Original Article

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Study of the Morphometrics of Fibula for Nutrient Foramina and Its Variations in Indian Population

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Abstract

Introduction: The fibula is located lateral to the tibia in the leg. The fibula is the bone of choice for grafting and to reconstruct large defects after tumor resection, because of its length, biomechanical stability, limited donor site morbidity and predictable vascular pedicle. *Objectives*: The objectives of the study are: (1) To locate and describe the position, number & direction of nutrient foramina of fibula. (2) To observe any variations in location,position and number of nutrient foramina of fibula. *Methods*: The study sample comprised of 80 dry adult human fibulae.Present study was conducted at bone bank of Department of Anatomy, Government Medical College, Aurangabad. The data pertaining to the above parameters were noted, subjected to statistical analysis and were photographed. *Results*: In the present study of 80 dry adult human fibulae, noted; (1.) Absence of nutrient foramen (NF) in 2 (2.5%) fibulae. (2.) Single nutrient foramen was present in 71 (88.75%) fibulae. (3.) 5 (6.25 %) fibulae showed double nutrient foramen. (4.) 2 (2.5%) fibulae showed triple nutrient foramen. (5.) The most common location of nutrient foramen was on medial crest in 52 (58.42%) and least common on anterior border in 1 (1.25%) fibulae. (6.) Out of total 89 foramena 84 (94.67%) foramen were on the middle third of the fibula. *Conclusion*: The present study showed 12.7% variation in number of nutrient foramen.Accurate anatomical knowledge about the location and distribution of nutrient foramen is useful for orthopedic and plastic surgeons in planning the vascularised fibular graft at middle third of the shaft. .

Keywords: Fibula; Foraminal Index; Nutrient Foramen; Vascularised Fibular Graft.

Introduction

The word foramen is derived from Latin word 'foro' (to pierce).Foramena meansan aperture or perforation through a bone or membranous structure. The role ofnutrient foramen is nutrition and growth of the bones [1]. The external opening of the nutrient canal, has a particular position for each bone usually referred to as the nutrientforamen [2]. The principle source of blood to a long bone particularlyduring its active growth period is the nutrient artery. Nutrientforamina, allow blood vessels to pass through the bone cortex [3]. The fibula is located on the lateral side of tibia in the leg. A little proximal tothe midpoint of the posterior surface, the fibular shaft is pierced by a nutrient foramen, receives a branch of theperoneal artery. The detailed anatomical knowledge of the peroneal artery in relationto the fibula is the key to raising osteofasciocutaneous free flaps incorporatingsegments of the bone. Free vascularized diaphysis grafts may also be taken on aperoneal arterial pedicle [4].

Generally the direction of the nutrientforamina is determined by the growing end of the bone [5]. The fibula reverses the ossificatory pattern in respect to other long bones [6]. Detailed data on the blood supply to the long bones and the association withthe areas of bone supplied has been continued to be a major factor in the developmentof new transplantation and resection techniques in orthopaedics [7]. The exact knowledge of position of the nutrient foramina of fibula is important to proceed with the free transplants of the vascularized bone graft. Commonly, the nutrient foramen is located in the middle third of the posterior surface of the fibula. The present study is undertaken, as the knowledge of nutrient foramina of fibula is

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useful for, anatomists, forensic experts, orthopedic, anthropologists and plastic surgeons for fibula graft and micro-vascular bone transfer.

Aims & Objectives

1. To locate and describe the position, number and direction of nutrient foramina of fibula.
2. To observe for any variations in location, position and number of nutrient foramina of fibula.

Methodology

The present study was conducted on 80 dry adult human fibulae in the Department of Anatomy, Government Medical College, Aurangabad, Maharashtra.

Materials Used

a. Sliding digital verniercalliper.

b. Osteometric board

After determining the side of the fibula, the length of fibula was measured by osteometric board. NF were identified by the presence of well marked groove leading to them. The NF was studied in variousregards i.e. the number of foramina on the shaft, surface, border on which it is present, direction from growing end, location in relation with length of the fibula. Number, distribution and direction of nutrient foramen in relation to specific surfaces, border and growing ends of fibulae. Part of bone possessed the absence, single or multiple foramen were noted. For determining the distribution of NF along the length of fibula each fibula was divided into three parts (upper, middle and lower 1/3rd) after measuring the length of the fibula and dividing by 3. The length of fibula measuring 30.1 to 35 cm were categorized as Type I, 35.1 to 40 cm as Type II, and 40.1 to 45 cm as Type III. All the data were first collected in a standardized excel sheet followed by tabulation for calculating the percentages of distribution of nutrient foramen along the length of fibulae.

Calculation of the Foraminal Index

The position of all nutrient foramina was determined by calculating foraminal index (FI) using the formula:

FI = DNF÷TL x 100 (Hughes [8] formula)

DNF = the distance from the proximal end of the bone to the nutrient foramen measured by vernier digital caliper with an accuracy of 0.01mm, later converted into cms.

TL =Total fibula length in cm from proximal end of bone to tip of lateral malleolus in cm by sliding caliper.

Results

Variations in the Number of Nutrient Foramen

Out of 80 fibulae in 2 (2.5%) fibulaenutrient foramen was absent, 71 (88.75%) fibulae showed single NF, 5 (6.25%) fibulae had Double NF and 2 (2.5%) fibulae had Triple NF.

Distribution of Nutrient Foramina in Right 40 and Left 40 Fibulae

Most common nutrient foramen was Single NF observed in 38 (95%) right and 33 (82.5%) left fibula. And less common foramen, Triple NF was seen in one each of the (5%) right and (0%) left fibulae.

Variations in the Direction of NF

In the total number of NF 75 (93.75%) foramen were directed away from growing end and abnormal direction of NF were seen in 5 (6.25%) foramen, i.e., towards the growing end, violating the law of ossification.

Discussion

The fibula is an ideal graft for reconstructing a long bone, especially when the skeletal defect is large [9]. The growing end of long bones is always located opposite to the direction of nutrient foramen. The

Table 1: Showing Variations in the Number of Nutrient Foramen

No. of foramen	No. of fibulae	Percentage
0	2	2.5
1	71	88.75
2	5	6.25
3	2	2.5

Table 2: Distribution of nutrient foramina in right and left fibulae

No. of foramina	Right Fibulae		Left Fibulae	
	No.	%	No.	%
0	1	2.5	1	2.5
1	38	95	33	82.5
2	3	7.5	2	5
3	2	5	0	0

Table 3: Direction of foramen towards and away from the growing end of fibulae in foramen

Side of Fibula	No. of Fibulae	Towards growing end		Away from growing end	
		No.	%	No.	%
Right	40	3	7.5	37	92.5
Left	40	2	5	38	95
Total	80	5	6.25	75	93.75

Variation in Distribution of Nutrient Foramen

Table 4: Number and location of nutrient foramina and their foraminal index of fibulae

Anatomical Site	No of Foramina	Range	Mean ± SD	p-Value
Anterior border	1	30.14 to 42.37	35.19±7.26	0.001
Interosseous border	4	48.23 to 59.18	59.48±9.13	0.001
Lateral surface	2	39.48 to 47.59	51.12±4.23	0.001
Medial crest	52	27.38 to 49.47	35.74±3.64	0.001
Medial surface	2	28.79 to 49.28	28.11±2.86	0.001
Posterior border	1	41.61 to 60.12	43.89±5.01	0.001
Posterior surface	18	25.91 to 52.76	24.91±3.54	0.001

direction of nutrient foramen is easily remembered by a 'dictum' that says, "To the elbow I go and from knee I flee". In the milking cow position the direction of nutrient foramina is always directed downwards [16].

Present study shows vary similar findings with previous observations made by various authors. Some findings doesn't appear similar with previous studies, this might be due to geographical and racial variation.

Conclusion

Vascular integrity of a long bone is vital, and knowledge of the nutrient artery anatomy entering the bone through nutrient foramen may be of value to the orthopaedic surgeon. The surgical exposure and periosteal stripping in open reduction and internal fixation procedures of diaphyseal fractures present further vascular insult to existing osseous

Number of Nutrient Foramen

Table 5: Prevalence of variations in number of nutrient foramen by various authors

Researchers	Year	No. of NF in %			
		0	1	2	3
Priya R[10]	2010	4.7	89.1	6.1	0
Prashanth K[11]	2011	9.8	90.2	0	0
Sanjeev[12]	2012	0	17	3	0
Gupta R[13]	2013	4.46	78.58	12.5	2.67
Anusha P[14]	2013	2	88	10	0
Present Study	2017	2.5	88.75	6.25	2.5

Position of Nutrient Foramina

Table 6: Prevalence of variations in position of nutrient foramina by various authors

Researchers	Year	Upper Third (%)	Middle Third (%)	Lower Third (%)
O Malukar[15]	2011	4	79	9
Gupta R[13]	2013	9.02	95	2
Anusha P[14]	2013	4	94	2
Present study	2017	3.21	94.67	2.12

Location of Nutrient Foramen

Table 7: Prevalence of variations in location of nutrient foramina by various authors

Researchers	Year	More frequent	Less frequent
O Malukar[15]	2011	90.8% on PS	2.2% on LS
Gupta R[13]	2013	87.96% on PS	6.77% on LS
Anusha P [14]	2013	95% on PS	24% on MS
Present study	2017	91.22 % on PS	10.86% on AB

injury.The morphometric study of nutrient foramen with regard to the number, location and position is assumed to be of great importance for clinicians, radiologists, orthopaedicians and vascular surgeons. Exact position and distribution of the nutrient foramina in bone diaphysis is important to avoid damage to the nutrient vessels during surgical procedures to plan for vascularised free fibular grafts is to include endostealas well as periosteal blood supply. The morphometric analysis of the position of the nutrient foramen of the fibula will help in harvesting vascularized graft of the bone, to preserve the circulation within bone, also to reconstruct and close the bone defects.

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