Primary nutrient foramina of tibia and fibula and their surgical implications

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Abstract

Aim: The study analyzes the position of primary nutrient foramina of tibia and fibula.

Materials and methods: 137 adult dry bones including 71 tibias and 66 fibulas were studied. The number and position of primary nutrient foramina was noted and the foraminal index was calculated.

Results: A single primary nutrient foramen was observed in all the tibia and fibula. 97.18% of tibia had foramen on the posterior surface and 2.82% on medial surface. In the fibula all the foramina were on the posterior surface. The mean foraminal index was 32.08 in tibia and 44.60 in fibula. In the tibias 74.65% of the foramina were in the upper third and in the fibula 95.45% of the foramina were in the middle third.

Conclusion: A knowledge of foraminal topography helps to preserve bone vasculature during surgeries. This increases the success of fracture fixation, bone grafting and knee replacement procedures involving the bones.

Key words: Bone grafting; Fibula; Foraminal index; Primary nutrient foramen; Tibia.

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Introduction

Long bones are supplied by a diaphyseal nutrient artery that enters the bone through a foramen called the primary nutrient foramen [1]. The arterial supply to the bone is vital during embryonic stage and early ossification [2]. The vasculature of the bone must be preserved by the surgeon during fracture fixation to enable good healing of fracture site [3]. During bone grafting procedures the recipient bone must have adequate blood supply in order to facilitate the acceptance of the graft [4]. After tumor resection adequate blood supply to the bone is very much essential for bone regeneration [5]. It is therefore essential for surgeons to be familiar with the topography of the nutrient foramina of the bones prior to surgery [6]. This will ensure good success of the surgical procedure and improve the prognosis. The nutrient foramina are always directed away from the growing end of the bones[7]. New surgical procedures on bones are devised on the basis of a sound knowledge on the location and distribution of nutrient foramina [8]. The tibia and fibula are involved in several surgical procedures such as external and internal fixation of fractures, knee replacement and bone grafting. Hence the surgeon must be familiar with the topography of their nutrient foramina. The authors believe that this study will help surgeons operating on the tibia and fibula by providing valuable information regarding topography of the foramina.

Materials and Methods

The study was conducted in 137 adult dry bones including 71 tibias and 66 fibulas in the Department of Anatomy, Yenepoya Medical College, Yenepoya University, Mangalore, India. Only normal bones were selected. Those with pathological deformity were excluded. Only the primary nutrient foramina were considered for the study. Secondary foramina smaller than size 24 hypodermic needle were excluded [9]. The primary nutrient foramina were identified using a magnifying lens. The foramen was identified by the presence of a groove and a raised edge at its commencement. After side determination of the bones the topography of the foramina was studied using the following parameters:

1. Number of foramina
2. Surface where the foramen is located
3. Foraminal index
4. Direction of foramen

The foraminal index was calculated using the Hughes formula [10] as described below.

Hughes formula for foraminal index is:
Foraminal index= PF/TL×100 where, PF represents the distance of the foramen from the proximal end of the bone and TL represents the total length of the bone.

The method used by Murlimanju et al. was followed in the study for calculating the foraminal index [11]. The foramen location was marked by an elastic band and then photographs were taken using a digital camera as shown in Fig. 1 and Fig. 2. The

foraminal distance from the proximal end of the bone was measured as shown in Fig. 3. The total length of the bone was also measured. A scale bar placed over the photograph was used for measurement. The distance from the proximal end of bone to the distal end was taken as the total length (TL). The distance from the proximal end of bone to the primary nutrient foramen (elastic band) was considered as the distance of the foramen (PF). In this method, though the bone length may differ depending upon the distance of the bone from the camera, the foraminal index which is a ratio will remain unaffected [11].

Fig. 1: depicts the technique of measurement of foraminal index in tibia.

Fig. 2: Depicts the technique of measurement of foraminal index in fibula.

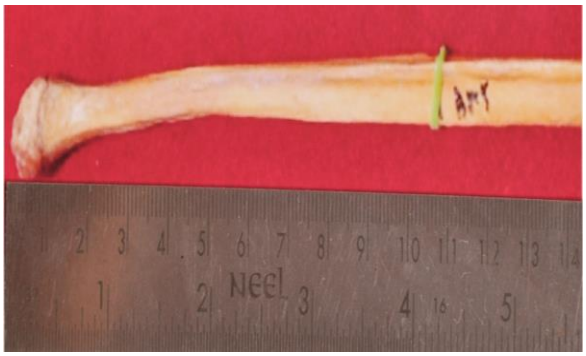

Fig. 3: depicts the technique of measurement of distance of foramen (marked by the band) from the proximal end of bone (PF).

Depending on the value of foraminal index the location of foramen can be described [12]:

1. Foraminal index less than 33.33 indicates that the foramen is in the upper third of the bone.
2. Foraminal index between 33.33 and 66.66 indicates that it is in the middle third of the bone.
3. Foraminal index more than 66.66 indicates that it is in the lower third of the bone.

Results

A single diaphyseal nutrient foramen was observed in all the tibia and fibula. There were no bones with double nutrient foramina. All the foramina were directed away from the growing end.

The topography of primary diaphyseal foramina of tibia is shown in table 1. 97.18% of the foramina were on the posterior surface and 2.82% of the foramina on the medial surface. 74.65% of the foramina were in the upper third and 25.35% were in the middle third.

The topography of primary diaphyseal foramina of fibula is shown in table 2. 100% of the foramina were on the posterior surface. 95.45% of the foramina were in the middle third and 4.55% of the foramina were in the upper third.

The mean foraminal index in tibia was 32.08. This implies that majority of the primary diaphyseal foramina in the tibia are in the upper third. The mean foraminal index in fibula was 44.60. This implies that majority of the primary foramina in the fibula are in the middle third of the bone. It is observed that in the tibia majority of the foramina are in the upper third on the posterior surface. In the fibula majority of the foramina are in the middle third and in the posterior surface.

Table 1: depicts the topography of primary diaphyseal foramina in tibia.

Surface of tibia	Number of foramina			Percentage of foramina		
N=71	**Right**	**Left**	**Total**	**Right**	**Left**	**Total**
Posterior surface	33	36	69	100%	94.74%	97.18%
Medial Surface	0	02	02	0%	5.26%	2.82%
Lateral Surface	0	0	0	0%	0%	0%
Upper third	27	26	53	81.82%	68.42%	74.65%
Middle third	06	12	18	18.19%	31.58%	25.35%
Lower third	0	0	0	0%	0%	0%

Table 2: depicts the topography of primary diaphyseal foramina in fibula.

Surface of fibula	Number of foramina			Percentage of foramina		
N=66	**Right**	**Left**	**Total**	**Right**	**Left**	**Total**
Posterior surface	32	34	66	100%	100%	100%
Medial Surface	0	0	0	0%	0%	0%
Lateral Surface	0	0	0	0%	0%	0%
Upper third	01	02	03	3.13%	5.88%	4.55%
Middle third	31	32	63	96.88%	94.18%	95.45%
Lower third	0	0	0	0%	0%	0%

Discussion

In the present study it was observed that all the tibiae and the fibulae had a single primary diaphyseal nutrient foramen. In a study by Murlimanju et al. a single foramen was observed in 98.6% of the tibiae and 90.2% of fibulae. 1.4% of the tibiae and 9.8% of the fibulae had absent foramina [11]. However, in the present study no absent foramina were observed. In those cases with absent foramina the bones derive their nutrition from periosteal vessels [13]. In a study by Patel et al. 100% of tibia had a single primary nutrient foramen and 80% of fibula had single foramen and the remaining 20% fibula had double foramina [14]. In a study by Sharma et al., 96% of tibia had a single nutrient foramen on its posterior surface. Double foramina were observed in 4% of the tibia. In the fibula 92% had single nutrient foramen and in 8% it was absent [15].

The mean foraminal index in the present study was 32.08 in tibia and 44.60 in fibula. In the study by Murlimanju et al. the mean foraminal index was 32.5 for tibia and 49.2 for fibula. 98.3% of foramina in tibia were in the 2/5th portion of the bone and 60% of foramina in fibula were in the 3/5th portion of the bone [11]. These observations are similar to that in our study. A similar observation was also made by Forriol Campos et al. [16], Pereira et al. [17], Mazengenya and Fasemore [18] and Gümüsburun et al. [5] in their studies. In the study by Pereira et al. the mean foraminal index was 32.7% for the tibia and 46.1% for the fibula [17]. In the study by Patel et al., in the tibia 90% of foramina were in the proximal third and 10% in the middle third. In the fibula 97.2% of the foramina were in the middle third and 2.7% in the distal third [14].

In the present study majority of the foramina were on the posterior surface of both the bones. A similar observation was made by Murlimanju et al.[11] and Gümüsburun et al. [5] in their studies. In the study by Pereira et al. in Brazilian ethnic group it was observed that most of the nutrient foramina are located on the posterior aspect in the lower limb bones [17]. In a study by Mazengenya and Fasemore in black and white South Africans the foramina were located mostly on the posterior surface of tibia and the fibula in both ethnic groups [18]. In a study by Seema et al. it was observed that the nutrient foramen in tibia was located under the soleal line at an average distance of 119.8 mm from intercondylar eminence in 95.50% of tibia. In the remaining 4% the foramen was on the soleal line and in 0.50% of cases on the lateral border. In the fibula the location of the primary nutrient foramen was on the posterior surface in 65 % of fibula, medial surface in 15%, on the inter-osseous border in 10%, lateral surface in 7% and on the posterior border in 3% fibula [19].

In this study all the foramina were directed away from the growing end. During development there is differential growth at the ends of bones which results in slanting of nutrient foramina [20].

Surgical Implications of topography of foramina

It is evident from this study that majority of the foramina are on the posterior surface of both the bones. In the tibia the majority of foramina are in the upper third of the bone and in the fibula in the middle third. This implies that the surgeon must be more careful while operating on the upper third of the tibia on the posterior surface and the middle third of the fibula on the posterior surface. Moreover, the medial and the lateral surfaces of both the bones are relatively safe as

foramina are scarcely found here. Therefore, the surgeon must be familiar with the topography of nutrient foramina of those bones that are involved in the surgery.

It is essential to preserve the nutrient foramina and the nutrient artery of both the donor and the recipient bone during bone grafting [4]. This will help in successful acceptance of the graft by the recipient. The surgeon must preserve the nutrient artery of the bone during fracture fixation for successful healing of the fracture site [3].

Conclusions

Majority of the primary diaphyseal nutrient foramina of tibia and fibula are located on the posterior surface. In the tibia majority of the foramina are in the upper third on the posterior surface. In the fibula majority of the foramina are in the middle third on the posterior surface. A sound knowledge of foraminal location is essential while operating on a bone. The surgeon must be careful at sites where there is high frequency of nutrient foramina. A knowledge of foraminal topography helps to preserve bone vasculature during surgeries. This increases the success of fracture fixation, bone grafting and knee replacement procedures involving the bones.

Conflict of interest

The authors do not have any conflict of interest to disclose.

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