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Anatomical study of nutrient foramina present in dried specimens of human fibulae of Eastern Odisha

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Abstract
Introduction & Aim: The fibula is a long bone present lateral to tibia in leg. It is used in grafting and reconstructing surgeries in case of large bony tumour resection, grossly fractured mandible, spine surgeries and even stabilizing the tibia. Aim of the study is to describe the relative location, number & course of fibular nutrient foramina and observe any variations by comparing with earlier studies by various authors.
Materials and Methods: Study was done by examining 51 adult dried fibulae consisting of 31 right sided bones and 20 left side bones. Each bone was carefully observed for various parameters as regards the surface anatomy of nutrient foramina present in the shaft. Foramen index was computed and compared with others.
Results: Nutrient foramina were found singly in 82.35% fibulae, 7.84% fibulae showed two foramina and 9.8% fibulae were devoid of any nutrient foramen. 16% foramina proceeded towards the growing end while 84% nutrient foramina were directed opposite to the growing end. 6% foramina were detected in upper zone and 94% were detected in the middle zone. Grossly the total nutrient foramina were placed on the posterior aspect of the fibulae, out of which, 72% surfaced on the medial crest, 20% were present between the posterior border and the elevated medial crest and 8% were sited between the interosseous border and the medial crest. Worked out Mean foramen index of the study was 50.02.
Conclusions: The anatomical knowledge of nutrient foramina aids the orthopaedic and plastic surgeons in planning bone grafting and bone reconstruction surgeries.

Keywords: Fibula, nutrient foramina, location, foramen index, bone graft

Introduction

Fibula is the slender lateral bone of leg without having any direct involvement in weight transmission. It gives attachment to particular groups of muscles and is a rich source of vascularised bone graft [1].
Theword ‘foro’ (to pierce) implies an aperture and nutrient foramen serves as a channel for passage of blood vessels to bones to provide nutrition as well as growth, as is evident from the term ‘Nutrient’ itself [2].
Nutrient artery enters through the nutrient canal of long bones and is the key source of vascular supply during growing period in intrauterine phase of life and also during ossification phases of bone growth and repair [3-5]. The slanted direction of the nutrient canal of all bones follows the rule, “to the elbow I go, from the knee I run away” which is across from the growing end [6].So, from the course of the nutrient canal we can know the growing end of a bone. The nutrient foramen has a particular position and differs from individual bone [7].
Knowledge of anatomical variations of nutrient foramina is necessary during orthopaedic surgeries involving bone graft to avoid injury to the nutrient arteries. As the nutrient foramina of the fibulae are commonly found in their mid-segments, this segment is always taken as a

harvest to reconstruct lost mandible, stabilize defective vertebral spine or tibia and also for dental implants. Fibular grafts with rich vascularity are particularly suitable to close large diaphyseal defective gaps due to their appropriate shape and mechanical structure for reconstruction after any bony excision and other bony deformities [8, 9].

Since the orthopaedic and plastic surgeons analyse the anatomical situations of nutrient foramina before planning their surgery, we focus here to examine the morphology of the nutrient foramina with regard to their number, location and direction in dried fibulae specimens of adult humans of the region of Eastern Odisha.

Materials and Methods

51 cadaveric adult human specimens of fibulae (31 right and 20 left) were obtained from the osteology sections of Anatomy departments of S.C.B. Medical College, Cuttack and IMS & SUM Hospital, Bhubaneswar, Odisha. Ethical consent from the IEC was not sought as the study involved dry bone specimens.Calculation of sample size was done takingthe previous data having standard deviation 16.59, absolute precision 10% and desired confidence level 95% [10]. Deformed or grossly broken fibulae and those showing gross asymmetry were excluded from the study. Nutrient foramina were pinpointed by passing fine hypodermic needle through the nutrient canals. Foramina found at the extreme ends of the specimen bones and those with smaller calibre allowing < 24gauge hypodermic needle were exempted from the analysis [11]. Nutrient foramina were examined with respect to their number, size, direction and location on the fibulae after marking with a black pen. Total bone length was determined by measuring the upper to lower end distance. The upper end distance from the nutrient foramen was also measured to calculate the Foramen index (FI) using Hughes formula [12].

$$FI = [DNF/TL] \times 100$$

Where, DNF represents distance between nutrient foramen to proximal endpoint of the bone & TL represents Total length of bone.

Results

Observational data of examined Nutrient foramina on the 51 fibulae have been tabulated and represented through tables, figures and graphs below.

Total 51 dried fibulae were examined (31 right, 20 left), solitary nutrient foramina were present in 42 fibulae (82.35 %), 4 fibulae showed double nutrient foramina (7.84 %) and 5 showed no nutrient foramina (9.8 %) [Table 1 and Fig.1].

Table 1: Observed Nutrient foramina in all fibulae

Side	No. ofFibulae	No. of Foramina			Direction of Foramina	
		0	1	2	Towardsgrowingend	Away fromgrowingend
Right	31	1	28	2	4	28
Left	20	4	14	2	4	14
Total	51	5 (9.80%)	42 (82.35%)	4 (7.84%)	8 (16%)	42 (84%)

Fig1: Fibula showing double nutrient foramina

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Fig2: Measurement of DNF and TL of fibula

Table 2: Nutrient foramina distribution of on fibular shaft

Side of Bone	No. of fibulae	No. of foramina	Lengthwise distribution	Number	%
Right	31	32	Upper 1/3	1	3.12%
			Middle 1/3	31	96.87%
			Lower 1/3	0	0
Left	20	18	Upper 1/3	2	11.11%
			Middle 1/3	16	88.88%
			Lower 1/3	0	0
Total	51	50	Upper 1/3	3	6%
			Middle 1/3	47	94%
			Lower 1/3	0	0

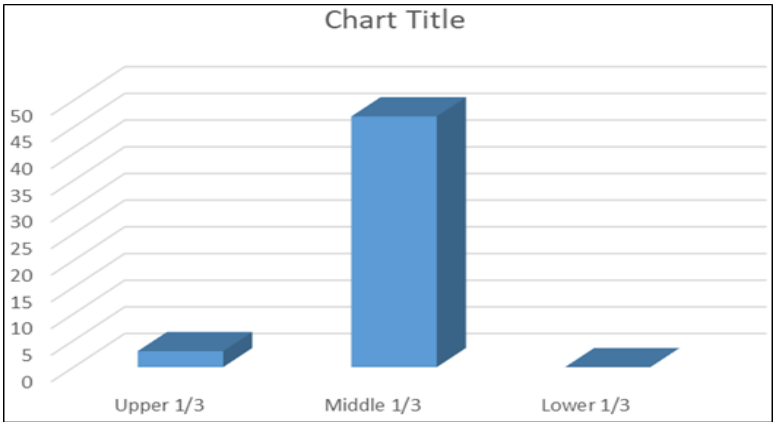

Fig3: Segment wise dispersal of nutrient foramina on the fibular shaft

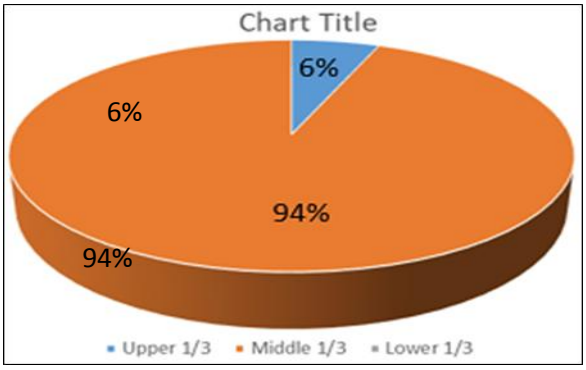

Fig4: Percentage of segment wise dispersal of nutrient foramina on shaft of fibulae

Table 3: Mean Total length of Fibulae & Mean Extent of DNF from upper endpoint

Side of Bone	No. of Fibulae	Distance (in cm) of DNF from the upper end		Total bone length (in cm)		FI	
		Mean	SD	Mean	SD	Mean	SD
Right	31	17.91	3.45	34.43	1.85	51.89	9.10

Left	20	16.48	5.27	34.69	3.47	46.72	13.97
Total	51	17.39	4.20	34.52	2.52	50.02	11.23

Table 4: Position of nutrient foramina as presented on shaft of fibulae

Side of Bone	No. of Fibulae	No. of foramina on fibular shaft			
		Total number offoramina	On medial crest	Betweenmedial crestandinterosseous border	Between posterior border and medial crest
Right	31	23	2	7	32
Left	20	13	2	3	18
Total	51	36 (72%)	4 (8%)	10 (20%)	50

Total 50 nutrient foramina were examined (32 from right fibulae and 18 from left), 8 foramina pointed towards the proximal growing part (16%) while 42 nutrient foramina were pointed opposite to growing end (84%) [Table 1]. Out of 50 DNF, maximum 47 were found in the middle 3rd (94%), 3 were found in upper 1/3rd (6%)and foramen were absent in lower 1/3rd [Table 2, Figure 3 and 4].

Of right sided fibulae mean total length was 34.43±1.85 cm, mean distance of Nutrient Foramina from the proximal upper ends was 17.91±3.45 cm with the mean foramen index calculated to be 51.89±9.1. Of left sided fibulae mean total length was 34.69±3.47 cm, mean extent of Foramina from the proximal upper end was 16.48±5.27 cm [Fig.2] with the mean foramen index calculated to 46.72 ± 13.97. Of the whole observed fibulae, 50.02 was the computed Mean Foramen Index [Table 3].

Absolutely Nutrient foramina were found on the posterior aspect, out of which 36 were mounted on the medial crest (72%), 10 were present in the interval surface of posterior border and the medial crest (20%) while 4 surfaced between medial crest and the interosseous border (8%) [Table 4].

Discussion

In the present study, 42 (82.35%) fibulae presented with single nutrient foramen, 4 (7.84%) revealed double foramina while 5 (9.8%) showed no foramina. This remark match up with the studies of Murlimanju*etal*.[13] who presented 90.2% fibulae having single foramina and 9.8% fibulae without any foramina and Sharma *et al*. who found 92% fibulae having single nutrient foramina and 8% fibulae without any foramina. Patel *et al*. found 80% of fibulae with single foramina and the remaining 20% with double foramina [14,15]. As our findings, absence ofNF was also observed by McKee [16]in 5.6% cases from 322 fibulae and by Ongeti[17] in 5.5% cases from 200 fibulae. This missing may be due to congenitally absent nutrient artery or due to very minute nutrient arteries with diameter size less than 0.5 mm in which cases fibulae are likely to be supplied by periosteal arteries [18].

In our study, 42 (84%) nutrient foramina were directing opposite to the growing ends whereas 8 (16%) foramina were directing towards the maturing ends of the fibulae.Jayaprakash T.[11] also observed 45 (95.74%) nutrient foramina being directing opposite to the growing ends while 2 (4.25%) nutrient foramina directing to the growing ends of study fibulae. Report by Rakesh Gupta *et al*. showed 20.30% nutrient foramina directing to growing ends refuting the statute of nutrient artery direction to be opposite of the maturing end [19].

In our present study, 94% foramina were found on the middle 1/3rd, 6% were located on upper 3rd and no foramen seen on the lower 1/3rd of the shaft of fibulae. The results are closer to the study done by C. Sreekanth & Vinayaka Naik who found maximum 83 number of fibulae having nutrient foramina in the middle third while10 fibulae presenting on upper third and only 1 bone is showing in lower third [20]. Manish Dev Sharma *etal*.[21] also observed that out of 150 fibulae, 97.07% nutrient foramina were located in the middle third, 1.95% were situated in the distal third and only 0.97% were placed on the upper third.

In this present study, mean length of fibulae on right side was found to be 34.43 ±1.85 cm

and on left side fibulae found to be 34.69±3.47 cm.Mean Foramen Index of our study fibulae is 50.02 which is close to the index of Murlimanju[12]*etal*. who reported the mean foraminal index to be 49.2 and Kamath *etal*.[22] who also worked out the same foramen index as 44.60.
In our study all diaphyseal foramina existed on the posterior aspect of fibulae which is similar with the study of Jayaprakash T. [11] and Kamath *etal*.[22]who also established the same aspect of nutrient foramina distribution on the examined fibulae.
Present study shows 36 (72%) foramina on the medial crest, 10 (20%) foramina betweenposterior border and medial crest 4 (8%) foramina in the interval surface of interosseous border and medial crest which is at par with the study of Jayaprakash T. [11] who located 23 (48.93%) foramina on medial crest, 18 (38.29%) foramina between posterior border and medial crest while 6 (12.76%) nutrient foramina between medial crest interosseous border. Satish P *etal*.[1] found 66.6% nutrient foramina on the medial crest, 30.5% between interosseous border and the medial crest while 2.7% foramina existed on the lateral aspect of some fibulae.
Limitations of the present study is that the gender-wise examination could not be done due to non-availability of proper data of the specimen bones of the region.

Conclusion

This anatomical study about the nutrient foramina in dried specimens of fibulae from adult population of Eastern Odisha may add to similar other studies which may help clinicians, orthopaedicians and vascular surgeons to plan for successful bony graft implantation.Since mid-segments of the fibulae are the familiar territories for most of the nutrient foramina, this segment offers a right source of bony graft to be used for transplantation surgeries to reconstruct mandible, stabilize defective spines and harvest dental implants.

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Nil.

Conflicts of Interest

There are no conflicts of interest.

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