

MORPHOLOGY & TOPOGRAPHY OF NUTRIENT FORAMINA IN FIBULA AMONG MAHARASHTRA POPULATION

Dr. Botla Harika

Senior Resident, Department of Anatomy, G.M.C-Satara, India

Dr. Anjana Gaikwad

Professor & Head, Department of Anatomy, G.M.C, Alibug, India.

Dr. Swati Pandhare

Associate Professor, Department of Anatomy, B.J.G.M.C, Pune, India

Dr. Anjali Patil

Professor and Head, Department of Anatomy, B.J.G.M.C, Pune, India

ABSTRACT

Study of nutrient foramina is useful in surgical procedures such as bone grafting, microvascular bone transplantation and in many bone fractures in order to preserve the circulation and it provides a useful adjunct in pre-operative and intraoperative assessment to avoid disastrous ischemic complications in lower limb long bones, so it is important to study the morphological and topography of nutrient foramina. This study is carried out to know the variation and position and number of nutrient foramina present in lower limb long bone i.e., Fibula. **Objective:** The present study aims to study the fibula with respect to morphology and topography of nutrient foramina. **Methods:** This study included 100 (50 right and 50 left) adult dried fibula bones with inclusion and exclusion criteria in the Anatomy department of various medical colleges in Maharashtra. **Results:** Out of 100 bones, 46 right side and 44 left side fibulas showed single nutrient foramina and 4 right side and 4 left side fibulas had double nutrient foramina. On right side 80.3% foramen were present and on right side 85.19% were present on posterior surface, while 12.96% foramen were present on right side and 17.86% were present on left side on medial surface of fibula. **Conclusion:** In the study we found that the nutrient foramina in fibula is most commonly located on posterior surface (80.36% for left fibula and 85.19% for right fibula), in the middle third of the shaft and they were directed downwards.

KEYWORDS : Bone grafting; fibula; nutrient artery.

INTRODUCTION:

The circulation of blood is necessary for the osteogenesis, maintenance of bone growth, bone vitality and repair of fracture and other injuries. 90% of the supply to bone marrow is supplied by nutrient artery.^[1,2,3] Long bones of lower limb in their shafts have holes which are called nutrient foramina. The nutrient vessels move away from the growing end^[4,5,6] and it is very important to preserve nutrient blood supply in bone grafts in order to promote fracture healing.^[7,8,9,10] The topographical knowledge of these nutrient foramina is useful in operative procedures to preserve the circulation. Orthopedic surgical procedures like vascularized bone microsurgery requires the detailed knowledge of the blood supply. In free vascular bone grafting, blood supply by nutrient artery is extremely important and must be preserved in order to promote fracture healing.^[11,12] Clinically fibula is the commonest vital source of autologous cortical bone grafts to replace large bone defects, especially in mandibular reconstructions.^[13,14,15,16,17,18] This is because of the structure of fibula, which meets all the biomechanical requirements of the recipient bone. Thus, the knowledge of the anatomy of nutrient foramina is significantly important for orthopedic surgeons. Thus, the present study aims to study the fibula with respect to morphology and topography of diaphyseal nutrient foramen.^[19]

Study Design:

Study has done by Random sampling. Study will be carried out in Department of Anatomy, of various Medical Colleges in Maharashtra. This is completely osteology-based study carried out in department. Sample size of 100 dry bones of fibula.

Inclusion Criteria:

All fibula of adults, dry bones, free of deformity and fully ossified are studied in various Medical Colleges in Maharashtra.

Exclusion Criteria:

1. Fracture or replaced bones with implants
2. Any bone deformity.

Investigational Product Management:

Animals: Nil
Drugs: Nil

MATERIALS AND METHODS:

The study was conducted on a total of 100 (50 right and 50 left) adult human fibulas were examined in different medical colleges in Maharashtra.

Following materials were used during the study – a) Bone osteometry, b) Magnifying lens, c) Metallic measuring scale, d) Guide wires, e) 24 hypodermic needle (0.56mm in diameter), f) Digital camera for illustration.

With the help of above instruments following observation were done. The following Parameters of fibula will be analyzed on fibula for study assessment

1. Maximum length of fibula:

Upper point: Tip of styloid process, Lower point: Tip of the medial malleolus. Fibula should be placed with front side upwards on the osteometry board. The measurement will be taken in centimeters.

2. Location of nutrient foramina:

The location of nutrient foramina examined whether it is on posterior surface, medial surface or lateral surface will be recorded.



Fig1: Showing the maximum length of fibula and with the location of the nutrient foramina

3. Number of nutrient foramina:

Only the primary nutrient foramina were considered for the study. Position of the Primary nutrient foramina will be examined on posterior surface, medial surface and lateral surface of fibula.

4. Size of nutrient foramina:

Size of the primary nutrient foramina is measured by inserting size 24 hypodermic needle, and nutrient foramina less than size 24 hypodermic needle are considered as secondary nutrient foramina.



Fig 2: Showing the size of nutrient foramina

5. Distance of nutrient foramina from proximal end of fibula:

The distance of nutrient foramina from the tip of styloid process of the fibula will be measured on osteometry board and measurements will be taken in centimeters.

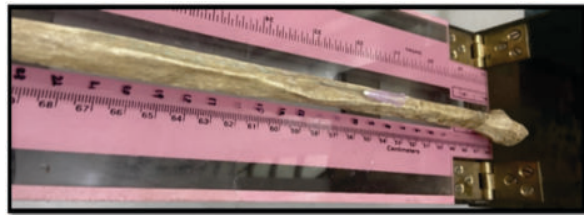


Fig3: Showing the distance of nutrient foramina from the proximal end of fibula

6.Direction of nutrient foramina:

Nutrient foramina direction will be observed whether it is directed upwards or downwards will be recorded.

RESULTS:

1. Maximum length of fibula:

The mean value of maximum length for the right sided fibula was 38 and the mean value for left sided fibula was 38.

1. Location	Left N	Right N
Mean Max Lt of Fibula (cm)	38	38
Range	36-77	35-77
T test	0.43 (not significant)	

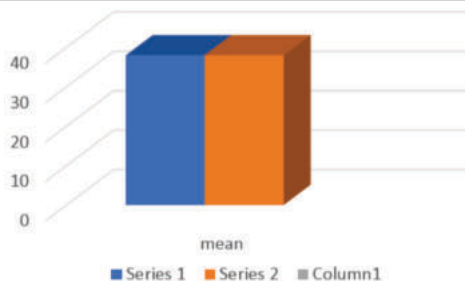


Figure 4: Graphical representation of maximum length of fibula

2. Number of nutrient foramina:

On the Left side out of 50 bones, 6 bones showed double nutrient foramina and 44 showed single nutrient foramina. On the right side out of 50 bones, 4 bones showed double nutrient foramina and 46 bones showed single nutrient foramina.

Number of nutrient foramina	Left (N)	Right (N)	p-value
1	44 (88%)	46 (92%)	
2	6 (12%)	4 (8%)	

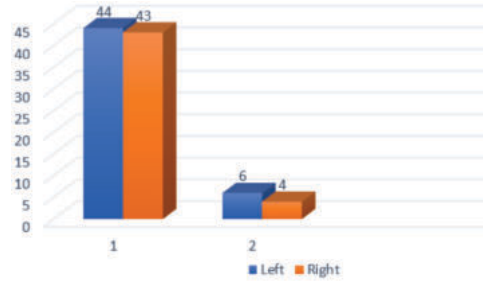


Figure 5: Graphical representation of number of nutrient foramina of fibula

3.Size of nutrient foramina:

On the right-side fibula, dominant nutrient foramina i.e., >24 gauze size was 31 and secondary nutrient foramina i.e., <24 gauze size 17 and equal to 24 gauze size was 6. On the left side fibula dominant nutrient foramina i.e.,>24 gauze size was 24 and secondary nutrient foramina i.e., <24 gauze size was 22 and equal to 24 gauze size was 10.

Size of nutrient foramina	Left (N)	Right (N)	p-value
>24	24 (42.86%)	31 (57.41%)	0.3
24	10 (17.86%)	6 (11.11%)	
<24	22 (39.29%)	17 (31.48%)	

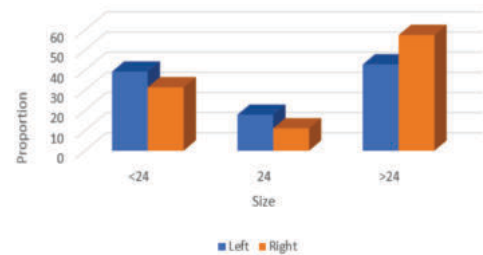


Figure 6: Graphical representation of size of nutrient foramina on fibula

4. Location of nutrient foramina:

In this study we found nutrient foramina predominantly on posterior surface of fibula. On left side fibula: 45 fibula shows nutrient foramina on posterior surface while 10 fibula shows nutrient foramina on the medial surface, and 1 fibula shows nutrient foramina on the anterior surface. On the right-side fibula: 46 fibula shows nutrient foramina on the posterior surface, 7 shows nutrient foramina on the medial surface and 1 fibula shows nutrient foramina on the anterior surface.

Location	Left (N)	Right (N)	p-value
Posterior	45 (80.36%)	46 (85.19%)	0.80
Medial	10 (17.86%)	7 (12.96%)	
Anterior	1 (1.79%)	1 (1.85%)	



Figure 7: Graphical representation of location of nutrient foramina on posterior, medial and anterior surface of fibula.

5.Distance of nutrient foramina from proximal end of fibula:

Distance of the nutrient foramina is calculated from the proximal end of the fibula. location of the nutrient foramina for the left sided fibula is approximately present at about 22 cm from the proximal end, for the right sided location of nutrient foramina from the proximal end is present at about 20 cm.

Distance	Left (N)	Right (N)	p-value
Distance of N.F from proximal end of fibula	22	20	0.43
Range	18-57	18-57	

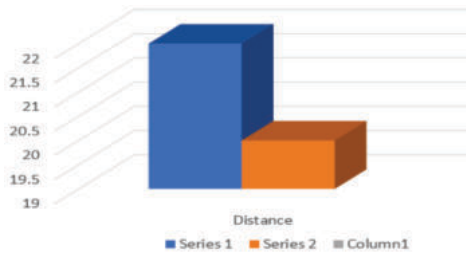


Figure 8: Graphical representation of location of nutrient foramina

6.Direction of nutrient foramina:

On the left sided fibula the dominant and secondary nutrient foramina of 49 fibula showed the downward direction and 7 showed the upward direction. On right sided fibula, 49 showed the downward direction and 5 showed the upward direction of the same.

Direction	Left(N)	Right (N)	p-value
Downwards	49 (87.50 %)	49 (90.74 %)	0.76
Upwards	7 (12.50 %)	5 (9.26 %)	

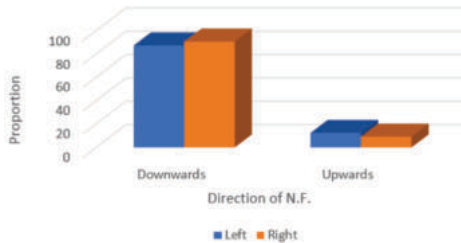


Figure 9: Graphical representation of direction of nutrient foramina.

Morphometric and topographical observations of nutrient foramen in fibula.

Sr.no	Parameter	Left	Right
1.	Maximum length of fibula	38	38
2.	Number of nutrient foramina	Single - 44	46
		Double - 6	4
3.	Size of nutrient foramina	<24 - 22	17
		24 - 10	6
		>24 - 24	31
4.	Location of nutrient foramina of various surfaces	Posterior - 45	46
		Medial -10	7
		Anterior -1	1
5.	Distance of nutrient foramina from proximal end of fibula	22	20
6.	Direction of nutrient foramina	Downwards - 49	49
		Upwards - 7	5

DISCUSSION:

Bone is a living tissue. It receives nutrition for its growth and development through a nutrient foramen which is a well-defined opening on the diaphysis of bone with elevated margins and a distinct proximal groove. ^[19] It gives passage to the blood vessels i.e., nutrient artery and the peripheral nerves to the medullary cavity of a bone. ^[20] The major blood supply to long bones is from the nutrient arteries, especially during the active growing period in the embryo and fetus, as well as during the early phases of ossification. Long bones are supplied by a nutrient artery that enters individual bones obliquely through nutrient foramen. This foramen in the majority of cases is located away from the growing end hence

derivation of that foramina seeks the elbow and flee from the knee. This is because one end of the limb bone grows faster than the other. ^[21] Though the foramina are directed away from the growing end, their topography might vary at the non-growing end. So the topographical anatomy of nutrient foramina may be of worth. The topographical knowledge of these foramina is useful in certain operative procedures to preserve the circulation. Therefore, it is important that the arterial supply is preserved in free vascularized bone grafts so that the osteocytes and osteoblasts will survive. When a bone graft is taken, the vascularization of the remaining bones has to be considered with the vascularity of this area allowing various options in grafting. It has previously been reported that the ideal bone graft for free transfer should include endosteal and periosteal blood supply with good anastomosis. The bony defect which is left behind following traumatic injuries, tumor resection procedures and pseudoarthrosis can all be reconstructed by bone grafting procedures and the preferred modality is free vascularized bone graft. The importance of preoperative angiography remains important to exclude the possible vascular anomalies in both recipient and donor bones for the microvascular bone transfers. ^[22] The nutrient arteries entering at points on shaft determines the number of nutrient foramina.

In this study n-100 fibula (50 left and 50 right) are studied. As per the comparison table mentioned in this study no author has done the side determined study for nutrient foramina.

Table: Comparison of present studies with past studies:

1. Maximum length of fibula:

In this study, out of 100 fibula the mean value of maximum length for both right and left sided fibula was 38cm. The range for the left sided fibula was 36cm -77cm and the right sided fibula was 35cm -77cm. No comparative study was found for the Maximum length of fibula.

S.no	Parameter	Myso rekar 1967 [9]	Sen dem ir & Cim en 1991 [10]	Kizi kant 2007 [12]	Priya nka Sinh α Et al 2016	Gumus -burum [7] 1994	Lon gia et al 1980	Present study
1.	Number of nutrient foramina							
	Single	92.8 %	74%	93%	78%	96%	-	Left- 44(78.57%)
	Double	3.3%	7.2%	5.4 %	22%	4%	-	Right- 46(86.79%) Left- 11(19.64%) Right- 7(13.21%)
2.	Location of nutrient foramina							
	Posterior surface	33%	88.5 %	59.2 %	97.5 %	-	-	Left - 45(80.36%)
	Medial surface	55.8 %	9.8%	25%	2.4%	-	-	Right- 46(85.19%) Left- 10(17.86%) Right- 7(12.96%)
3.	Direction of nutrient foramina							
	Downwards	95%	-	-	0	-	91.5 %	Left- 87.5%
								Right- 90.74%

	Upwards	5%	-	-	100%	-	9.5%	Left- 12.5%
								Right- 9.26%

2. Number of nutrient foramina:

The study done by Mysorekar showed 92.8% single nutrient foramina and 3.3% double nutrient foramina. In the study done by Sendemir and Cimen 74% showed single nutrient foramina and 7.2 % showed double nutrient foramina. In the study done by Kizikant, 96% showed single nutrient foramina and 5.4% showed double nutrient foramina while in the study done by Priyanka Sinha 78% showed single nutrient foramina and 22% showed double nutrient foramina. In this present study, on the left side out of 50 bones, 88% showed single nutrient foramina and 12% bones showed double nutrient foramina. On the right side, out of 50 bones, 92% showed single nutrient foramina and 8% bones showed double nutrient foramina.

3. Size of nutrient foramina:

Size of nutrient foramen can be attributed to greater amount of blood supply to a particular site because of the increasing functioning on the dominant side. Nutrient foramina \geq 24 gauze size of Hypodermic needle (0.56 mm in diameter) were considered as dominant nutrient foramina (D. F) while lesser than the size was taken as the secondary nutrient foramina (S. F).^[20] However, in present study we found nutrient foramen which are $>$ 24 gauze size needle i.e., dominant was 31 on right and 24 on left sided fibula. while secondary nutrient foramina i.e., $<$ 24 gauze size were 17 on right and 22 on left fibula. Knowledge of variations of the nutrient foramina is important preoperatively, if the surgeon intends that the implant includes endosteal vascularization and peripheral vascularization.^[23] No comparative study has been found for the size of nutrient foramina.

4. Location of nutrient foramina:

Knowledge of position of nutrient foramen has a probable role in the cases of vascular necrosis. It has been studied that the position of the nutrient foramina was directly related to the requirements of a continuous blood supply to specific aspects of each bone, for example the sites of major muscle attachments.^[11] In leg, the posterior compartment is the flexor compartment which is bulkier, stronger and more active muscles than the extensor compartments. So, the posterior compartment needs more blood supply than the anterior compartment. Mysorekar et al found 55.8% nutrient foramen on the medial surface and 33% on posterior surface. Sendemir and Cimen noted that the 88.5% nutrient foramina on the posterior surface and 9.8% foramina on the medial surface fibula. Kizikant noted that 59.2% foramina were on the posterior surface and 25% foramina were on the medial surface and Priyanka Sinha noted that 97.5% were on the posterior surface and 2.4% were on the medial surface of fibula. In this study, the location of the nutrient foramina was predominantly on the posterior surface of fibula. On left sided fibula, 80.36% nutrient foramina were on posterior surface, 17.86% were on the medial surface while 1.79% nutrient foramina on the anterior surface. On the right-side fibula, the 85.19% nutrient foramina were on the posterior surface, 12.96% nutrient foramina were on the medial surface while 1.85% nutrient foramina on the anterior surface of fibula.

5. Distance of nutrient foramina:

In this present study, the distance of the nutrient foramina is calculated from the proximal end of fibula. The location of the nutrient foramina for the left sided fibula is approximately present at about 22cm from the proximal end and for the right sided fibula the location of nutrient foramina is present at about 20 cm. No comparative studies were found for the distance of nutrient foramina with the exception that some have reported the majority of the foramina to be present at the upper one third of the diaphysis of fibula.^[19] The knowledge of

variations in the location of nutrient foramina is important preoperatively, if the surgeon intends that the implant includes endosteal vascularization and peripheral vascularization.^[24]

6. Direction of nutrient foramina:

The direction of nutrient foramina depends on the growing end of the bone, which grows about twice as faster as the other end.^[25] Periosteal slip theory of Schwalbe and the vascular theory elucidated by Hughes best explain the normal functioning and anomalies of nutrient canal direction.^[25] It was stated that variations in the direction of nutrient foramina were found only in the fibula.^[26] The Mysorekar noted that 95% nutrient foramina were downward directed and 5% were of upward direction. Priyanka Sinha noted that 100% of nutrient foramina were of upward direction. Longia noted that 91.5% nutrient foramina were of downward direction and 9.5% nutrient foramina were of upward direction. While in the present study, for the left sided fibula the number of nutrient foramina directed downwards were 87.50% and directed upwards were 12.50% and for the right sided fibula the number of downward directed nutrient foramina were 90.74% and upward directed nutrient foramina were 9.26%.

CONCLUSION:

In this study, we found that the nutrient foramen in fibula was mostly located on posterior surface, in the middle third of the shaft and they were directed downwards but, in some cases, it is located on the medial surface i.e., on left side 10 and on right 7 as a secondary nutrient foramen and directed upwards. Morphological changes and topographical variations of the nutrient foramina of fibula will be helpful for the Orthopedics surgeries while performing vascularized bone microsurgery and reconstructive surgeries.

REFERENCES:

1. Afzal E, Sherin F, Khan O, Siddiqui NH. Diaphyseal Nutrient Foramina In Dried Human Adult Long Bones Of Lower Limb In Pakistan. Journal of Ayub Medical College, Abbottabad: JAMC. 2017 Oct 1;29(4):623-5.
2. Beier F. Cell cycle control and the cartilage growth plate. Journal of cellular physiology. 2005 Jan;202(1):1-8.
3. Schiessel A, Zweymüller K. The nutrient artery canal of the femur: a radiological study in patients with primary total hip replacement. Skeletal radiology. 2004 Mar;33(3):142-9.
4. Al-Motabagani MA. The arterial architecture of the human femoral diaphysis. J Anat Soc India. 2002;51(1):27-31.
5. Anderson HC. Matrix vesicles and calcification. Current rheumatology reports. 2003 May;5(3):222-6.
6. Patake SM, Mysorekar VR. Diaphyseal nutrient foramina in human metacarpals and metatarsals. Journal of anatomy. 1977 Nov;124(Pt 2):299.
7. Gümüşburun E, Yücel F, Ozkan Y, Akgün Z. A study of the nutrient foramina of lower limb long bones. Surgical and Radiologic Anatomy. 1994 Dec 1;16(4):409-12.
8. Lütken P. Investigation into the position of the nutrient foramina and the direction of the vessel canals in the shafts of the humerus and femur in man. Cells Tissues Organs. 1950;9(1-2):57-68.
9. Mysorekar VR. Diaphyseal nutrient foramina in human long bones. Journal of anatomy. 1967 Sep;101(Pt 4):813.
10. Sendemir ER, Cimen A. Nutrient foramina in the shafts of lower limb long bones: situation and number. Surgical and Radiologic Anatomy. 1991 Jun 1;13(2):105-8.
11. Yaseen S, Nitya W. Morphological and topographical study of nutrient foramina in adult humeri. International journal of innovative research and development. 2014 Apr 11;3(4).
12. Kizilkamat E, Boyan N, Ozsahin ET, Soames R, Oguz O. Location, number and clinical significance of nutrient foramina in human long bones. Annals of Anatomy-Anatomischer Anzeiger. 2007 Feb 1;189(1):87-95.
13. Mazengenya P, Billings B. Topographic and morphometric features of the nutrient foramina of the fibula in the South African mixed-ancestry population group and their surgical relevance. Eur J Anat. 2016 Oct 1;20(4):329-36.
14. Menck J, Schreiber HW, Hertz T, Bürgel N. Angioarchitecture of the ulna and radius and their practical relevance. Langenbecks Archiv für Chirurgie. 1994 Jan 1;379(2):70-5.
15. Hidalgo DA. Fibula free flap: a new method of mandible reconstruction. Plastic and reconstructive surgery. 1989 Jul 1;84(1):71-9.
16. Lyberg T, Olstad OA. The vascularized fibular flap for mandibular reconstruction. Journal of Cranio-Maxillofacial Surgery. 1991 Apr 1;19(3):1138.
17. Zlotolow IM, Huryn JM, Piro JD, Lenchewski E, Hidalgo DA. Osseointegrated implants and functional prosthetic rehabilitation in microvascular fibula free flap reconstructed mandibles. The American journal of surgery. 1992 Dec 1;164(6):677-81.
18. Matsuura M, Ohno K, Michi KI, Egawa K, Takiguchi R. Clinicocoanatomic examination of the fibula: anatomic basis for dental implant placement. International Journal of Oral and Maxillofacial Implants. 1999 Nov 1;14(6):879-84.

19. Roumanas ED, Markowitz BL, Lorant JA, Calcaterra TC, Jones NF, Beumer 3rd J. Reconstructed mandibular defects: fibula free flaps and osseointegrated implants. *Plastic and reconstructive surgery*. 1997 Feb 1;99(2):356-65.
20. Sinha P, Mishra SR, Kumar P, Gaharwar A. Morphology and topography of nutrient foramina in fibula. *Ann Int Med Den Res*. 2016;2(6):7-12.
21. Pereira GA, Lopes PT, Santos AM, Silveira FH. Nutrient foramina in the upper and lower limb long bones: morphometric study in bones of Southern Brazilian adults. *Int J Morphol*. 2011 Jun 1;29(2):514-20.
22. Murlimanju BV, Prashanth KU, Prabhu LV, Chettiar GK, Pai MM, Dhananjaya KV. Morphological and topographical anatomy of nutrient foramina in the lower limb long bones and its clinical importance. *The Australasian medical journal*. 2011;4(10):530.
23. Gümüşburun E, Yücel F, Ozkan Y, Akgün Z. A study of the nutrient foramina of lower limb long bones. *Surgical and Radiologic Anatomy*. 1994 Dec 1;16(4):409-12.
24. Neil James E. A Study on Nutrient Foramina in the Shaft of Long Bones of Upper and Lower Limbs at Sree Mookambika Institute of Medical Sciences (Doctoral dissertation, Sree Mookambika Institute of Medical Sciences, Kulasekharam).
25. Collipal E, Vargas R, Parra X, Silva H, Del Sol M. Diaphyseal nutrient foramina in the femur, tibia and fibula bones/Foramenes nutricios diafisarios de los huesos femur, tibia y fibula. *International Journal of Morphology*. 2007 Jun 1;25(2):305-9.
26. Hughes H. The factors determining the direction of the canal for the nutrient artery in the long bones of mammals and birds. *Cells Tissues Organs*. 1952;15(3):261-80.
27. Gray H. *Anatomy Descriptive and Surgical*(“ Gray's Anatomy”). Running Press; 1974