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Original Article

Variation of the Nutrient Foramen of Fibula and its Clinical Significance

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Abstract

Background

The fibula is a long bone located at the lateral aspect of the leg. Its diaphysis is principally nourished by one or more nutrient arteries entering the shaft through an opening referred to as the nutrient foramen. The present findings on the morphometrics of the foramen may be helpful to forensic experts, radiologists and clinicians for diagnosis and management of various bony conditions.

Materials and Methods

This was a descriptive cross sectional study conducted on fifty dry adult human fibulae collected at the Department of Anatomy, Chitwan Medical College from June to September 2020. Total fibular length along with the number and location of all nutrient foramina present were recorded. Foraminal index of the fibula was calculated as well.

Results

The study revealed that the average length of Nepalese fibulae was 34.1 ± 1.9 cm. Eighty-eight percent fibula had a single nutrient foramen, 4 % had two and 8 % had none. The most common location was between the medial crest and posterior border (63%, in fibula with single foramen), followed by the medial crest (30%) and between the medial crest and interosseous border (7%). The average foraminal index was 44.01 ± 7.9 % with a range of 34.9 to 65.7 %.

Conclusion

Single nutrient foramen located at the middle third on posterior aspect was the most common finding. Regional data on the number and location of the foramina would be useful to forensic experts and clinicians for various diagnostic and treatment purposes.

Keywords: *Diaphysis, Fibula, Grafts, Osteology*

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Introduction

Fibula is the slender lateral bone of the leg which provides attachment for many muscles. It consists of upper end, lower end and shaft [1]. The nutrient foramen (NF) is the largest opening present on the shaft of long bones, allowing the nutrient artery to enter through it; the role of which is important in providing nutrition and growth. The radially oriented branches of the nutrient artery penetrate the cortex centrifugally and anastomose with the periosteal vessels to supply the diaphysis of fibula [2, 3].

The position and direction of the nutrient foramina are known to vary in human long bones [4]. Commonly, one or two nutrient arteries enter the shaft of the fibula at the middle third segment through these foramen; however, its presence has also been reported in proximal one fourth to one third as well as the middle two quarters [5].

The knowledge and position of the nutrient foramina of fibula is important to proceed with the free transplants of the vascularized bone graft to restore large bony defects [6]. It is very important that the nutrient blood supply is preserved in the vascular bone for precursor cells to survive, and thus the graft healing is facilitated with the usual replacement of the graft by creeping substitution [3]. The information on the nutrient foramina is relevant during fracture healing as well [7]. Measurements around the nutrient foramen of the fibula have also been used by forensic experts for human identification, gender discrimination and height interpretation [8]. On radiograph, nutrient foramen may mimic longitudinal stress fracture or may be misdiagnosed as lytic bone lesions [8]. Longitudinal stress fractures that start near the nutrient foramen can sometimes be difficult to diagnose and treat [8].

Because of the clinical importance of the nutrient foramen mentioned above and the paucity of studies from Nepal, we aimed to investigate its morphology and variations in fibula and also to add our regional data to the world literature for further studies.

Materials and Methods

A descriptive cross sectional study was conducted on dry adult human fibulae collected at the Department of Anatomy, Chitwan Medical College. Measurement of the fibulae was done at the dissection hall of Anatomy after getting approval from institutional review committee (CMC-IRC/076/077-129). The study period was from June to September 2020.

Sample size was calculated to be 49.79 using the formula $n = Z^2 \times \sigma^2 / e^2$, where, n = sample size, Z = 1.96 for 95 % confidence level, σ = 9 for population standard deviation taken from Kizilkanat et al [9] and e = margin of error as 2.5, since the researcher wants the error of estimation to be not to differ from 2.5 cm from the true mean.

A total of fifty clean and dried fibulae with normal anatomical configuration, twenty five from each sides, were included in the study. Deformed fibulae, fibula with broken pieces or those with pathology were excluded from the study. The side determination of the fibulae was done using standard method. The fibulae were serially numbered from 1 to 50 using blue permanent marker pen. The instruments used for the study were a measuring tape, 150 mm digital vernier caliper (product of China, accurate up to 0.01 mm), hand lens, stainless steel needle (25 Gauge), marking pen, etc. The total length of each fibula in centimeters was measured with the help of a measuring tape. Total length was the distance from the apex of head to the distal aspect of lateral malleolus. The nutrient foramen was observed only at the diaphysis with a hand lens. The opening with an elevated margins and presence of a proximal groove were accepted as nutrient foramen. The total number of foramen was recorded. The presence of foramen on different surfaces of shaft of fibula was observed and noted. The distance of the foramen/foramina in centimeters from the upper end to the midpoint of the bone was measured by using digital vernier caliper. The Foraminal Index of the samples was calculated using the formula given by Hughes [10], i.e., dividing the distance of foramen from the proximal end by the total length of bone, which will be multiplied by hundred. Foraminal Index (FI) = Distance of the foramen from proximal end / Total length of bone x 100

All the data were numerally coded in excel and analysis was done in Statistical Package for Social Sciences (SPSS) version 20. The mean and standard deviation of the total length of fibula and number of foramen as well as Foraminal index was calculated and described.

Results

A total of fifty fibulae, 25 of right side and 25 of left side, were studied. The mean length of the fibula was found to be 34.1 ± 1.9 cm (range 31.5 to 38 cm), the right being 34.01 ± 1.89 cm and the left side being 34.18 ± 1.94 cm. Figure 1 shows the three types of fibula with different numbers of the foramen present. Fibulae having single nutrient foramen were more frequent (88%, n = 44) as compared to fibulae with the absence of foramen (8%, n = 4) or those with double foramen (4%, n = 2) as shown in Table 1.

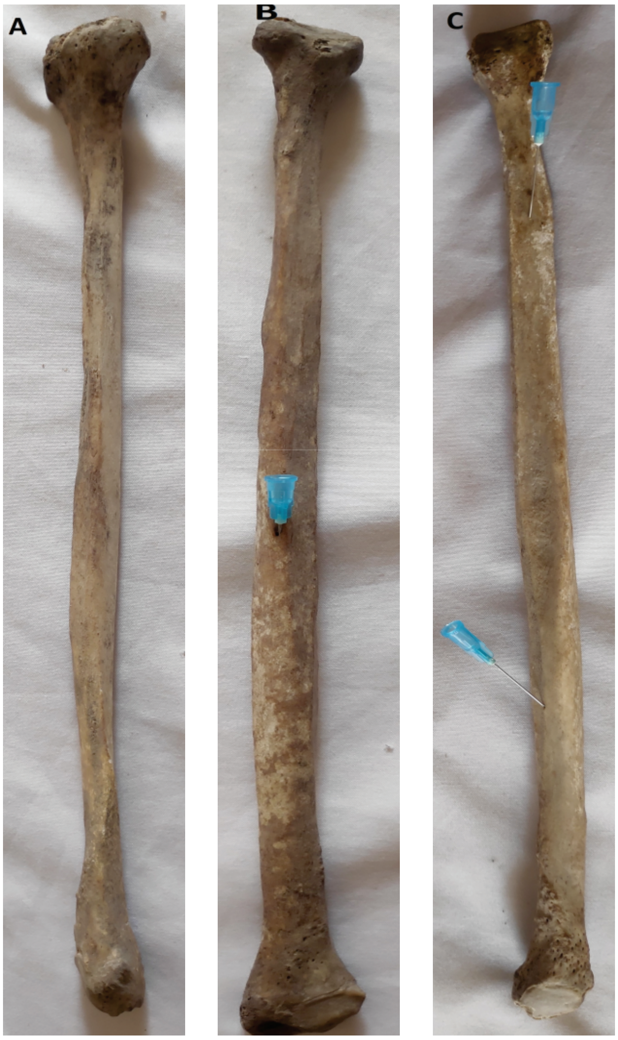

Figure 1: Fibula with zero (A), single (B) and double (C) nutrient foramen

Table 1: Number of nutrient foramen on the shaft of fibula

Number of foramen	Right, n (%)	Left, n (%)	Total, n (%)
Single	23 (92)	21 (84)	44 (88)
Double	1 (4)	1 (4)	2 (4)
Absent	1 (4)	3 (12)	4 (8)

The distribution of nutrient foramen opening located on the different surfaces on the fibula is shown in Chart 1.

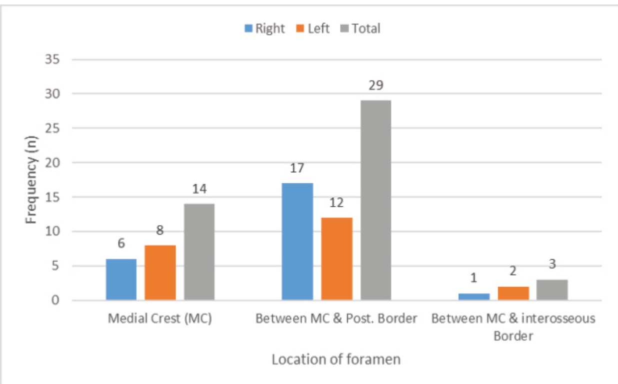

Chart 1: Distribution of location of the nutrient foramen

Figure 2: Location of NF (between MC and posterior border)

The average Foraminal index was 44.01 ± 7.9 % with a range of 34.9 to 65.7 %. Chart 2 and 3 shows the distribution of the Foraminal index in terms of total number and distance from midline.

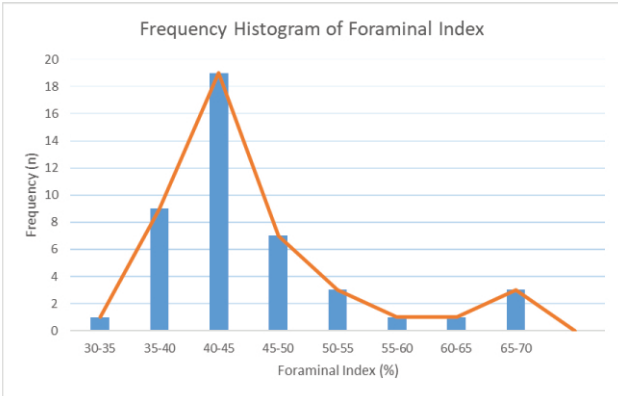

Chart 2: Frequency distribution of the Foraminal index

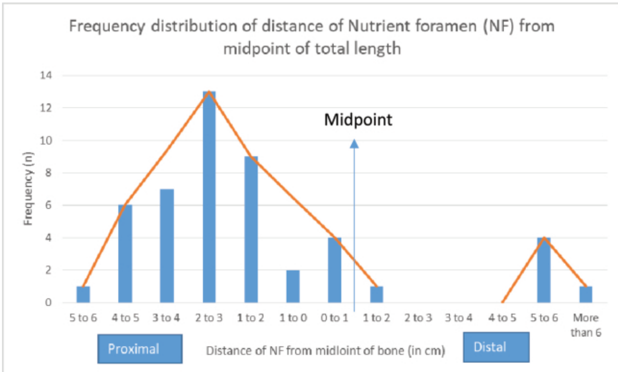

Chart 3: Frequency distribution of nutrient foramen from midline

Discussion

The current study reports on the topography and morphometry of the nutrient foramina on the fibulae of the Nepalese population.

The total length of the fibula correlates with the individual's height, which in turn, is influenced by his/her genetic makeup influenced by nutrition, hormones, activity levels, medical conditions and various environmental factors. Data of fibular length from Nepal is lacking. We found the average fibula length to be 34.1 ± 1.9 cm. Few representative studies of average fibular length includes studies by Ambekar et al (from India) [8], Kizilkanat et al (from Turkey) [9] and Mazid et al (from Pakistan) [11] who noted it to be 353.5 mm, 340.2 mm and 345.6 mm respectively.

In the present study, we could not appreciate any nutrient foramen in 8 % specimens (n=4); 88 % (n=44) of fibulae had a single primary diaphyseal nutrient foramen while the remaining 4 % (n=2) had 2 foramen. Kamath et al [12] as well as Campos et al [13] noted single NF in all samples whereas Prashanth et al noted predominantly a single foramen in their study [14]. Sharma et al [6] found up to 3 nutrient foramen in their study sample while Gupta et al [15] noted up to 4 nutrient foramen. Leaving these extremes, most studies, however, noted up to two nutrient foramina [4,16-19].

When the nutrient foramina is not found, it may be due to its true absence, in which case the periosteal vessels form the main blood supply; or it may be due to the maceration process, which may have obscured the small caliber nutrient foramina present. Fibula with no nutrient foramen on preoperative angiography, should not be chosen for a microvascular bone transfer. Mysorekar et al as well as Gupta et al noted that right sided fibula were more likely to have absent foramen as compared to the left side [4,15]. Due to very less sample size in our study, we could not test the significance of this side difference.

In this present study, NF was found posteriorly in all the studied samples; none on the medial or the lateral surfaces. On the posterior surface, it was located anterior to the medial crest in 6 %, on the medial crest in 28 % and posterior to the medial crest in 58 % of cases. Few other authors also noted all foramen to lie on the posterior surface of fibula [4, 9, 14, 15, 17]

Unlike our study, highest number of foramen was noted at the medial crest by Mysorekar et al [4]. Sendemir et al [16] found the medial surface to harbor the most NF; while it was found to be equally distributed among the medial and posterior surfaces in the study by Campos et al [13]. With a posterior vascular pedicle, the ipsilateral fibula is suitable for skin cover while the contralateral one is appropriate for mucosal lining. Stronger and more active muscles are present on the posterior surface of the fibula. Kizilkanat et al and Sinha et al have suggested that it may be the cause for the predominance of NF posteriorly where the requirement of blood is highest [9,20]. Presence of nutrient foramen on medial or lateral surface possibly could result from the variation of progress of degree of rotation during embryonic life [20].

The mean Foraminal index in the present study for the fibula with single foramen was 44.01 ± 7.9 %. The dispersion of data was more for right fibula as compared to the left (64 verses 60.2). Nutrient foramen of all the studied fibulae in our study lies in the middle 3rd (FI of 34.9 to 65.7 %) of the bone. Most of the previous studies had similar findings [4, 15, 21] except some studies which reported it higher up [9, 22]. The lower third seemed to be the area least preferred [15, 21, 22] or not [4] at all by the NF in most studies.

An accurate knowledge of the location of the nutrient foramina in long bones should help prevent intraoperative injuries in orthopedic surgery for proper fracture healing [9]. Nonunion and malunion of bones are more common in part of shaft away from the NF where the blood circulation is comparatively less. Stress fractures may start from the site of nutrient foramen with potential weakness and may need special films for proper diagnosis [8]. These data on bony morphometry may help forensic experts in human identification of local skeleton during mass disasters [19].

Harvest of a vascularized fibula should incorporate the area of the bone segment with the foramen and should be 6 cm away from the proximal end and 4 cm from the distal end [23]. The presence of NF more distally is advantageous to the plastic surgeon as it allows greater versatility and longer workable pedicle length. The segment of harvested fibula distal to the single NF or in between two NFs could be safely folded (double barreled) and utilized for thicker bone void. Double barreling the fibula enables enhanced aesthetic and functional results as well as immediate one-stage osseointegrated dental implantation [24]. Similarly, length of the incision in harvesting the fibular vascularized graft would be less thereby decreasing the complication of compartment syndrome when the exact site of NF is known [25].

Limitation: Cross-sectional design and limited sample size is one of the limitations of the present study. Age and gender differences could not be analyzed as the samples were preserved human bones. Some of the NF may have been missed due to attrition or mishandling.

Conclusion

Single nutrient foramen located at the middle third on posterior aspect was the most common finding observed in the studied samples.The study confirmed previous reports regarding the number and position of the nutrient foramina in fibular diaphysis. The regional data that we provided may be relevant to radiologist for interpretation of radiological images, forensic experts for medico-legal interpretation, orthopedic surgeons for fracture healing and plastic surgeons for fibula harvesting during vascularized bone grafting.

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Conflicts of interests: None

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