



Primary Nutrient Foramina of Tibia and Its Surgical Implications

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Abstract

Introduction: Nutrient foramina of tibia are located in the proximal third of the shaft. In most of the cases nutrient foramina are located away from the growing end of the bone. During growing period 80% blood supply of bone occurs through nutrient artery. Through knowledge about the nutrient foramina and blood supply of long bone is one of the important features for success of new technique in bone transplantation and resection in orthopedics.

Materials and methods: The present study was conducted on 70 dry tibiae (39 right and 31 left sided) of unknown sex from department of Anatomy of National medical College, Birgunj, Nepal. Study was done carefully for the number, position, distance of nutrient foramina from upper end and foraminal index of tibia.

Results: In this study, a single diaphyseal nutrient foramen was observed in all the tibia. There were no bones with double nutrient foramen. 90% of the foramina were present in the upper third and 10% of the foramina were in the middle third, there were no any nutrient foramina on the lower third of the bone. 82.8% of the foramina were present on the posterior surface, 14.3% were on the medial surface and 2.9% were on the lateral surface.

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, Foraminal Index, Nutrient Foramina, Tibia

Introduction:

Tibia is the largest and strongest bone of the leg present in the medial aspect. Tibia derives its blood supply from three sources- medullary nutrient, epiphyseal- metaphyseal and periosteal. Functionally the three parts are interrelated systems that allow a reserve that can be called on if one of the divisions is adversely affected by injury or disease (Kumar S, Kumar A, Ratnesh R, et al. 2018). Tibia primarily receive about 80% of blood supply from nutrient arteries during growing period and their absence, vascularization occurs through periosteal vessels (Kumar S et al. 2018). The nutrient arteries enter the tibia through the nutrient foramen. In most cases, nutrient foramen located away from the growing end (Kumar S et al. 2018).

The vasculature of the bone must be preserved by the surgeon during fracture fixation to enable good healing of fracture site (Kamath V et al. 2016). During bone grafting procedures the recipient bone must have adequate blood supply in order to facilitate the acceptance of the graft (Wavreille G et al. 2006). It is therefore essential for surgeons to be familiar with the topography of the nutrient foramina of the bones prior to surgery (Gandhi S et al. 2013). This will ensure good success of the surgical procedure and improve the prognosis. The statistical data related to the location of nutrient foramina is important for operating surgeons to select the osseous section levels and place the graft without damaging nutrient arteries thus preserving diaphyseal vascularization and also the transplantation consolidation (Tejaswi H.L, Shetty K, Dakshayami K.R. 2014). New surgical procedures on bones are devised on the basis of a sound knowledge on the location and distribution of nutrient foramina (Shamsunder Rao V, Jyothinath Kothapalli. 2014). The aim of this study is to analyze the position of primary nutrient foramina of tibia.

Materials and Methods

The present study was conducted in 70 adult dry bones of tibia (39 right sided and 31 left sided) of unknown sex and origin obtained from the department of Anatomy, National Medical College, Birgunj, Nepal. All bones were labeled from 1 to 70. Only normal bones were selected. Those with pathological deformities were excluded. Only the primary nutrient foramina were considered for the study. Secondary foramina smaller than size 24 hypodermic needle were excluded (Raj Kumar et al. 2013).

Study design: Quantitative

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 foramen was studied using the following parameters:

1. Number of foramina.
2. Size of nutrient foramina.

Nutrient foramina larger than size of 24 hypodermic needle (0.56 mm in diameter) were considered as dominant nutrient foramina while smaller than those considered as secondary nutrient foramina.

3. Surface where the foramen is located.
4. Foraminal index.
5. Direction of foramen.

The foraminal index was calculated using the Hughes formula (Hughes H. 1952), as described below.

Hughes formula for foraminal index is:

$$\text{Foraminal Index} = \text{PF/TL} \times 100$$

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 foramen location was marked by an elastic band and then photographs were taken using a digital camera as shown in figure 1.



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



Fig. 2: Scale bar with ostiometric board

The foraminal distance from the proximal end of the bone was measured as shown in fig. 2. The total length of the bone was also measured. A scale bar placed over the ostiometric board was used for the measurement.

The distance from the proximal end of the bone to the distal end was taken as the total length (TL). The distance from the proximal end of the 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 (Murlimanju et al. 2011).

Depending on the value of foraminal index the location of foramen can be described (Ukoha UU, umeasalugo KE, Nzeako HC et al. 2013).

1. Foraminal index less than 33.33 indicates that the foramen is in 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. There were no bones with double nutrient foramen. All the foramina were directed away from the growing end. The topography of primary diaphyseal foramina of tibia is shown in table 1.

Table 1: No. of nutrient foramina in tibia according to its region (zone)

Zone	No. of nutrient foramina		Total no. of foramina
	Right Tibia n=39 (%)	Left Tibia n= 31 (%)	
Upper third	33 (84.6%)	30 (96.8%)	63 (90%)
Middle third	6 (15.4%)	1 (3.2%)	7 (10%)
Lower third	-	-	-
Total	39 (55.7%)	31 (44.3%)	70 (100%)

90% of the foramina were present in the upper third and 10% of the foramina were in the middle third, there were no any nutrient foramina on the lower third of the bone. 82.8% of the foramina were present on the posterior surface, 14.3% were on the medial surface and 2.9% were on the lateral surface respectively as shown in table 2.

The mean foraminal index of right tibia was 33.31(SD±3.00) cm and the left tibia was 32.25(SD±4.67) cm. This implies that majority of the primary diaphyseal foramina in the tibia were in the upper third.

Table 2: No. of nutrient foramina in tibia according to its surface

Surface	No. of nutrient foramina		Total no. of foramina
	Right Tibia n=39 (%)	Left Tibia n= 31 (%)	
Posterior	29 (74.4%)	29 (93.5%)	58 (82.8%)
Medial	10 (25.6%)	-	10 (14.3%)
Lateral	-	2 (6.5%)	2 (2.9%)
Total	39 (55.7%)	31 (44.3%)	70 (100%)

The mean of the distance between nutrient foramen and highest point of intercondylar eminence (the distance from the upper end to the nutrient foramen) on the right tibia was 11.90 (SD±1.38) cm and on the left tibia was 11.35 (SD±2.04) cm as shown in table 3.

Table 3: Distance of nutrient foramina from upper end of tibia

Mean	Right Tibia	Left Tibia
Foraminal Index	33.31 (SD±3.00)	32.25 (SD±4.67)
Total Length	35.63 (SD±2.24)	35.04 (SD±2.38)
Distance from upper end	11.90 (SD± 1.38)	11.35 (SD±2.04)

Discussion

In this study we found single primary diaphyseal nutrient foramina on the posterior surface in most of the tibia. According to Murlimanju et al. (2011) a single foramen was observed in 98.6% of the tibiae and 1.4% of the tibiae had absent foramina. However, in the present study no absent foramina were observed. In a study by Ukoha UU, umeasalugo KE, Nzeako HC et al. (2013), in those cases, with absent foramina the bones derive their nutrition from periosteal vessels. Study conducted by Patel et al. (2015), showed 100% of tibia had a single foramen. Sharma et al. (2015) found 96% of tibia had a single nutrient foramen on its posterior surface, whereas double foramina were observed in 4% of the tibia only.

In the present study 90% of the nutrient foramina were found on the upper third of the bone and 10% of the nutrient foramina were present in the middle third of the bone. The mean foraminal index was 33.31 cm for right tibia and 32.25 cm for the left tibia. These observations are similar to the study by Murlimanju et al. (2011) in which the mean foraminal index was 32.5 cm and 98.3% of the foramina were in the 2/5th portion of the bone. A similar observation was also made by Forriol Campos et al. (1987), Pereira et al. (2011), Mazenganya and Fasemore et al. (2015) in their studies. In the study by Pereira et al. (2011) the mean foraminal index was 32.7% for the tibia and 46.1% for the fibula. But, according to Patel et al. (2015) 90% of the foramina were in the upper third and 10% were in the middle third.

In the present study, the average lengths of right and left tibia were 35.63 cm and 35.04 cm respectively. Similarly, the average distance of nutrient foramina from intercondylar eminence on right side and left side were 11.90 cm and 11.35 cm respectively. Seema et al. (2015) observed that the nutrient foramen in tibia was located under the soleal line at an average distance of 11.98 cm 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 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 Mysorekar VR (1979).

Conclusion

Majority of the primary diaphyseal nutrient foramina of tibia are located on the upper third on the posterior surface. A sound knowledge of foraminal location is essential while operating on the 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.

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