A STUDY OF ULNAR DIAPHYSIAL NUTRIENT FORAMINA IN NORTH INDIAN POPULATION WITH ITS CLINICO-ANATOMICAL CO-RELATION

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Abstract:

Introduction: *Nutrient foramen is a natural orifice into the diaphysis of a bone connecting an oblique conduit (nutrient canal) carrying a nutrient artery and nerves to the medullary cavity. This is the major blood supply during the growing period and in the initial stages of ossification. The knowledge of the topography of nutrient foramen helps the surgeons for more accurate management in the case of fractures, dislocation, tumour resections, and selection of the section of bone for bone grafts and minimizing the vascular insult which may lead to non-union or delayed healing.*

Aims*: The goal of this study is to determine the number, direction, position, and distance of NF in the North Indian population from the proximal end of the completely ossified ulna, as well as to analyse its clinico-anatomical relationships.*

Material and Methods*: The current research was performed on 100 Ulna bones from the Department of Anatomy, Government Medical College Amritsar, Punjab, of unknown age and sex.*

Results: *In a study of 100 ulna bones, NF was found to be missing in 3%, double in 5%, and single in 92%. The location of NF in relation to the length of ulna was 25.4% in the upper 1/3rd, 62.7% at the middle 1/3rd, 11.76 % at the junction of the middle and upper 1/3rd, and no nutrient foramen at the distal 1/3. The NF was discovered on the anterior surface at 69.60 percent, the interosseous border at 12.74 percent, and the interosseous border at 17.6 percent.*

Conclusion: *Clinically, comprehensive knowledge of the nutritional foramen is critical, especially for orthopaedic surgeons doing procedures such as tumour resections, bone grafting, and bone transplantation.*

Keywords: *Ulna, Nutrient foramen, Foraminal index, diaphysis.*

INTRODUCTION

Morphology has been described as the sole of anatomy. Amongst bones the form and morphometric parameters of ulna have always invoked a keen interest not only to the anatomist but also to the anthropologist, the forensic expert and the clinicians for stature estimation, assessment of age, for sex determination and for treatment purposes. The role of Nutrient foramina in the nutrition and growth of bone is evident from the term "nutrient" itself[1]. The nutrient foramen is an opening into the bone shaft which gives passage to the blood vessels of the medullary cavity of a bone for its nourishment and growth[2]. Nutrient canal typically become slanted during growth. The direction of slant from surface to marrow cavity points towards the end that has grown least rapidly. This is due to greater longitudinal growth at the faster growing end. Usually, nutrient arteries move away from the growing ends of the long bones. Nutrient arteries, the main blood supply to long bones, are particularly important during the active growth period, as well as during the early phases of ossification[3]. All long bones have one or more nutrient arteries, which enter through a nutrient foramen without branching in the foramen and that are accompanied by several thin-walled veins and a myelinated nerve[4]. The position of the nutrient foramen is calculated by 'Hughes' foraminal index formula, where ulna is divided into three parts[5]. The blood supply of the long bones is important in healing of the bone fractures and in surgical procedures. A knowledge of the nutrient foramen in relation to its position, number, direction and its variations in forearm bones is essential for the healing of bone fractures[6]. It is the largest and the principal source of blood to the shaft of the long bone and so is known as the "Nutrient Artery". The nutrient artery and its ascending and descending medullary branches form the important source of blood supply to the bone marrow and inner 2/3rd of the compact part of the diaphysis[7]. In the bones where nutrient foramen was absent, the periosteal vessels become the sole source of the blood supply[8]. A convention for the anatomical description of nutrient foramina is important for microvascular bone transfer as it is becoming more popular these days[9].

MATERIAL AND METHODS

The research was carried out at the Government Medical College in Amritsar, India. To conduct this study, 100 adult human ulna bones of unknown sex and age obtained from the Department of Anatomy, Govt. Medical College, Amritsar. Before being used, the ulnae were cleansed and dried. With the aid of a hand lens and a hypodermal needle, the direction of NF was detected in all bones. The elevated borders and a unique groove close to them were used to identify them. The foraminal index (FI) was calculated to identify the location of the NF in respect to the proximal1/3rd, middle1/3rd, and distal1/3rd along the length of the ulnar diaphysis.

Foraminal Index: FI = (DNF/TL) x 100

* DNF is the distance from the proximal end of the bone to the nutrient foramen
* TL is total bone length.

Using a Vernier calliper, all measurements were obtained to the closest 0.1 mm. For continuous variables, means and standard deviations were used, whereas for categorical variables, percentages were used. Any foramen that was within 1mm of a boundary was considered to be on that border.

Inclusion Criteria: The ulnae included in the study fulfills the following characteristics:

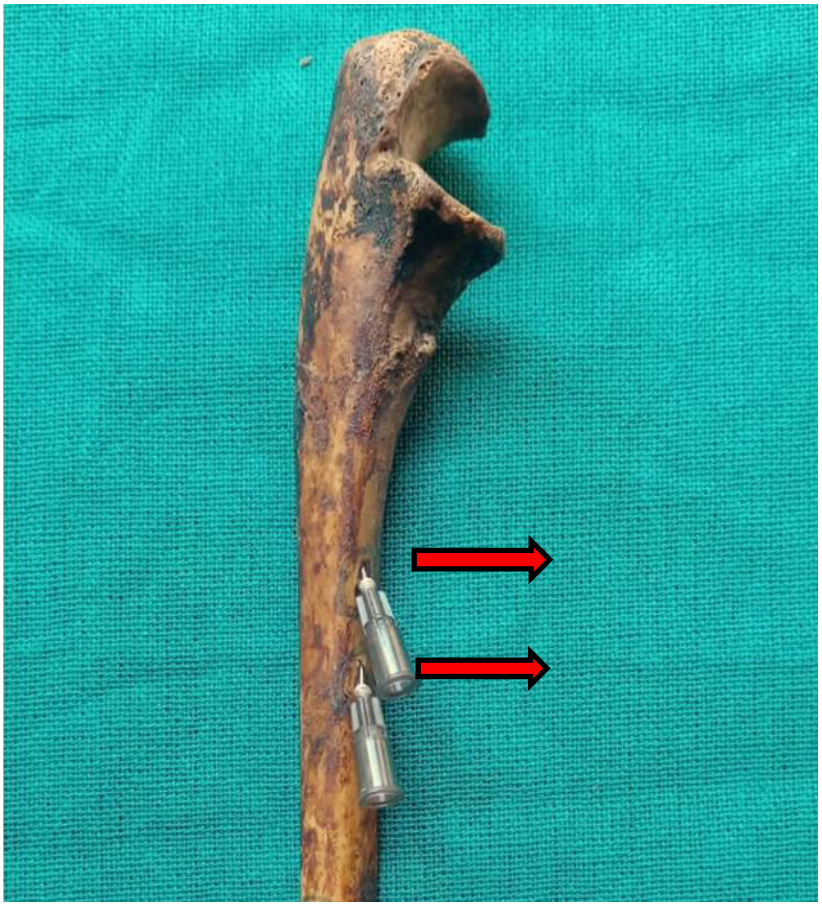
1. All the bones were dry, macerated and thoroughly cleaned.
2. These bones were numbered.
3. The ulnae selected for the study were complete in all respects so as to give correct measurements.

Exclusion Criteria: Ulnae with apparent pathology or fractured ends were disqualified from the study.

RESULT: The orientation of the nutrient foramina was oblique and directed proximally in all 100 bones examined. A single nutritional foramen was discovered in 92 percent of the ulna. [TABLE 1].

TABLE 1: Number of Nutrient Foramina

Number of NF	Absent	Single	Double	Total
Total number of NF	0	92	10	102
Number of bones	3 (3.0%)	92 (92.0%)	5(5.0%)	100`



Photograph showing double nutrient foramen. (Sample no.37)

In regard to the diaphyseal length of the ulna, the location of NF at the upper1/3rd, middle 1/3rd, and at their junction was 25.4%, 62.7%, and 11.76% respectively. All of the bones were missing NF in the bottom third. [TABLE 2].

TABLE 2: Location of NF along the length

Location of NF along the length of the diaphysis	**Number of NF**
Upper 1/3rd	26(25.4%)
Junction of upper 1/3rd & middle 1/3rd	12(11.76%)
Middle 1/3rd	64(62.7%)
Lower 1/3rd	0

The position of NF with relation to the circumference of the shaft was 69.60 percent, 12.74 percent, and 17.64 percent on the anterior surface, Interosseous border, and anterior border of the ulna, respectively [TABLE 3].

TABLE 3: Position of NF with relation to the circumference

Position Of Nutrient Foramina Along The Circumference	**Number of NF**
Anterior surface	71(69.60%)
Interosseous border	13(12.74%)
Anterior border	18(17.64%)
Medial surface	0
Posterior border	0
Posterior surface	0

Photograph showing hypodermal needle in the nutrient foramen

A. On the Anterior Border (sample no.71).
B. On the Interosseous Border (sample no.100)
C. On the Anterior Surface (sample no.66)

In the present study, the mean value for the Foramina index from the upper end was found to be 36.19±7.95mm [TABLE 4].

TABLE 4: **Foraminal Index from The Proximal End of Ulna.**

Measurement	**Mean±SD (mm)**	**Range (mm)**
Total length of the bone (TL)	261.75±18.40	243.35 -280.15
Distance from the proximal end of ulna	96.87±19.52	77.35 -116.39
Foraminal Index (FI)	36.19±7.95	28.24 - 44.14

DISCUSSION:

"To the elbow I go, from the knee I flee," goes a classic tune about the direction of the nutrition foramen. This is due to the fact that one end of the limb grows more quickly than the other[5].

The majority of the bones in current study contained only one nutrient foramen, which was consistent with previous studies. **Mysorekar VR[6], Chatrapati and Misra[11], Longia GS et al[12], Kizilkanat E et al[3], Kumar BN[13], Udayshree[14], Joshi P[15], Veeramuthu M[16]**and **Thakur KK[17]** also found double nutrient foramen in their studies. Furthermore, in our research, the absence of nutrient foramen was consistent with **MysorekarVR[6], Veeramuthu M[16]** and **Thakur KK[17]**. If the nutritive foramen is missing, the periosteal veins become the only source of blood flow in the bones**[6,8,10].**

TABLE 5: Comparison of Distribution of Nutrient Foramen

Author	Population	No. of bones studied	No. of bones with following no. of nutrient foramen			
			0	1	2	3
MysorekarVR[6]	Indian	180	2	174	4	-
Chatrapati and Misra[11]	Indian	68	-	65	3	-
Kate BR[1]	Indian	50	-	50	-	-
Longia GS[12]	Indian	200	-	190	8	2
Kizilkanat E et al[3]	Turkish	102	-	101	1	-
Kumar BN[13]	Telangana India	147	1	140	6	-
Udayshree L[14]	South India	38	-	37	1	-
Joshi P[15]	Rajasthan (India)	50	-	48	2	-
Veeramuthu M[16]	Tamil Nadu (South India)	59	1	57	1	
Thakur KK[17]	Jammu (India)	70	2	66	2	-
Present study	North Indian	100	3	92	5	-

In present study, nutrient foramina predominate in the middle one-third of the population (62.7%). Table 6 shows that our research was in accordance with research done by **Ashwini S[18] (60.70%) MysorekarVR[6]** (65%), **Kumar BN[13]** (67.34%), **Veeramuthu M[16]** (68%), and **Ukoha[7]** (69.23%). In comparison to the current study, **Thakur KK[17]** (73%) and **Udayasree[14]** (87%) found considerably higher values. Since there are no muscle attachments in the distal portion of the bone, there are no nutrient foramina and hence no nutrient arteries. This might be the cause of non-union and delayed healing of fractures in the lower half of the ulna bone[2].

TABLE 6: Comparison of Location of Nutrient Foramen in Relation to The Length of The Shaft

Author	Population	No. of Bones	No. of nutrient Foramina	Location of Nutrient Foramina			
				Upper 1/3rd	Junction of Upper 1/3rd	Middle 1/3rd	Lower 1/3rd
Ukoha[7]	Nigerian	50	39	25.6%	-	69.23%	-
Kumar BN[13]	Telangana (India)	147	147	29.25%	3.5%	67.25%	-
Ashwini S[18]	Karnataka (India)	84	102	39.30%	-	60.70%	-
Veeramuthu M[16]	Tamil Nadu (India)	59	59	32%	-	68%	-
Udayasree L[14]	South India	38	38	13%	-	87%	-
Joshi P[15]	Rajasthan (India)	50	50	56%	-	44%	-
Thakur KK[17]	Jammu (India)	70	70	18.50%	8.5%	73%	-
Present study	North Indians	100	102	25.5%	11.8%	62.7%	-

According to the research conducted by **Veeramuthu M**[16] (76%), **Ashwini S**[18] (77.38%), **Thakur KK**[17] (81%) **Kumar BN**[13] (89%), and **Udayasree**[14] (97%), NF is most frequently positioned on the anterior surface near to the anterior or interosseous border of the ulnar diaphysis. The result of the present study (69.60%) was close to the observation of **Virupaxi RD**[19] (65%) for the incidence of the position of nutrient foramina over the anterior surface.

The current study's findings (36.19±7.95) on the foraminal index from the top end were reported in conjunction with those of **Joshi P**[15] (36.52) and **Ukoha**[7] (36.70±4.56) as depicted in table 7. Because the indices were varied, it was impossible to compute the whole length of the bone from the distance between the NF and the ulna's upper end. According to these findings, the NF is present in the top 2/3rd of the diaphysis and missing in the bottom 1/3rd.

TABLE 7: Comparison of Statistical Results of Index of Nutrient Foramen from Upper End

Author	Ukoha[7]	Solanke KS[20]	Joshi P[15]	Present study

Population		Nigerian	Pune (India)	Rajasthan (India)		North Indian
Total no of bones		50	80	50		100
Index from the upper end	**Mean (mm)**	36.70±4.56	36.52	Right	34.63± 6.2	36.19±7.95
				Left	34.42±5.79	
	Range (mm)	34.14±41.26	-	Right	20.83-48.27	28.24±44.14
				Left	23.92-45.85	

CONCLUSION:

Anatomy has traditionally been a reliable source of information for surgical operations such as prosthesis placement. The outcomes of this study corroborated previous studies on ulnar NF. Due to a lack of NF and hence nutritional arteries, fractures in the lower portion of the ulna are more likely to delay or fail to heal. Thus, a good insight of the precise position and exact location of the NF is critical for identifying the portion of the bone that is sufficiently supplied and assists in the preservation of circulation during certain surgical operations as well as the restoration of normal anatomy.

CONFLICTS OF INTEREST: NIL.

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