ORIGINAL ARTICLE

A STUDY OF DIAPHYSEAL NUTRIENT FORAMINA IN HUMAN TIBIA

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ABSTRACT

Introduction: Nutrient foramen is the external opening of the nutrient canal in a bone. An understanding of the location, number, direction and caliber of diaphyseal nutrient foramina in Tibia is very important clinically, especially in orthopedic surgical procedures.

Method: This study was conducted on 312 (161 Right and 151 Left) macerated specimens of adult human Tibia. All the parameters like average number, average distance of the nutrient foramen from the upper end of Tibia, 'foraminal index', the most common location and the frequency of the location on the anatomical surfaces and borders of each of the Tibia, the caliber and the direction of each diaphyseal nutrient foramina and the frequency of the cases not obeying the Berard's rule in Tibia is studied.

Results: The average number of diaphyseal nutrient foramina found in Tibias was 0.97. Foraminal index (FI) was 45.01%; ranging from 32.86% to 28.09% and the mean FI was 37.57%. The location of nutrient foramina observed was 99.3% on the posterior surface. In 3 out of 312 tibiae there was nutrient foramina directed upwards and the tibiae had 100% dominant nutrient foramina.

Conclusion: No author has reported tibia without NF and therefore the average number was always reported as greater than one, while we report 0.97. Also this is the first study where we report that in 3 tibias the Berard's rule was not followed Therefore findings of this study do confirm the observations reported in earlier studies but some significant differences are also observed.

Keywords: Diaphyseal nutrient foramen, tibia, nutrient artery, foraminal index

INTRODUCTION

All arteries supplying the long bones are 'nutrient' but the artery to the diaphysis is known as '*nutrient artery*'. The main blood supply to long bones is from these diaphyseal arteries, especially during the active growing period in the embryo and fetus, and during the early phases of ossification.

The principal nutrient foramen is commonly displaced nearer to one extremity of a long bone than the other and the canal is usually oblique with respect to the long axis of the bone. Berard (1835)[1] was the first to point out that in the human long bones the nutrient canals were obliquely disposed, pointing towards the elbow in the upper limb and away from the knee in the lower limb. The dissection room jingle "*To the elbow I go; from the knee I flee*" is originally in French, "Au coude je m'appuis, du genou je m'en fuis". This is called the Berard's rule of canal direction.

In 1674, Antonie van Leeuwenhoek[2], first observed and documented nutrient foramen in a tibia of a calf. Investigations on the vascular anatomy of long bones were in the past confined mostly to animals. A few authors have studied nutrient foramina in human long bones. Kizilkanat et al (2007)[3] and Mysorekar (1967)[4] have studied nutrient foramina of the six long bones in humans including tibia while Nelson et al (1960)[5], Longia et al. (1980)[6], Forriol et al. (1987)[7], Sendemir and Cimen (1991)[8], Hallock et al (1993)[9], Nagel (1993)[10], Gümüsburun et al. (1994)[11] and Kirschner et al. (1998)[12] have studied the nutrient foramina in tibia.

The aim and objective of this study was to examine the tibia bone in detail with respect to the nutrient foramina and observe and record all parameters.

MATERIALS AND METHOD

This study was conducted on 312 (161 Right and 151 Left) macerated specimens of adult human Tibia. These were of Indian Gujarati race and of unknown sex. The instruments used for the study were an osteometric board, vernier calipers, hypodermic needles of size 20G and 24G, steel measuring scale, hand lens, divider, marking pen etc. Each tibia was numbered serially with a marking pen to help in identification. Their side (Left or Right) was determined. The diaphysial nutrient foramina were observed in all the bones with a hand-lens and encircled with a marker pen.

Various parameters like the total length (TL) of tibia between the superior margin of the medial condyle and the distal aspect of the medial malleolus, total number of nutrient foramina, the distance of the foramen from the upper end of the bone, the foraminal index (FI) for each nutrient foramen that was to be that obtained using the formula: FI= DNF/TL × 100. Where DNF was the distance from the proximal end of the bone to the nutrient foramina and TL was the total bone length. Thereafter the mean of foraminal index, least foraminal index and the highest foraminal index for tibia was to be determined and recorded.

The descriptive term used for the surface and borders of the diaphysis of tibia was recorded according to the Grey's textbook of anatomy, for uniformity and standardization. The location of the nutrient foramina was also recorded in terms of the fraction of the bone it occupied from the upper end. The tibia was divided into three fractions each and denoted as I, II and III. The direction of the obliquity of the nutrient foramina and their canals was to be noted. It would be recorded as 'upward' or 'downward' with respect to the proximal end of the long bone being up. Hypodermic needles of gauge 20 and gauge 24 would be used to measure the caliber of the foramen and canal. If the size 20 G passed through the nutrient foramen satisfactorily, it would be classified as 'Large' sized. If the needle of size 24G passed through the foramen and the size 20G did not pass through, the nutrient foramen was to be classified as 'Middle' sized. Both large and middle-sized foramen was to be categorized as being Dominant. If the needle of size 24G could not pass through the foramen it would be classified as 'Small' sized or 'Secondary' nutrient foramen.

RESULTS

The observations were recorded and the data was compiled and is presented in tables. No. 1 &2.

Table 1: General Observations

Characteristics	Right	Left	Total
Bones exam-ined	161	151	312
No. of Foramina	158	144	302
Range of total length	32.1-41.6	32.1-40	32.1-41.6
Mean of total length	36.1	36.8	36.44
Range of distance of NF*	10-14.9	10.4-14.3	10-14.9
Mean of distance of NF*	11.8	12.18	11.98
Mean of Foraminal Index	32.66	33.09	32.86
Least Foraminal Index	28.09	29.55	28.09
Highest Foraminal Index	37.37	37.57	37.57
NF of Big size	149	144	293
NF of Medium size	9	0	9
NF of Small size	0	0	0
Bones with NF not seen	3	7	10
Bones with 1 NF	157	143	300
Bones with 2 NF	1	0	1
Bones with 3 + NF	0	0	0
NF directed upwards	1	2	3
NF directed downwards	157	143	300
NF located on PS	157	142	299
NF located on AMS	0	0	0
NF located on ALS	0	0	0
NF located on AB	0	0	0
NF located on PB	0	0	0
NF located on IB	1	2	3
Location of NF on I part	103	87	190
Location of NF on II part	55	57	112
Location of NF on III part	0	0	0

*Distacne from upper end

Table 2: Comparison of size of the Nutrient Foramina in right and left side tibia

Size of nutrient foramen	Right	Left
Big	149	144
Medium	9	0
dominant (BIG+MED)	158	144
Small (Accessory)	0	0

In the present study among the 312 bones, 3.2% bones are without nutrient foramina while 96.5% had single nutrient foramina and 0.3% had 2 nutrient foramina. In present study **Mean number of nutrient foramina per Tibia bone was 0.97.**

In present study lowest foraminal index was 28.09 and highest foraminal index was 37.57 and mean foraminal Index was 32.86.

FIG:1 LARGE NUTRIENT FORAMINA ON TIBIA WITH A 20 G HYPODERMIC SYRINGE NEEDLE PASSING IN

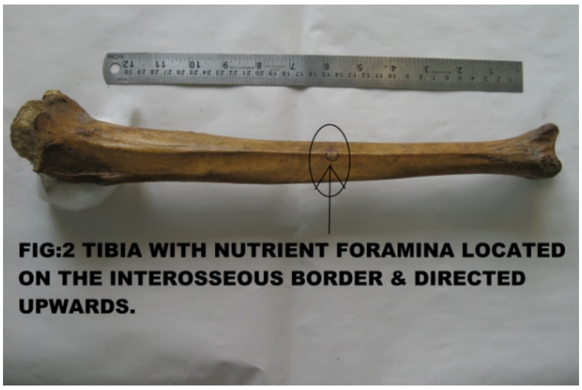

FIG:2 TIBIA WITH NUTRIENT FORAMINA LOCATED ON THE INTEROSSEOUS BORDER & DIRECTED UPWARDS.

Typical nutrient foramina is illustrated in Fig.1 and a tibia with upwards directed nutrient foramina and location on interosseous border is illustrated in Fig. 2.

DISCUSSION

Gray's Anatomy text book[13] describes the location of nutrient foramina, and the direction of being obliquely downwards. Morris' Text book of Human Anatomy[14] states that 'the tibia is a very vascular bone. The nutrient artery of the shaft is furnished by the posterior tibial artery and is the largest of its kind in the body'. The mean total length obtained is 36.44 cms and is very similar to the mean total lengths reported by other authors.[3,10] In the present study the tibia bone was found to have variable number of nutrient foramina, ranging from '0' (No nutrient foramina found), to '2' on a single bone. We find that no author reports more than 2 NFs and tibia without NF is not reported earlier. In this study in 10 (7 Left and 3 right) bones nutrient foramina could not be located. It may be very small and obscured and escaped detection. One bone with 2 nutrient foramina was found and earlier authors too have reported it as a rare find. The majority of tibiae had a single nutrient foramen in this study similar to earlier studies.[3,4,6,7,8,9,10,12] The mean number of nutrient foramina per tibia was compared with the other authors, and we find a similar value near to 1, which denotes that the tibia has only one nutrient artery supplying it mostly. The incidence of tibia bones having variable number of nutrient foramina was analyzed with respect to the sides (Right or Left), and the result is similar to other authors.[4]

The mean foraminal Index was obtained for the present study as 32.86%, least FI being 28.09% and highest FI as 37.57%. The other authors report a similar FI, though the range is more in study of Sendermir et al (1991)[8]. When the FI is compared on the right and left side in the present study a similar value is obtained for each side..

The nutrient foramina were located on the posterior surface of the tibia in this study in most of the bones. On comparing the result of this study with the other authors, some report the same [8,10,3] while Mysorekar (1967)[4] reports 1 NF on antero-medial surface and records a few cases with nutrient foramina on the interosseous border and the antero-lateral surface also. Nelson et al (1960)[5] also report nutrient artery penetrating the postero-lateral cortex at a point just below the oblique line of the tibia, below the origin of the soleus muscle, in their study of 14 amputed limbs.

On studying location of Nutrient Foramina on the corresponding '3rd' fraction from the upper end of the tibia and on comparing this result with Mysorekar (1967)[4], we get a nearly similar result. Location is most frequently on the 1st part, also reported earlier [6,9] which is of much clinical significance because this explains why the lower end of tibia is less vascular with no nutrient foramina located in whole study, and therefore non-unions are common on the lower part of shaft of tibia. The incidence of location of nutrient foramina on the corresponding 3rd parts from upper end of Tibia bone was analyzed with respect to the sides (Right or Left), and the result was similar to other authors[4].

In all the bones studied the direction of the nutrient foramina was directed upwards except in three bones, signifying that the upper end (near the knee joint) is the growing end. None of the other authors have reported tibia with canal directed downwards.

The size or caliber of the nutrient foramina was determined and the result was similar to earlier studies [3]. No small or 'accessory' or 'secondary' foramen is recorded in this study. The right and left sides were compared with respect to the caliber of the nutrient foramen and it was found that both sides had similar caliber.

The importance of this study lies in the clinical applications. An understanding of the location, number, direction and caliber of diaphyseal nutrient foramina in long bones is very important clinically, especially in orthopedic surgical procedures. Accidental ligation of the nutrient artery of a long bone leads to an immediate decrease in the bone blood flow. Non-unions happen when the bone lacks adequate stability and/or blood flow. The tibia is a good example to illustrate the rate of healing in relation to vascular supply, with those areas or regions with a good blood supply showing more rapid healing than those with a poor blood supply.[15] Fractures in the distal third of the tibial shaft tend to show delayed union or malunion: one suggestion being that there may be a tear of the nutrient artery at the fracture line, thus reducing the blood supply to distal site[16]. Injury to the nutrient artery at the time of fracture, or at subsequent manipulation, may be a significant factor predisposing to faulty union. [17,18, 19, 21]

CONCLUSION

The findings of this study do confirm the observations reported in earlier studies but some significant differences are also observed. No author has reported tibia without NF and therefore the average number was always reported as greater than one, while we report 0.97. Also this is the first study where we report that in 3 tibias the Berard's rule was not followed. Therefore findings of this study do confirm the observations reported in earlier studies but some significant differences are also observed.

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