Original Research Article

"A comparison of epidural levobupivacaine 0.5% with racemic bupivacaine 0.5% for lower abdominal surgery" A study on morphometric study of nutrient for amina of fibula

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Abstract

Background and objectives: In the leg, the fibula is placed lateral to the tibia. Because of its length, biomechanical stability, reduced donor site morbidity, and predictable vascular pedicle, the fibula is the bone of choice for grafting and rebuilding major defects after tumour removal. The study's objectives are as follows: (1) to locate and describe the site, number, and orientation of fibula nutritional foramina. (2) To look for differences in the location, position, and quantity of nutrition foramina in the fibula. **Methods:** The study sample consisted of 100 dry adult human fibulae (107 right and 93 left) from Kakatiya Medical College's Department of Anatomy. Fibulae were gathered from our institution's undergraduate medical students at KMC, Warangal. The data relevant to the aforementioned criteria were recorded, subjected to statistical analysis, and photographed. **Results:** In the present study of 100 dry adult human fibulae, noted;

i. The absence of nutritional foramen (NF) in 12 (6%) of the fibulae.
ii. A single nutritional foramen was found in 87 (87.0 percent) of the fibulae.
iii. Nearly 8 percent of the fibulae had twin nutrient foramen.
iv. 1 (1%) fibulae had triple nutrient foramen.
v. The total number of nutrient foramen in 94 fibulae was 100.
vi. The most common site of nutritional foramen was on the medial crest in 42 (43.75 percent) of the fibulae and the least common on the anterior border in 1 (1.04 percent).
vii. 90 (95.0 percent) of the foramen were located in the middle region of the fibula.
viii. h88 (93.61%) foramen were directed away from the developing end (AFGE), 15 (15.94%) towards the growing end of the fibula.

Interpretation and conclusion: The number of nutrient foramen varied by 13.5 percent in the current study. Orthopaedic and plastic surgeons can plan the vascularised fibular graft at the middle third of the shaft with accurate anatomical knowledge about the location and distribution of the nutrient foramen.

Keywords: Fibula; Foraminalindex; Nutrientforamen; Vascularised fibular graft.

Introduction

The US Food and Drug Administration approved levobupivacaine, a pure S() bupivacaine enantiomer, in 1997. While some research revealed that the clinical effects of bupivacaine and levobupivacaine were indistinguishable, other studies found that levobupivacaine caused less adverse effects such as hypotension, bradycardia, and nausea.The term foramen derives from the Latin word 'foro' (to pierce), which refers to an opening or puncture in a bone or membranous substance. The name 'Nutrient' implies the role of nutrient foramen in bone nourishment and growth[1]. Each bone has a unique site for the external opening of the nutrient canal, sometimes referred to as the nutritional foramen[2]. The nutrition artery is the primary blood supply for a long bone, especially during its active growing phase. The main artery, dubbed the 'Nutrient Artery,' runs along the shaft of the long bone[3]. Bones are adaptable structures that adapt to their mechanical environment, and begin to do so as early as foetal development. These holes, referred to as nutritional foramina, provide passage for blood vessels through the bone cortex[4].

The tibia and fibula are the bones of the leg, with the former being the preaxial bone and so corresponding to the radius of the forearm, and the latter to the ulna, the postaxial bone[5]. In the leg, the fibula is placed on the lateral side of the tibia.

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It resembles an old brooch or pin when worn in conjunction with the tibia. The fibula is significantly thinner than the tibia and is not directly engaged in weight transmission. It has a proximal head, a narrow neck, a long shaft, and a lateral malleolus on the distal side. The shaft is divided into three boundaries and surfaces, each of which corresponds to a distinct group of muscles. A few millimetres anterior to the posterior surface's midpoint (14-19 cm from the styloid process), the fibular shaft is punctured distally by a nutrient foramen that receives a branch of the peroneal artery. A thorough understanding of the anatomy of the peroneal artery in relation to the fibula is necessary for raising osteofasciocutaneous free flaps including bone fragments. On a peroneal artery pedicle, free vascularized diaphysis grafts may also be taken[3].

In comparison to other long bones, the fibula reverses the ossificatory trend[6]. The nutritive artery is the primary blood supply to a long bone and is particularly critical during the embryonic and foetal stages of growth, as well as during the early stages of ossification[7]. When the nutritional arteries supply 70% to 80% of the intraosseous blood supply to long bones throughout childhood, medullary bone ischemia ensues, resulting in decreased vascularization of the metaphysis and growth plate[8]. Detailed information on the blood supply to the long bones and its relationship to the areas of bone supplied has remained a critical aspect in the development of innovative orthopaedic transplantation and resection techniques[9]. It is critical to understand the location and function of the fibula's nutrition foramina before proceeding with the free transplantation of the vascularized bone graft. The nutritional foramen is typically positioned in the middle part of the fibula's posterior surface. Since trauma, tumour removal, and congenital pseudoarthrosis have all been repaired by a free

vascularized bone graft[10]. Due to their structure and mechanical qualities, fibular grafts are particularly useful for restoring big diaphyseal lesions[11].The study is being conducted because understanding the fibula's nutrient foramina is beneficial for anthropologists, anatomists, forensic experts, orthopaedic and plastic surgeons doing fibula grafts and micro-vascular bone transfers. The morphometric examination of the site of the fibula's nutrition foramen will aid in harvesting vascularized bone grafts, preserving blood circulation within the bone, as well as reconstructing and closing bone defects.

Materials and methods

The present study was conducted on 100 dry adult human fibulae in the Department of Anatomy, Kakatiya Medical College, Warangal, Telangana, India. Fibulae obtained from undergraduate medical students of our institution KMC. The fibulae were serially numbered from 1to100 using blue plastic number plates.

Materials used

a. Sliding caliper.
b. Vernier digital caliper.
c. 1-100 blue plastic number plates.
d. Thin stiff wire.
e. Magnifying hand lens.
f. Samsung digital camera.
g. Black marker pen.

Source of data

100 dry adult human fibulae in the Department of Anatomy, KMC, Warangal. Fibulae obtained from undergraduate medical students of our Institution KMC, Warangal.

Study period

January 2020 to January 2021

Study design

Descriptive study

Study setting

Department of Anatomy, KMC, Warangal, Telangana, India.

Sample size

100 dry adult human fibulae.

Inclusion criteria

100 dry adult human fibulae irrespective of sex and race.

Exclusion criteria

Deformed fibula, fibula showing gross asymmetry or broken were rejected a sunsuitable for the study.

Method of collection of data

After determining the side of the fibula, the length of fibula was measured by sliding caliper of 60cm. NF were identified by the presence of well marked groove leading to them, often slightly raised edge at the commencement of that canal. The NF was studied in regards with, 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 were analyzed. Keen observation was done for direction of nutrient for a men by using magnifying handlens and then a thin stiff wire was passed through the for a men to confirm its direction. Then it was noticed that which part/parts of bone possessed the absence, single or multiple for a men. NF in each fibula was encircled using black marker pen. NF directed away from the growing end was marked with the downward arrow and NF directed towards the growing end was marked with upward direction.

Calculation of the for aminalindex

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

FI=DNF÷TLx100(Hughes[29]formula)

DNF = the distance from the proximal end of the bone to the nutrient for a men measured by vernier digital caliper with an accuracy of 0.01mm, later converted in to 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 for a men

The observations made on the 100 dry adult human fibulae have been listed and the number, location and distribution of the nutrient for a men has been completely tabulated in the master chart, and represented in the tables.

Out of 100 fibulae observed, in 6(6%) fibulae, nutrient for a men was absent, 86(86.0%) fibulae showed single NF, 7(7 %) fibulae had Double NF and1(1%) fibulae had Triple NF.

Table1: Study of No. of nutrient for a men in 100 fibulae

No. of for a men	No. of fibulae	Percentage
0	6	06
1	86	86
2	7	07
3	1	01
Total	100	100

Most common nutrient for a men was Single NF observed in 45(84%) right and 40(85 %) left fibula. And less common foramen, Triple NF was seen in one each of the(1.86 %) right and(2.12 %) left fibulae.

Table2: Distribution of nutrient foramina in right(53) and left(47) fibulae

No. of foramen	Right fibulae		Left fibulae	
	No.	%	No.	%
Zero	3	5.6	4	8.5
One	45	84	40	85
Two	4	7.54	2	4.44
Three	1	1.86	1	2.12

In 100 dry adult human fibulae, 27(13.50%) fibulae showed variations. Out of these double NF were common with 9 (33.33%) right and 4 (7.54 %) left fibulae. And the absence of NF was on 2 (4.44 %) right and 4 (8.5 %) left fibulae. Triple NF was noted one on each of the right sand left fibulae(1.65 %).

Table3: Variation in nutrient foramina of 14 fibulae

Number of the Nutrient foramen	Right fibulae		Left fibulae	
	No.	%	No.	%
0	02	14.2	04	28
2	05	28	03	21.4
3	01	7.1	01	7.1

Variations in the direction of NF

Total number of NF was 100 in 94 fibulae, 83(85%) foramen were directed away from growing end and abnormal direction of NF were seen in 15 (15.9 %)foramen, i.e., towards the growing end, violating the law of ossification.

Table 4: Direction of foramen towards and away from the growing end of fibulaein100 foramen

Fibula	No. of fibulae	Towards growing end		Away from growing end	
		No.	%	No.	%
Right	51	9	17.7	48	54.54
Left	43	6	13.9	40	45.45
Total	94	15	15.94	88	93.61

In 13 fibulae, double NF was observed in 3 (40 %)fibulae with direction one towards the growing end and another away from the growing end was common. Whereas in 2 left fibulae, the direction of NF towards and away from the growing end was equal(16 %).

Table5: Direction of a double nutrient foramen in 8 fibulae

Side of fibula	Both towards the growing end		One towards the growing end, another away from the growing end	
	No.	%	No.	%
Right	3	37	2	25
Left	2	25	1	12.5

Out of 100fibulae, one each of the right and left fibulae had triple nutrient foramen. The direction of one NF was TGE and the direction of two NF was AFGE in right fibulae. Whereas in left fibula, the direction of one NF was AFGE and the direction of two NF was TGE.

Table 6: Direction of triple nutrient foramen in 2fibulae

Side of fibula	Towards growing end	Away from growing end
Right	1	2
Left	2	1

Variation in distribution of nutrient foramen

In 100 right fibulae, 94 NF were observed, of which one (0.96%) foramen was in upper third, three NF(2.4%)were in the lower third and rest of the NF54(98.0 %) were observed in middle third. In 43 left fibulae, 92 nutrient foramen were observed, of which one each nutrient foramen was in upper (0.88%) and lower third(0.88%) and remaining 90(97.82%) nutrient foramen was noted in the middle third. The distribution of nutrient foramen was common in the middle third 97.07% and less common in the upper third 0.97%.P-value was not significant.

Table7: Distribution of 205 nutrient foramen on the segments of 188 fibulae

Side of fibula	No. of fibulae	No. of nutrient foramen	Length wise distribution	Number	%	p-value
Right	51	53	UT	01	0.86	0.7154
			MT	49	96.03	
			LT	03	3.9	
Left	43	47	UT	01	0.87	
			MT	40	95.34	
			LT	01	1.04	
Total	94	100	UT	02	0.97	
			MT	90	95.0	
			LT	03	3.14	

Variation in location of nutrient t foramen

Nutrient foramina on medial crest were frequent with 28 (53.83%) on right and 14 (32.55%) on left fibulae, least frequent was on anterior border on one each right(0.94%) and left fibula(1.01%). P-Value was not significant.

Table8: Location of 96 nutrient foramina on Surfaces and borders of fibulae

Location	NFon53 Right fibulae		NF on 43 Left fibulae		Total nutrient foramen		p-value
	No.	Percentage	No.	%	No.	%	
MC	28	52.83	14	32.55	42	43.75	0.2342
PS	16	30.18	21	48.83	37	38.54	
IB	04	7.5	02	4.65	06	6.25	
AB	01	1.2	01	2.32	01	1.04	
PB	01	1.2	01	2.32	02	2.08	
MS	00	00	04	9.3	04	4.16	
LS	01	1.2	02	4.65	03	3.12	

Foraminal index

The mean and standard deviation of foraminal index of nutrient foramina in upper third was 65.21+3.13
The mean and standard deviation of foraminal index of nutrient foramina in middle third was 44.72+8.12
The mean and standard deviation foraminal index of nutrient foramina in lower third was 22.61+1.6
The standard deviation was more in the middle third(8.86) compared to upper and lower third of the fibula.
The P-value was significant in relation to the number and location of nutrient foramen(P <0.001).

Table9: Distribution of the nutrient foramen based on the foraminal index of the fibulae

Foraminal index	Mean+SD	95%CI	p-Value
Lower1/3rd	65.21+3.13	(60.02)	0.001
Middle1/3rd	44.72+8.12	(41.02)	
Upper1/3rd	22.61+1.6	(8.60)	

The range of foraminal index was 25.48 to74.88. P<0.0000012 was significant for location and foraminal index.

Correlation of the length of fibula with number of nutrient foramen, and the direction of nutrient foramen

Out of 92 left fibulae, nutrient foramen on Type–I was 12 (27.9%), Type-II was 25 (58.13%) and Type-III was 6(13.9%).
All together, out of 188 fibulae, nutrient foramen was frequently observed in Type-II and association between length of fibula and NF was not established, with P–Value was in significant.

Table10: Association between the length of fibulae and nutrient foramen

Length of fibula in cm	Right fibula		Left fibula		P-Value
	No.	%	No.	%	
30.1-34(TypeI)	16	31.37	12	27.90	0.2234
34.1-38(TypeII)	32	62.72	25	58.13	
38.1-41(TypeIII)	03	5.88	6	13.95	
Total	51	100	43	100	

Table11: The length of the fibula, location of nutrient foramen with foraminal index

51NFon	Mean±SD	Mini	Max
Fibula length	32.13±2.61	28	37.8
DNF	17.1±3.14	7	25.02
FI	41± 8.65	21.12	68.08

The half the length of the fibula is 17.8 cm. The location of nutrient foramen is; 178 – 169 = 11 cm. The nutrient foramen is 11 cm (Approximately 11 cm), proximal to the midpoint of the fibula.
The foraminal index was between 23.58 and 72.48 with mean FI of 46%. The P-Value was not significant in association of length of the fibula and the number of nutrient foramen. The single NF and double NF were more frequently observed in the TypeII of the fibular length.

Figure1: Twelve specimens of fibulae, with absence of nutrient foramen

Figure2: Thirteen specimens of fibulae with double nutrient foramen

Figure3: Double nutrient foramen in specimen No.82 with direction of one NF towards growing end and another away from growing end

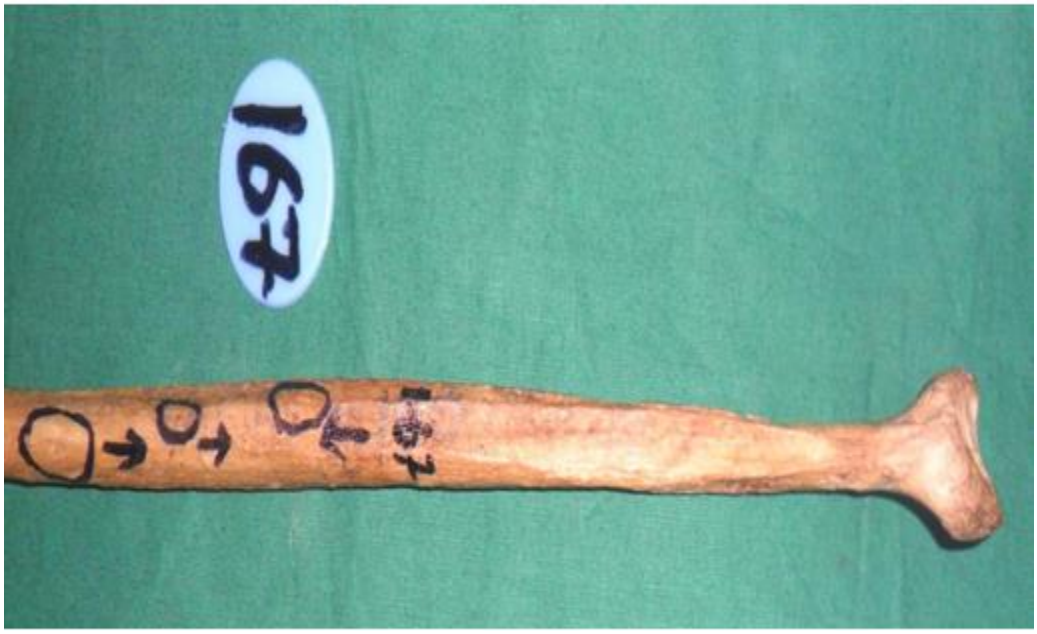

Figure4: Specimen number 167, showing triple NF. The direction of 2 foramen were towards the growing end, one NF directed away from the growing end

Discussion

According to different authors, the mean length of the fibula was found to be 34.56 to 36.58cm. In adults the availability of length of fibula for graft ranges from22-26cm. Unlike the Iliumandrib, the slender fibula has considerable strength owing to the high proportion of cortical bone and it's triangular cross section. It fits to the radius and ulna with its diameter and to the femur, tibia, or humerus with it smedullary cavity. Therefore, the fibula is an ideal graft for reconstructing along bone, especially when the skeletal effect is large.[12]

The growing end of long bones is always located opposite to the direction of nutrient foramen. The 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.[13]

It is well known that one of the causes of delayed union or non-union of fracture is lack of arterial supply. Them orphological knowledge of nutrient foramina is significantly important for orthopaedic surgeons undertaking an open reduction of a fracture to avoid injuring the nutrient artery and thus reducing the chances of delayed or non-union of the fracture. These nutrient arteries pass through the nutrient foramina, the position of nutrient foraminainmammali an bones are variable and may alter during the growth.[14]

Bone is well supplied with blood vessels which ramify freely in the periosteum, in the shafts of long bones by vessels in the medullary cavity. Impairment of circulation by interruption of blood vessel supplying the long bone due to injury or fracture may lead to necrosis and delayed union of bone in fracture healing. Thus, it isof great clinical importance to know the blood supply of long bones for an orthopaedic surgeon. When a bone graft is taken, the vascularization of the remaining part of bone has to be considered. The vascularity allows various options in grafting.[2]

In the present study, observations were made on the 100 adult dry human fibulae. Variations in the number, location and distribution of nutrient foramen was observed, analysed and compared with earlier studies by various authors. Variation in the number of nutrient foramen was accounting for 13.5%. Position of NF was frequently noted on the middle third of the bone (97.07%), 50.73% of the fibular nutrient foramina was located on the medial crest and 38.04% on the posterior surface.

This study varies from other studies in presence of 5.32% of NF on inter osseous border, 0.93% each on anterior and posterior border. The direction of 82.36% of NF was distal (away from growing end), while 12.32 % had a proximal (towards the growing end) direction. In the fibular length of 34.1-38cm (TypeII), the distribution of single nutrient foramen was 57, double nutrient foramen was 8.

In the present study absence of nutrient foramen was observed in 12 (6%) fibulae. This finding is similar to the findings of McKee NH,[15] where absence of NF were observed in 5.6% who conducted study on 322 fibulae and similar to Ongeti,[16]with 5.5% who conducted study on 100 fibulae. This may be due to congenitally absent nutrient vessel or due to nutrient artery of caliber less than 0.5 mm in such cases the bone is likely to be supplied by periosteal arteries.[15]

In the present study 86 of the fibulae possessed single nutrient foramen, while 6.5%(13) of the fibulae possessed double nutrient foramina and 1%(2) fibula had triple foramen, which is closer to the study conducted by Gupta R.[7]GuptaR[17] was the only author who observed 4 nutrient foramen in 2 fibulae(1.79%) out of 112 fibulae.

The foraminal index was between 23.58 and 72.48 with mean FI of 46%. The P-Value was not significant in association of length of the fibula and the number of nutrient foramen. In bones with two nutrient foramina, it suggests that one of them would be the main NF and the other accessory NF; one contained anartery and vein, other only anartery. When three NF were present a solitary artery entered through one foramen, other contained both anartery and vein, and another contained a solitary vein.[18]

Variations of the nutrient foramina has to be well recognized and should influence the orthopedic practice of plating having regard to these facts for fear of loss of source of blood supply. Change due to periosteal slipping or bone growth at one end does not seem to satisfy the phenomenon of particular direction taken by nutrient canal as it occurs even before the growth is completed. Most probably, if the embryonic folded position of the fetus is visualized all the vessels follow a rule that 'all nutrient arteries course caudally'. From the hemo dynamic point of view it may be easier for the heart to force the blood in one direction only, namely

from cephalic to caudal side. This agrees with adult rule of to the elbow Igo, from the knee Iflee'.[19]

Position of nutrient foramina

Observations on position of NF proves beyond doubt the fact that nutrient artery of fibula enters the bone in middle third segment agreeing with description made in classic literature.[3]

In the present study, most of the nutrient foramina of the fibula were situated in the middle third of the bone(95 %), the rest of the nutrient foramen(1.95%) was located in the distal third of the bone and 0.97% was placed on the upper third. These findings were closer to GuptaR[17] and AnushaP.[20]

The average length of fibula in the present study was 36.1 ± 2.04 cm. The average nutrient foramen was 17.39±3.77. Compared to the average length of fibula, the nutrient foramen was, 345÷166=2.07. The half the length of the fibula is 18.7cm. The location of nutrient foramen is;178.1–166=2.1cm. The nutrient foramen is 2.1cm (Approximately2cm), proximal to the midpoint of the fibula.

Choiin2001 has described position of nutrient foramen among Koreans,3 cm proximal to the mid length of the fibula. The Kenyan fibula is 15-20 cm longer than the Mongolians. This position of NF showed always is noted to avoid injury to the nutrient t foramen, which carries nutrient artery.[21]

Adequate dissection around the position and the location of the nutrient foramen will minimize the length of the incision in harvesting the fibular vascularised graft. This will minimize the complication of compartment syndrome.[22]

In this present study, 43.75 % of the fibular foramina were located on the medialcre stand 38.04% on the posterior surface. Similarly, Mysorekar[6] reported that 56% of NF were located on the medial crest while 33% over posterior surface of fibula. However, some authors observed more nutrient foramina on the posterior surface compared to those on the medial crest and medial surface. The present study varies from other studies in presence of 5.36% of NF on interosseous border, 0.97% each on anterior and posterior border.

Kizilkanat quoted that the position of the nutrient foramina was directly related to the requirements of a continuous blood supply to specific aspects of each bone, forexample where there were major muscle attachments. It might be that, being more bulky, stronger and more active, flexors need more blood supply compared to extensors of limbs.[23]

Direction of nutrient foramina

Directions of NF were more commonly towards lower end in relation with classic description, as direction of NF is always away from growing end.[3]

In the present study, the direction of 85% of NF was distal, while 15.94 %had a proximal direction, in accordance with the Gupta R, [17]& Anusha P.[20]Mysorekar[6] quoted that variation, in the direction of nutrient foramina were foundonly in the fibula and NF were situated much below the middle third of the bone. If the nutrient artery in these fibulae arose from lower part of peroneal artery, the anomalous direction could be explained on this assumption. This could be due topeculiar ossification of bone. It is possible that in fibula one end may act as growing end for a certain period and then subsequently the other.[6]

Clinical anatomy

The fibula is a common source of bone for grafting. Even after a segment of shaft has been removed, walking, running, and jumping can be normal. Free vascularised fibula have been used to restore skeletal integrity to upper and lower limbs in which congenital bone defects exist and to replace segments of bone after tumour excision. The rest parts of fibula usually do not regenerate because the periosteum and nutrient artery are generally removed with the piece of bone so that the graft will remain alive and grow when transplanted to another site.[24]

Conclusion

The current study has paved the way for future research on a big scale by other authors in other demographic regions of our nation and other parts of the world. Because the difference in frequency of variants can be caused by a variety of variable elements such as race, gender, genetics, and environmental factors, among others. The current study has also laid a solid foundation for comparable osteological studies that are currently being conducted by anatomists all over the world, and it has piqued the curiosity of other authors who wish to add to and support the findings reported in similar studies. Due to the high occurrence of nutrition foramen in the femur and fibula, variations in the number of nutrient foramen in lower limb long bones have been the focus of numerous anatomical research. In the fibula, there has been evidence of variation in the number of nutrition foramen ranging from 5 to 26 percent. As a result, orthopaedic and plastic surgeons should have a thorough awareness of the distinctive morphological features of the nutrition foramina. Orthopaedic surgical treatments such as joint replacement therapy, fracture repair, bone grafts, and vascularized bone microsurgery require an understanding of the position and amount of nutrition foramina found in long bones. In the tibia, longitudinal stress fractures are more common, but they can also develop in the femur and fibula.

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