

MORPHOMETRIC STUDY OF NUTRIENT FORAMEN OF THE DRIED HUMAN TIBIAE

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ABSTRACT

Background: Nutrient foramen is an opening over which the nutrient artery enters and supplies the shaft of the long bones. The nutrient foramen usually lies near the soleal line and transmits a branch of the posterior tibial artery. The posterior tibial artery is a branch from the popliteal artery. The nutrient vessel may also arise at the level of the popliteal bifurcation or as a branch from the anterior tibial artery.

Methods: The present study was conducted on 200 dry human tibia bones of unknown sex and age. The tibia bones were observed for nutrient foramen macroscopically.

Results: In our study the right sided 7 tibia bones and 6 left sided tibia bones have double nutrient foramen. The position of the nutrient foramen in the upper 1/3rd is observed in 77.47% tibia and in the middle 1/3rd in 17.84% of the tibia. The direction of the nutrient foramen is downwards in all the tibia bones

Conclusions: The tibia is the most commonly fractured long bone and contributes significantly to the fracture care worldwide. Fracture of the tibia through the nutrient canal disrupts the blood flow in the nutrient artery, thus contributing delayed union and non-union of the bone. Knowledge of the blood supply and location of nutrient foramen is important in the treatment and planning of surgery in fractures.

KEY WORDS: Nutrient foramen, Tibia, Posterior tibial artery.

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INTRODUCTION

The tibia also called as shin bone or shank bone is present on the medial aspect of the leg. It is one of the strongest weight bearing bone of the body. The nutrient artery is the principal source of blood supply to a long bone which enters the bone through the nutrient foramen. The nutrient arteries provide 70-80% of the interosseous

blood supply to the long bones during childhood and in the case of their absence vascularization occurs through the periosteal vessels [1]. Injury to the nutrient artery at the time of fracture, or during subsequent manipulation and surgery may be a significant predisposing factor to faulty union of long bones. The site of entry and the angle with which the nutrient artery enters the

bone creates a distinct groove proximal to foramen and characteristically directed away from the dominant growing epiphysis [2].

The nutrient foramen of the tibia is the largest and is most often located on the posterior aspect of the tibia. In the tibia, nutrient foramen is generally present on posterior surface where there is a large vascular groove near the end of the vertical line, which is a faint line descending from the centre of the soleal line and directed distally. The foramen transmits a branch of the posterior tibial artery; or a branch may arise at the level of the popliteal bifurcation or as a branch from the anterior tibial artery.

The tibia is the most commonly fractured long bone and contributes significantly to the fracture care worldwide. Fracture of the tibia through the nutrient canal disrupts the blood flow in the nutrient artery, thus contributing delayed union and non-union of the bone. Knowledge of the blood supply and location of nutrient foramen is important in the treatment and planning of surgery in fracture. The success of nailing of long bone fractures chiefly in the weight bearing bones like the femur and tibia is explained by the periosteal and medullary blood supply to the bone cortex. The length of a long bone from a given piece can be calculated based on the comparative association between the length of the bone and distance of nutrient foramen from either ends which is significant in medical and anthropological work. The stature of the individual can be found from the length of the long bones. The location and the number of the nutrient foramina in long bones is vital in various orthopaedic surgical procedures like joint replacement therapy, fracture repair, bone grafts and vascularized bone surgery. In bone grafts, the nutrient blood supply is crucial and must be preserved to promote fracture repair. During preoperative angiography it is important to exclude the possible vascular anomalies in both recipient and donor bones for the microvascular bone grafts [4].

Some pathological bone conditions such as acute haematogenic osteomyelitis are closely related to the vascular system of the bone. The rate of healing of a fracture is related to the vascular supply of the bone. The areas or regions with good blood supply heal more rapidly

than those with poor blood supply. The tibia is a good example for this process. The absence of nutrient foramina in the distal third of the tibia tend to show delayed union or malunion.

Hence, the present study was undertaken to provide information about various dimensions of the nutrient foramina of the tibia like the number of the nutrient foramen, location, direction of the nutrient foramen, distance from the upper end, anteroposterior and transverse diameters at the level of the nutrient foramen.

MATERIALS AND METHODS

In the present study 200 dried human tibia of unknown sex and age were studied. The right sided tibia bones were 102 and left sided bones 98 were examined.

Following parameters were noted:

- (1) Number of nutrient foramina on each tibia.
- (2) Situation of nutrient foramina in tibia (upper, middle or lower one third of the shaft)
- (3) Direction of the nutrient foramina (upward/downward)
- (4) Location of nutrient foramen in reference to the vertical line on posterior surface of tibial shaft. This vertical line normally divides the area below the soleal line into medial and lateral parts
- (5) Distance of nutrient foramina from upper end of the bone
- (6) Total length of the bone.
- (8) Anteroposterior diameter at the level of nutrient foramen.
- (9) Transverse diameter at the level of the nutrient foramen.

The observations were meticulously recorded and tabulated. The morphometric values were subjected to statistical analysis.

Fig. 1: Tibia showing double Nutrient Foramen.



Fig. 2: Tibia Showing Nutrient Foramen Lateral to the Vertical Line.



Fig. 3: Tibia showing Nutrient Foramen Medial to Vertical Line.



Fig. 4: Nutrient Foramen on the Vertical Line.



Fig. 5: Nutrient Foramen on the Lateral Surface.



RESULTS

Table 1: Number of the nutrient foramina on the tibia.

No of foramina	No. of Tibia		Total no. of foramina	Percentage
	Right	Left		
0	0	0	0	0%
1	95	92	187	93.50%
2	7	6	26	6.50%

In the whole series of 200 tibia examined, 186 tibia had single nutrient foramen and 14 tibia had double foramina. i.e., Single foramina was found in 93.5% of the tibiae, double foramen in 6.5%.

LOCATION

Table 2: Position of the nutrient foramina on the tibia.

Position	Total no. of foramina	Percentage
Lateral to vertical line	118	59%
Medial to vertical line	28	14%
On the soleal line	9	4.50%
On the vertical line	22	11%
On the lateral border	8	4%
On the lateral surface	8	4%
On the medial surface	7	3.50%

Table 3: Lengthwise distribution of Nutrient foramen in the tibial diaphysis.

Side	No of tibia	Number of nutrient foramen	Lengthwise distribution	Number	Percentage
Right	102	104	Upper 1/3 rd	89	0.8165
			Middle 1/3 rd	14	0.1284
			Lower 1/3 rd	0	0
Left	98	104	Upper 1/3 rd	76	73.07%
			Middle 1/3 rd	24	23.07%
			Lower 1/3 rd	0	0%
Total	200	213	Upper 1/3 rd	165	77.47%

Table 4: Total Length & Mean of NF from Proximal.

TIBIA	Mean of the total length (CMS)	Mean of the distance of the nutrient foramen from the proximal end(CMS)
LEFT (N=98)	36.58+/-2.31	11.7495+/-1.63
RIGHT(N=102)	36.82+/-2.4	11.225+/-1.19

Table 5: Mean AP diameter and Transverse diameter of the shaft at the level of nutrient foramen.

TIBIA	Mean AP diameter at the nutrient foramen(cms)	Transverse diameter at the nutrient foramen(cms)
Left tibia	1.828+/-0.5	2.096+/-0.5
Right tibia	1.77+/- 0.44	2.267+/-0.4

Mean of the anteroposterior diameter at the level of the nutrient foramen on the left tibia is 1.82 cm and on the right side is 1.77 cm.

DISCUSSION

The nutrient foramen of the tibia is the largest and is most often located on the posterior proximal diaphysis of the tibia.

The morphological knowledge of nutrient foramina is significantly important for orthopaedic surgeon undertaking an open reduction of a fracture to avoid injuring the nutrient artery and thus lessening the chances of delayed or non-union of the fracture.

An understanding of the position and number of the 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]. Investigations on the vascular anatomy of long

bones are important to human because it is relevant to fracture treatment. There may be instances in which the vascular integrity of a long bone is vital, and knowledge of the nutrient anatomy may be of value to the orthopaedic surgeon. The surgical exposure and periosteal stripping in open reduction internal fixation procedures of diaphyseal fractures present further vascular insult to existing osseous injury. Depending upon the desired effect of internal fixation, its devices often require different bony surface exposures. Some of these exposure may involve dissection in regions of the nutrient artery. It must be in mind that any injury to the nutrient arteries of the bones must be avoided. This will entail careful consideration as to their origin from the main trunks and situation where they enter the bones [4].

The healing of fractures, as of all wounds, is dependent upon blood supply. Injury to the nutrient artery at the time of fracture, or at subsequent manipulation, may be a significant factor predisposing to faulty union. If surgeons could avoid a limited area of the cortex of the long bone containing the nutrient foramen, particularly during an open reduction, an improvement in the management of this problem might be attained [5].

Table 6: Table showing the number of the nutrient foramen in tibial shaft by different authors in comparison with the present study.

Author (year)	Total no of bones	No. of nutrient foramina One	Two	Three
K.Aparna(2017)	92	82	10	0
Vijayalakshmi(2016)	50	49	1	0
Venkatesh (2016)	71	71	0	0
Narinder (2015)	70	70	0	0
Tejaswi.H.L.(2014)	150	148	1	1
Swati Gandhi(2013)	100	98	2	0
Ankolekar(2013)	50	24	26	0
Kizilkant(2007)	200	190	10	0
Collipal(2007)	100	98	2	0
Longia(1980)	200	160	30	10
Kate (1971)	180	178	2	0
Mysorekar(1967)	49	49	0	0
Present study(2018)	200	187	13	0

Recent results confirmed the hypothesis that vascularized bone and joint allograft survival depends strongly on the blood supply and control of rejection. Anatomical factors were suspected to be responsible for this phenomenon. To improve the surgical technique for the

transplantation of femoral diaphyses and knee joints in human, one must consider the number and position of nutrient foramina.

Number of nutrient foramen: In our present study, out of the whole series of the tibia examined, single foramina was found in 93.5 % (187) of the tibiae, double foramen in 6.5% (13).

This is in agreement with the studies reported by Kirschner et al in which 93.5% a single foramen & in 6.5% two foramina were found. Longia et al observed a single foramen in 95% and double foramina in 5% of the tibia which almost coincides with our present study.

Position of the nutrient foramen: The position of the nutrient foramen was directly related to the requirements of a continuous blood supply to specific aspects of areas of major attachments.

In the present study, 59% of the nutrient foramina were located on the posterior surface lateral to the vertical line, 14% of the foramina were found medial to the vertical line, 4.5% foramina were seen on the soleal line, 11% foramina were found on the vertical line, 4% foramina on the lateral border, 4% foramina on the lateral surface and foramina on the medial surface which contributed to 3.5%. The present study coincides with the study conducted by Mysorekar VR, K. Udhaya et al, Ojaswi et al (20) and Nidhi agarwal

Table 7: Situation of nutrient foramen in relation to the position of the tibia in comparison with the previous authors.

Studies	Region	Sample size	Upper1/3rd	Middle 1/3	Lower 1/3rd
Mysorekar(1967)	India	180	78.30%	21.60%	0.10%
Longia(1980)	India	210	91.90%	8.10%	0%
Kirschner(1998)	Germany	200	93.50%	6.50%	0%
Collipal(2007)	Chile	50	100%	0%	0%
Chirag R.vadhel(2010)	India	188	92.60%	6.90%	0.50%
Swathi Gandhi(2013)	India	100	100%	0%	0%
Tejaswi H.L(2014)	India	150	94.90%	5.10%	0%
Neelam sinha(2017)	India	50	84.29%	15.71%	0%
Present study	India	200	77.47%	17.84%	0%

Situation of the nutrient foramen in relation to the vertical line on the posterior surface of the tibia: In our present study, 77.47% of the nutrient foramen were in the proximal 1/3rd of the tibia, 17.84% in the middle 1/3rd and there were no nutrient foramen in the lower 1/3rd of the tibia.

Similarly many authors reported the presence of the majority of nutrient foramen in the proximal 1/3rd of the tibia Mysorekar et al, Longia et al, Gumusburn et al, Collipol et al. These results were in accordance with those of Chirag R.vadhel and Tejaswi et al.

Direction of the nutrient foramen: The direction of the nutrient foramen was determined by using hypodermic needle. In all the 200 bones examined the nutrient foramen is directed downward.

The present study confirmed the previous reports suggesting that the nutrient foramina in the tibia were directed away from the knee (Mysorekar, 1967). According to Vrinda Hari Ankolekar et al study in all the cases (100%), the direction of nutrient foramen was directed vertically downwards.

All the previous studies confirmed that the nutrient foramen is directed downwards which coincides with our present study.

Total Length of The Tibia: Total length of the tibia was measured using a measuring tape. The total length of the tibia was taken as the distance between the proximal margin of the medial condyle and the tip of the medial malleolus. The measurement of total length of the tibia is useful in calculating the foramen index of the tibia. The stature of the individual can also be assessed based on the length of the tibia.

In the present study the length of the left tibia is 36.58+/- 2.31 cm and the length of the right tibia is 36.82+/-2.4 cms.

Distance of the nutrient foramina from the upper end: The distance of the nutrient foramen from the upper end was determined using a vernier calipers. In the present study, the distance from the upper end of the tibia on the left side is 11.75cms and on the right side it is 11.23 cms.

The present study coincides with the previous studies and provides information about the nutrient foramen.

CONCLUSION

The blood supply to the long bone occurs through the nutrient arteries which enter through the nutrient foramina. The blood supply is crucial

during the initial phase of ossification and in techniques such as bone graft, tumor resection, traumas and in transplant procedure in orthopaedics.

The present study provides the mean values of different morphometric measurements of the tibia as well as information about its nutrient foramen. The present study gains clinical significance as the anatomy of the nutrient foramen of the tibia becomes important because fractures involving the upper 1/3rd of the tibia through the nutrient canal disturbs the blood supply to the shaft. This may result in delayed union. Its predictable location during bone graft procedures favours safe manipulation and prevents injury to the nutrient vessels during surgical procedure. So, our study provides additional information to the surgeons in various modalities of fracture repair, bone grafting.

Conflicts of Interests: None

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