A STUDY OF THE NUTRIENT FORAMINA IN DRY HUMAN TIBIA BONES OF TELANGANA REGION

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ABSTRACT

Introduction: Nutrient canal opens externally at certain location on the bone surface, called nutrient foramina. Nutrient artery plays major role in bone formation during growth of the embryo.

Aim: The aim of the present study is to determine the number, position, size, direction of the nutrient foramina and the Foramen Index of the human dry tibia bones

Materials and Methods: The study was carried out in 74 right sided and 77 left sided dried human tibia bones of unknown age and sex in telangana population. Foramen index (FI) was calculated using the formula: FI = (Distance of nutrient foramina from upper end/Total length) x 100.

Results: In the present study almost all of the bones showed nutrient foramina away from the knee but two left sided and three right sided tibia bones defied the growing end theory. The total length of the tibia, in the present study, is observed to be 37.26 ± 2.83 on right side and 37.54 ± 2.30 on left side, with foramen Index of 32.09 ± 3.76 cm on right side, and 32.12 ± 3.13 left side. Nutrient foramina are located predominantly in the upper third of the bone. No foramina were observed in lower third of the bones. On an average 79% of foramina are located below the soleal line. In the present study, only two right sided tibia bones, showed three nutrient foramina. Two nutrient foramina were observed in 13.51% right sided and 10.39% left sided tibia.

Conclusion: Preserving the nutrient arterial blood supply is vital in cases of bone grafting, fractures healing, joint replacement therapy and vascularised bone micro surgeries. So the thorough knowledge of morphology and morphometry of nutrient foramina is now a necessity.

KEY WORDS: Tibia, Nutrient foramen, Foramen Index.

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INTRODUCTION

Nutrient canal opens externally at certain location on the bone surface, called nutrient foramina [1]. Apart from the many other small vessels, Nutrient artery plays major role in bone formation during growth of the embryo [2].

Nutrient foramina allows the nutrient artery to pass through the bone cortex [3]. The nutrient artery enters the diaphysis of the long bones obliquely. The point of entrance and angulations are relatively constant [4]. Usually, the direction of the nutrient foramina is away from the

growing end of the bone, but it is not always true in case of mammals [5,6]. In cases of bone grafting, fracture healing, joint replacement therapy and vascularised bone micro surgeries, preserving the nutrient arterial blood supply is vital [6,7].

Aim: The aim of the present study is to determine the number, position, size, direction of the nutrient foramina and the Foramen Index of the human dry tibia bones

MATERIALS AND METHODS

The study was carried out in the department of Anatomy, Mamata Medical College, Khammam, Telangana. In the present study, 74 right sided and 77 left sided dried human tibia bones of unknown age and sex without any pathological changes were taken into consideration. Required measurements of the bone were taken using an osteometric board.

Foramen index (FI) was calculated using the formula: $FI = (DNF/TL) \times 100$ (Hughes 1952 [8]; Shulman 1959 [9]).

DNF = the distance from the proximal end of the bone to the nutrient foramen.

TL = total bone length.

Number, direction and distribution of the nutrient foramina were observed by Hand lens. Syringe needles of various gauzes were used to measure the size of foramina. Only the foramina on diaphysis and of the size greater than 24 gauze were taken into consideration.

a) Size of the 18 gauze needle was considered to be between 1.27 mm or more [≥ 1.27 mm].

b) Size of the 20 gauze needle was considered to be between 0.90 mm and 1.27 mm [≥ 0.90 mm to < 1.27 mm].

c) Size of the 22 gauze needle was considered to be between 0.71 mm and 0.90 mm [≥ 0.71 mm to < 0.90 mm].

d) Size of the 24 gauze needle was considered to be between 0.55 mm and 0.71 mm [≥ 0.55 mm to < 0.71 mm].

RESULTS

Out of 74 right sided bones, 62 bones have single foramina, 10 bones have two nutrient foramen (Fig No. 1) and in 2 bones showed three nutrient foramen (Fig No. 2). On the left side,

out of 77 bones, sixty nine bones showed single foramen, eight bones showed two foramen (Fig No. 3) and none of them showed three foramen.

The nutrient foramen are directed downwards (i.e away from the knee) in almost all the bones except 3 right sided and 2 left sided tibial bones, in which the nutrient foramina is directed towards the knee joint. (Fig No. 2 & 3)

Size of foramina, total length of the bone, distance from the upper end to proximal nutrient foramina, foramen index, Segmental position and location of nutrient foramen on the bone are shown in the Table No. 1,2,3, 4 & 5.

Fig. 1: Right Tibia showing two nutrient foramina, on the soleal line and below the soleal line.

Fig. 2: Left Tibia showing three nutrient foramina (one foramina above the soleal line and two below the soleal line)

Fig. 3: left Tibia showing two nutrient foramina (one of which is directed towards the upper end and the other below the soleal line.

Fig. 4: left Tibia showing nutrient foramina on soleal line.

Table 1: Showing the size of the nutrient foramen.

Size of the foramen	Right (N=88)	Percentage	Left (N=85)	Percentage
≥ 1.27 mm	63	71.59%	53	62.35%
≥ 0.90 mm to < 1.27 mm	6	6.81%	12	14.11%
≥ 0.71 mm to < 0.90 mm	6	6.81%	12	14.11%
≥ 0.55 mm to < 0.71 mm	13	14.77%	8	9.09%

N = total no.of foramen

Table 2: Showing the length of the bone, distance of the proximal nutrient foramina from the upper end and foramen index.

Side	Total length of the bone		Distance from upper end to NF		Foramen Index	
	Median in cm	Mean $\pm$ SD in cm	Median in cm	Mean $\pm$ SD in cm	Median	Mean $\pm$ SD
Right (n = 74)	37	37.26 $\pm$ 2.83	13.3	12.03 $\pm$ 1.51	32.08	32.09 $\pm$ 3.76
Left (n = 77)	37.5	37.54 $\pm$ 2.30	12.2	11.97 $\pm$ 1.37	32.27	32.12 $\pm$ 3.13

n = total number of bones, SD = standard deviation, NF = Nutrient foramina

Table 3: Showing the mean length of tibia with foramen index in different population (all the values are expressed in centimetres).

Author & Area of Population	Mean length of Tibia		Foramen Index	
	Right side	Left side	Right side	Left side
Vrinda et al (Karnataka) [25]	37.3	38.7	35.92	34
E.Collipal et al [4]	35.58	35.49		
Agarwal et al (Vindhya region) [14]	37.75 $\pm$ 3.32		32.96 $\pm$ 6.06	
Bichitrananda Roul (Raipur) [26]	37.2		33.33	33.33
Gupta Chandini et al (South India) [27]	37.75 $\pm$ 3.45	37.68 $\pm$ 1.61	34.66	34.83
Udhaya et al (South India) [28]	35.23 $\pm$ 2.4	35.91 $\pm$ 2.11	30.60 $\pm$ 3.80	31.45 2 $\pm$ 2.90
Seema et al (North India) [29]	35.16 $\pm$ 2.65	34.9 $\pm$ 2.71		
Pedzisai et al (South African black people) [18]	38.44		31.45 $\pm$ 2.52	31.87 $\pm$ 3.63
Pedzisai et al (South African white people) [18]	37.12		31.45 $\pm$ 2.52	31.87 $\pm$ 3.63
Pradeep et al (Gujarath) [30]	37.13 $\pm$ 2.32	37.94 $\pm$ 1.89		
Roopam et al (Gujarath) [21]	36.1	36.44	32.66	33.09
Shital et al (Gujarath) [31]	36.5 $\pm$ 2.45			
Swapna (Aurangabad) [33]	36.19			
VijayaLakshmi et al (banglore) [33]	37.4 $\pm$ 2.61		33.7 $\pm$ 3.32	
Prashanth et al (Mangalore) [22]			32.5	
Pereira et al (Brazil) [40]	-		32.9 $\pm$ 6	32.3 $\pm$ 2.8
Present study (Telangana)	37.26 $\pm$ 2.83	37.54 $\pm$ 2.30	32.09 $\pm$ 3.76	32.12 $\pm$ 3.13

Table 4: Showing the percentages of number of nutrient foramina in various studies.

Author	One foramina		Two foramina		Three foramina		Zero foramina	
	Right	Left	Right	Left	Right	Left	Right	Left
Vrinda et al (Karnataka) [25]	98%		0	2%	-	-	-	-
Kirschner et al [34]	93.50%			6.50%	-	-	-	-
Tejaswi et al [16]	94.87%			1.28%	3.84%		-	-
Chhatrapati et al [35]	100%	100%	-	-	-	-	-	-
Mysorekar et al [13]	98.88%	98.88%	1.12%	1.12%	-	-	-	-
Kate [36]	15%			80%	5%		-	-
Longia et al [7]	93.87	96.07	6.12	3.93%	-	-	-	-
Kizilkanat et al [17]	98%			2%				
Swati et al [39]	50%			50%	-	-	-	-
Udhaya et al [28]	96.29%			3.70%				
Sharma et al [37]	96%			4%	-	-	-	-
Pedzisai et al (South African blacks) [18]	99.40%			0.60%	-	-	-	-
Pedzisai et al (South African whites) [18]	98.30%			1.70%	-	-	-	-
Swapna et al [33]	94.30%			1.90%	3.80%		-	-
Seema et al [29]	93.34%	96.67%	6.60%	3.30%	-	-	-	-
Roopam et al [21]	97.51%	94.70%	0.62%	-	-	-	1.86%	4.34%
Bhatnagar et al [38]	95%			5%	-	-	-	-
Prashanth et al [22]	100%	98.60%	-	-	-	-	-	1.40%
Pereira et al [40]	98.60%			1.40%	-	-	-	-
Agarwal al [14]	100%		-	-	-	-	-	-
Vadhe et al [15]	100%		-	-	-	-	-	-
Gupta Chandini et al [27]	100%		-	-	-	-	-	-
Bichitrananda et al [26]	83.70%			16.20%	-	-	-	-
Present study	83.70%	89.61%	13.51%	10.39%	2.70%	-	-	-

Table 5: showing the segmental Location of the nutrient foramina (all values are expressed in percentages).

Author	Upper 1/3rd		Middle 1/3rd		On SL		Below SL		Above SL		Other site	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Tejaswi et al [16]	93.8	96	6.2	4	1.35		93.23					
Vrinda et al [25]	91.66	88.46	8.33	11.54	12.5	15.38	15.38	16.66	70.12	65.96	2	2
Mysorekar et al [13]	77.5		22.5		-	-	-	-	-	-	-	-
Kirschner et al [34]	93.5		6.5		-	-	-	-	-	-	-	-
Collipal et al [4]	100		-		3.77		94.33		-	-	1.88	
Seema et al [29]	99.5		0.5		4		95.5		-	-	0.5	
Swapna et al [33]	100		-		-	-	-	-	-	-	-	-
Udhaya et al [28]	76.42		23.57		-	-	-	-	-	-	-	-
Agarwal et al [14]	92.85		7.5		-	-	-	-	-	-	-	-
Bichitrananda et al [26]	91.89		8.1		-	-	-	-	-	-	-	-
VijayaLakshmi et al [33]	58.82		41.17		-	-	-	-	-	-	-	-
Longia et al [7]	92.3	91.5	7.7	8.5	-	-	-	-	-	-	-	-
Swati et al [39]	100	100	-	-	-	-	-	-	-	-	-	-
Roopam et al [21]	63.97	58	36.03	42	99.36						0.63	
Vadhe et al [15]	99.5		0.5		0	8.51	100	91.48	-	-	-	-
Prashanth et al [22]	98.3 9(in upper 2/5th)		1.7 (3/5th)		-	-	95.65	-	2.89		1.45	
Present study	73.86	81.18	26.4	18.82	17.04	11.76	77.27	81.17	5.68	7.05	-	-

DISCUSSION

Nutrient artery supplies seventy to eighty per cent of blood to long bones during childhood [10]. In the case of their absence, the vascularisation occurs through the periosteal vessels¹¹. Posterior tibial artery gives a nutrient branch to tibia and is the largest of its kind in the body [12]. Hemang Joshi [24] opined that the thorough knowledge of nutrient foramina is essential for open reduction of a fracture, to avoid unnecessary injury to the nutrient artery.

In the hemodynamic point of view, all the nutrient arteries course caudally in the embryonic period. Due to unequal growth of the ends of long bones, the direction of the nutrient artery is away from the growing end in limb long bones [13]. Henderson RG [5] and Hughes [8] observed that it was not always true in case of mammals. Agarwal et al [14], Vadhel et al [15], Tejaswi et al [16], and Kizilkanat et al [17] reported that the nutrient foramen is directed away from the knee joint. In the present study almost all of the bones showed nutrient foramina away from the knee but two left sided and three right sided tibia bones defied the growing end theory, corroborating with observations by Henderson⁵, Pedzisai et al [18], anjana et al [19].

The total length of the tibia, in the present study, is observed to be 37.26 ± 2.83 on right side and 37.54 ± 2.30 on left side, with foramen Index of 32.09 ± 3.76 cm on right side, and 32.12 ± 3.13 left side. The variation in lengths in different

population with foramen index is tabulated to be compared. (Table No. 3). Dr Ales Hrdlicka [20], in his anthropological study of 2000 tibia, observed that the left tibia is slightly longer on an average. The same is found in the present study coinciding with the observation of Dr Ales Hrdlicka and most of the authors mentioned in the table No. 3.

Regarding the number of nutrient foramina in tibia, many researchers reported the double and triple diaphysial nutrient foramen on the tibia as a rare occurrence (Table No. 4). In the present study, only two right sided tibia bones of total 74, showed three nutrient foramina. Two nutrient foramina were observed in 13.51% right sided and 10.39% left sided tibia. Roopam et al [21] and Prashanth et al [22] reported absence of nutrient foramina in 3.7% and 1.4% of tibia respectively. Patake [23] opined that, in the absence of nutrient foramen, the bone is likely to be supplied by periosteal arteries.

Location of the nutrient foramen in tibia was observed to be consistent by many authors i.e. in the upper one third and on the posterior surface. In the present study also nutrient foramina are located predominantly in the upper third of the bone than the middle third. No foramina of the size greater than 24 gauge were observed in lower third of the bones, which may be the reason for delayed or non-union of fractures in the lower third of tibia. On an average 79% of foramina are located below the soleal line and very less percentage above the

soleal line, corroborating with the findings of the authors mentioned in the table no. 5.

CONCLUSION

Preserving the nutrient arterial blood supply is vital in cases of bone grafting, fractures healing, joint replacement therapy and vascularised bone micro surgeries. So the thorough knowledge of morphology and morphometry of nutrient foramina is now a necessity. The present study in the tibia bones adds to the literature available and especially gives insight into the morphometric parameters in the population of Telangana.

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