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Original Article

Anatomy Section

A Study of Diaphyseal Nutrient Artery Foramina of Dry Fibula in Human, done in a Government Medical College of Upper Assam, India

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ABSTRACT

Introduction: The nutrient foramina is the external opening in each bone which has a particular position and number in its diaphysis. A thorough knowledge of the position, number, direction and variation of the nutrient foramina of fibula is very much important, as this is one of the most common bone used in bone grafts, vascularised bone microsurgery and mandibular reconstruction.

Aim: To determine the position of nutrient artery foramina in fibula and also their size and direction.

Materials and Methods: This was a descriptive cross-sectional study which was conducted in the Department of Anatomy, Assam Medical College, Dibrugarh, Assam, India, from March-June 2021. The study was conducted on 167 numbers of adult human cleaned and dried fibulae. The number, position, size and direction of nutrient foramina were recorded in a pretexted proforma. Foraminal Index (FI) was calculated and the range, mean and standard deviation of FI were determined.

Results: In the present study, 167 bones were taken but only 159 showed nutrient foramina. Single dominant foramen was found in 92.5% (147/159) of bones. Secondary foramina were present in 7.5% (12/159) of bones. The FI was calculated. According to FI, maximum number of foramina was present on middle third of fibula (92.56%). In 7.44% of fibula the foramina were located in distal third of the bone.

Conclusion: A thorough anatomical knowledge of the nutrient foramen is useful in planning the vascularised fibular graft. Hence the result of this study will provide detail data about the number, position and direction of nutrient artery foramina in fibula for successful outcome of various orthopaedic and plastic reconstructive surgeries.

Keywords: Dominant nutrient foramen, Foraminal index, Secondary nutrient foramen, Vascularised fibular graft

INTRODUCTION

Nutrient foramen is the external opening on bones which allows blood vessels to pass through the bone cortex. The term 'Nutrient' itself depicts the important role of nutrient foramen in nutrition and growth of the bone [1]. The fibula is one of the long bones of the leg which plays insignificant role in weight transmission during walking. But this is a very important bone for muscle attachment and commonly used for bone grafting [2]. The nutrient artery supplying fibula is a branch of peroneal (fibular) artery, which enters the bone through the nutrient foramen located on the shaft of the bone [3]. In majority of the cases, the nutrient foramen of fibula is directed away from the growing end [4].

Vascularised fibular graft are most commonly used for mandibular reconstruction and they have provided good reserve of masticatory function [5,6]. Fibular grafts are important in upper limb skeletal reconstruction as fibula meets all the biomechanical requirements of the recipient bone of the upper limb. The size of the fibula perfectly fits in upper limb bone reconstruction. Hence a fibular graft can be used in diaphyseal reconstruction of the humerus [7]. The vascularised fibular flap is advantageous to be relatively easy to be shaped in its own when grafted in a resected tumour site. This will reduce the operation time as well as complications on donor site [8]. Therefore, a detailed knowledge about the anatomy of nutrient foramina of fibulae is very important for surgeons in managing open reduction of fracture, so that an injury to nutrient artery can be minimised [7]. Hence, the accurate location and any variation related to anatomy of nutrient foramen should be known. Thus, the objective of the present study was to study the different position, number and direction of nutrient foramina of fibula.

MATERIALS AND METHODS

The present was a descriptive cross-sectional study, conducted during the period from March-June, 2021 in the Department of Anatomy, Assam Medical College, Dibrugarh, Assam, India. Clearance from Human Institutional Ethical Committee was taken vide letter no. AMC/EC/5934 Dibrugarh dated the 10th June, 2021.

Inclusion criteria: Only fibula bones with well-defined foramina on the diaphysis were included in the study.

Exclusion criteria: Any fibula bone with foramina present in the ends was excluded. Defective or damaged bones were also excluded from the study.

The present study consisted of 167 adult human [Table/Fig-1] cleaned and dried fibulae (70 right-sided and 97 left-sided bones) collected randomly from undergraduate students and also from bones available in the Department of Anatomy.

[Table/Fig-1]: Adult human fibulae.

All selected bones were serially numbered and photographs were taken. Nutrient foramina were observed using cleaned hand lens in all bones. Though many minute foramina may be present on the surface of diaphysis, the nutrient foramina were distinguished by their elevated margins and presence of a distinct groove proximal to the elevated margins [9].

The different variables and measurements were recorded in a pretexted proforma and following data were collected.

Number: Bones were first examined for the number of nutrient foramina. All the borders and surfaces of the bones were thoroughly examined with the help of a magnifying hand lens from proximal to distal end. Both the dominant and secondary foramina were noted down.

Position: First the positions of all nutrient foramina were measured with the help of a measuring tape from the upper end of the bone. The total length of the fibulae was also measured using measuring tape. Then, FI was calculated by using the following formula:

FI=(DNF/TL)×100 (Hughes1952; Shulman 1959) [10,11].

DNF=Distance from the proximal end of the bone to the nutrient foramen [Table/Fig-2].

TL=Total length of the bone [Table/Fig-3].

[Table/Fig-2]: Photograph showing the measurement of distance of nutrient foramina from proximal end (DNF).

[Table/Fig-3]: Photograph showing measurement of total length (TL) of fibulae.

The positions of the foramina were quite variable. So the different positions were categorised into three types according to FI [12].

Type 1: FI from 01 up to 33.33- The nutrient foramen was located in the proximal third of the bone.

Type 2: FI from 33.34 up to 66.66- here the nutrient foramen was located in the middle third of the bone.

Type 3: FI above 66.67- in this category the nutrient foramen was located in the distal third of the bone.

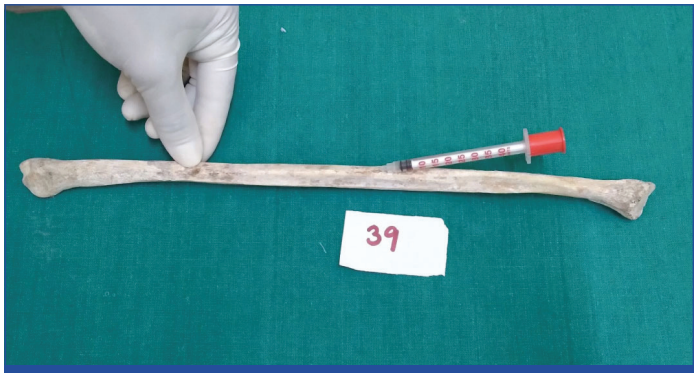
Size: A hypodermic needle of size 24 (0.56 mm in diameter) was used to determine the size of nutrient foramina. Any nutrient foramina smaller than the size of this needle (0.56 mm in diameter) were considered as secondary nutrient foramina (SF). Those nutrient foramina which were equal to or larger than 0.56 mm were accepted as dominant nutrient foramina (DF) [13]. The dominant nutrient foramina allowed the needle to be introduced easily, whereas the secondary foramina allowed the entry of the needle with some resistance.

Direction of nutrient foramina: The direction of nutrient artery foramina were detected by introducing the needle into the foramen and the direction was noted i.e., whether it is going towards the growing end or away [Table/Fig-4,5].

STATISTICAL ANALYSIS

The results were analysed and tabulated. The range, mean and standard deviation of FI were determined by using software Microsoft Excel version 2010.

[Table/Fig-4]: Direction of nutrient foramen (towards the growing end).



[Table/Fig-5]: Direction of nutrient foramen (away from the growing end).

RESULTS

In the present study, total 167 numbers of fibulae (70 right-sided and 97 left-sided) were examined. Total 159 numbers of nutrient foramina were found. Out of these 159 numbers of nutrient foramina, 147 were dominant foramina and 12 were secondary foramina [Table/Fig-6]. Foramina were absent on five of right-sided bone and three of left-sided bone. Most of the foramina were located on posterior surface. On the right side most of the foramina were located between medial crest and posterior border on posterior surface. On the left side most of the foramina were located between interosseous border and medial crest on posterior surface. Not a

Side of the bone (Total no. of bones)	Absence of foramina	Anatomical site (location of foramina)	Total no. of foramina	No. of foramina	
				DF	SF
Right (70)	5	Posterior surface (Between interosseus border and medial crest)	26	23	3
		Posterior surface (Between medial crest and posterior border)	32	30	2
		Posterior surface (On the medial crest)	0	-	-
		On the interosseous border	7	7	-
		Medial surface	nil	-	-
		Lateral surface	nil	-	-
Left (97)	3	Posterior surface (Between interosseus and medial crest)	52	49	3
		Posterior surface (Between medial crest and posterior border)	29	26	3
		Posterior surface (on the medial crest)	nil	-	-
		On the interosseus border	10	9	1
		Medial surface	2	2	-
		Lateral surface	1	1	-
Total (167)	8		159	147	12

[Table/Fig-6]: Showing number of foramina, their anatomical location and number of dominant (DF) and secondary foramina (SF).

single foramen was found on medial crest. This study recorded 17 numbers of nutrient foramina on interosseous border (7 on right side and 10 on left side). There was absence of foramina on medial surface and lateral surface on the right side. On the other hand two foramina on medial surface and one foramen on lateral surface were recorded on left side. Multiple foramina were absent in this study.

In the present study, most of the nutrient foramina (152/167=91.01%) were located along the middle third of the fibula i.e., Type 2. The rest of the foramina (7/167=4.2%) were located in the distal third of the fibula. Out of 70 numbers of bones on the right side nutrient foramina were present in 65 numbers of bones. All the nutrient foramina were located in middle third of fibula, i.e., Type 2 (65/70. i.e., 92.85%). Also, maximum number of nutrient foramina was located on the middle third (92.56%) of the bone on left side. The rest of the foramina (7.44%) were present in the distal third i.e., Type 3 on the left side. Not a single foramen was detected in the proximal third of the bone i.e., Type 1. The range of FI on right side (middle third of fibula i.e. Type II) was from 35.2-63.6. On left side the range was from 36.3-68.8 (both middle and distal third of fibula) [Table/Fig-7]. Mean and standard deviations are shown in [Table/Fig-7].

Location	Side	Range	Mean±Standard deviation
Posterior surface (Between interosseus and medial crest)	R	35.7-62.8	47.16±8.19
	L	36.3-68.0	49.58±10.07
Posterior surface (Between medial crest and posterior border	R	42.8-63.6	51.07±6.12
	L	51.1-64.3	57.18±4.49
Posterior surface (On the medial crest)	R	-	-
	L	-	-
On the interosseus border	R	35.2-63.4	50.23±12.15
	L	59.3-68.8	64.46±3.22
Medial surface	R	-	-
	L	43.2-59.4	51.30±11.46
Lateral surface	R	-	-
	L	-	-

[Table/Fig-7]: Showing range, mean and standard deviation of foraminal indices of fibulae.

Maximum numbers of nutrient foramina were directed away from the growing end [Table/Fig-8]. On the right side 87.7% foramina were directed away from the growing end and 12.3% of foramina were directed towards the growing end. On the left side 93.6% foramina directed away from the growing end and 6.4% directed towards the growing end [Table/Fig-8].

Side	No. of fibula	No. of nutrient foramina	Direction of nutrient foramina	No.	%
Right	70	65	Towards the growing end	8	12.3
			Away from the growing end	57	87.7
Left	97	94	Towards the growing end	6	6.4
			Away from the growing end	88	93.6
Total	167	159	Towards the growing end	14	8.8
			Away from the growing end	145	91.2

[Table/Fig-8]: Direction of nutrient artery foramina on both sides.

DISCUSSION

Proper anatomical knowledge regarding number and location of nutrient foramina is important to avoid any intraoperative injury of nutrient artery in orthopedic, plastic and reconstructive surgeries. Because any disruption in its blood supply leads to structural and functional defects as observed by Forriol Campos F, Al-Motabagani MAH and Kirschner MH et al., [14-16].

A total number of 167 dry adult human fibulae were considered for the present study. The number, position, size and direction of nutrient foramina were observed. The results were analysed and compared with earlier studies done by different authors [2,5,7,10]. Absence of nutrient foramina was noted in 4.8% of bone in this study. Earlier in 2016 in central Rajasthan Manish DS et al., found absence of foramina in about 6% of bones [17].

In the present study, in 92.4% of bone, single dominant nutrient foramina were observed. Multiple foramina were absent which was also observed earlier by Nidhi A et al., Manish DS et al, and Gupta R et al., [13,17,18].

Position of the nutrient foramen is affected by two important factors i.e., growth rate at two ends of the shaft and bone remodelling. In this study in maximum number of fibulae, the nutrient foramina were located along the middle third of the bone on the posterior surface. On the right side all foramina were of type 2, whereas on left 92.56% were of type 2 and 7.44% was of type 3. So this was in accordance to study conducted by Nidhi A et al., and Gupta R et al., [13,18]. So, it is important to know the exact position of the nutrient foramina preoperatively, as the fibula is commonly used for bone grafting. Not a single foramen was found on proximal third of the bone i.e., type 1. The FI is important to keep the vascularised bone graft vital because this will help in healing of the graft to recipient bone [19].

In this study, in 7.6% bones secondary nutrient foramina was observed, which was also noted by Nidhi A et al., [13]. At the time of this study any literature showing correlation between size of nutrient foramina and blood supply could not be found. But preoperatively the surgeons must be aware about it for proper selection of osseous section that has a major arterial supply through dominant nutrient foramina.

The direction of nutrient foramina varies which was observed in this study. In 8.8% bones, the nutrient foramina were directed towards the growing end and in 91.2% it was away from the growing end which was also observed by Manish DS et al., [17].

Limitation(s)

This study has some limitations. Present study could not determine the age and sex of the bones so the morphological differences could not be studied. These differences may alter the results, as the anatomy of foramina may differ in different genders. Some foramina might get ossified in elderly people which give a false result of absence of foramina.

CONCLUSION(S)

In this study, it was observed that the nutrient foramen in fibula is most commonly located in the middle third of shaft on the posterior surface. Maximum numbers of the foramina were directed towards the distal end. In few numbers of the cases, it was located on the interosseous border. Dominant nutrient foramina were more common as compared to secondary nutrient foramina. Research findings of this study may provide some additional data which will be helpful to clinicians for surgical procedures such as joint replacement therapy, repairing of fractures and techniques involving vascularised fibular graft for reconstructive surgeries.

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