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Morphology and Topography of Nutrient Foramina in Fibula.

Priyanka Sinha[1], Suniti Raj Mishra[2], Pramod Kumar[3], Anamika Gaharwar[4], Sushobhana[5]

[1]Lecturer, Department of Anatomy, G.S.V.M. Medical College, Kanpur, U.P, India
[2]Professor & Head, Department of Anatomy, G.S.V.M. Medical College, Kanpur, U.P., India
[3]Associate Professor, Department of Anatomy, Rajkiya Medical College, Jalaun, U.P., India
[4]Assistant Professor, Department of Anatomy, G.S.V.M. Medical College, Kanpur, U.P., India
[5]Postgraduate Resident, Department of Anatomy, G.S.V.M. Medical College, Kanpur, U.P., India.

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ABSTRACT

Background: The nutrient arteries entering at particular points on shaft determines the number and location of nutrient foramen. An understanding of the position and number of the nutrient foramina in long bones is important for various orthopaedic surgeries like bone grafts, joint replacement and vascularized bone microsurgery. Objective- The present study aims to study the fibula with respect to morphology and topography of diaphysial nutrient foramen. **Methods:** This study was conducted in Department of Anatomy, G.S.V.M. Medical College, Kanpur. A total of 100 (50 right and 50 left) adult human fibula were examined for number, position, size, location and direction of nutrient foramina. Foramina Index was evaluated. **Results:** Out of 100 bones, 78% bones showed single foramen and 22% bones had double foramen. On right side, 98.3% foramen were present on posterior surface and 1.6% was present on medial crest. On left side, 96.7% of foramen were present on posterior surface and 3.2% of foramen were present on medial crest. All the foramina were located in the middle third of the shaft and directed distally, away from knee joint. **Conclusion:** In the study we found that the nutrient foramen in fibula is most commonly located on posterior surface (97.5%), in the middle third of shaft and directed distally.

Keywords: bone; bone graft; fibula; foramina index; nutrient artery

INTRODUCTION

Bones are the living tissue that adapt to their mechanical environment. During the intrauterine life, they adapt to the presence of naturally occurring holes, known as nutrient foramen, which allow blood vessel to pass through bone cortex.[1] Nutrient artery is the principal source of blood to a long bone mainly during the growing period and during the early phases of ossification.[2-5] The blood supply of long bones, generally given by one or two diaphysial nutrient arteries, and numerous metaphysial, epiphysial and periosteal arteries.

Name & Address of Corresponding Author
Dr. Suniti R Mishra
Professor & Head,
Department of Anatomy,
G.S.V.M. Medical College, Kanpur
Uttar Pradesh, India.

Nutrient foramina reflect the bone vascularisation to a certain degree and knowledge about the location of these foramina is useful in certain operative procedure to preserve the circulation. The nutrient blood supply is very crucial in free vascular bone grafting, and must be preserved to promote fracture repair. It is a source of rich blood supply, which is necessary not only for the survival of osteoblast and osteocyte but also facilitates graft healing in the recipient.[6] It was claimed that an ideal bone graft must include the intact endosteal as well as periosteal vessels with good anastomosis so as to give good results in free transfers.[7] Vascularized fibular grafts (VFG) are one of the most commonly used vascularised grafts, being extensively used for mandibular reconstruction, both alone[8-10] and with dental implants[11] and have provided good restoration of masticatory function. The indication of vascularised fibular grafts is also known in upper limb skeletal reconstruction. This is because of structure of the fibula, which meets all the biomechanical requirements of the recipient bone. The size of the fibula fits perfectly in forearm bone reconstruction, and may also be used in diaphyseal reconstruction of the humerus. The advantages of the free vascularized fibular flap

include its ability to be shaped with relative ease and to be grafted at the same time tumors are resected, with a consequent reduction in operation time along with only few complications occurring at the donor sites.[12] Thus the knowledge of anatomy of nutrient foramina is significantly important for orthopaedic surgeons doing open reduction of fracture, in order to avoid injuring nutrient artery and there by lessens the chances of delayed or non-union of fracture. For these reasons the precise location and relevant anatomy of nutrient foramen should be known. Thus, the present study aims to study the fibula with respect to morphology and topography of diaphysial nutrient foramen.

MATERIALS AND METHODS

This study was conducted in Department of Anatomy, G.S.V.M. Medical College, Kanpur. A total of 100 (50 right and 50 left) adult human fibula were examined in the department. Following materials were used- a) Magnifying lens, b) Bone Osteometer, c) Metallic measuring scale, d) Guide wires, e) 24 hypodermic needle (0.56 mm in diameter), f) Digital camera for illustration.
With the help of above instruments following observation were done.

1. Number of Nutrient Foramina: The nutrient foramen were observed and counted only on the shaft of fibula with a hand lens. The foramen with elevated margins and presence of a proximal groove were accepted as nutrient foramen.
2. Position of Nutrient Foramina: The presence of foramen on different surfaces of shaft of fibula was observed.
3. Direction of Nutrient Foramen: A guide wire was used to determine the direction of the foramen.
4. Size of Nutrient Foramen: Nutrient Foramina equal or larger than the size of 24 No. hypodermic needle (0.56 mm in diameter) were considered as Dominant Nutrient Foramina (D.F) while smaller than this size were taken as being Secondary Nutrient Foramina (S.F).[5]
5. Location of Nutrient Foramina: The location of only Dominant Foramina (admitting 0.24 hypodermic needle) was considered and their distribution in bone length was determined by calculating a Foramen index (FI) using the formula [13-14] [Figure 1-2].:

$$FI = (DNF/TL) \times 100$$

DNF - The Distance from the proximal end of the bone to the Nutrient Foramen.
TL – Total length of the bone.

Depending on foramina index, the location of nutrient foramen in relation to length of bone is classified as:

a. Type 1(0-33% of bone length)
b. Type 2(33%-66% of bone length)
c. Type 3(66%-99% of bone length)

Figure 1: Measurement of length of fibula on osteometer board.

Figure 2: Measurement of distance of location of nutrient foramen from upper end of fibula with vernier calliper. Obliquity of needle showing direction of nutrient canal

RESULTS

Number of nutrient foramen**:** On right side, out of 50 bone, 40(80%) bones showed single foramen [Figure 2] and 10(20%) bones showed double foramen [Figure 3] .On left side, out of 50 bone, 38(76%) bones showed single foramen and 12(24%) bones showed double foramen [Figure 4]

Figure 3: Showing two nutrient foramen on fibula

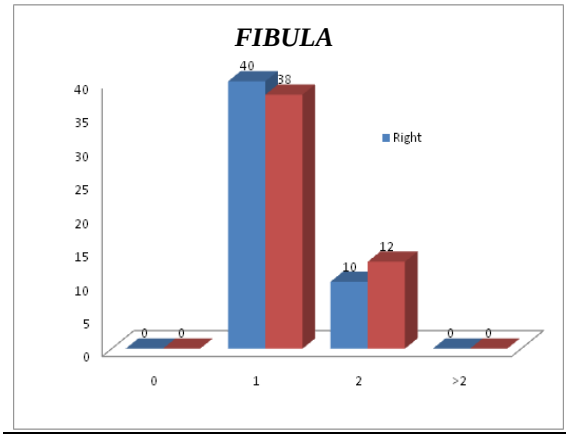

Figure 4: Graphical representation of the no. of nutrient foramina

Position of nutrient foramen; On right side, out of 60 foramen, 59(98.3%) foramen was present on posterior surface and 1(1.6%) was present on medial crest. On left side, out of 62 foramen 60(96.7%) of foramen was present on posterior surface and 2(3.2%) was present on medial crest.

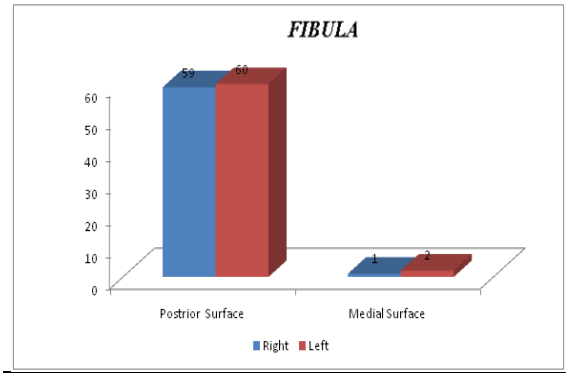

Figure 5: Graphical representation of position of nutrient foramen on fibula

Size of nutrient foramen: On right side, out of total 60 Foramen, 50 Foramen were Dominant and 10 Foramen were secondary. On left side, out of total 62 Foramen, 54 Foramen were Dominant and 8 Foramen were secondary.

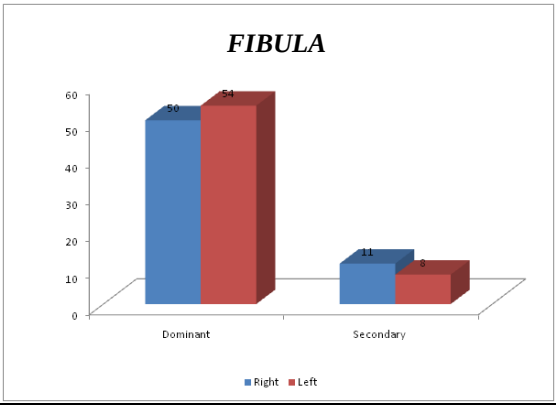

Figure 6: Graphical representation of size of nutrient foramen on fibula

Location of nutrient foramen: Both on the right and left side all the dominant foramen (100%) were of type II.

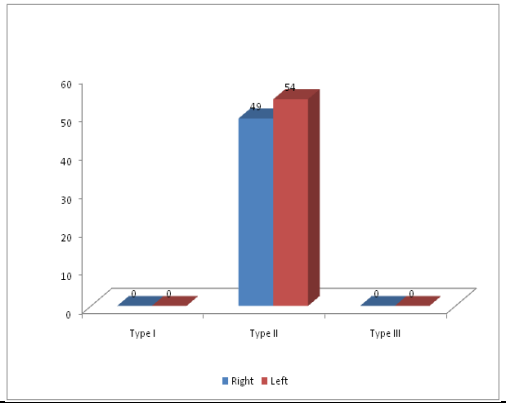

Figure 7: Number of Type I, II and III foramen.

Foramina index: On right side, the range of Foramina index was 36.3 – 58.2 with the mean value of 45.86 ± 4.55. On left side, the range of Foramina index was 37.1 – 57.6 with the mean value of 46.82 ± 4.96. On comparison of two sides we found -'t' test value was 1.00 and 'p' value was > 0.05, thus the result was insignificant.

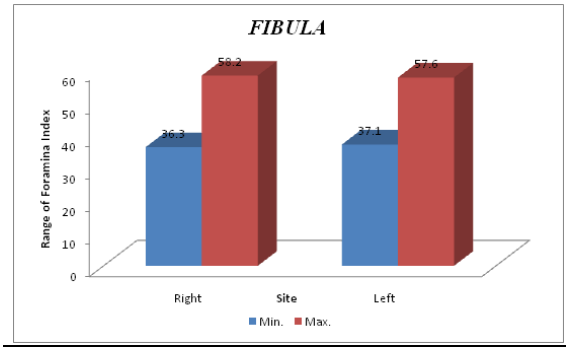

Figure 8: Graphical representation of foramina indices (type II)

Direction of nutrient foramen: The direction and obliquity of all the nutrient foramen observed in fibula of both sides were away from knee joint.

Table 1: Showing Morphometric & Topographic Observations Of Nutrient Foramen In Fibula.

S.N	Parameter	Right (n=50)	Left (n=50)
1	Number of foramina		
	0		
	1	-	-
	2	40(80%)	38(76%)
	>2	10(20%)	12(24%)

		P value >0.05 not significant	
2	Position of Nutrient Foramen		
	Posterior Surface	59	60
	MedialSurface	1	2
		P value >0.05 not significant	
3	Direction of Nutrient Canal		
	Towards Knee joint	0	0
	Away Knee j oint	All (100%)	All (100%)
4	Size of nutrient foramen		
	Dominant foramen	50	54
	Secondary foramen	10	8
5	Location of Dominant Foramen (Foramina Index)		
	Type I	-	-
	Type II	49 (100%)	54(100%)
	Type III	-	-
6.	Foramina index		
	Range	36.3-58.2	37.1-57.6
	Mean	45.86	46.82
	Standard deviation	4.55	4.96
		P value >0.05 not significant	

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 diaphyses of bone with elevated margins and a distinct proximal groove, giving passage to the blood vessels (nutrient artery) and the peripheral nerves to the medullary cavity of a bone[15]. Vascular foramen present at the ends of the bone are not accepted as nutrient foramen[16]. The nutrient artery in fibula is a branch of peroneal (fibular) artery[17]. During the embryonic development, all the nutrient arteries run towards caudal end to facilitate the haemodyanamic flow of blood from cephalic end to caudal end. This is in agreement to the concept “to the elbow I go, from knee I flee” in adults. An understanding of the position and number of the nutrient foramina in long bones is important in orthopaedic surgeries such as bone grafts, joint replacement and vascularized bone microsurgery. The knowledge of statistical distribution of nutrient foramina on long bones facilitates the selection of the level of osseous section in the recipient in transplant surgeries in order to place the graft without damaging the nutrient arteries, preserving, thus, the diaphysial vascularisation.[18] However, there is still a need for a greater understanding of the morphology and topography of nutrient foramina in long bones.

The nutrient arteries entering at particular points on shaft determines the number of nutrient foramen. In the fibulae, (n-100) studied, right and left sides showed no significant variation in the number of foramina so the mean value of both sides was considered for comparison with previous studies. 78% of the bones presented a single nutrient foramen and 22% of the bones double nutrient foramina which is similar to data of previous studies.[3-5] [Table 2]. In a study, fibulae with three foramina were also observed[19] but no such numbers were observed in present study. Any of the bones in this study did not show the absence of nutrient foramen, which differs from[4-5] who recorded 3.3% and 1.3% respectively, of the bone with no foramen.

Knowledge of position of nutrient foramen has a probable role in few cases of vascular necrosis. It is reported 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, where there were major muscle attachments.[5] In leg the posterior compartment is the flexor compartment which has bulkier, stronger and more active muscles than the extensor compartment. Therefore, posterior compartment needs more blood supply than anterior compartment. In present study 97.5% of foramen were present on posterior surface, the flexor compartment of leg and 2.4% foramen present on medial surface, which is similar to previous studies [3-5] [Table 2]. This is in difference with studies of Mysorekar, 1967 reporting lower percentage of foramen on posterior surface.[20] In this study no foramen was present on lateral surface which is in disagreement with another study of reporting 1.6% of foramen on this surface.[3] Presence of nutrient foramen on medial or lateral surface possibly could result from the variation of progress of degree of rotation during embryonic life.

Size of nutrient foramen can be attributed to greater amount of blood supply on particular side due to increased functioning of this side, as it is dominant side. Nutrient Foramina equal or larger than the size of 24 No. hypodermic needle (0.56 mm in diameter) were considered as Dominant Nutrient Foramina (D.F) while smaller than this size were taken as being Secondary Nutrient Foramina (S.F).[5, 21]

Previous studies have shown a significantly larger proportion of foramen on right side which is not in agreement with present study. It was reported by a past worker that most of nutrient foramina in long bones were of the dominant type and that wherever a single nutrient foramen was observed, it was

always dominant.[5] However in the present study we found a fibula with only one nutrient foramen which was a Secondary Foramen. The present results contradicted with another study reporting about 67% of the nutrient foramina of fibula as secondary foramina[22] while in the present study 8.1% of foramina were of secondary size and 92% were dominant type.

Table 2: Comparison of present studies with past studies

Parameter	Mysorekar, 1967[20]	Longia et al, 1980[22]	Sendemir&Cimen,[3] 1991	Gumusburun, 1994[4]	Kizilkant, 2007[5]	Present study
Number of foramina						
0	3.8%	-	18.9 %	3.3 %	1.3 %	-
1	92.8%	-	74 %	96 %	93 %	78 %
2	3.3%	-	7.2 %	-	5.4 %	22 %
>2	-	-		-	-	-
Position of foramina						
Posterior surface	33 %	-	88.5 %	-	59.2 %	97.5 %
Medial crest	55.8 %	-	9.8 %	-	25 %	2.4 %
Lateral surface	-	-	1.6 %	-	15.8 %	-
Location (Foramina index)						
Type I	1.6 %	-	-	92.3 %	-	-
Type II	96 %	-	-	7.6 %	-	100 %
Type III	2.2 %	-	-	-	-	-
Direction of nutrient canal						
Proximal	5%	9.5 %	-	-	-	-
Distal	-		-	-	-	100 %

Knowledge of the variations in the distribution of the nutrient foramina is important preoperatively, if the surgeon intends that the implant includes endosteal vascularization and peripheral vascularization.[19,23] With the exception[24] who reported the majority of foramina to be located in the upper one-third of the diaphysis of fibula, in all other studies they are situated in the middle one-third of shaft. In the present study, all the foramina were located in middle third of bone length with foramina index between 36.3% to 58.2%. This is in agreement with previous studies.[20]

The direction of nutrient foramina depends on the growing end of bone, which grows about twice as faster as the other end.[13] "Periosteal slip" theory of Schwalbe[25] and the vascular theory elucidated by Hughes[13] best explain the normal functioning and anomalies of nutrient canal direction.[22,26] It was stated that variations, in the direction of nutrient foramina were found only in the fibula[20] but in this study as we did not find any variation in directions in fibula. His study is not in consonance with our study. In this study, the direction of

nutrient foramina observed was towards distal end in all fibula. In disagreement with the present results, some workers reported nutrient foramina directed towards the proximal end of fibula in 5% and 9.5% cases.[20, 22]

CONCLUSION

In the study we found that the nutrient foramen in fibula is most commonly located on posterior surface (97.5%), in the middle third of shaft and directed distally. In some of the cases, it is located in medial crest (25%) and a secondary nutrient foramina may also be present in 22% cases. Our research about nutrient foramina of fibula will be helpful to orthopaedic surgeons in fracture repair, vascularised bone microsurgery and reconstructive surgeries.

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