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A Study of Diaphyseal Nutrient Foramina in Human Tibia

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Abstract
Introduction: *The nutrient artery is the major source of blood supply to the long bones. It enters through a nutrient foramen which runs obliquely and usually directed away from the growing end. The nutrient artery of tibia is the largest nutrient artery of the body. The knowledge of presence, number, location and direction of nutrient foramina has clinical significance in orthopaedic procedures.*
Materials and methods: The present study was conducted on 100 dry adult tibia bones (49 Right, 51 Left) of unknown sex and origin from the Department of Anatomy, Regional Institute of Medical Sciences, Imphal, Manipur. The lengths of tibia were measured using an osteometric board. For the purpose of study, the tibia was divided into three equal segments. The presence, number, location and direction of nutrient foramen were noted.
Results: *The nutrient foramen was located in upper third of tibia in 67.2%, in middle third in 32.7% of tibia and no nutrient foramina were found in lower third. Out of 100 bones, 91% of tibia has single foramina, 8% has double nutrient foramina and 1% has triple foramina. Most of the nutrient foramina were located on the posterior surface (96.3%) compared to medial and anterior surfaces. Out of 110 nutrient foramina, 3 were seen directing towards proximal end i,e. towards the growing end.*
Conclusion: *The study will provide the essential data for nutrient foramen which will be helpful in surgical orthopaedic procedures.*
Key Words: *Anteromedial, Anterolateral, Fracture, Nutrient foramen, Tibia.*

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I. Introduction

Nutrient foramina are the foramina which leads into canals carrying nutrient vessels and usually directed away from the growing end (1). Nutrient artery to tibia is the largest nutrient of the body. The role of nutrient foramen in nutrition and growth of the bones is evident from the nutrient itself (2). The nutrient foramen is distinguished from any other foramen by the presence of distinct vascular groove outside the nutrient foramen (3,4).

Berard was the first to point out that in the human long bones, the nutrient canals were obliquely disposed pointing towards the elbow in the upper limb and away from the knee in the lower limb (18).

An absence of nutrient foramen in some bones has been observed, in which periosteal vessels become the sole source of the blood supply (17).

Tibia is the most commonly fractured long bone and contributes significantly to the total cost of fracture care worldwide (5). Clinical fracture of a long bone is usually accompanied by rupture of nutrient artery with variable disruption of the peripheral vessels associated with periosteal detachment. Following fracture, the ruptured nutrient artery and periosteal vessels together with those in the adjacent soft tissues start local bleeding (6). Fracture of tibia through the nutrient canal disrupts blood flow in the nutrient artery thus contributing to delayed union and non union of bone. Knowledge of blood supply and location of nutrient foramen is important in treatment and planning of surgery in fracture of tibia (8).

The tibia is a good example to illustrate the rate of healing in relation to vascular supply, with those areas or regions with a good supply showing more rapid healing than those with a poor blood supply (6). Fracture in the distal third of tibial shaft tend to show delayed union/ malunion, one suggestion being that there may be a tear of the nutrient foramen at the fracture line thus reducing the blood supply to distal site (27).

II. Aims And Objectives:

The main aim and objective of this study is to measure the length of tibia and assess the presence, number, location and direction of nutrient foramen and to discuss its clinical importance.

III. Materials And Methods:

The study was conducted on 100 dry adult tibia bones (49 Right, 51 Left) of unknown sex and origin available in the Department of Anatomy, Regional Institute of Medical Sciences, Imphal. Broken bones and unossified bones were excluded from the study. Only diaphyseal nutrient foramen were noted. The length of the tibia was measured using an osteometric board from the intercondylar eminence to the tip of medial condyle. It was caliberated upto 1mm. The tibia was divided into 3 segments. The number, location and direction of nutrient foramen were noted using hypodermic needle. All the data were tabulated and analysed using Microsoft Excel 2013.

IV. Results:

The observations of this study are tabulated and shown below:

Table 1.Distribution of nutrient foramina in different segments of Tibia.

Segments	Right	Left	Total no. of Foramen	% of Tibia
Upper 3rd	38	36	74	67.3%
Middle 3rd	19	17	36	32.7%
Lower 3rd	0	0	0	0

Majority of nutrient foramina were located in upper third constituting about 67.3% followed by 32.7% in middle third and no nutrient foramina were found lower third (Table 1).

Table 2. Number of nutrient foramina and incidence percentage

Number of Foramina	Total no. of Tibia	Right	Left	Total no. of Foramen	% per tibia	% of Foramina
Single	91	42	49	91	91%	82.7%
Double	8	6	2	16	8%	14.5%
Triple	1	1	0	3	1%	2.7%

Out of 110 nutrient foramina present in 100 tibia, 82.7% constitutes single foramen, 14.5% constitutes double foramen and 2.7% constitutes the triple foramina. Out of 100 tibia bones, 91% of tibia has single foramen, 8% has double foramen and 1% has triple foramen (Table 2).

Figure 1: Showing double nutrient foramina

As shown in figure 1, there is presence of double nutrient foramina one directing towards the proximal end and another towards the distal end.

Table 3. Distribution of nutrient foramina on different surfaces

	Posterior Surface					Anteromedial surface		Anterior Border	
	Above Soleal line	Below Soleal line	Interrosseous border	Total number	%	Number	%	Number	%
Right	2	46	5	53	96.4%	3	2.7%	1	0.9%
Left	2	47	4	53		0	0	1	0.9%

Most of the nutrient foramina were located on the posterior surface (96.4%) compared to anteromedial surface and anterior border (Table 3). In our study we found one nutrient foramen on anterior border which is usually not found in other previous studies. Majority of nutrient foramen were found to be located below the soleal line. Out of 110 nutrient foramina, 3 were seen directing towards proximal end i.e, away from the growing end. Moreover this finding was observed in tibia having double nutrient foramen (2 Right, 1Left).

Figure 2: Showing nutrient foramen on anterior border.

V. Discussion

An understanding of the position and number of nutrient foramina in long bones is important in orthopaedic surgical procedures such as joint replacement therapy, fracture repair, bone grafts and vascularized bone microsurgery(3). Preoperative planning of such procedures is vital for all such surgical interventions, together with an approximate understanding of the extraosseous vascular supply for a successful outcome (19).

As a nutrient foramen is a defect in cortical bone it forms a potential site of weakness (21). Nutrient foramen typically appears linear on radiographs and can mimic fracture. Anterior nutrient foramen can be misdiagnosed as osseous pathology such as fractures or lytic bone lesions and can be the cause of shin pain. Rawson et al had reported a case of a rare anterior tibial nutrient foramen in an adolescent patient with anterior shin pain (20).

When compared with other studies, the present study matches with some of the studies very closely. In the present study, the incidence of nutrient foramina in middle third is 32.7% which is close to that of Mysorekar (7) having an incidence of 22.5% (Table 4). But according to Tejaswi et al (8) and Kirschner (9), the incidence of nutrient foramina in middle third is 5.1% and 6.5% respectively which is low when compared to present study. Hence more studies can be encouraged in future.

Table 4: Number of nutrient foramina in different segments in different studies

Studies	No of tibia studied	Total No. of Foramina	Upper 3rd	Middle 3rd	Lower 3rd
Mysorekar(7)	180	182	77.5 %	22.5 %	0
Tejaswi(8)	150	152	94.9 %	5.1 %	0
Kirschner(9)	200	213	93.5 %	6.5 %	0
Present study	100	110	67.3 %	32.7 %	0

Table 5. Incidence of double nutrient foramina in different studies

Studies	Year	%
Mysorekar (7)	1967	1
Forriol Campus et al (10)	1987	7
Sendemir et al (11)	1991	5.2
Gumusburun et al (12)	1994	11.3
Kizilkanat et al (13)	2007	1.4
Gupta and Gupta (14)	2014	0.97
Shamsunder RV et al (15)	2014	14
Shah ST et al (16)	2015	1.33
Present Study	2016	14.5

When compared with other studies, the incidence of double nutrient foramina in present study is 14.5% which is close to that of Shamsunder et al (15) with an incidence rate of 14%.

Table 6. Incidence of nutrient foramen in different studies

Studies	Single (%)	Double (%)	Triple (%)
Kizilkanat et al (13)	98	2	0
Sharma et al (22)	96	4	0
Swapan et al(23)	94.3	1.9	3.8
Mazengenya et al (Black Africans)(24)	99.4	0.6	0
Mazengenya et al (White Africans)(24)	98.3	1.7	0
Udhya et al(25)	96.3	3.7	0
Gupta RK et al (14)	96.1	0.3	0
Pereira GAM(26)	98.6	1.4	0
Gumusburun et al (12)	-	-	2.8%
Present Study	91	8	1

Many studies have not found triple foramina, but we found 1% as compared to Swapan A et al (23) and Gumusburun et al (12) with a percentage of 3.8% and 2.8% respectively. In the present study, we found out 2.7% of tibia having its nutrient foramina directing towards the proximal end i,e. towards the growing end which is close to that of Longia et al (28) with an incidence rate of 3.7% .

VI. Conclusion

The present study will provide the essential data for tibial nutrient foramina which will be helpful in surgical and orthopaedic procedures. The present study provide the information about the position and number of nutrient foramen in tibia. The study results are mostly consistent with many of the previous studies even though there are some differences. As found in other studies, most of the nutrient foramina were found on the posterior surface i.e, below the soleal line which is an important point to be noted during surgical interventions. It has been noted almost all the previous studies have found some cases of double nutrient foramen in their studies but none found triple foramen except few studies. The present study shows only 1% of triple foramen which is a rare finding when compared with other studies. In the present study we found one case of nutrient foramen on anterior border which is a rare finding.From this study and other previous studies we come to know that fracture in distal third of tibia tend to show delayed union or malunion due to absence of nutrient foramina in lower third. Since the present study has found out higher appreciable incidence of 32.7% in the middle third, surgical interventions in the middle third may be cautiously approached. These findings will help in preserving the nutrient foramen for proper healing of fracture or grafting and planning of surgical interventions.

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