase. Nutrient artery enters the middle of the shaft through a nutrient foramen, runs obliquely through the cortex, and then divides into ascending and descending branches in the medullary cavity. It supplies the medullary cavity containing bone marrow and inner two- third of the outer shell of compact bone of diaphysis and metaphysis. The nutrient artery of the tibia is the largest nutrient artery of the body.^(2, 3)

NF is particularly important during its active growth period in the embryo and foetus, as well as during the early phases of ossification. During childhood, the nutrient arteries provide 70-80% of the interosseous blood supply to long bones. When this supply is compromised, medullary bone ischemia occurs with less vascularization of the metaphysis and growth plate, and in the case of their absence, the vascularization occurs through the periosteal vessels.⁵ Nutrient foramina reflect not only bone vascularization but also pathological bone conditions like fracture healing, developmental abnormalities or acute haematological osteomyelitis. An understanding of the location, number, direction and calibre of nutrient foramina in long bones is very important clinically specially in orthopaedic surgical procedures such as bone grafting, vascularized bone microsurgery, peripheral vascular occlusive disease, longitudinal bone growth, non-unions, joint replacement therapy, and resection techniques, intramedullary reaming and plating, as well as in medico legal cases, in operative procedures to preserve the circulation. Their probable role in few cases of vascular necrosis is pointed out.^(1, 4)

However, there is still a need for a greater understanding of the number, location, size, direction and obliquity of nutrient foramina in bones such as the humerus, radius, ulna, femur, tibia and fibula.

II. MATERIAL AND METHODS

The present study consists of the 75 adult human cleaned and dried long bones of the upper limb, obtained from the osteology collection in the department of Anatomy of Shri Guru Ram Rai Institute of Medical and Health Sciences Dehradun, Uttarakhand, India. The bones were divided into three groups. Group 1: Consist of 25 humeri, among which 9 humeri are right sided and 16 humeri are left sided. Group 2: Consist of 25 radii, among which 13 radii are right sided and 12 radii are left sided. Group 3: Consist of 25 ulnae, among which 12 ulnae are right sided and 13 ulnae are left sided. All selected bones were normal with no appearance of pathological changes. The specific age and sex characteristics of the bones studied are unknown. The bones sides are just observed morphologically by seeing the external features, therefore the unequal count of the bones of the right and left sided were taken for the observation as present in the osteology collection in the department. Determination of the nutrient foramina in all bones was observed with the help of a hand-lens. They were identified by their elevated margins and by the presence of a distinct groove proximal to them. Only well-defined foramina on the diaphysis were accepted. Foramina at the ends of the bone were ignored. The 24 gauge hypodermic needle (0.56 mm in diameter) is used to identify the dominant diaphyseal foramen (Kizilkanat et al; 2007).⁽¹⁵⁾ Osteometric board and scale were used to conduct the total length of the bones. Digital

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 8, August 2018

calliper was used to analyse the distance from the proximal end of the bone to the diaphyseal nutrient foramen. (Photograph: 1, 2, 3, 4) The following data was studied on the diaphyseal nutrient foramina for each bone:

- i. **Number:** Only well-defined foramina on the diaphysis were accepted.
- ii. **Position:** The position of all nutrient foramina was determined by calculating a foraminal index (FI) by using the formula:

$$FI = (DNF/TL) \times 100 \text{ (Hughes, 1952; Shulman, 1959)}^{(5, 6)}.$$

DNF = the distance from the highest point on the proximal end of the bone to the nutrient foramen, was taken to the nearest 0.1 mm using a Digital Calliper for the each bone.

TL = total bone length.

The distance between the proximal margins of the head and the most distal aspect of trochlea for humeri (photograph: 2), distance between the most proximal margins of the head and the tip of the styloid process for radii and the distance between the most proximal margins of the olecranon and the tip of the styloid process for ulnae were observed for the total length measurements with the help of the Osteometric board and scale.



Photograph 1: The Osteometric Board.



Photograph 2: Total length of the Humerus in Osteometric Board (proximal margins of the head to the most distal aspect of trochlea).

The foramen considered as in the proximal third of the bone with FI up to 33.33% as type: 1, FI from 33.33% up to 66.66% considered as type: 2, present on the middle third of the bone and FI above 66.66%, were considered as in the distal third of the bone and were type: 3.



Photograph 3: The distance from the head of the radius to the nutrient foramen by digital calliper



Photograph 4: Scale, Digital calliper, Hand lens, Hypodermic needle (24 gauge).

The results were analysed and tabulated using the Statistical Package of Social Sciences (SPSS) 8.0 windows. The range, mean and standard deviation of FI were determined.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 8, August 2018

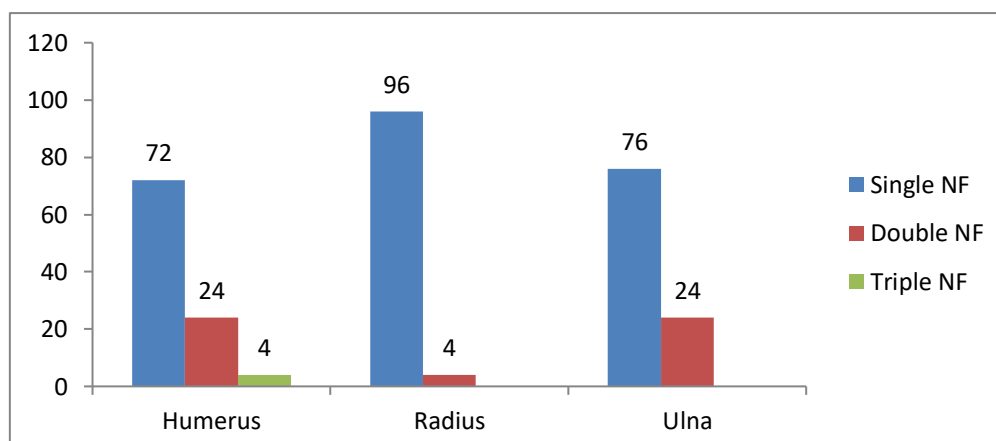
III. RESULTS

Of all the 25 humeri examined, 18(72%) had a single, 6(24%) had double and 1(4%) had triple NF (Table-1), (Fig.1). The maximum nutrient foramina were located along the whole middle third of the shaft of the humerus with the foramen index ranging between 29.87 and 68.63% of the bone length. Of the total 33 foramina, 1(3.03%) were in the proximal third (Type-1) 29(87.87%) were in the middle third (Type-2) and 3(9.09%) were in the distal third (Type-3) arranged according to the foraminal indices of the each bone which was calculated in the present study. And 22 NF (66.66%) were on the anteromedial surface, 6(18.18%) on the medial border, 3(9.09%) on the posterior surface and 2 NF (6.06%) on the anterolateral surface (Table- 2), (Fig.2). Of all 25 radii the total number of diaphyseal NF found was 26. Single nutrient foramen was present in 24 bones (96%) and double foramina present in 1(4%) bone (Table-1), (Fig.1). 8NF (30.76%) were in the proximal third (Type-1), and 18NF (69.23%) in the middle third (Type-2) with the foramen index ranging between 28.39 and 44.41% of the bone length. There were no foramina in the distal third (Type-3). Of all 26 radial foramina, 8NF (30.76%) were located on the anterior surface closer to anterior border, 10(38.46%) on the anterior surface closer to the interosseous border, 4(15.38%) were on the anterior surface midway between the interosseous and anterior borders, 2(7.69%) on the posterior surface closer to the interosseous (medial) border and 2NF (7.69%) at medial (interosseous) borders (Table-3), (Fig.3). Total number of diaphyseal nutrient foramina counted were 31 in number in examined 25 ulnae, 20 ulnae (80%) had a single nutrient foramen and 5(20%) had double foramina (Table-1), (Fig.1). 15NF (48.38%) were on the proximal third (Type-1) and 16NF (51.61%) on the middle third (Type-2) while no foramina on the distal third (Type-3). 11NF (35.48%) were located on the anterior surface closer to the anterior border, 6(19.35%) on the anterior surface closer to the interosseous (lateral) border, 11(35.48%) on the middle of the anterior surface, 2(6.45%) at the anterior borders and 1NF (3.22%) at the ridge of the upper 1/3rd of the anterior surface (Table-4), (Fig.4) with the foramen index ranging between 22.38 and 49.33% of the bone length. NF was located closer to the elbow than to the wrist in radii and ulnae.

Table 1: The number of the nutrient foramina observed on the long bones of the upper limb

S.No.	Bone	Total number of bone	Number of bone	Number of foramen	%
1	Humerus	n = 25	18	1	72
			6	2	24
			1	3	4
2	Radius	n = 25	24	1	96
			1	2	4
3	Ulna	n = 25	19	1	76
			6	2	24

Fig 1: Showing the % of the diaphyseal NF in the upper limb long bones



International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 8, August 2018

Table 2: The location of the nutrient foramina observed in the Humeri

S.No.	Location	Total number of foramina	Number of NF	%
1	Anteromedial Surface	33NF	22	66.66
2	Anterolateral Surface		2	6.06
3	Posterior Surface		3	9.09
4	At medial border		6	18.18

Fig 2: Showing the % of NF in different surfaces of Humeri

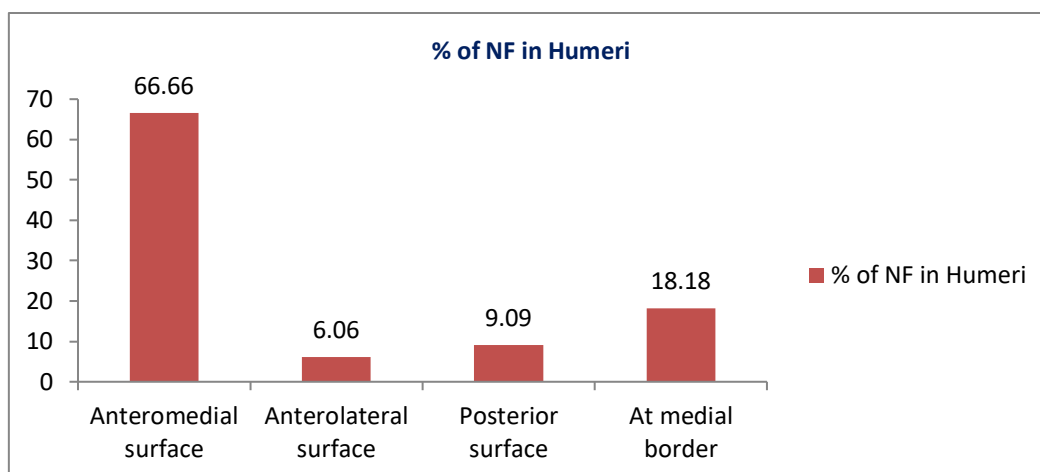


Table 3: The location of the nutrient foramina observed in the Radii

S.No.	Location	Total number of foramina	Number of NF	%
1	Anterior surface close to the anterior border	26NF	8	30.76
2	Anterior surface close to the medial border		10	38.46
3	At anterior surface		4	15.38
4	Posterior surface close to the medial border		2	7.69
5	At medial border		2	7.69

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 8, August 2018

Fig 3: Showing the % of NF in different surfaces of Radii

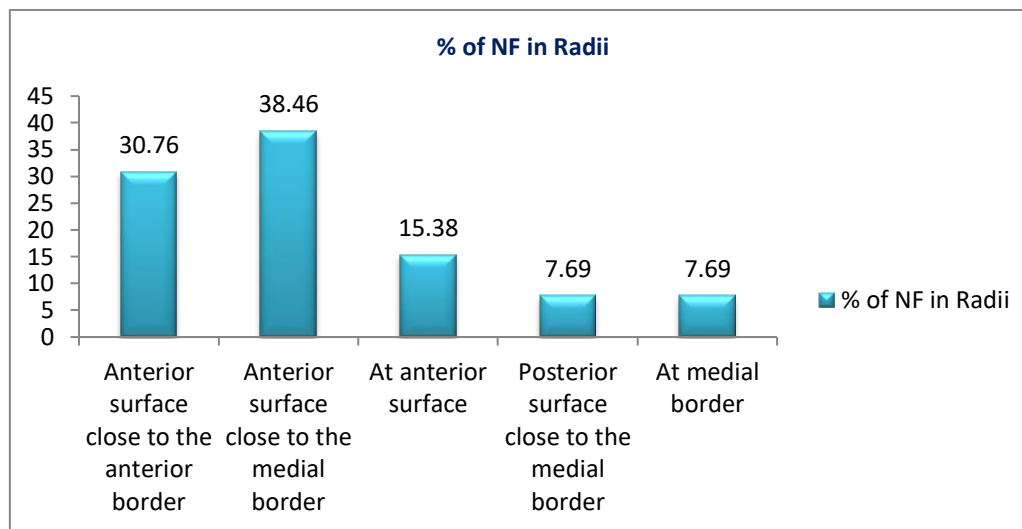


Table 4: The location of the nutrient foramina observed in the Ulnae

S.No.	Location	Total No. Of foramina	Number of NF	%
1	At anterior surface	31	11	35.48
2	Anterior surface near anterior Border		11	35.48
3	Anterior surface near lateral (interosseous) Border		6	19.35
4	At anterior border		2	6.45
5	At the ridge present at the upper part of the anterior surface		1	3.22

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 8, August 2018

Fig 4: Showing the % of NF in different surfaces of Ulnae

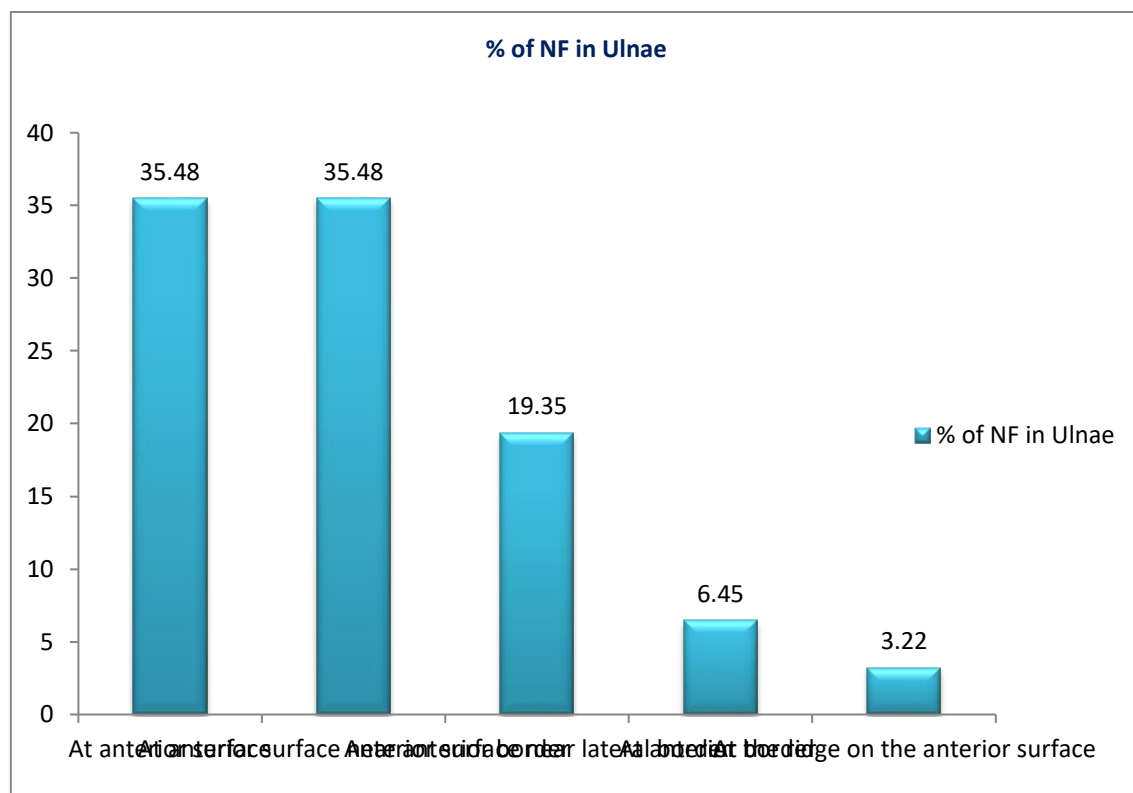


Table 5: The range and mean $\pm$ standard deviation (SD) of the foraminal indices of the bones of the upper limb

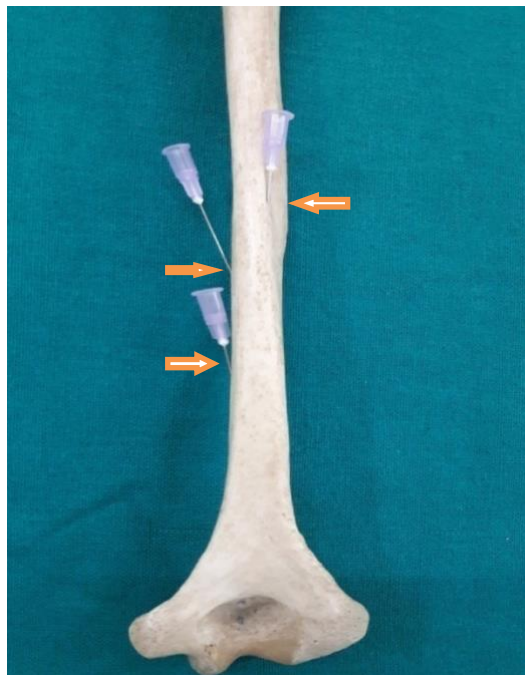
S.No.	Bone	Total number of Bone	Side	%	Range	Mean $\pm$ SD
1	Humerus	n = 25	R=9	36	29.87-67.26	56.04 $\pm$ 9.79
			L=16	64	43.48-68.63	55.48 $\pm$ 7.58
2	Radius	n = 25	R=13	52	28.39-42.32	34.87 $\pm$ 4.00
			L=12	48	29.95-44.41	38.10 $\pm$ 4.95
3	Ulna	n = 25	R=12	48	22.38-49.33	36.25 $\pm$ 8.23
			L=13	52	28.03-47.31	35.08 $\pm$ 5.91

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 8, August 2018



Photograph 5: Humerus- showing the triple nutrient foramina marked by 3 hypodermic needles at particular surfaces



Photograph 6: Radius- showing the single nutrient foramen at the anterior surface Close to the medial border



Photograph 7: Ulnae- showing the single nutrient foramen at the anterior surface (middle 1/3rd)

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 8, August 2018

IV. DISCUSSION

A single nutrient foramen had a percentage 18(72%) of the total humeral bones examined to that of double 6(24%) and triple foramina 1(4%). Approximately similar results were given by Forriol⁷. Some other studies reported a higher percentage of a single nutrient foramen(80- 88%).^{8, 9} The range of occurrence of double foramina varied from 13% to 42% Mysorekar¹⁰. The percentage of occurrence of triple foramina in the humeri did not exceed of 1-7%. Kizilkanat¹¹ stated four nutrient foramina in 1% of the humeri studied. The periosteal vessels were entirely responsible for the blood supply of the bone in absence of nutrient foramina in some humeri, reported by other authors. In accordance with the present results, previous studies reported the position of the nutrient foramina within the middle third of the bone, and equal percentage of foramina on both the anteromedial surface and the medial border.^{10, 11, 12} In the present study all of 25 radii examined 24(96%) had a single nutrient foramen and 1(4%) had a double nutrient foramen. Similarly the majority of radii (more than 90%) were found to possess a single nutrient foramen (Shulman⁵, Mysorekar¹⁰, Kizilkanat¹¹). Furthermore, Shulman¹⁸ reported the absence of nutrient foramina in 1.2% of radii examined. In the present study, 56.6% of the total nutrient foramina were distributed most often in the middle third of the radius and 43.3% were in the proximal third. The ratio of the present study were close to those reported by Mysorekar¹⁴ who found 62% of foramina located in the middle third of the bone and 36% in the proximal end. On the other hand, some reports stated that the majority of nutrient foramina were located in the proximal third of the bone.^{5, 7, 8, 11} The present results were in accordance with the previous studies who stated that the majority of nutrient foramina were located on the anterior surface of the bone.^{5, 7, 10, 12} In total 25 ulnae examined 20(80%) had a single nutrient foramen and 5(20%) of ulnae with double nutrient foramina. Nagel⁸ recorded a single nutrient foramen in all specimens examined; in the study. Other authors reported a single nutrient foramen in more than 91% of ulnae.^{7, 9, 11} Shulman (1959) and Mysorekar (1967) reported the absence of nutrient foramina in 0.6% and 1.1% of ulnae, respectively.^{5, 10} The nutrient foramina were located closer to the elbow than to the wrist. There were no foramina in the distal third (Type-3). Some authors reported that the majority of nutrient foramina were located in the middle third.¹⁰ while others stated that most of foramina were in the proximal third.⁵ However, all authors agreed that there were no nutrient foramina in the distal third of the ulna. In all previous studies, and in accordance with the present results, the nutrient foramina were mostly observed on the anterior surface of the ulna.^{5, 7, 10, 11, 12}

V. CONCLUSION

The present study provides the information of number and location of the diaphyseal nutrient foramina on the long bones of the upper limb in Uttarakhand region, India, and results are consistent with the previous studies. Most of the nutrient foramina were observed on the flexor surface of the bones and predominantly single. NF present mostly on the anterior surface of humerus, radius and ulna. It might be that, being more bulky, stronger and more active, flexors need more blood supply compared to extensors of limbs. The posterior surface of both radius and ulna often lack nutrient foramina especially in the middle and dorsal diaphysis. That is why the dorsal localization for the plate is preferred during operative procedure. The foramen may be a potential area of weakness in some patients and, when under stress because of increased physical activity or decreased quality of the bone, the foramen may allow development of a fracture. The areas of nutrient foramen distribution must be avoided during surgery as in most of the cases it can be a single source of blood supply. The healing of fractures, as of all wounds, is dependent upon blood supply. This study will provide the ethnic data for comparison as well as in various surgical procedures and in interpretation of radiological images.

REFERENCES

- [1]. Gray's. Gray's Anatomy the Anatomical Basis of Clinical Practice: Functional Anatomy of the Musculoskeletal System. 41st ed. Elsevier; 2016. p. 81-122.
- [2]. Sadler TW. Langman's Medical Embryology: Skeleton System. 11th ed Wolter's Kluwer India Pvt. Ltd: Wolter's Kluwer/Lippincott Williams & Wilkins; 2011. p.136-137.
- [3]. Singh Vshram. Textbook of General Anatomy: Skeleton. 2nd ed. New Delhi: Elsevier; 2014. p. 70-89.
- [4]. Trueta, J, Harrison, M. H. M. The normal vascular Anatomy of the Femoral Head in Adult man. Journal of Bone and Joint Surgery, 1953;35- B, 442.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 8, August 2018

- [5]. Shulman SS. Observations on the nutrient foramina of the human radius and ulna. Anat. Rec, 1959:134:685-697.
- [6]. Hughes H. The factors determining the direction of the canal for the nutrient artery in the long bones of mammals and birds. Acta anat. 1952:15:261-280.
- [7]. Forriol Campos F, Gomez Pellico L, Gianonatti Alias, M, Fernandez Valencia R. A study of the nutrient foramina in human longbones. Surg. Radiol. Anat, 1987:9:251-255.
- [8]. Nagel A. The clinical significance of the nutrient artery. Orthop. Rev, 1993:22:557-561.
- [9]. Patel SM, Vora RK. Anatomical Study of Nutrient Foramina in long bones of human upper limbs. IAIM, 2015:2(8):94-98.
- [10]. Mysorekar VR. Diaphysial nutrient foramina in human long bones. J. Anat, 1967: 101:813-822.
- [11]. EmineKizilkanata, NeslihanBoyana, Esin T. Ozsahina, Roger SoamesbOzkanOguza. Location, number and clinical significance of nutrient foramina in human long bones. Ann. Anat, 2007:189:87-95.
- [12]. Pereira GAM, Lopes PTC, Santos AMPV, Silveira FHS. Nutrient foramina in the upper and lower limb long bones: Morphometric study in bones of Southern Brazilian adults. Int. J. Morphol, 2011:29(2):514-520.