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Original Research Article

Morphometric study of nutrient foramen of tibia in Jharkhand population

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ABSTRACT

Background: Nutrient foramen gives passage to the nutrient vessels which supply major portion of the bone even bone marrow. Many vascular foramina are present in all bones for the passage of blood vessels. In long bones many small vascular foramina are present at the ends through which epiphyseal and metaphyseal blood vessels passes. In the shaft of long bones one or two larger foramina are present through which nutrient vessels passes. Nutrient artery provides 70% to 80% blood supply of long bones in children and if blood supply is decreased, it may lead to ischemia of bone resulting into less vascularisation of metaphysis and growth plate. Thus precise topographical knowledge of nutrient foramen is necessary for the surgeons to save the nutrient vessels during surgical procedures i.e. fracture fixation, bone grafting etc. Damage to the nutrient artery causes avascular necrosis of bone.
Methods: Total 70 dry bones of tibia were taken in the study, without knowledge of sex of the bone. Position, number and direction of the nutrient foramen were noted.
Results: single nutrient foramina present in 91.43% of cases and double in 6% of cases. 97.14 % nutrient foramina are directed downward and 2.86% directed upward. 90% nutrient foramina present on posterior surface, 1.42% on lateral surface and 8.57% on lateral border. 75% of nutrient foramina present in upper 1/3 and 25% in middle 1/3. Primary nutrient foramina (>24 G) present in 89.47% and secondary nutrient foramina (<24 G) present in 10.53% of cases.
Conclusions: A sound knowledge of nutrient foramen topography, prevent the injuries of vasculature of bone during surgeries.

Keywords: Nutrient foramen, Metaphysis, Epiphysial, Avascular, Necrosis

INTRODUCTION

Many vascular foramina are present in all bones for the passage of blood vessels. In long bones, many small vascular foramina are present at the ends through which epiphyseal and metaphyseal blood vessels pass. In the shaft of long bones, one or two larger foramina are present through which nutrient vessels pass.[1] These foramina are known as Nutrient foramina. The nutrient foramen is almost constant in position and direction (directed away from the growing end). Nutrient foramen runs obliquely in the shaft and opens into the medullary cavity.

Nutrient foramen of the tibia is said to be the largest foramen present in the human body usually lies near the soleal line, through which nutrient vessels pass (usually the branch of the posterior tibial artery).[2] In the medullary cavity like other nutrient arteries of long bones, it divides into ascending and descending branches. These branches give cortical branches, which pass through the endosteal canals to feed the fenestrated capillaries present in the

Haversian system and supply the inner two-thirds of the shaft centrifugally (high-pressure system). The outer one-third of the shaft is centripetally supplied by periosteal arteries (Low-pressure system). At the bony surface, the cortical capillaries make the capillary and venous connection with the periosteal plexus.

The nutrient artery also gives medullary branches which feed the hexagonal mesh of medullary sinusoids, that drain into the central venous sinus, which further drain into veins that follow the nutrient artery and coming out through nutrient foramen.

In mature long bones, the ascending and descending branches at the ends number of smaller helical branches which anastomose frequently with the metaphyseal and epiphyseal vessels. Nutrient artery provides 70 % to 80% blood supply of long bones in children and if blood supply is decreased, it may lead to ischemia of bone resulting in less vascularisation of metaphysis and growth plate.[3]

Hence precise topographical knowledge of nutrient foramen is necessary for the surgeons to save the nutrient vessels during surgical procedures i.e. fracture fixation, bone grafting, etc. Damage to the nutrient artery causes avascular necrosis of bone.

METHODS

The present study entitled "Morphometric study of the nutrient foramen of the tibia in Jharkhand Population" was conducted in the Department of Anatomy, Shahid Nirmal Mahto medical college Dhanbad, Jharkhand from May 2021 to July 2021. For this study 70 adult, dry tibia bones of unknown age and sex were obtained from the SNMMC Dhanbad (45 tibia bones) and Rajendra institute of medical sciences, Ranchi (25 tibia bones).

The study was approved by the scientific review and ethical committee SNMMC, Dhanbad.

Study design

The study was cross-sectional observational study.

Sampling technique

The sampling technique used was convenience sampling.

Following points were observed:

The number of the nutrient foramen, present in the tibia. nutrient foramen was identified by the presence of a groove and raised margin at its beginning. Size of the nutrient foramen as measured by different sizes of hypodermic needle. The direction of the nutrient foramen; determined by passing the needle into foramen. The tibial surface, where the nutrient foramen is located, was noted. Distance of nutrient foramen of the tibia from its lateral border was measured by digital vernier caliper. Segmental location of nutrient foramen i.e. in upper 1/3, middle1/3, or lower 1/3 was noted. Segmental location of tibia determined by Hughes formula.[4]

$$(FI) Foraminal\ index = PF \div TL \times 100$$

PF=Distance of nutrient foramina from the upper end of the tibia.

TL=Total length of tibia measured from the upper-end tibia to the lower end of the medial malleolus.

Note: length measured by measuring tape in centimeters.

FI:<33.33 = upper 1/3

33.33 -66.66 = middile 1/3

>66.66 = Lower 1/3

Inclusion criteria

Fully ossified bone, Bones without any damage or pathological changes.

Exclusion criteria

Bones exhibiting un-ossified parts, Damaged/broken bones. Bones with obvious pathological changes.Data obtained were analysed using Statistical package for social sciences (SPSS) version 20.

RESULTS

In the present study 37 right tibia and 33 left tibia were included. Age and sex determination was not done as it was beyond the scope of this study. Different morphometric measurements were taken and the results obtained were tabulated.

Table 1: Variation in the number of nutrient foramina present in the tibia.

No. of NF	Right tibia	Left tibia	Total	%
Single	33	31	64	91.43
Double	4	2	6	8.57

Table 2: Variation in direction of nutrient foramen in the tibia.

Direction of NF	Right tibia	Left tibia	Total	%
Downward	37	31	68	97.14
Upward	0	2	2	2.86

The maximum length of tibia obtained in the study was 41 cm and the minimum length was 31cm. The calculated mean length is 35.83±5.85 cm.

Table 3: Variation in the presence of nutrient foramen on the tibial surface.

Location of NF	Right tibia	Left tibia	Total	%
Posterior surface	34	29	63	90
Lateral surface	0	1	1	1.42
Lateral boarder	3	3	6	8.57
Medial surface	0	0	0	0
Medial border	0	0	0	0

Table 4: Approximate size of nutrient foramen in gauge, measured by hypodermic needle (N=76).

Approx. Size of foramen in gauge	Right tibia	Left tibia	Total	% distribution
28G	0	2	2	2.63
26G	2	4	6	7.89
24G	3	6	9	11.85
22G	10	5	15	19.74
20G	19	13	32	42.10
18G	6	4	10	13.15
16G	1	1	2	2.63

Table 5: Segmental location of the nutrient foramen (Calculated by Hughes formula) (n=76).

Segmental location of NF on the shaft	Right tibia	Left tibia	Total	%
Upper1/3	31	26	57	75
Middle1/3	10	9	19	25
Lower 1/3	0	0	0	0

Table 6: Distance of NF from the lateral border, present along the posterior surface. (Foramina present in the other parts were not included in this study. Out of these 76 foramina, localization on the posterior surface was observed in 37 right tibias and 31 left tibias. 07 foramina were present on the lateral border and 01 foramen was observed on the lateral surface).

Distance from the lateral border	Right tibia	Left tibia	Total	%
Less than or equal to10 mm	24	20	44	64.70
>10 mm and less than or equal to 20 mm	10	9	19	27.94
>20 mm	3	2	5	7.35

The maximum length of tibia obtained in the study was 41 cm and the minimum length was 31cm. The calculated mean length is 35.83±5.85 cm.

The maximum distance of nutrient foramen from the upper end is 20cm and the minimum distance is 7.5 cm. The calculated mean distance is 11.52±2.45 cm.

Figure 1: Double nutrient foramina.

Figure 2: Upward direction of nutrient foramen.

Figure 3: Location of nutrient foramen on lateral surface.

The maximum distance of nutrient foramen in the study was recorded as 23.17 mm with respect to the lateral border. The mean lateromedial diameter of the tibia at the level of the nutrient foramen is 24.2 mm±1.23.

Figure 4: Location of nutrient foramen on lateral border.

Figure 5: Sizes of nutrient foramen.

DISCUSSION

The blood supply of the long bone is mainly derived from the nutrient artery, which enters the bone through the nutrient foramen. The exact anatomical knowledge of nutrient foramen is very essential to the surgeons before the surgery. Any damage to it can cause ischemia, subsequently, interfering with the healing process.

In the present study, 37 right tibias and 33 left tibias were included. The results were compared with the other published studies.

In the present study single nutrient foramen was observed in 91.43% of bone (89.19% right and 93.94% left tibia) and double nutrient foramina was noted in 6% of bone (10.81% right and 6.06% left tibia). Many authors have found single nutrient foramen in most of the bones. Chavda et al found 100% of bone having single nutrient foramen.[5] Vinay et al reported 96.66% single nutrient formen and 3.33% double nutrient foramen.[6] Very few authors also got triple and absent nutrient foramen. Uday et al found single nutrient foramen in 83.70% right tibia and 89.61 left tibia. He reported double nutrient foramen in 13.51 % of the right tibia, 10.39% of the left tibia. Also 2.70% tibia having triple nutrient foramina was reported by him.[7] Joshi et al found 94% single nutrient foramen and in 6% absent nutrient foramen.[8] In the case of the absence of the nutrient foramen, which is a very very rare finding, periosteal vessels become the main source of arterial supply of shaft.

Most of the authors reported nutrient foramen in a downward direction. In the present study 97.14% of tibia were having nutrient foramen in a downward direction, however 2.86% tibia exhibited it in upward direction. Chavda et al also found 97.14% of tibia having nutrient foramen in a downward direction and 2.86% upward direction.[5] Kamath et al also found 100% nutrient foramen in a downward direction.[9] Hari et al also found 100% nutrient foramen in a downward direction.[10]

Many authors have reported location of nutrient foramen on the posterior surface. In the present study 90% of the tibia exhibited nutrient foramen on the posterior surface, in 1.42% tibia nutrient foramen was present on the lateral surface and in 8.57% of the tibia nutrient foramen was present along the lateral border. Kamath et al found 97.18% of tibia having nutrient foramen on the posterior surface and 2.82% on the medial surface.[9] Chavda et al found in 97.14% tibia on the posterior surface, in 1.43% on the lateral surface, and in1.43% in the lateral border.[5] The presence of nutrient foramen on the medial border or on the medial surface is very very rare.

Authors have reported most of the nutrient foramen in the upper 1/3rd of the tibia, few were reported in the middle 1/3rd and none reported in the lower 1/3rd. In the present study 75% nutrient foramen in upper 1/3rd and 25% in middle 1/3rd. Most of the nutrient foramen was present in the lower part of the upper 1/3rd or the upper part of the middle 1/3rd. Kamath et al found 74.65% foramen in upper 1/3rd and 25.35% in middle 1/3rd.[9] Chavda et al found 74.65% in the upper 1/3rd and 25.35% in the middle 1/3rd.[5] Mohan et al found 42% of the nutrient foramen in the upper 1/3rd and 58% in the middle 1/3rd. 11 Neelam et al found 84.29% of nutrient foramina were present in the upper 1/3rd, 15.71% in the middle 1/3rd, and none in the lower 1/3rd.[12]

Based on the size of the nutrient foramen; it is divided into primary and secondary. Nutrient foramen of size, less than 24 G is said to be secondary nutrient foramen and 24 G or more is considered to be primary nutrient foramen. The present study exhibited 89.47% are primary and 10.53% are secondary nutrient foramina. Hari et al found 80% primary and 20% secondary nutrient foramen. 10 Udaya et al found primary nutrient foramen in 88.14% of tibias.[7]

In the present study out of 76 foramina, only 68 were present on the posterior surface. Among these 68 foramina; 2 (2.94%) were present on the soleal line and the rest 66 (97.06%) were present below the soleal line. Out of these 66, 52 (78.78%) foramina were present lateral to the vertical line, 10 (15.15%) present medial to the vertical line, and 4 (6.06%) lie on the vertical line. A similar type of findings was observed by Chavda et al. He reported that

out of 68 foramina present on the posterior surface; 01 present on the soleal line and 67 present below the soleal line. Out of the 67, 61 (91%) were lateral to the vertical line, 2 (2.98%) medial to the vertical line, and 4 (5.97%) on the vertical line.[5]

Another dimension measured in the present study was the distance of the Nutrient foramen on the posterior surface from the lateral border. Most of the foramina were present within 10 mm (64.71%) from the lateral border. Very few foramina were located beyond 20 mm (7.35%).

The measured mean length of the right tibia was 37.36 cm and that of the left tibia is 36.99 mm. (Total mean length 36.83±3.34 cm). The mean distance of nutrient foramen of the right tibia from the upper end was 12.50 cm and in the left tibia was 13.4 cm. (mean distance 12.52 cm±2.23. Mohan et al found a total mean length of 36.58±2.38.[11] Mazengenya et al reported an average length of 38.44 cm in the black South African population.[13] Joshi et al, in their study on the Rajasthan population, reported an average distance of nutrient foramen from the upper end of the right tibia was 14.53±3.77 cm and in left tibia14±2.99 cm.[8]

Limitations

Since the study was conducted on dry bones, due to scarce availability in the department, only 76 tibia was included.

CONCLUSION

The nutrient foramen of the tibia is said to be the largest foramen in the body. The maximum size of nutrient foramen present was of 16 G. Most of the nutrient foramen was present on the posterior surface, directing towards the lower end and present in the upper 1/3 of the tibia. The nutrient foramen of middle 1/3rd was also present in its upper part in most bones. It was also observed that most of the nutrient foramina present were nearer to the lateral border i.e. lateral to the vertical ridge.

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