

Anatomical study of the nutrient foramen of lower limb long bones in South Indian population

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Abstract

Introduction: The nutrient artery which enters the nutrient canal obliquely would provide the vascular supply. The nutrient foramen can be seen as a well-marked groove, which shows raised edges at the starting of the canal. The knowledge about the nutrient foramen is enlightening to the orthopedician during the procedures like bone grafting and internal fixation.

Aims and Objectives: To determine the topography, direction and number of the nutrient foramina in lower limb long bones and to check if the nutrient foramen follow the general rule, the foramen is directed away from the growing end of the bone. To determine the foramen index of lower limb long bones from South Indian population.

Materials and Method: We studied the topography, direction and location of nutrient foramina in shafts of 260 lower limb adult dried long bones, which were collected from the osteology collection of the department of Anatomy, Mahatma Gandhi Medical College, Pondicherry and Sri Sathya Sai Medical College, Kancheepuram.

Results: It was observed that the most of the bones exhibited solitary nutrient foramen. The topography of nutrient foramen was mainly observed over the posterior surface. The mean foramen index of femur was 46.49, tibia was 34.82 and fibula was 49.58.

Conclusion: The present investigation provided the details about the data about morphology of nutrient foramen in lower limb long bones of South Indian population. It was observed that the double nutrient foramen were commonly seen in femur and were rare in the tibia and fibula bones. The morphological information about the nutrient foramen may assist in some operative procedures and bone grafting.

Keywords: Foramen index, Long bone, Nutrient foramen, Shaft

Introduction

The nutrition to the long bones arise from the nutrient artery, which enters the bone through the nutrient foramen. The foramen follows the rule “towards the elbow I go, from the knee I flee”, the foramen is directed away from the growing end of the bone. The one end of long bone grows higher than the other end. The function of nutrient artery is well understood in the early stages of ossification and growth.⁽¹⁾ Before the puberty, the long bones receive nearly 80% of nutrition from the nutrient artery and if they are absent, the blood supply comes from the periosteal artery.⁽²⁾

The knowledge of the nutrient foramen location could be useful in some surgeries like fracture management. In vascular bone grafts, the arterial supply is essential to the osteoblasts and osteocytes.⁽³⁾ The bone graft should have the periosteal and endosteal blood vessels along with the plenty of anastomosis.⁽⁴⁾ The topographical information about the nutrient foramen will help the surgeon in repairing the bony defect with the grafts, tumor removal. This is particularly important in selecting the grafts without injuring the nutrient artery. This preserves the vascularization of the shaft.^(5,6)

There are only a very few studies reported about the topography of nutrient foramen of lower limb long bones from the rest of the world.⁽³⁾ According to our knowledge, no single study available which has studied all the lower limb long bones from the South Indian

population. In this context, the objective of the present investigation was to study the location, number and direction of the nutrient foramen in lower limb long bones from South Indian population and to determine the foramen index.

Materials and Method

We studied 260 lower limb long bones, of which 90 were femur (right sided = 42 and left sided = 48), 90 were tibia (right tibia = 45 and left tibia = 45) and 80 were fibula (right fibula = 42 and left fibula = 38). The age and gender were not known. The bones were collected from the department of Anatomy, Mahatma Gandhi Medical College, Pondicherry and Sri Sathya Sai Medical College, Kancheepuram. The damaged bones and bones with obvious pathological deformities were not included in the present study. The bones were observed for the topography, number, direction and location of foramen in relation to a particular surface and border of the lower limb bone. The nutrient foramen were identified by the well-marked groove at the starting of the canal. A needle was passed through each foramen to confirm their patency. The foramina less than 1mm away from any border were included on that particular border.

The bone length was measured by using the osteometric board and the distance of foramen from the upper end was measured using the Vernier caliper. The foraminal index was determined using the following formula;

Foraminal index = $\frac{\text{Distance of nutrient foramina from the proximal end}}{\text{Total length of bone}} \times 100$

Foramen index gave the location of the nutrient foramen. Each bone was divided into 3 parts and the analysis was done. The data was analyzed statistically by using the SPSS software. The mean, standard deviation and range were tabulated.

Results

The present study included 90 femurs, the total number of nutrient foramen were 120, among them 60 had solitary foramen and 30 had two. About 92.5% of the foramen were located in the middle 1/3 of shaft and 78.3% were present over the posterior surface. In most of the bones, the nutrient foramen was directed upwards. The average femur length was 41.82 cms, the foramen mean distance from the proximal end was 19.47 cms and the mean foramen index of femur was 46.49. The morphological and topographical data of the nutrient foramen of femur is given in Table 1.

Table 1: Distribution of nutrient foramina in the Femur

Side	Total no of bones	Total no of NF	Upper 1/3	Middle 1/3	Lower 1/3	Post surf	Medial surf	Lateral surf
Right (%)	42 (46.6%)	57 (47.5%)	5 (4.1%)	52 (43.3%)	--	47 (39.2%)	7 (5.8%)	3 (2.5%)
Left (%)	48 (53.3%)	63 (52.5%)	4 (3.3%)	59 (49.2%)	--	47 (39.2%)	14 (11.7%)	2 (1.7%)

Among 90 tibia, 87 had single foramen and 3 had double foramen. The total number of foramen was 93, of which 83.87% were observed in the upper 1/3 of tibia and most of them were situated over the posterior surface of tibia. Many of them were found to be in the downward direction. The mean tibial length was 35.58 cms, mean distance of tibial nutrient foramen from the proximal end was 12.4 cms and the mean foramen index was 34.82. The frequency of distribution of tibial foramen is given in Table 2.

Table 2: Distribution of nutrient foramina in Tibia

Side	Total no of bones	Total no of NF	Upper 1/3	Middle 1/3	Lower 1/3	Post surf
Right (%)	45 (50%)	45 (48.38%)	38 (40.86%)	7 (7.52%)	---	45 (48.38%)
Left (%)	45 (50%)	48 (51.61%)	40 (43.02%)	8 (8.61%)	---	48 (51.61%)

Among the 80 fibula, only 3 had two nutrient foramen. The total number of nutrient foramina were 83, among them 89.15% were observed in the middle 1/3 and 87.8% were found over the posterior surface. The majority of foramen were inferiorly directed. The mean fibula length was 32.58 cms, the mean distance of fibular nutrient foramen was 15.73 cms and the mean foramen index of fibula was 48.58. The frequency of distribution of nutrient foramen of fibula is shown in Table 3.

Table 3: Distribution of nutrient foramina in Fibula

Side	Total no of bones	Total no of NF	Upper 1/3	Middle 1/3	Lower 1/3	Post surf	Lateral surf	IO border
Right (%)	42 (52.5%)	44 (53.1%)	2 (2.4%)	40 (48.2%)	2 (2.4%)	38 (45.78%)	4 (4.81%)	2 (2.41%)
Left (%)	38 (47.5%)	39 (46.9%)	3 (3.61%)	34 (40.96%)	2 (2.4%)	35 (42.17%)	3 (3.6%)	1 (1.2%)

NF – Nutrient Foramen

IO – Interosseous Border

Discussion

The long bones are mainly supplied by the nutrient arteries. Havers reported the direction of nutrient foramen and their variation in the angle of entry in different mammalian animals. Berard⁽⁷⁾ was the first to report the correlation of direction of canal along with

the growth and ossification of bone. Humphery⁽⁸⁾ postulated the periosteal theory, which says that the foramen is directed away from the growing end. Harris⁽⁹⁾ described that the location of the foramen during the growth period has been constant. Patake & Mysorekar⁽¹⁰⁾ opined that number of foramen is not

significant in relation to the bone length and the ossification. Pereira⁽¹⁾ reported the topography of nutrient foramen over the posterior surface of lower limb long bones. Kizilkanat⁽⁵⁾ reported the number and distribution of foramina in Turkish population.

The external orifice, which is referred as the nutrient foramen has a particular location for each bone.⁽¹¹⁾ There are various theories which explain the direction of foramen, among them 'periosteal slip theory' by Schwalbe⁽¹²⁾ and 'vascular theory' by Hughes⁽¹³⁾ were globally accepted. The nutrient canal becomes slanted during the childhood, due to the maximum longitudinal growth, which takes place at the end, which is growing fast. The commonest cause for the delayed fracture union or non-union is the lack of blood supply. The details about the nutrient foramen is important to the orthopedicians during the fracture reduction. This will prevent the injury to the nutrient artery and thereby avoiding the chances of delayed and fracture non-union.⁽¹⁴⁾

The present study observed the two nutrient foramen of femur in 33% of cases. The double nutrient foramen of femur was observed in 42.8% by Gümüşburun, et al.⁽³⁾ 46% by Sendemir and Cimen⁽¹⁵⁾ and 47.7% by Murlimanju et al.⁽¹⁶⁾ Among the 90 femur, nearly 78.3% of nutrient foramen were found over the posterior surface, which were directed upwards. The mean foramen index of femur was 46.4 in the present study, whereas this was 38.9 by Murlimanju et al.⁽¹⁶⁾ and 48.8 by Gümüşburun et al.⁽³⁾

The present study observed that, 83.8% of tibial nutrient foramina were situated over the upper 1/3 of tibia and most of them in posterior surface. The mean foramen index was 34.8 as compared to studies of Murlimanju et al.⁽¹⁶⁾ which was 32.5 and 33.1 by Gümüşburun, et al.⁽³⁾ Among the 80 fibulae, 86.7% foramen were found over the posterior surface, which were directed inferiorly. The mean foramen index of fibula was 48.58, this is similar to Gümüşburun⁽³⁾ is 47.8 and 49.2 by Murlimanju et al.⁽¹⁶⁾

The morphological knowledge about the nutrient foramen is essential to proceed with the free vascular bone grafting,⁽¹⁷⁾ as these have been used for the procedures like mandibular reconstruction and dental implants.⁽¹⁸⁾ The anatomical details about the nutrient foramen are required to the operating surgeon.⁽¹⁶⁾

Conclusion

We believe that the present study has provided relevant information about the nutrient foramen of lower long bones. The two nutrient foramen were seen often in the femur than the tibia and fibula. The nutrient foramen of femur is directed upwards and seen over the posterior surface and in the middle 1/3 of the shaft of femur. The tibia has the foramen directed inferiorly and found over the upper 1/3 of tibia and the posteriorly. In fibula, the nutrient foramen are directed inferiorly and seen over the posterior surface of fibula. The morphological data of the present study will be enlightening to the surgeons performing the operative

procedures like bone grafting and bone transplantation with free vascular grafts.

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