Anatomic Study of Nutrient Foramina in the Human Tibiae and Their Clinical Importance

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Research Article

Abstract: Vascularity of weight bearing bone like tibia is clinically important as it is the most common long bone to be fractured and delayed union and non union are the troublesome complications. Tibia is traversed by the nutrient arteries derived from the posterior tibial artery which are essential in the growth and maintenance of the bone. The present study was undertaken in 150 dried adult human tibiae obtained from the Department of Anatomy of Mysore Medical College and Research Institute, Mysore. The tibial diaphysis was divided into 3 equal parts after measuring the length with an osteometric board. The number, location and direction of the nutrient foramina were noted. In 94.9% of the tibia the nutrient foramen was located in the upper 3rd and in 91.21% the nutrient foramen was located in the posterior surface. Present study describes the location of nutrient foramina of tibia in much detail compared to the existing studies and will be helpful before planning surgeries on tibia.

Key words: Nutrient foramen, tibia, vascularity of long bones.

Introduction

The bones of the human leg are the tibia and fibula, the former being developmentally the preaxial bone and the latter the postaxial bone. The blood supply to a long bone like tibia is classically divided into three parts, medullary nutrient, epiphyseal – metaphyseal and Periosteal. These 3 are anatomic divisions and are convenient for descriptive purposes; 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 [1]. The nutrient arteries of the long bones include one or two vessels which enter the shaft of the long bones and obliquely perforate the cortex. Number of unnamed nutrient arteries traverse the ends of long bones and are important for growth and maintenance of the bone. The foramina through which these vessels pass are both numerous and constant, and are more conspicuous than the other one or two nutrient foramina in the shaft [2]. The tibia is the most commonly fractured long bone and contributes significantly to the total cost of fracture care worldwide [3]. 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 fractures of tibia. An attempt is made in the present study to throw more light on vascular patterns of tibia in terms of number, distribution and direction of nutrient foramen.

Materials and Methods

The present study was done using 150 dry normal adult tibia (80 right sided and 70 left sided) of unknown sex and origin obtained from the Department of Anatomy, Mysore Medical College and Research Institute, Mysore. The presence of nutrient foramina were confirmed by identifying a well marked grove which led to the commencement to the foramen. Number, distribution and direction of nutrient foramen in relation to specific surfaces of tibiae were analyzed. Only diaphyseal nutrient foramina were observed in all tibiae. Direction of the nutrient foramen was carefully observed by using a magnifying hand lens and then passing a fine needle (25 gauge) through the foramen to confirm its patency and direction. The topographical distribution of nutrient foramen along the length of tibial shaft was noted by dividing each bone into three parts (upper, middle and lower 1/3rd) after measuring the length of bone by using an osteometric board. All the data were tabulated and analyzed using SPSS software.

Observations and Results

Table 1: Number of nutrient foramina in tibia

No of foramina	No of tibia		Total number of foramina	%
	Right	Left		
0	0	0	0	0
1	79	69	148	94.87
2	1	0	2	1.28
3	0	2	6	3.84
Total	80	70	156	100

In the present study single foramen was found 94.87 % of the tibiae, double foramen in 1.28% and triple foramen in 3.84%.

Table 2: Lengthwise distribution of nutrient foramen in tibial diaphysis

Side	Number of tibiae	Number of nutrient foramen	Lengthwise distribution	Number	%
Right	80	81	Upper 3rd	76	93.8%
			Middle 3rd	5	6.2 %
			Lower 3rd	0	0
Left	70	75	Upper 3rd	72	96%
			Middle 3rd	3	4%
			Lower 3rd	0	0
Total	150	156	Upper 3rd	148	94.9%
			Middle 3rd	8	5.1%
			Lower 3rd	0	0

In 94.9 % of the tibiae the nutrient foramen was located in upper 3rd, 5.1 % in middle 3rd and none were present in lower 3rd. Sidewise distribution of the nutrient foramina is shown in table 2. Detailed topographic distribution of nutrient foramina on the different surfaces and borders of upper and lower end of tibia are described in table 3 and table 4.

Table 3: Location of nutrient foramina on upper 3rd of tibiae

	Location		Direction					
			Upper oblique		Lower oblique		Horizontal	
	No	%	No	%	No	%	No	%
Medial Surface	0	0	0	0	0	0	0	0
Lateral surface	3	2.02	1	33.33	2	66.66	0	0
Posterior surface a	3	2.02	0	0	3	100	0	0
Posterior surface b	135	91.21	0	0	135	100	0	0
Soleal line	2	1.35	0	0	2	100	0	0
Medial border	1	0.67	0	0	1	100	0	0
Lateral border	4	2.7	0	0	4	100	0	0
Total	148	100	1	0.67	147	99.33	0	0

Table 4: Location of nutrient foramina on middle 3rd of tibiae

	Location		Direction					
			Upper oblique		Lower oblique		Horizontal	
	No	%	No	%	No	%	No	%
Medial Surface	0	0	0	0	0	0	0	0
Lateral surface	0	0	0	0	0	0	0	0
Posterior surface a	7	87.5	1	14.3	6	85.7	0	0
Lateral border	1	12.5	0	0	1	100	0	0
Total	8	100	1	0.67	12.5	87.5	0	0

Discussion

Observations on the location of NF in different segments clearly showed maximum average number of NF were situated in the upper third of tibia (94.9%) in agreement with study conducted by Bardsley SL [4] and other studies as shown in table 5. No nutrient foramen was observed in lower third of shaft in the present study. Hallock GG in his study divided the tibia into quarters and found 100% of NF in second quarter [5].

Sl no	Studies	Number of tibia studied	Total number of nutrient foramen	Location		
				Upper 3rd	Middle 3rd	Lower 3rd
1	**Present study**	150	156	94.9%	5.1%	0
2	Mysorekar VR [6]	180	182	77.5%	22.5%	0
3	Kirschner MH [7]	200	213	93.5%	6.5%	0

The nutrient foramina in the upper third of tibia were more commonly located in posterior surface below the soleal line in 91.21%, but few were also found over the soleal line, lateral border or above the soleal line. The NF in the middle third was maximum in posterior surface. The other studies also had similar findings. Collipal found NF under the soleal line in 94.33%, in the soleal line in 3.77% and in the lateral border in 1.88% [8]. In Mysorekar VR study, 74% NF were lateral to vertical line, 10.98% on the line and the rest either just near the interosseous border or on the medial border or over the medial surface [6]. Thus the highlight of the present study on NF of tibia is its constant position below soleal line in upper third and normal direction away from the knee joint. The present study gains clinical significance as the anatomy of the NF especially its consistent location and large size becomes important because fractures involving upper third of tibia through nutrient canal which disrupts the blood supply to the shaft and results in delayed union [9] and during transfer of a large, straight, high density cortical bone graft as its predictable location favors easy manipulation [5].

Conclusion

The present study over the nutrient foramina of tibia reflected greater density at its upper and lower ends as they have a rich extraosseous blood supply provided by branches of anterior and posterior tibial arteries. The disruption of these extraosseous vessels following fracture and its subsequent operative stabilization may slow healing and increase the risk of delayed union or malunion. The scarcity of the nutrient foramen in middle and distal thirds of the shaft of tibia indicates poor extraosseous blood supply which may account for delayed union or non-union of the fractures situated at the junction of middle and distal third of shaft. Further, the shaft of the tibia represented a vascular entry zone in the posterior surface below the soleal line in the upper third of the bone, suggestive of vital role of posterior tibial artery in the vascularization of marrow and its wall. Utmost caution is needed during surgical intervention of this area as any fracture in this region through the nutrient canal may tear the nutrient artery resulting in delayed union or non-union.

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