Correlation between number and size of nutrient foramina to bone length: An anatomical study in lower limb long bones

Agrawal Nidhi, Arjun singh Parmar, DC Naik

Abstract

Background: The maintenance of normal longitudinal growth of bone is dependent upon a sufficient blood supply to the region of the epiphyseal cartilage line. Long bones are supplied by a nutrient artery that enters individual bones obliquely through a nutrient foramen. The aim of our study was to determine the number, position and size of nutrient foramina and if correlation exists between the length of the bone and number of nutrient foramina.

Material and Method: The study was done in Department of Anatomy, S.S. Medical College Rewa (M.P.). 201 adult human long bones of lower limb were collected from Department of Anatomy.

Results: In respect to number of nutrient foramina majority of bones have single nutrient foramina and most of the bones possess dominant foramina. No correlation was noted between number of nutrient foramina and length of the bone.

Conclusion: The findings in the present study was compared and analyzed with previous researchers. Information obtaining from anatomical description of these foramina is helpful to preserve the circulation of affected bony structures during orthopedic surgeries. It is also of relevance for those clinicians involved in surgical procedures where patency of the arterial supply to long bones is important.

Keywords: Lower limb long bones, Nutrient foramina (NF), Foraminal Index (FI), Dominant foramina (DF), Secondary foramina (SF), Total bone length (TL).

1. Introduction

Every long bone is supplied by number of arteries entering it through all aspects except areas covered by articular cartilage [1]. The blood supply to long bones are classically divided into three sets, medullary nutrient, epiphyseal – metaplateal and Periosteal [2]. The pathway for the nutrient artery comprises the nutrient foramen (NF) and nutrient canal (NC) on the diaphysis of long bones. Knowledge of these pathways is essential to conserve the main vessels during orthopaedic surgical procedures, such as bone grafting and fracture repair [3]. A nutrient artery is the principal source of blood supply to a long bone and is particularly important during its active growth period in the embryo and fetus, as well as during the early phase of ossification [4, 5]. During childhood, long bones receive about 80% of the interosseous blood supply from the nutrient arteries and in the case of their absence, the vascularization occurs through the periosteal vessels (Trueta, 1953). When this supply is compromised, medullary bone ischemia occurs with less vascularization of the metaphysis and growth plate [6]. So our present study focused to analyze the correlation between anatomical variation of nutrient foramina number and size to the bone length.

2. Materials and Methods

Random collection of 201 cleaned and dried long bones of human lower limb ie femur [81], tibia [70] and fibula [50] of both sides which are grossly normal and complete, obtained from the Department of Anatomy, S.S. Medical College Rewa (M.P.). All the bones belong to Indian subjects, the age and gender of which are not determined. After determining the side of each bone, they are serially numbered and photographed. The nutrient foramina are observed in all bones with the help of a hand-lens. They are identified by their elevated margins and by the presence of a distinct groove proximal to them [7]. Only well-defined foramina on the diaphysis are accepted. Foramina at the ends of the bone are ignored [8].
The following data is studied on the diaphyseal nutrient foramina of each bone

(A) **Number:** Bones were examined for the number of nutrient foramina. With the help of magnifying hand lens all surfaces and each border was thoroughly examined from proximal to distal end and both dominant and secondary foramina were counted and noted down.

(B) **Position:** The positions of all nutrient foramina were determined by calculating a foraminal index (FI) by using formula:

$$FI = \frac{DNF}{TL} \times 100$$  (Hughes1952; shulman 1959)

**DNF** = the distance from the proximal end of the bone to the nutrient foramen

**TL** = Total bone length.

3. Results

The results were analyzed and tabulated using the range, mean and standard deviation of foramina index determined.

**Table 1:** Number of nutrient foramina observed in long bones of lower limb

<table>
<thead>
<tr>
<th>Bone</th>
<th>Number of foramina</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femur</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Tibia</td>
<td>- 87 54 -</td>
</tr>
<tr>
<td>Fibula</td>
<td>2 58 - -</td>
</tr>
</tbody>
</table>

**Table 2:** Foraminal index and measurements associated with dominant nutrient foramina in the long bones of lower limb

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Femur</th>
<th>Tibia</th>
<th>Fibula</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNF</td>
<td>20.42±9.87</td>
<td>12.54±3.38</td>
<td>12.88±1.77</td>
</tr>
<tr>
<td>TL</td>
<td>43.67±2.04</td>
<td>37.75±3.32</td>
<td>35.80±2.53</td>
</tr>
<tr>
<td>FI</td>
<td>46.29±2.46</td>
<td>32.96±6.06</td>
<td>39.66±5.29</td>
</tr>
</tbody>
</table>

Data includes mean and standard deviation

Abbreviations: **DNF** = Distance of the nutrient foramen from the proximal end of the bone. **TL** = Total length of bone; **FI** = Foraminal Index.

**Table 3:** Range, Mean ± Standard deviation (SD) of foraminal indices observed in the long bones of lower limb

<table>
<thead>
<tr>
<th>Bone</th>
<th>Range</th>
<th>Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femur</td>
<td>30.35-64.97</td>
<td>46.29±2.46</td>
</tr>
<tr>
<td>Tibia</td>
<td>27.42-37.25</td>
<td>32.96±6.06</td>
</tr>
<tr>
<td>Fibula</td>
<td>35.92-68.79</td>
<td>39.66±5.29</td>
</tr>
</tbody>
</table>

4. Discussion

Our present study analyzes the following bone parameters in each:

**Correlation with the length:** The external opening of the nutrient canal, usually referred to as the nutrient foramen [12], has a particular position for each bone. Mysorekar [13] in his study on nutrient foramina long bones found no relation between length and number of foramina of bones which supports the finding in present study. As such no any data is available to confirm that bone length is directly proportional to number of nutrient foramina. For example the maximum length of femur was up to 45-47 cm either it consist of one NF or three. It is also obvious that hormones like Growth hormone, Androgens and Estrogens play a vital role in adolescent age for maintenance of bone growth [14]. Probably the nutrient foramina will remain the same since they are concerned with intraosseous plexuses within the medullary cavity for regeneration of the blood and formation of bone marrow as suggested by Trueta.

**Number of the nutrient foramina:** In the present study 78% femora possessing single dominant nutrient foramina, while 22% bones had double dominant nutrient foramina. That shows the majority of bones have single nutrient foramina which may represent the single source of blood supply. This is in agreement with previous studies reported by Kizilkanat et al [6], Pereira, G. A. M.; Lopes [15].

In the present study 100% tibiae possessing single dominant nutrient foramina. This is in agreement with previous studies reported by Kulkarni et al [10], Tejaswi H. L. [17], and Kizilkanat et al.

In this study, 04% fibulae we did not find any nutrient foramen and 96% presented a single dominant nutrient foramen. Similar data had been reported by Kizilkanat et al., BV Murlimanju, Pereira, G. A. M.; Lopes, P. T. C.; Santos, A. M. P. V. & Silveira, F. H. S.

**Size of Nutrient Foramina:** Our present study shows that about 76% nutrient Foramina of femur were dominant in nature and 24% were secondary. This result is also follows the previous studies.

In the tibiae studied 100% nutrient foramina were dominant in size. This is in agreement with previous studies reported by Kizilkanat et al., BV Murlimanju & Tejaswi H. L.

In this study of fibulae 82.75% foramina were dominant in size and 17.24% were secondary in size. Similar results reported by Kizilkanat et al., BV Murlimanju & Dr. Shamsunder Rao V [18].

5. Conclusion

The present study confirms information on the, number, size and position of the nutrient foramina on the lower limb long bones in populations of the Rewa region. There was no significant association between nutrient foramina parameters with bone length. The parameters of the nutrient foramina in the femur, tibia and fibula as reported will be useful to prevent intra operative injuries and poor prognosis during procedures such as vascularised bone grafting, fracture repair, tumour resections and any other orthopaedic interventions among the Rewa region populations.
Fig 1: lower limb long bones

Fig 2 and 3: Showing using of hand lens and nutrient foramen

Fig 4: Measurement of total length of femur

Fig 5: Measurement of total length of tibia

Fig 6: Measurement of total length of fibula

References
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