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Morphometric and Topographic Study of Nutrient Foramina of Fibula

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Abstract

Introduction: The study on morphology of nutrient foramina of fibula can provide prudent information for various bone grafting orthopedic surgeries. The present study was undertaken to generate morphometric and topographic data of fibula from western India, where there is paucity of such information. *Materials and methods:* This study included 140 specimens of dry human fibulae devoid of gross pathological deformities, obtained from department of Anatomy of four medical colleges in Mumbai (Topiwala National Medical College, Seth GS Medical College, Lokmanya Tilak Medical College and Government Medical College, Mumbai). All fibulae were observed for number, direction and location of the nutrient foramina. The position of foramina was labeled by using foraminal index (FI) which was calculated by applying the Hughes' formula. *Results:* Nutrient foramina were traceable in 125 (89.29%) fibulae. Dominant and secondary nutrient foramina was present in 121 (86.43%) and 10 (7.14%) fibulae respectively. 110 (88.71%) dominant foramina were in lower direction. Most of the foramina were present on the posterior surface. Dominant and secondary nutrient foramina were present on middle of shaft of fibulae in 91.12% and 50% of cases respectively. *Conclusion:* The present study confirms and compares the morphometric and topographic data on fibula from western part of India.

Keywords: Fibula; Foraminal Index; Nutrient Foramina.

Introduction

Bone grafts are frequently used in all specialties of orthopaedic surgery. Bone grafts and bone graft substitutes have a number of innate properties which permit them to initiate, stimulate, and facilitate bony healing. Osteoconduction is the process by which the graft provides a scaffold for the ordered 3-D ingrowth of capillaries, perivascular tissue, and osteoprogenitor cells. Osteoinduction is the recruitment of osteoprogenitor cells from surrounding tissue. Osteogenesis is the formation of new bone from either the host or graft tissue. Autogenous and allogenic cortical and cancellous bone grafts are all, to varying degrees, osteoconductive, osteoinductive, and osteogenic [1]. Bone grafts thus play a vital role in orthopedic surgeries.

Fibular grafting is a widespread procedure in orthopedic practice [2]. Biomechanically, the fibula bears only 15 percent of the axial load across the ankle, allowing for its use as an autogenous bone graft with minimal biomechanical consequences on the weight-bearing status of the lower limb. Given the length of fibular diaphysis that may be harvested, free fibular grafts are well suited for the reconstruction of segmental defects of the long bones, providing both mechanical strength and biological stimulus for healing. Furthermore, based upon the fasciocutaneous arterial branches of the peroneal artery, skin, fascia, and muscle may be harvested concomitantly with the fibula to allow for more complex soft tissue reconstruction. Finally, given the ability to transfer the proximal fibular epiphysis with the diaphysis during free vascularized fibular grafting, there is potential for preserving continued

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skeletal growth of the fibular graft [3].

The study on morphology of nutrient foramina of fibula can provide prudent information for various bone grafting orthopedic surgeries. This kind of information is available from different parts of India. The present study was an effort to generate similar data from western India, where there is paucity of such information. The study data also provides the opportunity for analyzing the variation in morphological parameters of fibular nutrient foramina across different parts of India.

Materials & Methods

This morphometric and topographic study was conducted in the department of Anatomy of four medical colleges in Mumbai (Topiwala National Medical College, Seth GS Medical College, Lokmanya Tilak Medical College and Government Medical College, Mumbai). This study included 140 specimens of dry human fibulae devoid of gross pathological deformities (87 right, 53 left sided).

All fibulae were observed for number, direction and location of the nutrient foramina. The distance of nutrient foramina from the proximal end and total fibular length was noted with the help of Vernier's Calipers.

The age and gender of bones were not determined in this study.

A magnifying lens was used to observe the nutrient foramina. The nutrient foramina were identified by the presence of a well marked groove leading them and a well marked, often slightly raised, edge at the commencement of the canal. Nutrient foramina were labeled as primary or dominant (DF) if diameter of the foramina was equal or more than the size of 24 g hypodermic needle (0.56 mm) (checked by inserting 24 g hypodermic needle; if able to insert, size of foramina was considered to be 0.56 mm or greater).Those smaller than the size of 24 g hypodermic needle were considered as secondary nutrient foramina (SF) [4].

Direction of nutrient foramina was confirmed with the help of a thin probe.

The side determination was done for the fibulae and thus surface for presence of nutrient foramina was confirmed accordingly.

The position of foramina was labeled by using foraminal index (FI) which was calculated by applying the Hughes formula i.e., dividing the distance of the foramen from the proximal end (D) by the total length of the bone (L) which was multiplied by hundred. [$FI = D / L \times 100$].

Subdivisions of foraminal position according to foraminal index (FI):

The positions of the foramina were grouped into three types according to FI as below:

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

Type 2: FI from 33.34 up to 66.66- The foramen is in the middle third of the bone.

Type 3: FI 66.67 & above - The foramen is in the distal third of the bone.

Results

140 fibulae were observed which included 87 right and 53 left sided.

Number of Nutrient Foramina

Nutrient foramina were traceable in 125 (89.29%) fibulae, while 15 (10.71%) had absentia of any nutrient foramina. 9 (6.43%) fibulae had both dominant and secondary nutrient foramina.

Dominant and secondary nutrient foramina was present in 121 (86.43%) and 10 (7.14%) fibulae respectively. 115 (82.14%) fibulae had exclusive presence of dominant nutrient foramen. 4 (2.86%) fibulae were exclusively supplied through secondary nutrient foramen.

Two fibulae had presence of multiple dominant foramina (2 & 3 dominant foramina respectively). Multiple secondary foramina were observed in 3 fibulae (Two fibulae with 2 & one fibulae with 4 secondary foramina respectively).

Total 142 nutrient foramina were found, 124 (87.32%) being dominant foramina and 18 (12.68%) secondary foramina.

Direction of Nutrient Foramina

110 (88.71%) dominant foramina were in lower direction i.e., away from the growing end. Number of secondary foramina directed in lower and upper end were almost equal, 8 (44.44%) and 10 (55.56%) respectively (Table 1).

Location of Nutrient Foramina

97.77% dominant foramina were present on the posterior surface whereas 3.22% were on lateral surface of fibulae. 94.44% secondary foramina were located on posterior surface with mere 5.55% on lateral surface. None of the fibulae had any primary or secondary foramina on medial surface.

Foraminal index was calculated by using Hughes formula (Table 2).

Based on the foraminal indices, dominant and secondary nutrient foramina were present on middle of shaft of fibulae in 91.12% and 50% of cases respectively (Graph 1). FI ranged from 22.83 to 73.46 for fibular nutrient foramina in this study (Table 2).

Table 1: Direction of dominant and secondary foramina

Direction	% in Upper direction (n)	% in Lower direction (n)
DF	11.29(14)	88.71(110)
SF	55.56 (10)	44.44 (8)

Table 2: Foraminal index of Fibulae

Foramina Index Parameter	Dominant Foramina	Secondary Foramina
Mean	45.42	50.62
S.D.	9.08	17.53
Min value	22.83	23.23
Max value	73.46	73.13

Table 3: Incidence of dominant, secondary and absent nutrient foramina in different studies

Study	Dominant foramina	Secondary foramina	Absent
Gumusburn et al[7]	92.14%	3.9%	3.9%
Agrawal et al[8]	82.75%	17.24%	4%
Bilodi et al[6]	85%	13%	2%
Pereira et al[9]		0.87%	
Prashanth et al[5]	90.2% [DF+SF]		9.8%
Present study	86.43%	7.14%	10.77

Table 4: Surface of fibula showing nutrient foramina in different studies

Study	PS	LS	MS	MC	IB	PB	AS
Agrawal et al[8]	22.22%	3.5%		67.25%			
Malukar et al[16]	90.8%	2.2%	6.8%				
Bilodi et al[6]	29.62%	22.23%	21.16%	8.99%	7.93%	2.11%	0.53%
Gumusburun et al[7]	48.36%	3.62%	19.40%	19.74%	0.64%	7.22%	-
Periera et al[9]	1.8	98.2					
Present study (DF)	97.7%	3.22					
Present study (SF)	94.44	5.56					

DF, dominant foramina; SF, secondary foramina; PS, posterior surface; LS, lateral surface; MS, medial surface; MC, medial crest; IB, interosseos border; PB, posterior border; AS, anterior surface

Table 5: Position of foramina on shaft of fibula based on FI in different studies

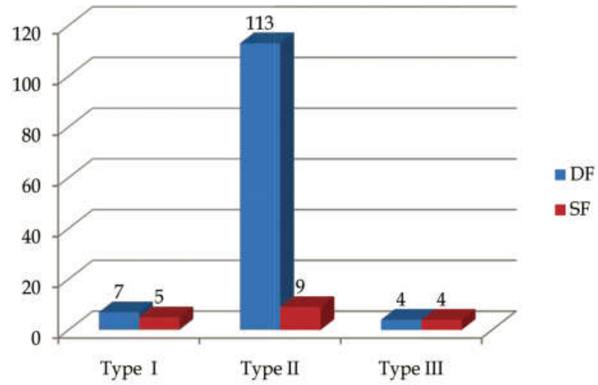
Study	Type I	Type II	Type III
Gumusburn et al[7]		98%	0.7%
Agrawal et al[4]		97.91%	2.08%
Bilodi et al[6]	29.10%	29.62%	38.62%
Malukar et al[16]	4.59%	85%	10.34%
Prashanth et al[5]	26.7%	60%	13.3%
Present study (DF)	5.66	91.13	3.23
Present study (SF)	27.78	50	22.22

FI, foraminal index; DF, dominant foramina; SF, secondary foramina

Table 6: Comparison of foraminal index in different studies

Study	Foramina Index (FI)	
	Mean ±S.D.	Range
Agrawal[4]	39.66 ± 5.29	35.92 to 68.79
Gumusburun[7]	48.13 ± 0.46	23 to 70
Pereira[9]	46.1	33.5 to 67.1
Present Study (DF)	45.42±9.08	22.83 to 73.46
Present Study (SF)	50.62±17.53	23.23 to 73.13

DF, dominant foramina; SF, secondary foramina



DF, dominant foramina; SF, secondary foramina

Graph 1: Distribution of nutrient foramina based on foraminal Index

Discussion

Presence of nutrient foramina was sighted in 89% cases from 140 fibulae. Nutrient foramina was absent in remaining 11% cases (Table 3). These findings correspond with the observations made by Prashanth et al, whereas, Bilodi et al reported just 2% fibula with absence of nutrient foramina. It has been cited that in such cases of absent nutrient foramina, the bone is supplied by periosteal vessels [5,6]. The absent foramina can be because of ossification in old age. As the age determination was not done in this study, we are unable to concretely comment on this aspect. The studies on foramina of fibula have shown the presence of dominant and secondary foramina in the range of 82-92% and 1-12% of cases (Table 3). The present study from western part of India also corresponds with the range found in the previous studies. The data shows that in majority of fibular cases, dominant or primary nutrient vessels are present while in some of the cases (6 fibulae) additional vessels through secondary foramina are also available. The study also showed presence of multiple dominant and secondary nutrient foramina in 5 fibulae. The lack of age and gender determination is a limitation in this study. Otherwise, it has been observed in previous studies that incidence of multiple nutrient foramina is high in males (15%) versus females (1%) [10].

Majority of dominant foramina in this study were directed towards lower end. Thus the finding consolidates the popular saying about direction of nutrient foramina "seek the elbow and flee from the knee" [11]. There are many theories put forward to explain the direction of normally and anomalously directed foramina. The 'periosteal slip' theory of Schwalbe and vascular theory of Hughes are widely accepted in the literature amongst these [12,13]. Patake and Mysorekar suggested that the number of foramina are not significantly related to the length of the bone [14]. It was proposed 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 [15]. 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.

The dominant as well as secondary foramina were found majorly on posterior surface of fibulae (98% & 94% respectively). As against this, study by Bilodi et al. found relatively equal distribution of nutrient foramina on posterior (29.62%), lateral (22.23%) and medial (21.16%) surfaces and predominantly on posterior surface by Agrawal et al [4,6] (Table 4).

The mean foraminal index and the range of values observed in this study correspond with the previously conducted studies by Gumusburun et al and Periera et al [7,9] (Table 5). The foraminal index has revealed the presence of foramina in middle third (Type II) of fibular shaft in most of the cases, including this study, except a relatively equal distribution along the shaft observed by Bilodi et al (29.62%, 38.62% and 29.1% respectively on upper, middle and lower thirds) (Table 6) [6]. The location of nutrient foramina of long bones may alter during growth [5]. The presence of samples from varied age groups in this study might be the reason for values of FI ranging from 22.83 to 73.46.

Conclusion

The present study confirms and compares the morphometric and topographic data on commonly used bone for grafting i.e. fibula. This data from western part of India can be considered as a useful addition of information required for various orthopedic resection and graft surgeries.

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