Original Research Article

A descriptive study of morphology, topography and clinical significance of primary nutrient foramina in Tibia

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Abstract

Introduction: Arterial supply to long bones comes through several vessels which enter the bone at different levels; they feed sinusoidal networks within the bone. Diaphysial nutrient arteries enter bone shaft obliquely through nutrient foramina. Foramens lead into nutrient canal. Nutrient arteries reach the medullary cavity through these canals where they divide into ascending and descending branches, which run toward epiphyses, dividing repeatedly into smaller helical branches close to the endosteal surface. **Materials and Methods:** This study was conducted in the department of Anatomy, Government Medical College, Kadapa from January 2020 to December 2020. We used 120 bones (60 of each side) available in our institute for teaching MBBS students. We do not have record of age and sex of the body donors from whose bodies the bones were obtained. We excluded old bones with indistinct/eroded features from our study. We did morphometric analysis of nutrient foramen with regard to its number and position. We noted surface orientation of the foramen on the tibia in each case, i.e., surface of the tibia on which it was present, relation to its borders, relation to soleal line, location (upper, middle, or lower third of shaft), and distance from the upper end. Measurements were done using digital. **Results:** Out of 120 tibias studied, 6 (2 of the right side Vernier caliper and 4 of the left side) presented with double foramen and rest of the bones had single foramen. Overall, we got 126 nutrient foramina and canal for observation. Only one canal (in a bone of the left side) was directed upward, and rest of the nutrient artery canals were directed downward. **Conclusion:** Knowledge about possible variations in number, position, and direction of nutrient canal can be of use for preservation of nutrient vessels during surgical procedures as well as in prognostic evaluation of the treatment given.

Keywords: Nutrient foramina, Vernier caliper, morphometric analysis.

Introduction

Arterial supply to long bones comes through several vessels which enter the bone at different levels; they feed sinusoidal networks within the bone. Diaphysial nutrient arteries enter bone shaft obliquely through nutrient foramina[1]. Foramens lead into nutrient canal. Nutrient arteries reach the medullary cavity through these canals where they divide into ascending and descending branches, which run toward epiphyses, dividing repeatedly into smaller helical branches close to the endosteal surface. Operative procedures like intramedullary nailing can damage these endosteal vessels. Near the epiphyses, diaphysial vessels are joined by terminal branches of metaphysial and epiphysial arteries[2].

Position of nutrient foramen and direction of canal are almost constant and characteristically directed away from the dominant growing epiphysis[3].

The nutrient foramen in the tibia usually lies near the soleal line and transmits a branch of posterior tibial artery; the nutrient artery may also arise at the level of popliteal artery bifurcation or as a branch from the anterior tibial artery[4]. A large vascular groove is present on bone surface leading toward the nutrient foramen; this can be useful for identification of foramen as well as in knowing the direction of ensuing nutrient canal[5].

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The nutrient artery can be damaged by fractures of the tibia disrupting the nutrient canal, and this can predispose to nonunion of bone fragments[6].

Knowing about number and position of nutrient foramen and direction of nutrient canal can be of great help in clinical as well as prognostic evaluation of diseases affecting the tibia. It can also be used to formulate orthopedic and microvascular surgical procedures more appropriately.

Materials and methods

This study was conducted in the department of Anatomy, Government Medical College, Kadapa from January 2020 to December 2020. We used 120 bones (60 of each side) available in our institute for teaching MBBS students. We do not have record of age and sex of the body donors from whose bodies the bones were obtained. We excluded old bones with indistinct/eroded features from our study. We did morphometric analysis of nutrient foramen with regard to its number and position. We noted surface orientation of the foramen on the tibia in each case, i.e., surface of the tibia on which it was present, relation to its borders, relation to soleal line, location (upper, middle, or lower third of shaft), and distance from the upper end. Measurements were done using digital Vernier caliper. We also noted the direction of nutrient canal in all cases. The direction of canal was established by passing needle (24G) into the foramen. Foramen index (FI) was calculated by Hughes formula: FI = (NFD/TL) × 100, Where NFD is the distance between the nutrient foramen and highest point on the intercondylar eminence; TL is the tibial length as measured between highest point on intercondylar eminence to the tip of medial malleolus of tibia.Measurements were done using digital Vernier caliper and osteometric board. We used these data to prepare tables in our study. Software used for statistical analysis was trial version of SPSS software, version 26, IBM Corporation (SPSS Inc., USA). We compared our findings with observations of earlier worker to find out whether our works findings were in sync with them or was there any difference between our observations and previous work findings and what are possible clinical implications of these findings.

Results

Out of 120 tibias studied, 6 (2 of the right side and 4 of the left side) presented with double foramen and rest of the bones had single foramen. Overall, we got 126 nutrient foramina and canal for observation. Only one canal (in a bone of the left side) was directed upward, and rest of the nutrient artery canals were directed downward.

The mean length of bone was 366.7 mm for the right tibia and 371.7 mm for the left tibia while the mean length of all tibias taken together was 369.2 mm. The mean distance of nutrient foramen from the proximal end was 114.66 mm in the right tibia and 114.72 mm in the left tibia and 114.69 mm overall.

Table 1: Position of nutrient foramen in relation to surface and borders

S.No	Surface of Tibia	Right Tibia	Left Tibia	Total
1	Posterior surface	54 (87.10)	52 (81.25)	106 (84.13)
2	Lateral surface	2 (3.22)	2 (3.125)	4 (3.17)
3	On lateral border	6 (9.68)	8 (12.50)	14 (11.11)
4	On medial border	0	2 (3.125)	2 (1.59)

Table 2: Surface positioning of foramen along the length of the shaft

S.No	Relation to soleal line	Right Tibia	Left Tibia	Total
1	Lateral to soleal line	48 (88.89%)	38 (73.08)	86 (81.13)
2	On the soleal line	4 (7.41)	12 (23.07)	16 (15.10)
3	Medial to soleal line	2 (3.70)	2 (3.85)	4 (3.77)

Table 3: Surface positioning of foramen along the length of the shaft

S.No	Region of Tibia	Right (%)	Left (%)	Total (%)
1	Upper one-third	48 (77.42)	54 (84.38)	102 (80.95)
2	Middle one-third	14 (22.58)	10 (15.62)	24 (19.05)
3	Lower one-third	0	0	0

Discussion

Multiple nutrient foramens and even the absence of foramen have also been reported by many authors. Roul and Goyal found double foramen in 16.20% (very high percentage compared to other workers' findings) of the bones studied, Almansour et al. have reported presence of three nutrient foramens in one of the bones studied by them, while Prashant et al. have reported the absence of nutrient foramen in 1.4% of bones studied by them. We also found double foramen in 5% of bones studied by us though we did not find any bone with three nutrient foramens or the absence of foramen[7].The tibial nutrient artery canal was found running craniocaudally in almost all works except for some works reporting upward directed canal in few instances. We also found upward directed canal in only one out of 126 nutrient foramens and canals observed. Most of the observers found nutrient foramen on the posterior surface of the tibia in almost all bones (97.14%–100%), but we found nutrient foramen on the posterior surface in only 84.13% of bones, while in 11.11% of bones, foramen was on the lateral border. Almansour et al. based on a retrospective study of computed tomography features of patients in whom external fixation pins were used for fracture management observed that almost half of the pins applied at the middle third of the tibia injured the tibial nutrient artery, despite adherence to published surgical guidelines for external fixation[8].Peng et al. in their observation say that proximal pins of external fixation should be fixed from a lateral rather than an anterior approach as this will protect the tibial nutrient artery and reduce the chances of nonunion or delayed union of fractures[9].Fracture of the tibia across the nutrient canal can damage the nutrient artery trunk and compromise blood supply of the bone. This can precipitate malunion/nonunion of the bony fragments after fracture[10].Tibias with multiple nutrient foramina receive nutrient arteries through each of the canals. Damage to any one of such canals will not lead to complete loss of blood supply to medullary cavity and deeper cortical bone. Arterial Pedicles enter through these canal and maintain the blood flow, hence bones with multiple foramen may heal faster in case of fracture.

Conclusion

The posterior surface of the upper one-third of the shaft, lateral to the soleal line, is the most common site for nutrient foramen, and the ensuing nutrient canal runs downward in majority of bones. This information may be of use in clinical workup as a fracture of bone or diseases affecting the bone above or below the level of nutrient canal would not damage the main trunk of the nutrient artery passing through the canal.Therefore it is very important for surgeons to have sound knowledge of precise topography of nutrient foramen which will help in preserving vasculature of bone during various surgical procedures like fracture fixation, bone grafting, knee replacement surgeries and tumour resection. Understanding of exact location and distribution of nutrient foramen will help in avoiding damage to nutrient vessels during surgery. This will ensure less postoperative complications, as well as this will also help in better outcome of operative procedure.

Conflict of Interest: Nil Source of support: Nil

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