ANATOMICAL STUDY OF NUTRITION FORAMINA ON THE DIAPHYSIS OF THE HUMAN FIBULA

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ABSTRACT:

Objectives: The main objective of the study is to give a detailed overview of the nutrient foramina and nutrient channels by macroscopic examination of fibula diaphysis and to determine its utmost important variations for clinical practice.

Methods and Materials: This was a descriptive study in which we observed 50 fibula. We considered only nutritional foramina located at diaphysis of the bone. During the research we determined the following parameters: total number of nutrient foramina on diaphysis of each bone, value of Foramina Index (FI), the length of the bones, the position of the nutritional foramina regarding to values of FI, and position of nutritional foramina on the sides of the diaphysis of bone and the obliquity of nutrient canal. The obtained data were statistically analysed using SPSS version 17.0.

Results: Nutritional foramina were recorded at 84.0% fibula. In 57.1% fibula nutritional foramina were placed on the facies posterior, in 40.5% on the facies medialis and on 2.4% bones nutritional foramina were on the facies lateralis. All fibula had nutritional foramina located on the middle third of the diaphysis of bone. Distally directed nutritional canals were observed on 90.5% fibula and proximally directed nutritional canals were observed on 9.5% fibula. There was a negative correlation between the length of the fibula of the right and left limb and the number of nutritional foramina.

Conclusion: Knowledge of the topography of nutritional foramina helps preserve bone vascularization during surgery.

Keywords: nutritional artery, nutritional canals, fibula, topography

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throsis of the tibia. Diaphysis of the fibula has a double blood supply: endosteal and periosteal, endosteal being encouraged by nutritional artery. There are some variations of NF regarding number, position and size, direction of the channels through the bones [7]. Considering the above mentioned, there is still a need for better understanding of the location, direction and number of NF and nutrient canals on the diaphysis of the fibula, which was the main goal of our study.

MATERIALS AND METHODS

Materials

The research was conducted at the Department of Anatomy, Faculty of Medicine, University of Sarajevo. It is a descriptive study, in which we analysed and interpret the results obtained by observing the bone material. The material for this study consisted of 50 macerated and degreased, fully ossified fibulas of adults. We had 25 fibula from the right extremities and 25 from the left extremities.

All selected bones were anatomically preserved, without visible pathological changes. Bones with visible defects were not included in the study. Age and sex of the person from whom the bone originate were not known. NF were observed only in the diaphysis of the fibula. Foramina were observed macroscopically, through a hand magnifier with 6x magnification. On diaphysis NF were noted by the elevated rim of the foramina and using a shallow groove that exists proximal to the NF. For each bone we recorded total number of macroscopic observed foramina on the diaphysis. Through each foramina we pulled a probe to verify the existence of foramina.

The exact position of each NF is determined by calculating the Foraminal Index (FI), using the following formula: FI = (DNF / TL) X 100; (DNF = distance between the proximal end of the bone and the foramen nutrition, TL = total length of the bones). In those bones that had two NF, bigger one was taken to calculate the FI. Diaphysis of each bone is divided into three equal parts, zones: zone I (proximal 1/3), zone II (middle 1/3) and zone III (distal 1/3). NF were divided into three groups regarding the value of FI:

- **Type 1**: FI value to 33.33, NF is in the proximal third of the diaphysis
- **Type 2**: FI value from 33.33 to 66.66, NF is in the middle third of the diaphysis
- **Type 3**: FI value through 66.66, NF is in the distal third of the diaphysis

Determination of the total length of the bone was done individually for each bone with help of osteometric board. We measured the distance between the top of the head of the fibula and lateral malleolus peak.

Location of NF was determined considering the sides of bone diaphysis. Sides that were considered for each bone were: facies lateralis, facies medialis and facies posterior.

To determine the obliquity of the nutritional canal, whether it is directed towards the proximal or distal end of the bones, we used thin hypodermic needle, which was ran through nutritional canal.

Statistical analysis

Categorical data were expressed in frequencies and the relevant percentages. The significance of differences in frequencies within the relevant subgroup was tested by Chi-square test or Fisher’s exact test. The existence of associations between categorical variables was tested by Chi-square test. To estimate the normal distribution of continuous variables we used the Kolmogorov-Smirnov and Shapiro-Wilk test, depending on the sample size. For independent continuous variables that followed a normal distribution the mean and standard deviation (SD) was determined. The significance of differences for continuous independent variables that followed a normal distribution was tested by Student t-test. Value of p <0.05 was considered statistically significant. The obtained data were statistically analysed using SPSS version 17.0.

RESULTS

Analysis of the frequency of NF on fibula sample showed that 42 (84.0%) fibula had NF, while 8 (16%) fibula did not have NF. 21 (84.0%) fibula from right extremity and 21 (84.0%) from the left extremity had NF. 19 (90.5%) of right fibula had one NF, and 2 (9.5%) of right fibula had two NF. All 21 (100.0%) left fibula had one NF (Table 1).

By analyzing the position of the NF on fibula we found that 24 (57.1%) of fibula had NF located on the facies posterior, 17 (40.5%) on the facies medialis and in 1 (2.4%) bone on the facies lateralis (Figure 1).

By analyzing the position of NF regarding sides of fibulas diaphysis on right and left extremity, we found that 13 (61.9%) of right fibulas had NF on its facies medialis and 8 (31.1%) on its facies posterior, and no NF found on facies lateralis. As far as left fibulas, we found that 16 (76.2%) NF were on facies posterior, 4 (19%) on facies medialis and only 1 (4.8%) NF were located on facies lateralis (Table 2).

By analyzing the direction of nutritional canal on fibulas we found that in 18 (85.7%) right fibulas nutritional canal were directed towards distal part of bone, and in 3 (14.3%) right fibulas canals were directed towards proximal part of bone. On left fibulas, in 20 (95.2%)
of them nutritional canals were directed towards distal part, and only 1 (4.8%) left fibula had canal directed towards proximal part (Table 3).

Based on Foraminal Index, in all 21 (100.0%) of the right fibula and 21 (100%) left fibulas, NF were localized in the middle third of the diaphysis (Table 4).

Examining the correlation between the length of the fibula and the number of NF, we found a negative correlation between the length of the fibula of the right extremity and the number of NF and negative correlation between the length of the fibula of the left extremity and the number of NF. Correlations were not statistically significant (Table 5).

**Discussion**

In most cases fibula receives vascularization from a nutritional artery, a. nutritia fibulae, branche of the a. peronaeae, which enters the fibula through the foramen nutritium [8]. However, there are numerous variations of NF, starting with fibula who has more than one NF to the lack of NF [7].

By analysing the number of NF in 50 (100%) of the fibula in our study, 42 (84.0%) had NF, and 8 (16%) did not have a NF. Most of the fibula had one NF, 90.5% of right and 100.0% of left fibula. On 2 (9.5%) fibula of the right extremity we recorded two NF.

Following the recent literature available to us, we find information about a study done on fibulae of the natives from the area of North India conducted by Rakesh et al. In a sample of 112 fibula, in 5% of them NF was not observed, 78.57% fibula had one NF, 14% fibula had two NF, 3% fibula had three NF, and 2% had four NF [9]. Without any major deviations from our results, are the data from the study of Bhatnagar et al. on 60 fibulas, where 57 had one NF and 3 bones had two NF [10].

There are no significant differences in number of NF regarding to race. According to a study on a sample of 200 adult Nigerians fibula from Ongeti al., 5.5% fibula had no NF, 10.1% had two NF and the rest of bones had one NF [11].

**Table 1. Frequency of NF on fibula from right and left extremities**

<table>
<thead>
<tr>
<th>Number of NF (n)</th>
<th>Fibula of the right extremity</th>
<th>Fibula of the left extremity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>1</td>
<td>19</td>
<td>90.5</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>9.5</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Table 2. Position of NF regarding sides of fibulas diaphysis on right and left extremity**

<table>
<thead>
<tr>
<th>Sides of fibula diaphysis</th>
<th>Fibula of the right extremity</th>
<th>Fibula of the left extremity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Facies medialis</td>
<td>13</td>
<td>61.9</td>
</tr>
<tr>
<td>Facies lateralis</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Facies posterior</td>
<td>8</td>
<td>31.1</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Table 3. The direction of the nutritional canals on fibulas of right and left extremity**

<table>
<thead>
<tr>
<th>Part of the bone</th>
<th>Fibula of the right extremity</th>
<th>Fibula of the left extremity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Proximal part</td>
<td>3</td>
<td>14.3</td>
</tr>
<tr>
<td>Distal part</td>
<td>18</td>
<td>85.7</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Table 4. Position of NF based on value of Foraminal Index**

<table>
<thead>
<tr>
<th>Position of NF</th>
<th>Fibula of the right extremity</th>
<th>Fibula of the left extremity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Proximal 1/3 of the diaphysis</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Middle 1/3 the diaphysis</td>
<td>21</td>
<td>100.0</td>
</tr>
<tr>
<td>Distal 1/3 the diaphysis</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Table 5. Correlation between length of the fibula and the number of NF**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of NF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of the fibula (right extremity)</td>
<td>r = - 0.164</td>
</tr>
<tr>
<td>Length of the fibula (left extremity)</td>
<td>r = - 0.138</td>
</tr>
</tbody>
</table>
By analysing the diaphysis of the fibula, we noticed that at 40.5% fibula (61.9% right and 19% of the left fibula) NF were on facies medialis, at 57.1% fibulas (31.1% and 76.2% of right of left) NF were located on facies posterior and the 2.4% fibula (4.8% left) NF were on facies lateralis.

In their research, Malukar et al., found NF predominantly located on the facies posterior, at 90.8% fibula, only 6.8% on the facies medialis and 2.2% on the facies lateralis [12].

Larger deviations from our results shows a study on a sample of 114 adults fibulas, from the area of Southern Brazil, where Pereira et al. recorded NF predominantly located on facies lateralis (98.2% fibula) and only 1.8% fibula with NF on the facies posterior [11].

Results of the study Kumar et al. show some differences from our results. These authors found NF on facies posterior in 29.62% fibula, on facies lateralis on 22.23% bones and in 21.16% fibulas on facies medialis. The rest of the NF were within the median edge (7.93%) and the rear edge (2.11%) and cristaed median (8.99%), parameters that we used in our study [14].

Collipal et al. recorded NF on facies posterior in 68% of tested fibula, 14% on the facies medialis and 4% on the facies lateralis. The rest of the NF were located along the medial (12%) and the lateral edge (2%), which we in our stud, did not take as parameters for determining a position of NF [15].

Observing the obliquity the nutritional canal through the diaphysis, we found distally directed canal on 90.5% fibulas (85.7% of the right and 95.2% of the left fibula) and proximally directed canal on 9.5% fibula (14.3% of the right and left 4.8%).

Slight deviations from our results found Rakesh et al. from area of North India [9]. In this study 79.70% canals were oriented towards the distal and 20.3% towards proximal end of the diaphysis on a sample of 112 fibula.

Kumar et al. found predominantly oriented nutritional canals towards the distal end of the diaphysis, on 187 of fibulas, and only 2 fibulas had proximally oriented canals. These results are in accordance with our findings [14]. In our study, at all observed fibulas, who had NF, they were located in the middle third of the diaphysis of bones.

Our results also coincide with the results of Bhatnagar et al., which showed that 96.96% fibulas had NF in the middle third and 3.3% in the distal third of the dyaphisis [10].

Kumar et al. noticed NF in the proximal third of the dyaphisis on 29.62% fibulas, in the middle third on 38.62% fibulas and in the distal third on 29.10% fibulas [14].

Rakesh et al. in their work on 112 fibulas, noticed NF on the proximal third of the diaphysis on 2.9% of the bones, 81.95% of bones had NF in the middle third, and 9.2% of bones with NF on the distal third of the diaphysis [9].

Negative correlation between the length of the right fibula and the number of NF and between the length of the left fibula and the number of NF was not statistically significant. Similar to our results, Sharma et al. in their study performed on 150 dry human fibulas did not find association between length of the fibula with total number of nutrient foramen and location of nutrient foramen and direction of nutrient foramen was not sufficiently justified [16]. Mysoerekar in his study on nutrient foramina of long bones found no relation between length and number of foramina of bones which supports the finding in present study [17]. As such no any data is available to confirm that bone length is directly proportional to number of nutrient foramina.

This study has some limitations. These include age and sex differences which were not considered as we were not able to estimate the age and gender of the bones studied. These differences might impact the results, since in older age some of nutrient foramina might get ossified, and nutrient foramina might differ in males and females. To date there are no studies that would suggest the existence of differences in number of nutrient foramina between females and males. A further cadaver-based study is therefore advocated in which the origin of the nutrient foramina and the sex of fibulas can be determined.

**Conclusion**

The results of our study showed that knowledge of the topography of NF on the diaphysis of the fibula has not only morphological, but primarily clinical significance. Evidence regarding the location of the NF has a significant role in patients in which surgical procedures on the fibula diaphysis is indicated in order to avoid unnecessary manipulation of the region of entry of the nutritive artery on bone diaphysis, which increases the risk of intraoperative and postoperative complications. Therefore, a protocol should be made, that would be applicable in certain surgical disciplines.

**Declaration of interest**

The authors report no conflict of interest.
References


