Research Article

Topography and indexing of nutrient foramina of tibia—a study in Vindhya region

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Abstract

Background: Clinically, longitudinal stress fractures are more commonly associated with the tibia. The healing of fractures, as of all wounds is dependent upon blood supply. So, detailed anatomical study of position and number of nutrient foramina is must. Nutrient foramen is an opening into the bone shaft which gives way to the blood vessels of the medullary cavity of a bone, for its nourishment and growth.

Objective: To investigate the number, position, size, and direction of nutrient foramina of tibia and calculation of foraminal index (FI).

Materials and Methods: The study was done in Department of Anatomy, Shyam Shah Medical College, Rewa, Madhya Pradesh, India, in 80 adult human tibiae. We have measured all the four parameters in each bone according to standard method.

Result: According to FI, most of the nutrient foramina of tibia were situated in the proximal third (type 1) below the soleal line. The mean FI was 32.96 ± 6.06, with the FI ranging between 27.20% and 37.25% of the bone length.

Conclusion: To conclude that our detailed study of topographic anatomy and morphology of nutrient foramina of tibia provides additional information to orthopedicians before planning surgeries on tibia.

KEY WORDS: Tibia, nutrient foramina, nutrient artery, foraminal Index (FI), dominant foramina (DF)

Introduction

Every long bone is supplied by a number of arteries entering it through all parts except areas covered by articular cartilage.[1] The blood supply to long bones are classically divided into three sets, medullary nutrient, epiphyseal—metaphyseal, and periosteal.[2] Usually, one main nutrient artery enters the shaft obliquely through the nutrient foramina leading to nutrient canal within the cortical part of shaft.[3] The nutrient artery to tibia is the largest one in all. It is derived from posterior tibial artery—branch of popliteal artery.[4] The rate of healing of a fracture is dependent upon the vascular supply of the bone. The areas or regions with a good blood supply are more rapidly healed than those with a poor blood supply. The tibia is a good example of such process.[5] So, understanding of the location and number of nutrient foramina in long bones is important, particularly in orthopedic surgical procedures such as joint replacement therapy, fracture repair, bone grafts and vascularised bone microsurgery, and in medicolegal cases. In free vascular bone grafting, the nutrient blood supply is extremely important and must be preserved to promote fracture repair, with a good blood supply being necessary for osteoblast and osteocyte cell survival and facilitating graft healing in the recipient.[6,7]

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Materials and Methods

This study was conducted in the Department of Anatomy Shyam Shah Medical College, Rewa, Madhya Pradesh, India. The materials for this study consisted of 80 adult human cleaned and dried tibiae (40 right sides and 40 left sides) collected from the Department of Anatomy and Department of Forensic Medicine. All selected bones were serially numbered and photographed. The specific age and sex characteristics of the bones studied were unknown. The nutrient foramina were observed in all bones with the help of a hand lens. They were identified by their elevated margins and by the presence of a distinct groove proximal to them.[8] Only well-defined foramina on the diaphysis were accepted. Foramina at the ends of the bone were ignored.[9] All distance measurements were 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 × 12 cm.

Following observations were studied on the diaphyseal nutrient foramina of tibia:

1. Number: With the help of magnifying hand lens, all surfaces and each border were thoroughly examined from proximal to distal end to calculate the total number of nutrient foramina in each bone.
2. Position: The positions of all nutrient foramina were determined by calculating a foraminal index (FI) by using formula:

$$FI = \left(\frac{DNF}{TL}\right) \times 100$$

where, DNF = the distance from the proximal end of the bone to the nutrient foramen;
TL = Total bone length. (For total length, we measured the distance between most upper ends of intercondylar eminence to lower end of tip of medial malleolus of tibia).

Subdivisions of Foraminal Position according to 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.

Location of nutrient foramina in reference to soleal line on posterior surface of tibial shaft (medial/ lateral to soleal line) was also determined.[11]

3. Size: Nutrient foramina smaller than the size of 24 hypodermic needle (0.56 mm in diameter) were considered as secondary nutrient foramina (SF) while those equal or larger than 0.56 mm were accepted as dominant nutrient foramina (DF).[12]
4. Direction and Obliquity: A fine stiff wire was used to confirm the direction and obliquity of the foramen.[13]

Statistical Analysis

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

Result

The observations were recorded, and the data were complied. Tables 1–3 give the details of the results in terms of nutrient foramina number, position, and direction, and Figures 1–4 give pictorial details of the foramina in tibia.

Table 1: Number and position of nutrient foramina of tibia

Bone	Number of foramina	Number of bones (%)
Tibia (n = 80)	0	0 (0)
	1	100 (100)
	2	0 (0)
	2	22 (22)
	Position of foramina	Direction
	Type 1 92.85 (%) Type 2 (07.15%) Type 3 –	All are directed distally (toward lower end).

Table 2: Position and number of dominant (DF) and secondary (SF) nutrient foramina observed in the tibia

Location	Total no. of foramina	%	No. of foramina				Absent
			Single foramen		Double foramen		
			DF	SF	DF	SF	
Posterior surface Lateral to vertical line	68	85	68	–	–	–	–
Posterior surface medial to vertical line	8	10	8	–	–	–	–
Posterior surface on the vertical line	4	5	4	–	–	–	–
Soleal line	–	–	–	–	–	–	–
Medial surface	–	–	–	–	–	–	–
Lateral surface	–	–	–	–	–	–	–
Total	80	100	80	–	–	–	–

Table 3: The range, mean ± standard deviation (SD) of foramina indices observed in the tibia

Location	Side	Range	Mean ± SD
Posterior surface lateral to vertical line	R	27.42–35.60	32.38 ± 2.61
	L	28.16–37.25	34.29 ± 4.17
Posterior surface medial to vertical line	R	27.2	27.2
	L	29.58–37.19	29.89 ± 0.43
Posterior surface on the vertical line	R	27.42–37.19	28.04 ± 0.88
	L	29.09–30.72	29.90 ± 1.15
Soleal line	R	–	–
	L	–	–
Medial surface	R	–	–
	L	–	–
Lateral surface	R	–	–
	L	–	–

Figure 1: Posterior aspects of tibia showing single nutrient foramen.

Figure 2: Posterior tibia showing direction of nutrient foramen.

Figure 3: Right tibia showing measurement of total length (TL).

Figure 4: Right tibia showing measurement of the distance from the proximal end of the bone to the nutrient foramen (DNF).

Discussion

Tibia one of the medial leg bone also called shin bone. [14] In our study, we found single dominant nutrient foramen in all 80 dry tibiae examined. We did not find any SF in any tibia. In this study, 92.85% of the nutrient foramina in the tibiae were situated in the proximal third (type 1). The mean FI is 32.96 ± 6.06 with the FI ranging between 27.20% and 37.25% of the bone length. Nutrient foramina were located in the middle third in the rest of the tibiae examined (type 2). There were no foramina in the distal third. The average total length (TL) was 37.75 ± 3.32 cm. In this series, all nutrient foramina studied were located on the posterior surface of the tibiae below the soleal line, and most of them were located lateral to the

vertical line running downward. In respect to direction, all the foramina were directed downward (toward lower end) away from the growing end.

Our study analyzes the following four parameters:

1. Number of the nutrient foramina: In this study, 100% tibiae possessed single DF, which may represent the single source of blood supply. This is in agreement with previous studies reported by Kulkarni and Vadhel,[11] Tejaswi et al.,[5] and Kizilkanat et al.[6] Because of the absence of nutrient foramina in the distal third of the tibia, fractures in that region tend to show delayed union or malunion.[15,16]
2. Position of nutrient foramina: Position of the nutrient foramina was directly related to the requirements of a continuous blood supply to specific aspects of areas of major attachments.[17,18] In this series, all nutrient foramina studied were located on the posterior surface of the tibiae below the soleal line, and most of them were located lateral to the vertical line, running downward. In this study, 92.85% of the nutrient foramina in the tibiae were situated in the proximal third. Rest 07.15% was located in the middle third. There were no foramina in the distal third of bone. These results were in accordance with those of Kulkarni and Vadhel and Tejaswi et al., but our result was not matched with Kizilkanat et al, who found most of the nutrient foramina in the middle third.
3. Size of nutrient foramina: Our study shows that all 100% foramina were dominant in nature. This is in agreement with previous studies reported by Kulkarni and Vadhel, Tejaswi et al., and Kizilkanat et al. The present results contradicted with those of Shaheen et al., who stated that, in tibia, 63.33% were secondary foramina, and the rest were dominant.
4. Direction and obliquity of nutrient foramina: This study confirmed the previous reports suggesting that the nutrient foramina in all tibiae (100%) were directed distally (away from the growing end) as reported by Kulkarni and Vadhel, Tejaswi et al., and Kizilkanat et al. Many theories have been put forward to account for the direction of foramina and the anomalously directed ones. Among them the 'periosteal slip' theory of Schwalbe[19] vascular theory of Hughes[20] and growing end theory of Mysorekar[21] are widely accepted in the literature. In our study, tibia follows the growing end theory of bone.

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.

Conclusion

This study reconfirms the previous reports regarding the number, location, size, and direction of the nutrient foramina in tibia. The single foramina were present in all 100% tibiae. Most of the foramina were located below the soleal line, and most of them were located lateral to the vertical line on posterior surface. Clinical procedures involving this area shall be done with extreme care to preserve the chief blood supply of tibia. So, our study provides additional information to surgeons of central Madhya Pradesh in various modalities of fracture repair and bone grafting.

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