A Study of Morphometric and Topographic Anatomy of Nutrient Foramen in Fibula

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INTRODUCTION

Fibula is the slender lateral bone of leg, characterised by a proximal head, a twisted shaft and a distal lateral malleolus. It is not directly involved in the transmission of body weight. A little proximal to the midpoint of its posterior surface, fibular shaft is pierced by a nutrient foramen, directed distally [1]. The direction of nutrient foramen determines the growing end of the bone. The blood supply of long bone occurs through the nutrient foramen which allows passage of nutrient vessels and nerves into the diaphysis. The knowledge about the nutrient foramina is of crucial importance especially in surgical procedures like bone grafting and micro-vascular bone transfer. In adults, fibula measures 35-45 cm in length and 1.5-2 cm in width. This furnishes a strong cortical strut, which can be used for bone grafting. ‘Free fibular grafts’ are well suited for the reconstruction of segmental defects of long bones, which provides mechanical strength and biological stimulus for healing [2].

The nutrient artery of fibula, a branch of peroneal artery runs along the posterior aspect of its diaphysis and enters the nutrient foramen. In addition, the fibula receives a number of segmental musculo-periosteal vessels, which also emanate from the peroneal artery and mostly supply the middle third of the diaphysis. The fibula is supplied by both of its endosteal and periosteal vessels. In the absence of nutrient artery which provides the endosteal blood supply, periosteal vessels form the sole source for supplying the entire diaphysis of the long bone. Vascularised bone grafts are immediately viable, as they are placed with intact vessels. Fibular shaft can be transplanted with its nutrient vessels, which also emanate from the peroneal artery and mostly supply the middle third of the shaft [3]. Usma R et al., studied 100 fibulae and noticed that nutrient foramina were located on the posterior surface in 62.89% and along the direction of nutrient foramina were observed and the data were presented in a tabulated format.

RESULTS

The mean height of the fibula on the right side was 35.86±2.44 cm, whereas on the left was 36.64±2.53 cm. It was observed that 92% of the right and 96% of the left bones presented a single foramen. The nutrient foramina were predominately present on the posterior surface of the middle third of the shaft and were directed away from the growing end of the bone.

CONCLUSION

As vascularised osteocutaneous fibular graft is recommended as a useful treatment option for bone transplant surgeries, the data gathered in this study could be useful for the orthopaedic surgeons.

MATERIALS AND METHODS

A descriptive cross-sectional study was carried out in a total of 50 (25 right and 25 left) dry adult fibulae of unknown sex and age obtained from the Department of Anatomy, Kanyakumari Government Medical College, Asaripallam, Tamil Nadu, India. The length of each bone was measured directly using a measuring tape. Number, location and the direction of nutrient foramina were observed and the data were presented in a tabulated format.

The Foramen Index (FI) was calculated using Hughes formula:

\[ FI = \frac{DNF}{TL} \times 100 \]

where DNF is the distance from the proximal end of the bone to the nutrient foramen and TL is the total length of the bone.

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Inclusion criteria: Fifty (25 right and 25 left) dry adult fibulae, irrespective of age and sex were included in the study.

Exclusion criteria: Fibulae showing notable loss of osseous material, previous signs of fracture or pathological abnormalities were excluded from the study.

Study Procedure

All the bones were observed for their length, number, location and the direction of the nutrient foramina. The total length of each bone was measured from the apex of the head of fibula to the tip of the lateral malleolus using a measuring tape [Table/Fig-1]. The position of the nutrient foramina on the fibular shaft was located and their distance from the proximal end of the bone was recorded.

The Foramen Index (FI) was calculated using Hughes formula:

\[ FI = \frac{DNF}{TL} \times 100 \]

where DNF is the distance from the proximal end of the bone to the nutrient foramen and TL is the total length of the bone.

Larger foramen was considered in bones with double nutrient foramina.

Keywords: Bone grafting, Diaphyseal nutrient foramina, Nutrient artery
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STATISTICAL ANALYSIS
Data was tabulated and statistical analysis in the form of mean and Standard Deviation (SD) was done for length and foramen indices of fibula. Simple percentage calculation was done for numeric and topographic variations of the diaphyseal nutrient foramen.

RESULTS
A total of 50 dry adult fibulae were examined for their length; number, location and direction of nutrient foramina and the following observations were made. Mean length of right fibula was 35.86±2.441 cm and 36.64±2.537 cm for the left. Mean foramen indices were 48.76±8.802 and 44.88±7.053 for the right and left fibula, respectively [Table/Fig-2]. Double nutrient foramina were noticed in 2 (8%) of right and 1 (4%) of the left fibula. Rest of the bones presented single nutrient foramen [Table/Fig-3]. Nutrient foramen was located on the posterior surface in 19 (76%) of right and 17 (68%) of left fibula. In 6 (24%) of the right and 8 (32%) of the left fibula foramen was located on the anteromedial surface [Table/Fig-3]. Nutrient foramen was directed away from the growing end in majority (100% right and 96% left) of fibula, while in 4% of left fibula foramen was directed away from the growing end [Table/Fig-3].

<table>
<thead>
<tr>
<th>Variables</th>
<th>Right Fibula (25)</th>
<th>Left Fibula (25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of nutrient foramen</td>
<td>One (23 (92%))</td>
<td>Two (2 (8%))</td>
</tr>
<tr>
<td>Location of nutrient foramen</td>
<td>Posterior (19 (76%))</td>
<td>Anteromedial (6 (24%))</td>
</tr>
</tbody>
</table>

[Table/Fig-2]: Foramen indices.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total Length (TL) (cm)</th>
<th>Distance of Nutrient Foramen from proximal end (DNF) (cm)</th>
<th>Foramen Index (FI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right fibula (25)</td>
<td>Mean±SD 35.86±2.441</td>
<td>17.58±3.95</td>
<td>48.76±8.802</td>
</tr>
<tr>
<td></td>
<td>Maximum 40.5</td>
<td>27</td>
<td>64.06</td>
</tr>
<tr>
<td></td>
<td>Minimum 31</td>
<td>11.5</td>
<td>36.32</td>
</tr>
<tr>
<td>Left fibula (25)</td>
<td>Mean±SD 36.64±2.537</td>
<td>15.8±2.471</td>
<td>44.88±7.053</td>
</tr>
<tr>
<td></td>
<td>Maximum 40.5</td>
<td>22</td>
<td>62.12</td>
</tr>
<tr>
<td></td>
<td>Minimum 29</td>
<td>13.5</td>
<td>34.56</td>
</tr>
</tbody>
</table>

[Table/Fig-3]: Number, location and direction of nutrient foramen.

<table>
<thead>
<tr>
<th>Direction of nutrient foramen</th>
<th>远离生长端 (Away from the growing end)</th>
<th>向生长端 (Towards the growing end)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 (100%)</td>
<td>24 (96%)</td>
<td></td>
</tr>
<tr>
<td>0 (0%)</td>
<td>1 (4%)</td>
<td></td>
</tr>
</tbody>
</table>

DISCUSSION
The fibula has been identified as the preferred choice for bone grafting procedures. Free vascularised fibular flaps are used for reconstruction of skeletal, soft tissue and growth plate defects. Fibula is an excellent vascularised graft source, because of its anatomic accessibility, independent blood supply and also because removing an intercalary segment with preservation of the proximal and distal fibular segments would have minimal effect on the gross function of lower extremity.

Length of fibula: The mean length of fibula in the present study was found to be 35.86±2.441 cm and 36.64±2.537 cm in the right and left sides, respectively. Similar observation was reported by Kaur J and Srivasatava D, who noticed that the mean length of the fibula was 35.58 cm, ranging between 32 cm and 40 cm [8]. They also revealed that the mean length of bone procurable for graft, sparing proximal 7 cm and the distal third of the bone for preserving the stability of ankle joint was 16.72 cm. The advantage of such graft is the available length of bone that can be utilised for large bone defects requiring more than 10 cm.

Foramen index: Zahid A et al., classified the position of nutrient foramina based on FI. Type-1 had FI less than 33.33, the foramen was in the proximal third of the bone. In Type-2, FI was in the range of 33.33 to 66.66, the foramen was in the middle third and in Type-3, FI was greater than 66.66, the foramen was in the distal third of the bone. They noticed that the mean FI on the left was 47.651±7.601 and on the right was 50.283±11.478 [7]. McKee NH et al., noticed that 96% of the foramina were on the middle third of the fibula and recommended that this segment of the shaft should be considered for free vascularised fibular grafts to increase the prospect of including the endosteal blood supply [8]. In the present study, mean FI on the right side was 48.76±8.802 and on the left was 44.88±7.053, suggesting high vascularity in the middle third of the bone. This finding was in accordance with previous studies, ensuring that middle third of the shaft is the ideal segment for bone grafting.

Number of nutrient foramina: A single nutrient foramen (92% in right and 96% in left fibula) appeared to be the most prevalent finding in the present study [Table/Fig-4]. Similarly double nutrient foramina were noticed in 8% of the right and 4% of the left fibula [Table/Fig-5]. This relatively small number of double nutrient foramina corroborated with the findings of Gumusburun E et al., [9].

In a study on Asian Indian subjects, Prashant KU et al., noticed that nutrient foramina corroborated with the findings of Gumusburun E et al., [9]. Furthermore, in a study by Shoma Alban et al., the nutrient foramina were noticed in 92% in right and 96% in left fibula, suggesting high vascularity in the middle third of the bone. This finding was in accordance with previous studies, ensuring that middle third of the shaft is the ideal segment for bone grafting.
90.2% of the fibula had single foramen and in 9.8%, the foramen was absent [10]. Another study conducted in the Indian population by Sharma MD et al., in 150 dry adult fibulae, revealed absence of nutrient foramina in 6%, single foramen in 86.5%, double and triple foramina in 6.5% and 1%, respectively [11]. The presence of nutrient foramina is primarily important for the vascularisation of the fibular shaft because, the survival of osteophytes in pathological conditions, are dependent on adequate nutrient blood flow.

Limitation(s)
The present study was conducted in limited sample of 50 dry fibulae, because of lack of adequate resources. Variations with respect to gender and age could not be detected, as the bones available for the study were of unknown age and sex.

CONCLUSION(S)
The distinct morphological characteristics and blood supply of fibula allows the use of vascularised fibular flaps, for the reconstruction of large intercalary bone defects with minimal postoperative complications. Findings in the present study on the distribution, position and direction of the nutrient foramina may prove useful for the surgeons to understand the vascularity of fibula better and to develop methods for harvesting vascularised fibular graft, preserving the nutrient artery.

REFERENCES