MORPHOLOGIC STUDY OF NUTRIENT FORAMINA IN DRIED FEMURS

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ABSTRACT

BACKGROUND
Diaphyseal fractures of femur are common cases in Orthopaedics and Traumatology Department. Vascularised bone graft is the preferred method used in bone reconstruction, as it ensures the survival of both donor and recipient bones. Position and direction of nutrient foramina in long bones of lower limbs varies from region to region, race and species.

MATERIALS AND METHODS
The descriptive study comprised of observation of Diaphyseal Nutrient Foramina (DNF) of 50 adult dried femurs. DNF was identified by their elevated margins and by the presence of a distinct groove proximal to them. Foramina equal to or larger than 24 hypodermic needle size were included. Foramen Index (FI) was calculated using Hughes formula.

RESULTS
28 (56%) bones showed single nutrient foramen, 21 (42%) bones showed double nutrient foramina. Nutrient foramen was absent in one bone. Majority of nutrient foramina were found on the linea aspera and posterior medial surface and least on the lateral surface, whereas none were found on the anterior surface. The mean foramen index was 44.07.

CONCLUSION
The anterior and lateral surfaces of femur are safe for orthopaedic manipulations due to scarcity of nutrient foramina on these surfaces.

KEY WORDS
Diaphyseal Nutrient Foramen, Femur, Foramen Index, Bone Graft, Linea Aspera.

study. Foramina equal to or larger than this were considered as dominant foramina.

4. Direction and Obliquity: A fine stiff wire was used to confirm the direction and obliquity of the foramen.

Foramen Index (FI) was calculated using Hughes formula.\(^6\)

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

Where DNF: The distance between the nutrient foramen and proximal end of the bone and TL: Total Bone Length.

All measurements were done using osteometric board. The statistical data analysis was carried out using SPSS 17 (Statistical Package for Social Sciences).

**RESULTS**

In the present study, 70 nutrient foramina were observed in the 50 dried femurs. 30 (42.85%) nutrient foramina were observed on right side and 40 (57.14%) were observed on left. In our study, 28 (56%) femurs had single nutrient foramen and 21 (42%) femurs had double nutrient foramina. In one femur, the nutrient foramen was not found. All the DNFs observed were directed towards the proximal end (Table 1 and Fig. 1).

The DNFs observed in vertical zones of femur include 28 on Linea aspera (LA), 24 on Medial lip of Linea aspera (MLA), 4 on Lateral lip of Linea aspera (LLA), 6 on Posterior Medial Surface (PMS), 1 on Posterior Lateral Surface (PLS) and 7 on Posterior Popliteal Surface (PPS). Distribution in horizontal zones include 57 in the middle 1/3rd of the femur and 13 in upper 1/3rd with no foramina detected in the distal third of the femur. The most common site of nutrient foramen was on linea aspera, least on lateral surface and none on the anterior surface. The DNFs on the upper 2/3rd of linea aspera with its medial and lateral lips accounts to majority compared to other surfaces (Table 2 and Fig. 2).

The mean Foramen Index (FI) of all the studied DNFs was 44.07 ± 11. The mean FI of DNFs on the left femur (45.12±11.61) was higher than that on the right femur (42.77±10.25).

**DISCUSSION**

The number and location of the nutrient foramina are important, as the knowledge of this could be utilised by orthopaedicians during surgeries, especially for short defects. One must consider the number and location of nutrient foramina for vascularised bone graft. So this study was taken up. Of the 50 dried femurs studied (23 right, 27 left), 70 nutrient foramina were observed.

In the present study, 21 (42%) bones showed double nutrient foramina. The present results correlate with the studies done by Gopala Krishna\(^1\) and Muralimananju\(^7\). The blood supply to the sites of muscle attachment is directly reinforced by the nutrient arteries. The localisation of nutrient foramina in the upper 2/3rd corresponds to the segment of bone with more muscle attachments sustaining more stress. On comparison we can infer that the variation in the occurrence of DNF varies not only between different populations of the world, but also between the different regions of India (Table 3).

The factors such as genetic constitution and food habits could be related to the difference in the occurrence of DNF in different populations, as these factors have been shown to determine the number and site of DNF.\(^3\) Absence of nutrient foramina was observed in one bone. This is in concordance

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**Table 1. Distribution of DNFs in Femur**

<table>
<thead>
<tr>
<th>Side</th>
<th>Single DNF</th>
<th>No DNF</th>
<th>Double DNF</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>14</td>
<td>01</td>
<td>08</td>
<td>23</td>
</tr>
<tr>
<td>Left</td>
<td>14</td>
<td>-</td>
<td>13</td>
<td>27</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>01</td>
<td>21</td>
<td>50</td>
</tr>
</tbody>
</table>

**Table 2. Distribution of Nutrient Foramen on Femoral Diaphysis in Vertical and Horizontal Zones**

<table>
<thead>
<tr>
<th>Different Zones</th>
<th>Vertical Zones</th>
<th>Nutrient Foramen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Zones</td>
<td>LA</td>
<td>MLA</td>
</tr>
<tr>
<td>Upper 1/3</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Middle 1/3</td>
<td>24</td>
<td>23</td>
</tr>
<tr>
<td>Lower 1/3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total Number of Foramen</td>
<td>28</td>
<td>24</td>
</tr>
</tbody>
</table>

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**Table 3. Number of Nutrient Foramina per Bone**

<table>
<thead>
<tr>
<th>Studies By</th>
<th>Region</th>
<th>Sample Size</th>
<th>One Per Bone %</th>
<th>Two Per Bone %</th>
<th>Not Found %</th>
<th>Nutrient Foramen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present study</td>
<td>South India</td>
<td>50</td>
<td>40</td>
<td>60</td>
<td>1</td>
<td>70</td>
</tr>
<tr>
<td>Gopala Krishna(^1)</td>
<td>South India</td>
<td>126</td>
<td>59.49</td>
<td>40.51</td>
<td>0</td>
<td>158</td>
</tr>
<tr>
<td>Muralimananju(^7)</td>
<td>South India</td>
<td>86</td>
<td>47.7</td>
<td>44.2</td>
<td>4.6</td>
<td>136</td>
</tr>
<tr>
<td>Raj Kumar(^8)</td>
<td>North India</td>
<td>101</td>
<td>32.0</td>
<td>68.0</td>
<td>2</td>
<td>150</td>
</tr>
</tbody>
</table>
with the previous studies. However, in the absence of DNF, the shaft of the femur receives irrigation from the periosteal vessels. In the present study, all the nutrient foramina were directed towards the proximal end of the femora (Away from the growing end). One end of the bone growing faster than the other contributes to the direction of nutrient foramen.

Based on the size of the defect to be covered, either long or short vascularised bone graft may be indicated. The anterior and lateral surfaces are safe for orthopaedic manipulations due to scarcity of nutrient foramina. In transplant techniques, diaphyseal vascularity should be maintained by preserving the DNF. Also, if endosteal vascularisation is to be included, the segment of donor bone to be grafted must contain DNF.

Carroll et al. opined that any damage to the precise area of nutrient foramen or nutrient canal or nutrient artery by traumatic or iatrogenic reasons may result in delayed union or non-union as healing process is dependent on blood supply. Hence, the knowledge on incidence, position and distribution of the nutrient foramina is important for a clinician. The present study provides information about the size, direction and distribution of diaphyseal nutrient foramina in adult dried femurs of coastal Karnataka region.

Limitations of the Study
The present study was done on the small sample size. Moreover, the age and gender differences were not considered in this study. The gender differences might alter the position and morphology of nutrient foramina in males and females. Moreover, the nutrient foramina of the long bones might be altered during growth; hence, the sample of long bones confined to a specific age group would be better. Hence, further studies carried on with a larger sample size would provide larger database which will outline the relationship and significance of number, size and location of nutrient foramen with bone metabolic activity level, static and dynamic stresses on different zones or segment of bone.

CONCLUSION
The current study concludes that the occurrence of single DNF is greater than double DNF when considered in western coastal region of south India. Majority of nutrient foramina were seen in the middle 1/3rd of posterior surface of femur. The anterior and lateral surfaces are ideal locations for orthopaedic interventions due to scarcity of nutrient foramina on these surfaces. Thus, the knowledge on localisation of DNF helps the clinicians involved in surgical procedures. This knowledge is also useful for the orthopaedicians in evaluation of stress fractures.

REFERENCES