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Original Research Article

STUDY OF DIAPHYSEAL DOMINANT AND SECONDARY NUTRIENT FORAMINA IN FIBULA: ITS CLINICAL RELEVANCE IN VASCULAR BONE GRAFT SURGERY

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ABSTRACT

Background: The external opening of the nutrient canal, usually referred to as the nutrient foramen has a particular position in each bone. An understanding of the position and number of the nutrient foramina in fibula is important, as this is one of the most common bones used in bone grafts, vascularized bone microsurgery and mandibular reconstruction. Nowadays fibula flap is the most accepted flaps used in the mandibular reconstruction especially in the malignancy of oral and oropharyngeal regions.

Materials and Methods: The present study was conducted in 160 dry human fibula obtained from department of Anatomy, N.S.C.B. Medical college Jabalpur {M.P.}. We have measured the different parameters in each bone according to standard method.

Result: In our study we found that 95% bones possess single dominant nutrient foramina. According to Foraminal Index (FI), the position of most of foramina [97%] was fall in Type 2 (middle third of the fibula). The mean foraminal index (FI) was 39.66±5.29. The average total length (TL) of fibula was 35.80±2.53.

Conclusion: To conclude that our study provides detailed data about the position and number of nutrient foramina of fibula that is considered as a determining factor for the success of new techniques for bone transplant and resection in orthopaedics.

KEY WORDS: Fibula, Nutrient foramina, Dominant nutrient foramina, Secondary nutrient foramina, Foraminal Index (FI)

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INTRODUCTION

The Fibula is one of the two lateral long bones of the leg, and homologous to ulna in upper limb. Although it transmits insignificant force in walking, it is an important bone for muscle attachment and significant source of the bone graft [1]. When a bone graft is taken, the vascularisation of the remaining bones has to be considered with good vascularity. It has been reported that ideal bone graft for the free transfer should include endosteal and periosteal blood supply with good anastomosis [2]. The artery that supplies to the shaft of the long bone is the largest artery and it is called as the

"Nutrient Artery" [3]. In fibula this nutrient artery is a branch of peroneal (fibular) artery, which enters to the bone through the nutrient foramen [4]. Nutrient foramen is a natural opening into the bone shaft which gives passage to the blood vessels of the medullary cavity of a bone, for its nourishment and growth [5]. This foramen, in the majority of cases is directed away from the growing end hence it is popularly stated that foramina `seek the elbow and flee from the knee [6].There are few reports available on the morphology of nutrient foramina of the fibula in central India. So our research emphasizes the anatomical description of nutrient foramina of fibula which is very helpful in orthopaedic surgical procedures such as joint replacement therapy, fracture repair, vascularised bone microsurgery and the latest developing fibular flap technique in the mandibular reconstruction [7].

MATERIALS AND METHODS

This study was conducted in the Department of Anatomy N.S.C.B. Medical College, Jabalpur [M.P.], India. The present study consisted of 160 adult human cleaned and dried fibulae (80 right sides & 80 left sides) collected from Department of Anatomy N.S.C.B. Medical College, Jabalpur [M.P.], India. All selected bones were serially numbered and photographed. The specific age and sex characteristics of the bones studied are unknown. The nutrient foramina are observed in all bones with the help of a hand-lens. They are identified by their elevated margins and by the presence of a distinct groove proximal to them [8]. Only well-defined foramina on the diaphysis are accepted. Foramina at the ends of the bone are ignored [9].

The following data is studied on the diaphyseal nutrient foramina of fibula:

(A) Number: Bones were examined for the number of nutrient foramina. With the help of magnifying hand lens all surfaces and each border was thoroughly examined from proximal to distal end and both dominant and secondary foramina were counted and noted down.

(B) Position: The positions of all nutrient foramina were determined by calculating a foraminal index (FI) by using formula:

FI = (DNF/TL) x 100 (Hughes1952; shulman 1959)

DNF = the distance from the proximal end of the bone to the nutrient foramen

TL = Total bone length.

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

The positions of the foramina can be grouped into three types according to FI as below [10]:

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 above 66.67- The foramen is in the distal third of the bone.

(C) Size: Nutrient foramina smaller than the size of 24 hypodermic needle (0.56 mm in diameter) were considered as secondary nutrient foramina (S.F.) while those equal or larger than 0.56 mm were accepted as dominant nutrient foramina(D.F.) [11].

(D) Direction and Obliquity: A fine stiff wire was used to confirm the direction and obliquity of the foramen [12].

All measurements have taken to the nearest 0.02 mm using an Aerospace sliding caliper. Photographs were taken in natural daylight by a Nikon digital Camera of 10 megapixels. Each photograph had a definition of 16 x 12 cm.

Fig. 1: Photograph of posterior aspects of fibula showing the size of nutrient foramina by inserting a 24 size needle.

Fig. 2: Photograph of fibula showing Measurement of TL (Total Length).

Fig. 3: Photograph of fibula showing Measurement of DNF (Distance of NF from proximal end).

Fig. 4: Photograph of posterior aspects of fibula showing direction of NF.

Statistical analysis: The results were analyzed and tabulated. The range, mean and standard deviation of FI were determined.

RESULTS

Table 1: Study of position and number of dominant (DF) and secondary (SF) nutrient foramina observed in the fibula.

Location	Total no of foramina	%	No. of foramina				Absent
			Single foramen		Double foramen		
			DF	SF	DF	SF	
Posterior surface (on the medial crest)	115	67.25	110	5	-	-	-
Post surface(b/w med. crest & post. border)	38	22.22	27	11	-	-	-
Post surface(b/w med. crest &interossous border)	12	7.01	12	-	-	-	-
Lateral Surface	6	3.5	3	3	-	-	-
Medial Surface	-	-	-	-	-	-	-
Total	171	100	152	19	-	-	-

In our present study 160 fibulae (80 rights &80 lefts) were examined, we found total 171 nutrient foramina, including both dominant and secondary. Out of 160 the 152 bones (95%) presented a single dominant nutrient foramen, while in 08 (05%) bones we only found single secondary nutrient foramen not any dominant one. Along with dominant nutrient foramina, 11 bones also possess secondary nutrient foramina. In the present study most of the nutrient foramina were located along the middle third of the fibula (97.91%), (Type-2), the rest (2.08%) were located in the distal third (Type-3), while no foramina detected in the proximal third of the fibula. The mean foraminal index (FI) is 39.66±5.29 & foraminal index ranging between 35.92 to 68.79 % of the bone length. In our study, 67.25% of the fibular foramina were located on the medial crest and 22.22% on the posterior surface between medial crest and posterior border while 3.5% were located on the lateral surface (Table-1,2 and 3).

Table 2: Study of range, Mean and Standard deviation (SD) of foraminal Indices observed in the fibula.

Location	Side	Range	Mean±SD
Post surface (on the medial crest)	R	35.92-65.56	40.37±6.30
	L	36.39-68.79	42.81±0.84
Post surface(b/w med. crest & post. border)	R	37.85-51.50	44.67±9.65
	L	39.04-55.68	41.03±2.39
Post surface(b/w med. crest & interossous border)	R	38.42- 60.21	50.45± 7.96
	L	37.76-58.89	48.67±3.35
Lateral Surface	R	55.43-65.78	60.60±5.70
	L	54.55-62.44	58.49±3.87
Medial Surface	R	.....	.....
	L	.....	.....

Table 3: Study of direction of nutrient foramina in Fibula.

Side	No. of Fibula	No. of Nutrient foramina	Direction of Nutrient foramina	No.	%
Right	80	91	Towards the growing end	11	12.08
			Away from the growing end	80	87.91
Left	80	80	Towards the growing end	8	10
			Away from the growing end	72	90
Total	160	171	Towards the growing end	19	11.11
			Away from the growing end	152	88.88

DISCUSSION

Bone is a living tissue hence it requires nutrition for its growth and development [13]. This is provided by continuous blood supply to the bone, and therefore any disturbance in its blood supply leads to structural and functional defects. Detailed topographical study of nutrient foramen is considered as a determining factor for the success of new techniques for bone transplant and resection in orthopaedics [14, 15].This study has some limitations. These include age and sex differences which were not considered as we were not able to estimate the age and gender of the bones studied. These differences might alter the results as the anatomy of foramina might differ in males and females. In old ages, some foramina might also get ossified. So it is better to consult a forensic expert to segregate the bones and analyse them based on a specific age group and gender. Since the nutrient foramina of the long bones may alter during growth, the sample long bones should be confined in a specific age group [16, 17].

Our present study analyzes the following four parameters:

Number of the nutrient foramina: In our study we found 95% fibulae presented a single dominant nutrient foramen which represents the single source of blood supply. This is in agreement with previous studies reported by Kizilkanat et al. Pereira, G. A. M.; Lopes, and BV Murlimanju.

Position of Nutrient Foramina: Two well-known factors may affect nutrient foramen position; these are growth rates at two ends of the shaft and bone remodeling. The present study results that the position of most of the nutrient foramina were along the middle third of the fibula (97.91%), (Type-2), near the medial crest (posterior surface). So it is important to know the distribution of the nutrient foramina preoperatively, especially regarding the fibula which is used in bone grafting.

Size of Nutrient Foramina: In whole series of 160 fibulae, only 08 fibulae (05%) have secondary nutrient foramina, rest 152 bones have dominant nutrient foramina. Similar results reported by Kizilkanat et al. (2007), BVMurlimanju (2011) and Dr. Shamsunder Rao V (2014). Correlation between size of nutrient foramina and blood supply has not mentioned clearly in previous studies but it must be important that surgeons might be aware preoperatively to choose the osseous section that had got a major arterial supply that must be entered through the dominant nutrient foramina.

Direction and Obliquity of nutrient foramina: In this study we found that, the direction of 88.88% of nutrient foramina was distal, (away from the growing end), while 11.11% had a proximal direction (towards the growing end). So our study does not fully obey the "growing end theory" by Mysorekar that might be due to changing nature of epiphysis (from traction to pressure epiphysis) at the lower end of bone after birth.

Table 4: Comparison of present study with prior studies.

Parameters taken in fibula	Kizilkanat et al 2007 [17]	Sammera Yassin Shaheen 2009	Gupta et al 2013	Present study 2015
Number of single dominant nutrient foramina	96%	80%	78.57%	95%
According to FI Position of nutrient foramina	Type 1-nil Type 2- 96.5% Type 3- 3.5%	Type 1- nil Type 2- 97.2% Type 3- 2.7%	Type 1-9.02% Type 2-81.95% Type 3-9.02%	Type 1-nil Type 2- 97.91% Type 3- 2.08%
Size of nutrient foramina	DF-96% SF- 04%	DF- 11.1% SF- 88.8%	.....	DF- 95% SF- 05%
Direction of nutrient foramina (Away from the growing end)	.....	77.71%	79.70%	88.88%

(FI- Foraminal Index, DF-Dominant foramina, SF- Secondary foramina)

CONCLUSION

The results on the nutrient foramina incidence and distribution in fibulae are more consistent with previous study done by Turkish Anatomist Kizilkanat et al. Dominant nutrient foramina were more common as compare to secondary nutrient foramina. All the foramina were located on the middle one third of bone on posterior surface. So our study provides additional data that may be helpful for those clinicians involved in surgical procedures such as joint replacement therapy, fracture repair, vascularised bone microsurgery, and a recent technique involving fibular flap in the mandibular reconstruction.

Conflicts of Interests: None

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