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Morphometric And Comparative Study Of Nutrient Foramina Of Femur And Humerus Bones And Its Clinical Importance In Egyptian Population

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ABSTRACT

Background : knowledge with respect to nutrient foramina of bones is helpful in surgeries, for example, microvascular bone exchange to safeguard the dissemination. In any case, there is not many information on Morphometric investigates of the supplement foramina of femur and humerus in Egyptians.
Subjects and methods : Between June 2019 and September 2020, we prospectively assess morphology of nutrient foramina included 350 adult long limb bones of femur and humerus Department of Anatomy in Al-Azhar University . the age and gender of which were not determined of Egyptian subjects. The bones were examined for the number, location and direction of the nutrient foramina.
Aim of the work : To investigate the morphology of nutrient foramina of femur and humerus regarding to their numbers and localizations and to determine their foraminal index to provide detailed data on such features.
Results : The foramina were most determined in anteromedial aspect 61% of cases on the shaft of bone in the humerus , its foramial indices were 32.1 – 68.7 % and the most of study (84%) had one nutrient foramen. In femur, we founded that the range of foraminal indices of bone 26.1 – 68 % , mainly sample (88%) located in the middle third of the bone and (30%) had one nutrient foramen, (60%) had two nutrient foramina and only (10%) had three nutrient foramina. 56.1% nutrient foramina were located in between upper and middle 1/3rd of the Femur,,18.7% nutrient foramina were located in between middle and lower 1/3rd of the Femur ,, 23% nutrient foramina were located in middle half of the length of the Femur.
Foraminal Index (FI): (Distance of nutrient foramen / Total length) ×100
Conclusion: The anatomical information of the nutrient foramen of the long bones of limb as femur and humerus is important for orthopaedic surgeons during surgical operations of bones.

Keywords: Nutrient Foramen, Long Bones, Foramina Index, Position, Location.

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INTRODUCTION

bones support the body by make a frame, tendons, muscles & ligament bind to bone, so without establish of bone the body can't move. Also bone can protect some internal organs for example the ribs save the heart & lungs, & skull save the brain. (N. Su, J. Yang, Y. Xie, X. Du, H. Chen, H. Zhou,L. Chen,2019)
All bone in the body have large or small openings (foramina) consider as an entry to blood vessels called a nutrient foramina and extend along shaft of bone, to make a nutrient canal which contain artery to nutreint the bone & nerve to enervate the bone(A. Kumar, Sonia Jaiswal, P. K. Sharma, V. Tewar,2018)
So nutrient foramen known as vascular channel cross from cortex of bone to supply the bone. (Malukar O, Joshi H. , 2011)
The nutrient foramen is also central in the development of longitudinal stress fractures, as they either develop from it or from its close areas (A. Kumar, Sonia Jaiswal, P. K. Sharma, V. Tewar,2018).
Clinically, the fracture of long bones is accompanied by rupture of nutrient arteries and periosteal vessels leading to local bleeding (Trueta, 1974). The knowledge of the nutrient foramina morphometry is consequently important in some orthopedic surgical procedures, such as joint replacement therapy, fracture repair, bone grafts, vascularized bone microsurgery and also in medico-legal cases (Rao VS, Kothapalli J 2014).

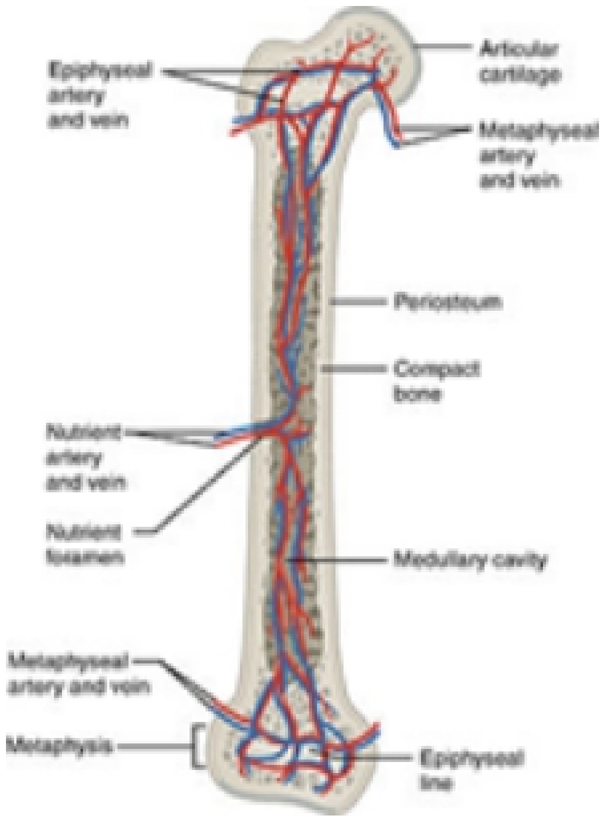

Fig1: Nutrient canal

Humerus bone
humerus is one of the long bones which found in upper limb and is called forelimb in land vertebrates. This bone is the contact between shoulder and elbow which join from upper with depression of glenoid cavity of scapula & join with elbow joint below. (_ N. Su, J. Yang, Y. Xie, X. Du, H. Chen, H. Zhou, L. Chen, 2019)

The proximal landmarks of humerus bone
_ head: Head of humerus consider an upper end of bone, found medially upwards & backwards.
_ neck: Which seprated between greater tubercle & lesser tubercle.
_ greater tubercle: Found laterally of humerus anterior & posterior. It serves a connection place for three muscle, supraspinatus, infraspinatus, teres minor.
_ lesser tubercle: Found more medially & smaller than greater tubercle, it gives attachment to subscapularis muscle from anterior surface only.
_ intertubercular:

Shaft
Shaft is body of bone to attachment for many muscles.
deltoid tuberosity.
The radial groove

Distal region:
_ supraepicondylar ridges: Found latarelly & medially.
_ lateral and medial epicondyles:
_ trochlea: Found medially & extend to posterior surface.
_ capitulum: Lateral to trochela.
_ coronoid, radial and olecranon fossa

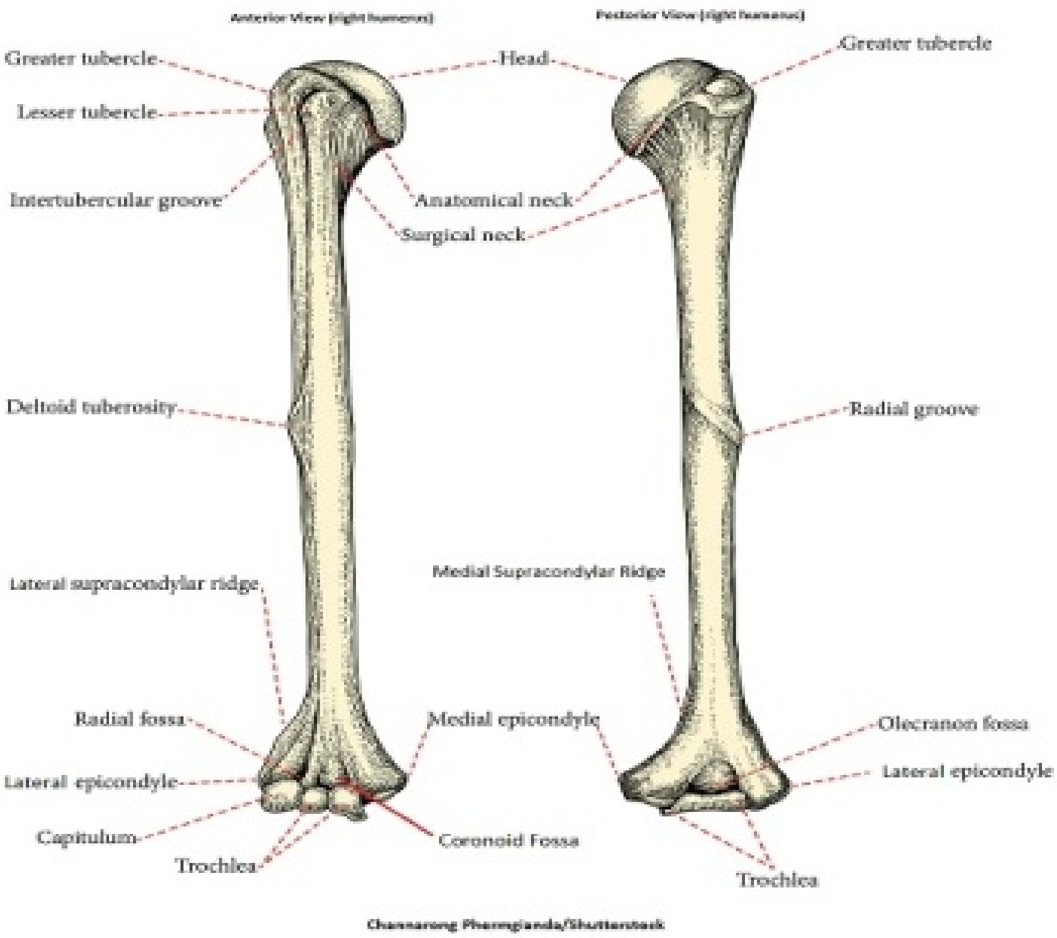

Fig 2: anatomy of humerus bone.

Femur bone
Bone of thigh & it is the longest bone in the body. Femur connect with pelvis bone in hip joint. (_ N. Su, J. Yang, Y. Xie, X. Du, H. Chen, H. Zhou, L. Chen, 2019).
Consist of :

Proximal
_ Head: Smooth surface wrapped by cartilage & attach with acetabulum of pelvic bone.
_ Neck: Connect the body of femur with head.
_ Greater trochanter: Projection in lateral side of bone found from anterior side.
_ lesser trochanter: Project smaller than greater trochanter found in posteromedial aspect of the femur bone.
_ intertrochanteric line & crest

Shaft
linea aspera.
gluteal tuberosity
popliteal fossa

Distal
_ Medial and lateral condyles.
_ Medial and lateral epicondyles
_ Intercondylar fossa

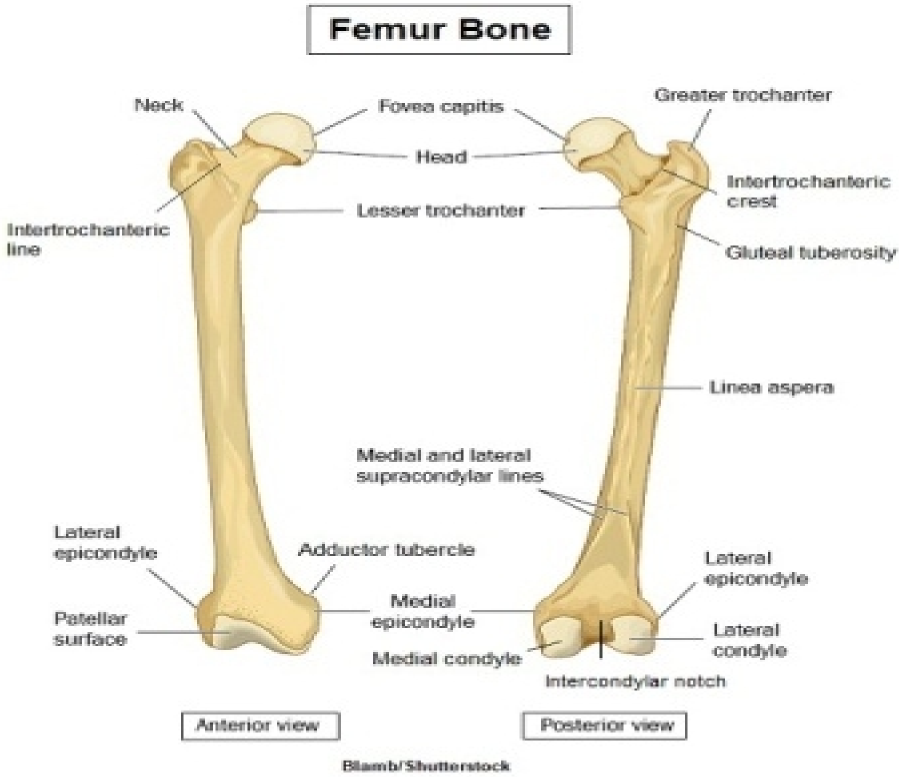

Fig3: anatomy of femur bone.

METHOD

The study included 350 adult long limb bones which included 100 femora (50 right, 50 left) and 250 adult humeri (125 right and 125 left). Bones were obtained from the osteology section of our Department of Anatomy. All the bones belonged to Egyptian subjects, the age and gender of which were not determined.Exclusion criteria included the following: non-Egyptian patients, cases with congenital anomalies, bones which had gross pathological deformities were excluded from the study. All the bones were macroscopically observed for the number, location and direction of the nutrient foramina. We used a magnifying lens to observe the foramina.The identification of nutrient foramina was done by the presence of a well-marked groove leading to them and by a well-marked, often slightly raised, edge at the commencement of the canal. Only diaphysial nutrient foramina were observed in all the bones and a 24 gauge needle was passed through each foramen to confirm their patency. The number of the foramina in relation to specific borders or surfaces of the diaphysis were analyzed. The foramina within 1mm from any border were taken to be lying on that border. An elastic rubber band was applied around these for those bones which had double nutrient foramina; the larger foramen was taken into consideration during the estimation of FI. The FI was determined for all the bones which give the location of the nutrient foramen, each bone was divided into five equal parts and was analyzed topographically. The data was collected on a standardized sheet and tabulated. This study was approved by the local ethical committee of Al-Azhar University.The diameter of the main nutrient foramen was estimated using steel hypodermic needles of known gauge. The steel hypodermic needles were inserted into the major nutrient foramen, starting from the needle with least cross-sectional diameter (gauge 24), to find out the needle with maximum cross-sectional diameter that can be accommodated within the foramen. The diameter of the major nutrient foramen was estimated using the outer diameter of the bore of the largest steel hypodermic needle that accommodated into the foramen (Poornima & Angadi, 2015) . Needles of gauge 24 (0.57 mm) , 22 (0.72 mm), 20 (0.91 mm) and 18 (1.27 mm) were used in this study (Sigma-Aldrich, 2017).

The major nutrient foramen was marked by tying a thread around the shaft at the location of the foramen. The length of the femur or humerus and the distance from the major foramen to the proximal end of the femur or humerus were measured using the osteometric-board and a standard measuring tape graduated in centimeters and millimeters and two 15 cm rulers The linear distribution of the major nutrient foramen on shaft of femur was classified using the foramen index discussed by Kumar et al. (2013).

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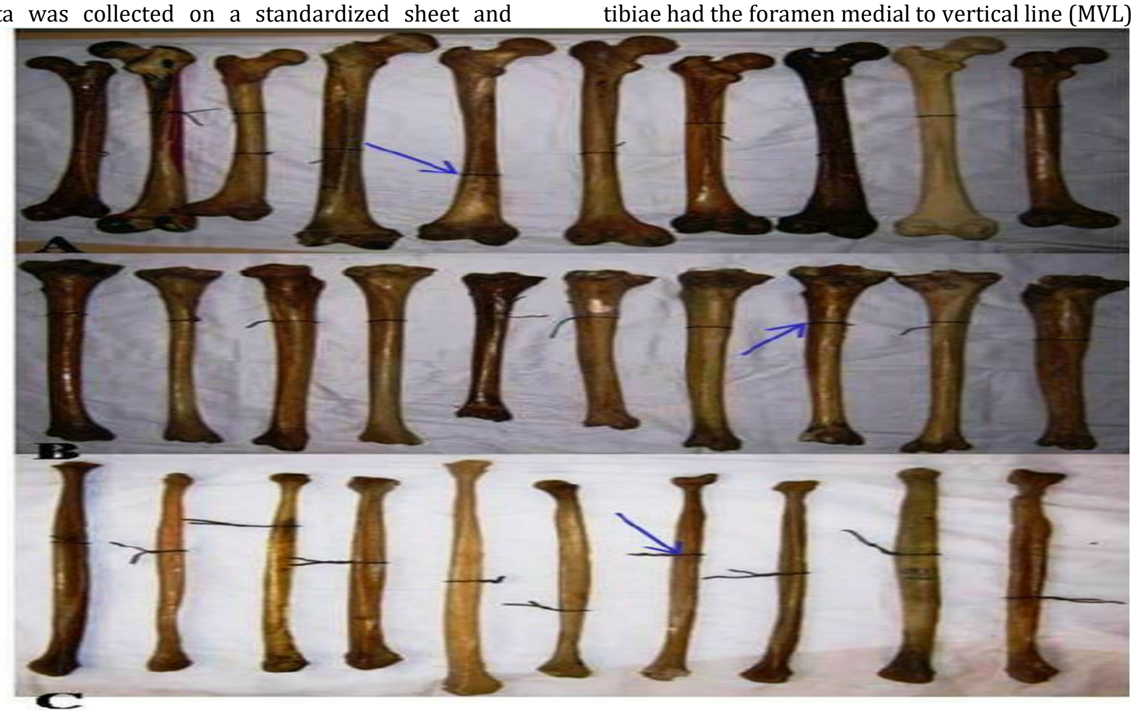


Fig4: The lower limb long bones with rubber bands tied at the level of the foramina.

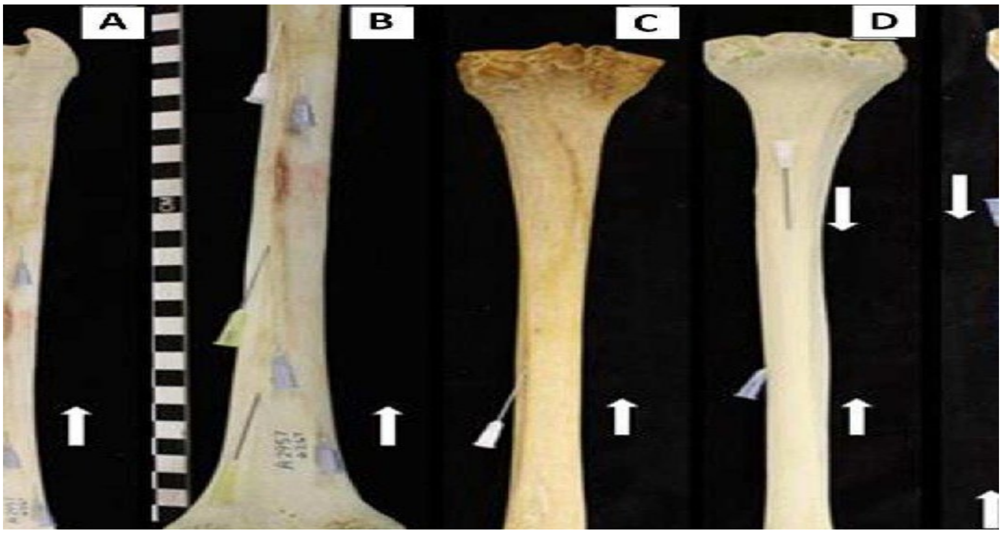


Fig5: The lower limb long with rubber bands tied at the level of the foramina.

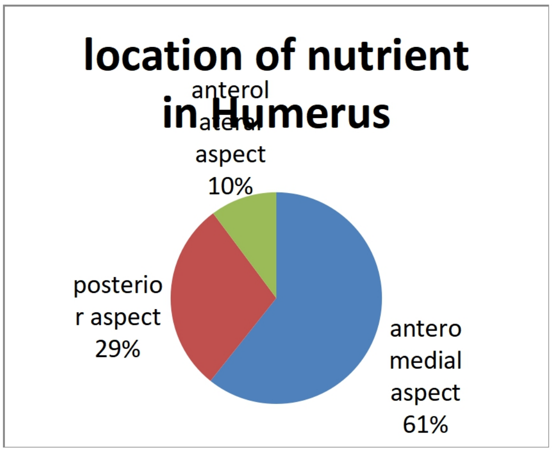
statistical analysis was performed using commercial software SPSS 18 (SPSS Inc., USA, Chicago), t test for continuous variables and Chi square (X2) test. P <0.05 was considered statistically significant.

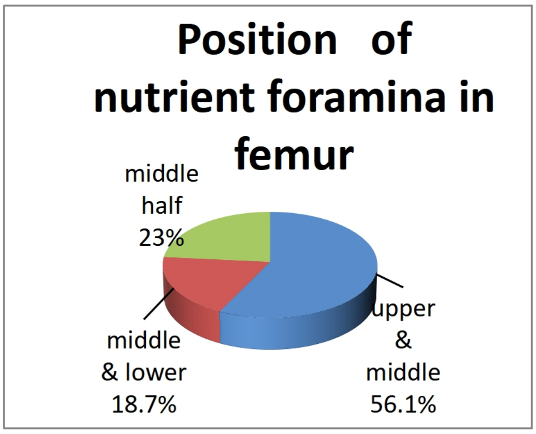
RESULTS

In this study the anatomic situation of the nutrient foramina was detected. Mainly, the nutrient foramina of the long bones of the upper extremity were located closer to the elbow than the shoulder or wrist. On the contrary, the nutrient foramina were closer to the hip in the femurs

Number of nutrient foramina observed.

Bone	Number of foramina	Number of bones (%)	The mean length of bone(cm)	Range of foraminal indices of bone (%)
Humerus (n=250)	Absent 1 2	5(2) 210 (84) 35 (14)	31.14	32.1 – 68.7
Femur (100)	1 2 3	30(30) 60(60) 10(10)	44.42	26.1 – 68.6





DISCUSSION

All bones have larger or smaller foramina (openings) for the entrance of blood-vessels; these are known as the nutrient foramina and are particularly large in the shafts of the larger long bones, where they lead into a nutrient canal, which extends into the medullary cavity. The nutrient canal (foramen) is directed away from the growing end of bone. The growing ends of bones in upper limb are upper end of humerus and lower ends of radius and ulna. In lower limb, the lower end of femur and upper end of tibia are the growing ends. The nutrient arteries along with veins pass through this canal. In long bones the nutrient canal is establish in the shaft. It is well known that one of the causes of delayed union or non-union of fracture is lack of arterial supply. The biologic process of repair of a traumatic or surgically induced fracture has been discussed as developing slowly or not at all. The morphological knowledge of nutrient foramina is significantly important for orthopedic surgeons undertaking an open reduction of a fracture to avoid injuring the nutrient artery and thus lessening the chances of delayed or non-union of the fracture. (Joshi H,et al , 2011)

The external opening of the nutrient canal, frequently referred to as the nutrient foramen, has a particular position for each bone. It is generally agreed that the vessels which occupy the nutrient foramen are derived from those that took part in the initial invasion of the ossifying cartilage, so that the nutrient foramen was at the site of the original center of ossification . Hughes observed that the variant foramina were common in the femur, rare in the radius and very rare in other bones. Conversely, Mysorekar found anomalously directed foramina only in the fibula and said, this was due to the peculiar ossification pattern in that bone. Variations in the direction of nutrient foramina have been observed in many tetrapods and there is some similarity in the foraminal pattern in mammals and birds (N. Su, J. Yang, Y. Xie, X. Du, H. Chen, H. Zhou, L. Che, 2019)

Schwalbe16 explained that growth at the two ends of a long bone before the appearance of the epiphyses is equal. Hence, the nutrient foramen before the birth should be directed horizontally. Many theories have been located forward to account for the direction of foramina and also the anomalously directed ones. Among them the 'periosteal slip' theory of Schwalbe16 and vascular theory of Hughes12 are widely accepted in the literature . Patake and Mysorekar observed that the number of foramina does not seem to have any significant relation to the length of the bone. It was suggested that the direction of nutrient foramina is determined by the growing end of the bone. The growing end is supposed to grow at least twice as fast as the other end. (Kamath V, Asif M, 2016)

The nutrient artery runs away from the growing end as the growing bone might pull and rupture the artery. So the nutrient foramina are directed away from the growing end. Two well-known factors may affect nutrient foramen position. These are growth rates at two ends of the shaft and bone remodeling. Addressing the growth rates and bone remodeling, the bones of different age groups need to be studied. The fetal bones could also help in analyzing this concept. The present study could not address these factors as the study involved cadaver dry bones. Lacroix(1951) recommended that the pull of muscle attachments on the periosteum explained certain anomalous nutrient foramina directions. Nutrient arteries which are the main blood supply to long bones are particularly vital during the active growth period and at the early phases of ossification. So the nutrient arteries should be kept patent until the growth is completed and even after the growth. Therefore they are directed away from the growing end. These nutrient arteries pass through the nutrient foramina, the position of nutrient foramina in mammalian bones are variable and may alter during the growth. The nutrient artery of femur may arise from the medial circumflex femoral artery or from any artery parallel to the diaphysis. (PEREIRA GM , LOPES PTC , SANTOS AMPV, SILVERA FHS, 2011)

Mysorekar et al ,(1979) reported that the important know the arteries in the limps such as in the tibia the artery originates directly from the popliteal or posterior tibial artery. The fibula is supplied from one or more branches of the peroneal artery and both foramina of the femur be supposed to be treated as main ones and the presence of which is not surprising in view of the length of the femur. He reported that the femur generally has two nutrient foramina and they are restricted to the linea aspera or its surroundings in the middle third of the bone.So, the nutrient artery is the principal source of blood supply to a long bone and is particularly important during its active growth period in the embryo and fetus, as well as during the early stage of ossification. The nutrient artery enters individual bones obliquely through a nutrient foramen. (Zichao Xue, 2018)

Nutrient foramen are directed towards elbow in upper limb (directed towards lower end of humerus and upper ends of radius and ulna), while in lower limb nutrient foramen is directed away from knee (that is, upper end for femur and lower ends of tibia and fibula). This is supposed to be due to one end of limb bones growing faster than the other and generally follows the rule, "to the elbow I go, from the knee I flee." Their positions in mammalian bones are variable and may alter during the growth phase. The topographical data of these nutrient foramina is useful in operative procedures to preserve the circulation. When working on the direction and obliquity of nutrient canals postulated periosteal slipping theory, the canal lastly directed away from the growing end. Nutrient artery is the major source of blood supply to the bone and hence plays an important role in fracture healing. Orthopedic surgical procedures like vascularized bone microsurgery requires the detailed knowledge of the blood supply. In free vascular bone grafting, the blood supply by nutrient artery is particularly important and must be preserved in order to promote fracture healing. (Yaseen S,, 2014)

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. Position of the fracture relative to the nutrient foramen of the long bone and the patterns of edema are the secondary signs in the key of the diagnosis of this type of fracture (Sigma-Aldrich, 2017)

Carroll S. (1963) reported that nutrient arteries, the main blood supply to long bones, are particularly essential during the active growth period, as well as during the early phases of ossification. The topographical awareness of the nutrient foramina is useful in operative procedures to preserve the circulation. In the present study, we investigated 336 adult human long bones which were from the osteology section of our Department of Anatomy of Al-Azhar University.

CONCLUSION

The direction of the nutrient foramen is important in knowing the growing end of the long bone. In case of bone graft, the nutrient blood supply is very important and it should be preserved to promote fracture healing, so nutrient foramen have a clinical significant to oncologists & orthopedic surgeons. (A. Kumar, Sonia Jaiswal, P. K. Sharma, V. Tewari, 2018)

Studying for nutrient foramen have a high importance during the growing period, also during the early phases of ossification, and in procedures such as bone grafts, transplant techniques in orthopaedics. (K. Bohra, Priyanka Katara, Rajesh Arora, Chandrakala Agarwal, 2016).The learning to nutrient foramina is helpful in surgical operations to maintain the circulation.

REFERENCES

1. Abhijit K RPrathap Kumar JShailaja Shetty, MORPHOLOGICAL AND MORPHOMETRIC STUDY OF NUTRIENT FORAMINA OF FEMUR IN SOUTH INDIAN POPULATION, Mar 2020DOI: 10.16965/ijar.2020.107ISBN: 2321-4287.
2. Forriol C., F.; Pellico, L. G. ; Alias , M. G. & Fernandez V., R. A study of the nutrient foramina in human long bones . Surg . Radiol. Anat., 9:251- 5 , 1987.
3. Joshi H, Doshi B, Malukar O. A study of the nutrient foramina of the humeral diaphysis. NJIRM 2011; 2
4. Kumar, R.; Mandloi, R. S. ; Singh, A. K.; Kumar, D. & Mahato, P. Analytical and morphometric study of nutrient foramina of femur in Rohilkhand region . IJMHS, 3(2) : 2013. Available from : https:// www.semanticscholar.org/paper/ANALYTICAL-ANDMORPHOMETRIC-STUDY-OF-NUTRIENT-OF-IN-KumarMandloi/b6979b251eabf912c73b4723aeb58d995e7e089e .
5. Malukar O, Joshi H. Diaphysial Nutrient Foramina In Long Bones And Miniature Long Bones, NJIRM; 2011 ; 2(2) : 23-26.
6. PEREIRA GM , LOPES PTC , SANTOS AMPV, SILVERA FHS (2011). Nutrient foramina in the upper and lower limb long bones : Morphometric study in bones of southern Brazilian adults . Int J Morphol , 29 : 514 – 520 15_ Sharma, M. ; Prashar, R. ; Sharma, T. ; Wadhwa, A. & Kaur, J. Morphological variations of nutrient foramina in lower limb long bones. Int. J. Med. Dent. Sci., 4 (2) : 802 - 8, 2015. .
7. Sigma-Aldrich . Syringe Needle Gauge Chart . Sigma-Aldrich Chemicals Technical Library , 2017.
8. Sharma M, Prashar R, Sharma T, Wadhwa A, Kaur J. Morphological variations of nutrient foramina in lower limb long bones. Int J Med and Dent Sci. 2015;4(2):802-08.
9. Kamath V, Asif M, Bhat S, Avadhani R. Primary nutrient foramina of tibia and fibula and their surgical implications. Indian J Clin Anat Physiol. 2016;3(1):41-44.
10. Mohan K, Devaraj B, Ramanathan S, Rethinasamy M. Morphometric study of nutrient foramen in the long bones of lower limb. Int J Anat Res. 2017;5(2.3):3943-48.
11. Rao VS, Kothapalli J. The Diaphyseal nutrient foramina architecture - a study on the human upper and lower long bones. IOSR-JPBS. 2014;9(1):36-41
12. A. Kumar, Sonia Jaiswal, P. K. Sharma, V. Tewari THE STUDY OF NUTRIENT FORAMEN OF BONES OF ARM AND FOREARM IN ADULTS **2018 10.24041/ejmr2018.59**
13. K. Bohra, Priyanka Katara, Rajesh Arora, Chandrakala Agarwal,, A Study of Diaphyseal Nutrient Foramina in the Adult Dried Humerus and Femur Bones, 2016, DOI:10.21276/IJMRP.2016.2.5.024
14. S. K. Sahu, Dali Meher, Morphological and topographical anatomy of nutrient foramina in human clavicles of Eastern Odisha 2017.
15. Zichao Xue, H. Ding, Human Humeral Diaphysis of the Nutrient Foramina : Anatomical Study, 2018.
16. N. Su, J. Yang, Y. Xie, X. Du, H. Chen, H. Zhou, L. Chen, Bone function, dysfunction and its role in diseases including critical illness, 2019, DOI:10.7150/ijbs.27063