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Original Research Article

AN OSTEOLOGICAL STUDY OF NUTRIENT FORAMINA IN RADIUS AND ULNA WITH ITS EMBRYOLOGICAL AND CLINICAL SIGNIFICANCE

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ABSTRACT

Background: The knowledge of variations of the position nutrient foramina and hence nutrient arteries is important for the orthopedicians and radiologists for various procedures. The incidence of normal position of nutrient foramina and nutrient artery in the shaft of long bone is 99%.

Aims and Objectives: Nutrient artery provides the main source of blood supply to the long bones in the human body. The nutrient artery enters the shaft of the long bones, through a foramen termed 'nutrient foramen'. The nutrient artery passing through the nutrient foramen plays a pivotal role in the growth and development of the long bones. The presence, position, number, direction and distances from the various landmarks on the bone have clinical significance. The present study was done on the radius and ulna of South Indian population to know the number, position of nutrient foramina and to discuss the embryological basis and clinical significance of the variations.

Materials and Methods: The present study consists of forearm bones: 69 radii and 84 ulnae which were taken from Department of Anatomy, Ramaiah Medical College, Bangalore, India and studied keenly for the number, position, direction and distance of nutrient foramina in relation to length and from the proximal epiphysis of the long bones were noted with osteometric board and digital vernier calipers and also the direction of nutrient foramina were noted with a probe.

Results: The mean position of the nutrient foramen in radius from its upper end was 8.71cms and in ulna was 9.31cms. The main nutrient foramina and the accessory nutrient foramina were directed upwards in all the radii and ulnae studied. The nutrient foramina were present in middle 1/3rd (65.8%), anterior surface (69.6%) for radius and middle 1/3rd (60.7%), anterior surface (77.3%) for ulna.

Conclusion: This study will provide the ethnic data for comparison among various populations. It is also helpful in interpretation of radiological images and for orthopedic procedures. Precise knowledge of usual and anomalous position of nutrient foramina and hence the nutrient artery may help the orthopaedician for the internal fixation at appropriate place in the long bone. The location of nutrient foramen is important for bone grafts, tumour resections, in traumas, congenital pseudoarthrosis and more recently in microsurgical vascularised bone transplantation.

KEY WORDS: Nutrient Artery, Internal Fixation, Diaphysis, Long Bone, bone graft, bone transplantation.

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INTRODUCTION

Nutrient artery is the chief artery supplying the long bone along with periosteal arteries. They usually take origin from the regional artery of that region. The nutrient artery enters the shaft of the long bones, through a foramen termed 'nutrient foramen'. Nutrient foramen is an opening in the shaft of long bone which conducts the nutrient arteries and the peripheral nerves into the medullary cavity of a long bone.

One or two main diaphyseal nutrient arteries enter the shaft obliquely through one or two nutrient foramina leading to nutrient canals. Except for a few with double or no foramina, all of long bones have a single nutrient foramen.

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. The direction of nutrient foramen of all bones is away from growing end. The nutrient foramina in the long bones of human limbs are described as being directed towards the elbow and away from the knee. This is said to be due to one end of long bones growing faster than the other [1].

The nutrient arterial supply is essential during the growing period, during the early phases of ossification, and in procedures such as bone grafts, tumour resections, traumas, congenital pseudoarthrosis and more recently in microsurgical vascularised bone transplantation [2].

MATERIALS AND METHODS

An osteological study on nutrient foramina in radius and ulna, was conducted in Department of Anatomy, Ramaiah Medical College Bangalore,Karnataka,India. This study was done in 69 radii and 84 ulnae. Each bone is examined in detail for the number, position & direction of nutrient foramina. The nutrient foramen is identified by the presence of a well marked groove and raised edge at the commencement of the canal. All measurements were taken with osteometric board and digital vernier calipers. The direction of the nutrient foramen was noted with the help of a probe.

Inclusion Criteria: Adult human radii and ulnae irrespective of sex, race was taken for study.

Exclusion Criteria: Radii and ulnae showing any gross asymmetry or broken will be rejected as they were unsuitable for the study.

RESULTS

The average distance of the nutrient foramen from the upper end in radius was 8.71cms and in ulna was 9.31cms. The main nutrient foramina and the accessory nutrient foramina were directed upwards in all the radii and ulnae studied. This shows that the growing end of radii and ulna were the lower ends. The most common position of the nutrient foramina was in the middle 1/3rd (65.8%), anterior surface (69.6%) for radius and middle 1/3rd (60.7%), anterior surface (77.3%) for ulna. The observations in radii were tabulated in Table 1 and 2; while that of ulna were tabulated in Table 3 and 4.

The presence of main nutrient foramina along with accessory nutrient foramina in radius and ulna are shown in Figure 1 and Figure 2 respectively.

Table 1: Showing the number of radius examined along with accessory nutrient foramen.

RADIUS	
No. of bones examined	**69 (100%)**
No. of bones with Accessory Nutrient Foramina	**7(10.15%)**

Table 2: Showing the position and number of accessory nutrient foramina in radius.

Accessory Nutrient Foramina in Radius:	
Position:	**Number(%)**
Upper 1/3rd	1(14.29%)
Middle 1/3rd	4(57.14%)
Lower 1/3rd	2(28.57%)

Fig. 1: Showing the Main Nutrient foramen (white arrow) and the accessory nutrient foramen (blue arrow) in Radius.

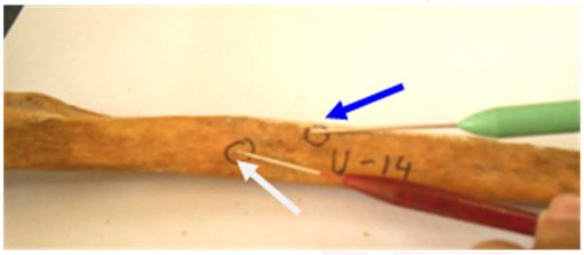
Table 3: Showing the number of ulna examined along with accessory nutrient foramen.

ULNA	
No. of bones examined	84(100%)
No. of bones with Accessory Nutrient Foramina	18(21.42%)

Table 4: Showing the position and number of accessory nutrient foramina in ulna.

Accessory Nutrient Foramina in Ulna:	
Position	**Number(%)**
Upper 1/3rd	9(50%)
Middle 1/3rd	4(22.22%)
Lower 1/3rd	5(27.77%)

Fig. 2: Showing the Main Nutrient foramen (white arrow) and the accessory nutrient foramen (blue arrow) in Ulna.



DISCUSSION

The nutrient foramina are cavities that conduct the nutrient arteries and the peripheral nerves on the shaft of long bones. Long bones receive most of the interosseous blood supply from the nutrient arteries, and sometimes through the periosteal vessels. Nutrient arteries play an important role in nutrition and growth of the bones particularly during its growth period in the embryo and fetus as well as during early phases of ossification [3].

Berard was the first person to correlate the direction of the canal with the growth and ossification of the bone. Humphrey had worked on the direction and obliquity of nutrient canals postulated periosteal slipping theory, the canal finally directed away from the growing end. Harris has stated that the position of nutrient foramina is constant during the growth of long bone. Lutken has stated that position of nutrient foramina is variable & typical position of nutrient foramina can be determined after a study on human bones [4].

The direction of nutrient foramina in human long bones is directed away from the growing end. This is due to one end of long bone is growing faster than the other end [5].

In many tetra pods**,** there is variation in the directions of nutrient foramina, but in mammals and birds Hughes pointed out that Anomalous canal are frequent, especially in femur [6].

The nutrient foramen is defined as the largest of the foramen present on the shaft of long bone allowing nutrient artery to enter the bone, the role of which is important in providing nutrition and growth of long bones.

An understanding of the location and the number of the nutrient foramina in long bones is therefore important in orthopedic surgical procedures such as joint replacement therapy, fracture repair bone grafts and vascularized bone microsurgery as well as medico legal cases [3].

The nutrient foramina was identified by the presence of a well marked grove leading to the foramen, and by a well marked often slightly raised edge by the side of the foramen at the commencement of the nutrient canal. For direction of nutrient canal, a fine stiff wire was used and it was passed through the nutrient foramen to confirm its direction [7].

Importance of nutrient foramen is relevant to fracture treatment. Combined periosteal and medullary blood supply to the bone cortex helps to explain the success of nailing of long bone fractures [7].

In the radius the nutrient foramen is, invariably, above the middle of the bone and in the ulna, it is in the middle third and In both, the foramen most frequently occurs on the anterior surface nearer either the anterior or interosseous border. There is some symmetry in the position of the foramina on the two sides [5].

The predominance of Nutrient foramina in radius was on the anterior surface (73.2%) and the percentage of bones with a single Nutrient foramen (99.4%) and two Nutrient foramina (0.63%). 82.2% of the Nutrient foramina of the ulna were located on the anterior surface. All ulnae examined have at least one Nutrient foramen and 1.4% of the bones have two Nutrient foramina [2].

The present Osteological Study of Nutrient Foramina in radius and Ulna were compared with

Table 5: The present study of nutrient foramina of radius were compared with the previous similar study.

RADIUS	G.Vinay, A.Kumar 2011 [4]	Present study
No. of bones studied	32	69
No. of radii with a single Nutrient foramen	31(96.8%)	62(89.8%)
Anterior Surface	78.80%	69.60%
Middle 1/3rd	72.70%	65.80%
Average distance from upper end	7.81 cm	8.71cm

the previous similar study is tabulated in Table 5 and 6.

Table 6: The present study of nutrient foramina of ulna were compared with the previous similar study.

Ulna	G.Vinay, A.Kumar 2011 [4]	Present Study
No. of bones studied	32	84
No. of ulnae with a single Nutrient foramen	28 (87.5%)	66 (78.6%)
Anterior Surface	80.50%	77.38%
Middle 1/3rd	55.50%	60.70%
Average distance from upper end	7.56 cm	9.31 cm

Embryological Significance: 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. This agrees with adult rules "towards the knee and away from elbow". This is said to be due to unequal growth of the ends of the long bones. The arrangement of diaphyseal nutrient foramen in long bones usually follows a definite pattern. Position is constant and seen on flexor surfaces. Direction and obliquity of nutrient canal shows the general pattern. The direction of nutrient foramina in human long bones is directed away from the growing end. This is due to one end of long bone is growing faster than the other end [8].

The forces responsible for the determination of the direction the nutrient canal is hard to find out. Le Gros Clark in 1939 gave the most precise explanation. "The nutrient foramen and the canal of the shaft of a long bone are always directed obliquely away from the growing end of the vone, i.e. in the upper limb towards the elbow and in the lower limb away from the knee. This obliqyity is a necessary consequence of the mode of growth in length of the bone. To befin with, the nutrient artery, which is a branch of a main artery in the neighbourhood, runs directly into the shaft, entering it at right angles. As the shaft extends in lrngth away from the growing end the artery is carried with it, so that its entrance becomes more and more oblique in a direction towards the opposite extremity of the bone" [9].

"Although in the large limb bones epiphyses are formed at both ends, the growth takes place mainly at one end, the so called growing end of the bone. In the case of upper limb, this is the end farther away from the elbow and in the lower limb nearer to the knee" [9].

"This might be taken to imply that a) growth at one end bone towards which the nutrient canal is directed is negligible and b) growth of the bone is the only potent factor determining the relative position of structures in the limb" [10].

Clinical Significance: Exact location and distribution of the nutrient foramina in bone diaphysis is important to avoid damage to the nutrient vessels during surgical procedures [11].

Position and number of the nutrient foramina in long bones is very important in orthopedic surgical procedures like joint replacement therapy, fracture repair, bone grafts and vascularized bone microsurgery [12].

Injury to the nutrient artery at the time of fracture, or at subsequent manipulation, may be a significant factor predisposing to faulty union. The levels of osseous section are selected according to the localization of the diaphyseal nutrient foramina in order to preserve diaphyseal vascularization of the recipient to support the consolidation with the osseous graft [13].

CONCLUSION

The direction of the nutrient foramen is important in knowing the growing end of the long bone. In bone grafts, the nutrient blood supply is crucial and it should be preserved in order to promote the fracture healing. Its knowledge is of importance to the orthopaedic surgeons and oncologists.

The knowledge of the nutrient foramen is of utmost importance for the orthopaedic surgeons during procedures like bone grafting and more recently in microsurgical vascularised bone transplantation.

All bones had nutrient foramina, if long bones had no nutrient foramen. This suggests that in case of obliteration of nutrient foramen, the epiphyseal artery might have taken up the responsibility for supplying the bone.

The knowledge about these foramina is useful in the surgical procedures to preserve the circulation [14].

Conflicts of Interests: None

REFERENCES

[1]. H. Grey, P.L. Williams, L.H. Bannister, M.M. Berry, P. Collins, M. Dyson, J.E. Dussek, M.W.J. Ferguson et al.1995. Gray's Anatomy: 38 edition. London, Churchill Livingstone. 1995:1417.

[2]. G.A.M.Pereira, P.T.C. Lopes, A. M. P. V.Santos, F. H. S. Silveira. 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.

[3]. V.S.Rao, J.Kothapalli. The Diaphyseal nutrient foramina architecture - a study on the human upper and lower limb long bones. IOSR Journal of Pharmacy and Biological Sciences. 2014;9(1):36-41.

[4]. G. Vinay, A.S. Kumar. A study of nutrient foramina in long bones of upper limb. Anat Karnataka. 2011;5(3):53-6.

[5]. Mysorekar VR. Diphysial nutrient foramina in human long bones. J Anat. 1967;101(4): 813-822.

[6]. Hughes H. The factors determining the direction of canal for the nutrient artery in the long bones of mammals and birds. Acta Anat. 1952;15(3):261-280

[7]. O. Malukar, H.Joshi. Diaphysial nutrient foramina in long bones and miniature long bones. NJIRM 2011;2:23-26.

[8]. B.Roul, M.Goyal. A study of nutrient foramen in long bones of superior extremity in human being. International Journal of Current Research in Life Sciences.2015;4(4):198-200.

[9]. Le Gros Clark WE. The tissues of the body, 6th edn. Oxford: ELBS. 1980;79-80,105.

[10]. H.Hughes. The factors determining the direction of the canal for the nutrient artery in the long bones of mammals and birds. Acta Anatomica. 1952;15(3):19.

[11]. Kumar R, Mandloi R S, Singh A K, Kumar D, Mahato P. Analytical and morphometric study of nutrient foramina of femur in Rohilkhand Region. Innovative Journal of Medical and Health Science. 2013;3:52-54.

[12]. Kizilkanat E, Boyan N, Ozsahin ET, Soames R, Oguz O. Location, number and clinical significance of nutrient foramina in human long bones. Ann. Anat., 2007;189:87-95.

[13]. Wavreille G., Remedios, Dos C., Chantelot C. Anatomic bases of vascularized elbow joint harvesting to achieve vascularised allograft. Surg. Radiol. Anat., 2006;28:498–510.

[14]. Murlimanju B.V, Prashanth K.U, Latha V.P, Vasudha V.S, Mangala M.P, Rajalakshmi R. Morphological and topographical anatomy of nutrient foramina in human upper limb long bones and their surgical importance. Rom J Morphol Embryol 2011;52(3): 859-862.

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