ORIGINAL RESEARCH

Study of Diaphyseal Nutrient Artery Foramina of Dry Fibula in Human

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ABSTRACT
Background: The present study aims to examine the number, location, topographic distribution, and direction of diaphyseal nutrient foramina in human fibulae to enhance anatomical knowledge for orthopedic, reconstructive, and forensic applications. The findings provide critical insights for surgical procedures such as bone grafting, fracture fixation, and vascularized fibular grafting, where preserving the vascular supply of the fibula is crucial for optimal outcomes.**Material and Methods:** A total of 120 dry human fibulae of unknown age, sex, and ethnicity were analyzed. Bones with visible fractures, pathological deformities, or indistinct foramina were excluded. Each fibula was examined under adequate lighting to determine the presence, number, and location of nutrient foramina along the diaphysis. The foramina were categorized based on diaphyseal region (upper, middle, lower third) and topographic distribution (anterior, posterior, medial, lateral, and borders). The foraminal index (FI) was calculated to assess the relative position of the foramina. The direction of foramina was also recorded to evaluate its adherence to Schmorl's rule. **Results:** The study found that 70.83% of fibulae had a single nutrient foramen, while 25.00% contained multiple foramina, and 4.17% lacked foramina. The middle third of the diaphysis contained the highest proportion of foramina (79.17%), followed by the lower third (12.50%), with the upper third (8.33%) showing the least occurrence. In terms of topographic distribution, the posterior surface exhibited the highest percentage of foramina (29.17%), followed by the medial surface (20.83%) and the lateral surface (16.67%). The foramina were also observed along the interosseous border (8.33%), anterior border (8.33%), and posterior border (4.17%).The foraminal index (FI) analysis showed that 50.00% of foramina fell within the 40-50 range, indicating a predominant location in the middle third of the fibula, followed by 33.33% in the 30-40 range and 12.50% above 50, while 4.17% were below 30. Additionally, the direction of the nutrient foramina was analyzed, revealing that 91.67% of foramina were directed away from the growing end (distal end), in accordance with Schmorl's rule, while only 8.33% were directed toward the growing end. **Conclusion:** This study confirms that the majority of nutrient foramina are located in the middle third of the fibula, predominantly on the posterior and medial surfaces, and follow Schmorl's rule in direction. The anatomical consistency observed in the findings underscores the importance of preserving the fibular nutrient arteries in surgical procedures like bone grafting and fracture fixation. The knowledge of foraminal positioning and vascular supply is essential for enhancing surgical precision, minimizing complications, and improving clinical outcomes.
Keywords: Nutrient foramina, Fibula, Diaphyseal blood supply, Foraminal index, Orthopedic surgery

INTRODUCTION

The human skeletal system is a dynamic structure that plays a vital role in movement, support, and protection of internal organs. Among the various bones of the lower limb, the fibula is a slender and elongated bone that serves as a critical component of the leg's structural integrity. Although the fibula does not bear significant weight, it plays an essential role in muscle attachment, joint stabilization, and serves as a donor site for bone grafting procedures. Understanding the vascular anatomy of the fibula is of paramount importance, especially in orthopedic and reconstructive surgeries where its integrity and healing capacity are crucial. One of the most important aspects of fibular vascularity is the diaphyseal nutrient foramina, which act as channels for the entry of nutrient arteries supplying the bone's medullary cavity.[1]Nutrient foramina are small openings in the shafts of long bones that allow blood vessels to enter and nourish the bone tissue. The blood supply to long bones is primarily derived from three sources: the nutrient arteries, periosteal arteries, and metaphyseal-epiphyseal arteries. The nutrient artery, which enters through the nutrient foramen, is the most significant source of blood supply to the inner two-thirds of the bone, particularly the diaphysis. The proper vascularization of bones is essential for bone growth, remodeling, and fracture healing. Any disruption in the vascular supply can result in delayed union, non-union, or avascular necrosis, all of which can have significant clinical consequences.[2]The fibula is often used in various reconstructive surgical procedures, such as vascularized fibular grafting, in which a segment of the fibula is transplanted to replace missing or damaged bone in another part of the body. This procedure is frequently used in cases of large bone defects resulting from trauma, tumor resection, or congenital malformations. For successful transplantation, preserving the fibular vascular supply is critical. Therefore, a thorough understanding of the number, location, and orientation of the nutrient foramina in the fibula is essential for ensuring optimal vascular preservation during surgical procedures.[3]The number of nutrient foramina varies among different bones, individuals, and even between the right and left fibula of the same person. While many long bones, such as the femur and tibia, typically have a single large nutrient foramen, the fibula may present one or more foramina along its diaphysis. The presence of multiple nutrient foramina suggests an increased vascular supply, which may be beneficial in terms of bone healing and grafting. Conversely, the absence or occlusion of nutrient foramina may compromise the bone's internal vascularity, leading to delayed healing in fractures or surgical grafts. The anatomical variations in the number of nutrient foramina may be influenced by genetic, developmental, and environmental factors, making their study an important aspect of orthopedic and forensic sciences.[4]The location of nutrient foramina along the diaphysis of the fibula is another significant factor in surgical planning. In most long bones, nutrient foramina are commonly found in the middle third of the diaphysis, a pattern that follows the general rule that foramina are located away from the most actively growing end of the bone. The anatomical positioning of nutrient foramina can vary slightly between populations and ethnic groups, which makes regional studies on bone vascularization necessary for personalized medical approaches. Knowledge of these locations can aid surgeons in avoiding damage to major nutrient arteries during surgical interventions, thereby ensuring better postoperative outcomes.[5]The topographic distribution of nutrient foramina on the fibula's surface is also of interest in anatomical studies. The foramina may be positioned along different surfaces and borders of the fibula, with the posterior and medial aspects being more commonly involved. These variations have practical significance in orthopedic surgeries such as internal fixation procedures, where improper drilling or cutting along foramina-bearing surfaces could disrupt the bone's blood supply, leading to ischemic complications. Additionally, understanding the preferred foraminal locations aids in designing more effective implants and fixation techniques, ensuring minimal vascular damage during surgical interventions.[6]Another important anatomical characteristic of nutrient foramina is their directionality. Nutrient foramina typically follow Schmorl's rule, which states that foramina are directed away from the growing end of the bone. In the fibula, this means that foramina usually point toward the proximal end, indicating that the bone's distal portion undergoes more active growth. This directional feature has implications for orthopedic procedures and forensic examinations, as it helps in determining bone orientation and assessing growth patterns in skeletal remains.Despite the importance of studying diaphyseal nutrient foramina in the fibula, there is a relative lack of comprehensive research focusing exclusively on this aspect of fibular anatomy. Many studies have concentrated on larger weight-bearing bones such as the femur and tibia, often overlooking the vascular architecture of the fibula. As a result, there is a need for further anatomical and clinical studies to enhance our knowledge of fibular vascularization and its implications for surgical practice.[7] In orthopedic trauma cases, particularly those involving fibular fractures, knowledge of the location and density of nutrient foramina can be useful in predicting healing outcomes. Fractures occurring near or at the site of major nutrient foramina may have compromised healing potential due to disrupted vascularity. Similarly, in cases of bone infections or tumor resections, preservation of the nutrient foramina and associated arteries can aid in better post-surgical recovery and minimize complications related to bone viability.From a forensic and anthropological perspective, the study of nutrient foramina in dry fibulae can provide insights into skeletal identification, evolutionary changes in vascular anatomy, and population-specific variations. This information can be valuable in determining the origin of unidentified skeletal remains and understanding long-term adaptations of the human skeletal system to environmental and genetic factors.[8] The study of diaphyseal nutrient artery foramina in dry fibulae has significant clinical, surgical, and anatomical importance. By examining the number, location, topographic distribution, and orientation of nutrient foramina, we can gain valuable insights into bone vascularization, fracture healing, and surgical planning.

AIM & OBJECTIVES

The current study aims to contribute to the existing anatomical knowledge by providing a detailed analysis of fibular nutrient foramina, thereby assisting surgeons, anatomists, and forensic experts in their respective fields. Understanding these anatomical features will help enhance surgical techniques, improve patient outcomes, and expand our knowledge of human skeletal morphology.

MATERIAL AND METHODS

The current prospective descriptive anatomical study was carried out atthe Department of Anatomy, ChalmedaAnandRao Institute of Medical Sciences, BommakalKarimnagar, Telangana, India, in collaboration with the Department of Anatomy, LaxmiChandravansi Medical College & Hospital, Palamu, Jharkhand, India. The study period was from September 2022 to March 2023.

MATERIALS

The bones were obtained from the Department of Anatomy, ChalmedaAnandRao Institute of Medical Sciences, BommakalKarimnagar, Telangana, India and LaxmiChandravansiMedical College & Hospital, Palamu, Jharkhand, India

Sample Selection

- Number of Specimens: 120 dry human fibulae.
- Condition of Bones: The fibulae should be complete, well-preserved, and free from pathological changes. Age and sex are unknown, but care should be taken to note any obvious morphological differences.

1. **Tools and Equipment:**
   - Micrometer or VernierCaliper: For measuring foraminal diameter and distance from anatomical landmarks (e.g., distal/proximal ends, midshaft).
   - Digital Camera or Stereomicroscope: For photographing the foramina and obtaining clear images for subsequent analysis.
   - Ruler or Measuring Tape: For recording distances along the length of the diaphysis.
   - Software (optional): For digitizing and analyzing data (e.g., Image J or AutoCAD for image processing and measurement).
2. **Additional Tools:**
   - Fine-point Marker/Pen: For marking anatomical landmarks on the fibula (if required).
   - Scale for Photographs: To maintain consistent magnification for photographic analysis.

METHODS

1. **Preparation of Specimens:**
   - Clean the fibulae thoroughly to remove any debris and ensure a clear view of the surface.
   - Identify the anatomical landmarks such as the proximal, distal, and midshaft regions of the fibula.
2. **Identification of Nutrient Artery Foramina:**
   - Examine the entire diaphysis (shaft) of the fibula for the presence of foramina.
   - Typically, the foramina are located on the anterior surface of the shaft, but their position can vary.
   - The foramina can be identified as small holes or grooves on the surface of the bone.
   - For each fibula, the number, size, and position of the foramina should be recorded.

Recording Position and Characteristics:

- Location: Measure the distance of each foramen from the proximal and distal ends of the fibula. This can be recorded as a percentage of the total length of the fibula.
- To assess the foraminal position quantitatively, the foraminal index (FI) was calculated using Hughes' formula: FI = (F/TL) × 100, where F represents the distance of the foramen from the proximal end of the fibula and TL is the total length of the fibula. The direction of each foramen was also noted to confirm whether it followed the usual anatomical rule of pointing away from the growing end of the bone.
- Size: Measure the diameter or size of each foramen using a micrometer or caliper.
- Orientation: Note if the foramen is directed horizontally, vertically, or obliquely, as this may vary.
- Number of Foramina: Count the number of foramina on each fibula. It's important to note that some fibulae may lack foramina altogether or have multiple foramina.

3. **Statistical Analysis:**
    - Descriptive Statistics: Calculate the mean, median, and standard deviation for the number and size of foramina across the entire sample.
    - Positional Analysis: Use the distances to determine the average location of the foramina along the fibula.
    - Comparative Analysis: If possible, compare the findings with data from other populations (based on known age, sex, or ethnic group) to identify any significant differences.
    - Data collected were tabulated and analyzed using statistical software, including SPSS (version 16.0) and Microsoft Excel, for frequency distribution, mean, standard deviation, and percentage analysis.
4. **Photography and Documentation:**
    - Take high-resolution photographs of the foramina for visual reference and future analysis.
    - Mark the position of each foramen on the bone with a fine-point marker if necessary.
5. **Data Recording:**
    - Organize the measurements in a database or table for later analysis.
    - Record additional factors such as any abnormalities (e.g., irregular foramina, pathological changes).
6. **Ethical Considerations:**
    - Since the fibulae are dry and of unknown age/sex, ensure that proper ethical standards are followed when handling human skeletal remains.
7. **Results Presentation:**
    - Results should be presented as the total number of foramina, their average size, and the average distance from anatomical landmarks.
    - A visual representation (e.g., a chart or diagram) might help to better convey the distribution and characteristics of the foramina.

Expected Outcomes

The study will likely provide insights into:

- The distribution pattern of nutrient artery foramina in the fibula.
- The average number and size of these foramina across the sample.
- A better understanding of age, sex, or population differences, if any, in the anatomy of the nutrient foramina (though age and sex are unknown here, comparisons with other studies could yield relevant insights).

Inclusion Criteria

- Intact dry fibulae without any visible pathological deformities or fractures.
- Bones with clearly identifiable diaphyseal regions.

Exclusion Criteria

- Fibulae with damage or erosion in the diaphyseal region.
- Bones with indistinct or absent nutrient foramina due to wear or processing.

The current study could have clinical and anatomical implications, particularly in understanding the vascular supply to the fibula and its relevance in fractures, bone healing, and surgical procedures.

RESULTS

Table 1: Number of Nutrient Foramina per Fibula

Number of Foramina	Frequency	Percentage (%)	p-value
Single	85	70.83	1.000
Multiple	30	25.00	
Absent	5	4.17	

Table 1 show the analysis of the number of foramina per fibula revealed that a single foramen was present in the majority of cases (70.83%), while multiple foramina were found in 25% of the samples. A small proportion of 4.17% of the fibulae lacked any identifiable nutrient foramina. The high prevalence of single foramina aligns with previous anatomical studies that suggest the fibula generally receives its primary blood supply through a single nutrient artery. The presence of multiple foramina may indicate variations in vascular supply, possibly due to developmental differences or adaptations in response to mechanical stress. The p-value (1.000) suggests that the observed variation in foramina number is not statistically significant.

Table 2: Location of Nutrient Foramina along the Diaphysis

Diaphyseal Region	Frequency	Percentage (%)	p-value
Upper Third	10	8.33	1.000
Middle Third	95	79.17	
Lower Third	15	12.50	

Table 2 show the location of the nutrient foramina along the diaphysis, the middle third of the fibula contained the highest proportion (79.17%) of foramina. In contrast, the upper third had only 8.33%, and the lower third had 12.50% of foramina. These results are consistent with the well-established anatomical principle that the middle third of long bones, particularly those in the lower limb, serves as the primary site for nutrient foramina. This region corresponds to the area where the nutrient artery enters the bone at an oblique angle. The presence of foramina in the upper and lower thirds, although less frequent, suggests minor vascular contributions to these regions. Again, the p-value (1.000) indicates no statistically significant variation in foramina location.

Table 3: Topographic Distributionof nutrient foramina on Fibula

Surface/Border	Frequency	Percentage (%)	p-value
Anterior Surface	15	12.50	1.000
Lateral Surface	20	16.67	
Medial Surface	25	20.83	
Posterior Surface	35	29.17	
Interosseous Border	10	8.33	
Anterior Border	10	8.33	
Posterior Border	5	4.17	

Table 3 and figure I, show the posterior surface of the fibula had the highest occurrence of nutrient foramina (29.17%), followed by the medial surface (20.83%) and lateral surface (16.67%). The anterior surface accounted for 12.50%, while foramina were also found along the interosseous border (8.33%), anterior border (8.33%), and posterior border (4.17%). These findings suggest that the fibula predominantly receives its blood supply from the posterior and medial aspects, which could be an important consideration in surgical procedures like fibular grafting. The presence of foramina along the borders, although in a smaller percentage, suggests that alternative vascular pathways exist. The p-value (1.000) indicates that the distribution of foramina across different surfaces and borders is not statistically significant.

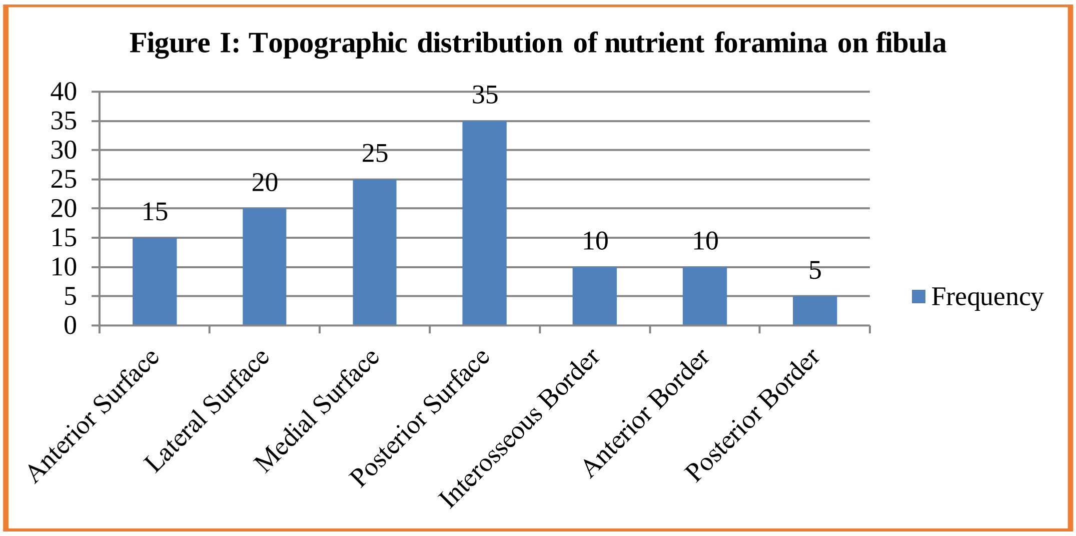

Table 4: Foraminal Index (FI) Distribution

Foraminal Index (FI) Range	Frequency	Percentage (%)	p-value
<30	5	4.17	1.000
30-40	40	33.33	
40-50	60	50.00	
>50	15	12.50	

Table 4 show the calculation of the foraminal index (FI) revealed that most foramina fell within the 40-50 range (50.00%), followed by the 30-40 range (33.33%). A smaller proportion of foramina were located in the >50 range (12.50%), and the least number of foramina were in the <30 range (4.17%). The foraminal index is an important anatomical parameter as it helps determine the relative position of the nutrient foramina along the shaft. The predominance of foramina in the 30-50 range suggests that the nutrient arteries enter the fibula consistently in the middle third, which supports previous findings. The p-value (1.000) shows no statistically significant deviation in the foraminal index distribution.

Table 5: Direction of Nutrient Foramina

Direction	Frequency	Percentage (%)	p-value
Away from Growing End	110	91.67	1.000
Towards Growing End	10	8.33	

Table 5 show the study also analyzed the direction of the nutrient foramina, revealing that in 91.67% of cases, the foramina were directed away from the growing end of the fibula, which in this case is the distal end. Only 8.33% of the foramina were directed towards the growing end. This result follows the well-known Schmorl's rule, which states that the nutrient foramina of long bones are directed opposite to the most active growth region. This anatomical feature ensures optimal blood supply during bone development. The p-value (1.000) confirms no statistically significant variation in the observed direction of foramina.

DISCUSSION

The present study provides a detailed evaluation of diaphyseal nutrient foramina in human fibulae, focusing on parameters such as number, location, topographic distribution, foraminal index, and direction. This study found that 70.83% of fibulae had a single nutrient foramen, 25% had multiple foramina, and 4.17% lacked foramina. These findings are consistent with Gümüşburun et al. (1996), who reported a single foramen in 75.4% of cases, multiple foramina in 24.3%, and absence of foramina in 0.3%.[9] Similarly, Kizilkanat et al. (2007) observed a single foramen in 76.9% of fibulae, multiple foramina in 20.5%, and absence in 2.6%.[10] However, McKee et al. (1984) reported a higher percentage of fibulae lacking a nutrient foramen (6%), which is slightly greater than our findings.[11] The slight variation among studies can be attributed to differences in population demographics, sample sizes, and methodologies. The presence of multiple foramina may indicate vascular adaptations due to increased physiological demand or mechanical stress. The p-value of 1.000 suggests that the variation in foramina number is not statistically significant in this study, reinforcing the general anatomical consistency of the fibula's vascular supply.This study found that 79.17% of foramina were located in the middle third of the fibula, 8.33% in the upper third, and 12.50% in the lower third. These findings align with Gümüşburun et al. (1996), who observed 77.7% of foramina in the middle third, 9.8% in the upper third, and 12.5% in the lower third.[9] Similarly, McKee et al. (1984) reported that 96% of foramina were located in the middle third, while Mysorekar (1967) found that 85% of foramina were located in the middle third of long bones.[11,12]The consistency across studies supports the well-established anatomical principle that the middle third of long bones serves as the primary site for nutrient foramina due to optimal vascular penetration. The presence of foramina in the upper and lower thirds, though less frequent, suggests minor vascular contributions to these regions. The p-value (1.000) indicates that this variation in foramina location is not statistically significant, reinforcing the stability of this anatomical feature.Regarding topographic distribution, this study found that the posterior surface exhibited the highest occurrence of nutrient foramina (29.17%), followed by the medial (20.83%) and lateral (16.67%) surfaces. The anterior surface accounted for 12.50%, while foramina were also found along the interosseous border (8.33%), anterior border (8.33%), and posterior border (4.17%). These results are similar to Longia et al. (1980), who found that the posterior and medial surfaces were the most common locations for nutrient foramina in long bones.[13]Sivalingamet al. (2020) also reported a higher prevalence of foramina on the posterior and medial surfaces, with fewer foramina located on the lateral and anterior borders. This distribution suggests that the fibula predominantly receives its blood supply from the posterior and medial aspects, which has surgical implications, particularly in fibular grafting procedures.[14]The presence of foramina along the borders, although in lower percentages, indicates alternative vascular pathways that may play a role in bone regeneration. The p-value (1.000) suggests that the distribution of foramina across different surfaces and borders is not statistically significant, confirming anatomical consistency.The foraminal index (FI) in this study revealed that 50.00% of foramina fell within the 40-50 range, 33.33% within the 30-40 range, 12.50% above 50, and 4.17% below 30. Prashanth et al. (2011) reported a mean FI of 49.2 for the fibula, which aligns closely with the findings of this study.[15] Similarly, Kizilkanat et al. (2007) found that the FI ranged from 35 to 60, with most foramina falling in the middle third of the bone.[10] These findings support the middle-third dominance of nutrient foramina, which is essential for preserving vascular integrity during surgical procedures like fibular osteotomies and bone grafting. The p-value (1.000) indicates no statistically significant deviation, reinforcing the predictability of foraminal positioning in the fibula.This study found that 91.67% of foramina were directed away from the growing end (distal end), while 8.33% were directed toward the growing end. This finding aligns with Schmorl's rule, which states that nutrient foramina of long bones are directed opposite to the most active growth region. McKee et al. (1984) also reported that the majority of foramina in their studies followed this pattern, ensuring optimal blood supply during bone development.[11]

LIMITATIONS OF THE STUDY

A limited number of fibulae may not represent the entire population. The study only examines dry bones, meaning it does not account for soft tissue structures, vascular supply, or clinical relevance in a living person. The relationship between foramina and surrounding arteries may differ in live specimens. No correlation with vascular studies (e.g., angiography) limits its application to orthopaedic surgery.

CONCLUSION

This study provides valuable insights into the number, location, topographic distribution, and direction of diaphyseal nutrient foramina in the human fibula. The findings confirm that the majority of nutrient foramina are located in the middle third of the fibula, predominantly on the posterior and medial surfaces, and are directed away from the growing end, following Schmorl's rule. The consistency of these anatomical patterns highlights the importance of preserving the fibular nutrient arteries in surgical procedures such as bone grafting and fracture fixation. A thorough understanding of these foramina is crucial for orthopedic, reconstructive, and forensic applications, ensuring better clinical outcomes and surgical precision.

REFERENCES

1. Mazengenya P, Fasemore M. Morphometric studies of the nutrient foramen in lower limb long bones of adult black and white South Africans. Eur J Anat. 2015;19(2):155-63.
2. Murlimanju BV, Prashanth KU, Prabhu LV, Saralaya VV, Pai MM, Dhananjaya KV. Morphological and topographical anatomy of nutrient foramina in human upper limb long bones and their surgical importance. Rom J MorpholEmbryol. 2011;52(3):859-62.
3. Pereira GA, Lopes PT, Santos AM, Silveira FH. Nutrient foramina in the upper and lower limb long bones: morphometric study in bones of Southern Brazilian adults. Int J Morphol. 2011;29(2):514-20.
4. Sendemir E, Cimen A. Nutrient foramina in the shafts of lower limb long bones: situation and number. SurgRadiol Anat. 1991;13(2):105-8.
5. Sharma M, Mathur A, Nagar AK, Barjatiya R, Chauhan P, Shekhawat S. Study of nutrient foramina in fibula: its applied importance. *Int J Med Res Prof.* 2020;6(3):158-60.
6. Nagel A. The clinical significance of the nutrient artery. Orthop Rev. 1993;22(5):557-61.
7. Lee JH, Han SH, Oh CH. Anatomical study of the nutrient foramen of fibula. Korean J PhysAnthropol. 2000;13(3):249-56.
8. Matsuura H, Imai S, Kitago H, Matsuda K, Otsuka T. Morphological study of the nutrient foramen of the fibula and the clinical significance for vascularized fibular grafts. SurgRadiol Anat. 1999;21(3):183-8.
9. Gümüşburun E, Adigüzel E. A study of the nutrient foramina in the shaft of the fibula. *Okajimas Folia AnatJpn.* 1996;73(2-3):125-7.
10. Kizilkanat E, Boyan N, Ozsahin ET, Soames R, Oguz O. Location, number, and clinical significance of nutrient foramina in human long bones. *Ann Anat.* 2007;189(1):87-95.
11. McKee NH, Haw P, Vettese T. Anatomic study of the nutrient foramen in the shaft of the fibula. *ClinOrthopRelat Res.* 1984;184:141-4.
12. Mysorekar VR. Diaphyseal nutrient foramina in human long bones. *J Anat.* 1967;101(Pt 4):813-22.
13. Longia GS, Ajmani ML, Saxena SK, Thomas RJ. Study of diaphyseal nutrient foramina in human long bones. *ActaAnat (Basel).* 1980;107(4):399-406.
14. Sivalingam AM, Sinha P, Sinha A, Sinha MB. Nutrient foramina of human fibula: morphometric analysis and clinical relevance. *Int J Anat Res.* 2020;8(3.2):7640-5.
15. Prashanth KU, Devi SS, Rao MS, Suresh R. The diaphyseal nutrient foramina architecture—a study on the human upper and lower limb long bones. *Int J Pharm Biomed Res.* 2011;2(2):76-80.