Research Paper

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Nutrient Foramina in the Upper and Lower Limb Long Bones: A Morphometric Study in Bones of Western Uttar Pardesh

Medical Science

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ABSTRACT

The major blood supply to long bones occurs through the nutrient artries, which enter through the nutrient foramina. The supply is essential during the early phase of ossification and in procedures such as bone graft, tumor resections, traumas and in transplant technique in orthopedics. The present study analyzed the number of nutrient foramina in the diaphysis of ; 70 humeri ,60 (radii, ulnae, femora, tibiae, fibulae & clavicle). The nutrient foramina is predominant on the anterior aspect of upper limb and on the posterior aspect of the lower limb long bones. The mean of foraminal number was 56.94 % for humeri, 37.76% for radii, 36.98%for ulnae, 46.60% for femora, 34.49% for tibiae, 45.73% for fibulae, 51.14% for clavicle. Present study analyzed data corresponding to the population of western Uttar Pardesh providing ethnic data to be used for comparison and that may help in surgical procedures.

Introduction

Nutrient foramen is an opening into the bone shaft which gives passage to the blood vessels of the medullary cavity of a bone. The major blood supply to long bones occurs through the nutrient arteries, which enter through the nutrient foramina. This supply is essential during the growing period, during the early phases of ossification(1). 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 (2). There are considerable intracortical anastomoses between the inner medullary and outer periosteal vessels. (3) Some pathological bone conditions such as developmental abnormalities, fracture healing or acute hematogenic osteomyelities are closely related to the vascular system of the bone (4). Detailed data on the blood supply to the long bones and the association with the areas of bone supplied has been continued to be a major factor in the development of new transplantation and resection techniques in orthopaedics (5).

However, there is still a need for a greater understanding of the location and number of nutrient foramina in long bones. Importance of nutrient foramen is relevant to fracture treatment. Combined periosteal and medullary blood supply to the bone cortex helps to explain the success of nailing of long bone fractures particularly in the weight bearing like femur and tibia and deploying grafts of vascularised fibula bone in bony defects due to trauma.

Mysorekar et al (1967) stated that nearly half of humeri had a single nutrient foramen and the rest had more than one foramen. Regarding majority of radii and ulnae observed a single nutrient foramen, and reported few specimens with no foramen. He found that half of femora had more than one nutrient foramen, while the majority of tibiae and fibulae had a single nutrient foramen. He could not detect nutrient foramina in 3.9% of fibulae (6).

Longia et al. (1980) observed a single foramen in about 50% humeri, two in 13% and none in 2%. All of radii have a single nutrient foramen & majority of all ulnae examined had a single except fewer with double and triple foramina. In the femora, they observed double nutrient foramina in less than half of specimens; the majority of tibiae and fibulae studied had a single nutrient foramen (7).

Forriol Campos et al. (1987) analyzed a single nutrient foramina in (75%) and two in the rest humeri, while in all radii and ulnae only a single nutrient foramen. They observed a single in 50% & three foramina In 10% femora. A single nutrient foramen in the majority of tibiae (90%), and rarely double foramina. However, a single nutrient foramen was observed in all fibulae examined (8).

Nagel (1993) recorded (80%), single & double foramina in remaining humeri, a single nutrient foramen in all radii and ulnae and reported double nutrient foramina in 80% of femora examined. In 10% a single while triple foramina were identified in 10%. There was a single nutrient foramen in almost of the tibiae examined (9).

Material & Methods

The material of the present study consisted of 430 adult human cleaned and dried bones of the upper and lower limbs which included 70 humerus,60 radius,60 ulna,60 femur,60 tibia,60 fibula and 60 clavicle . They were obtained from the Department of Anatomy, Teerthanker Mahaveer Medical College, Moradabad Uttar Pardesh. Bones which had gross pathological deformities were excluded from the study. All the bones were macroscopically observed for the number and location of nutrient foramina. A magnifying lens was used to observe the foramina. A 24 gauge needle was passed through each foramen to confirm their patency.

The following data was studied on the diaphyseal nutrient foramina of each bone .

Number:- Bones were examined for the number of nutrient foramina .

Location:- The position of all nutrient foramina was determined by calculating a foraminal index (FI) by applying the Hughes formula, dividing the distance of foramen from the proximal end (D) by the total length of bone (L) which was multiplied by hundred.

FI= D/Lx100

The positions of foramina was divided into three type according to FI as follows:-

Type1:-FI up to 33.33, the foramen was in proximal third of the bone.

Type2:-FI from 33.33 upto 66.66, the foramen was in the middle third of the bone.

Type3:-FI above 66.66, the foramen was in the distal third of the bone.

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

Name of bone	Number Of Foramina				
	0	1	2	3	4
Humerus	1	63	5	1	-
Radius	-	60	-	-	-
Ulna	1	57	2	-	-
Femur	1	33	26	-	-
Tibia	-	57	3	-	-
Fibula	-	57	3	-	-
Clavicle	-	54	6	-	-
Total Bones	3	381	45	1	-

Range , mean and Standard Deviation of bones		
Bones	Range	Mean ± SD
Humerus	38.88% to 73.21%	56.94 ± 7.37
Radius	26.72 - 46.64%	37.76 ± 3.92
Ulna	28.38 - 49.56%	36.98 ± 5.17
Femur	29.85% - 63.21%	46.6 ± 11.25
Tibia	27.35% - 45.97%	34.49 ± 4.42
Fibula	25% - 65.21%	45.73 ± 12.26
Clavicle	30% - 76.92%	51.14 ± 11.34

Location according to Foraminal Index			
Bones	Type 1	Type 2	Type 3
Humerus	4(5.2%)	69(90.7%)	3(3.9%)
Radius	26(43.3%)	34(56.6%)	-
Ulna	22(36.06%)	39(63.93%)	-
Femur	13(15.2%)	71(83.5%)	1(1.17%)
Tibia	57(90.47%)	6(9.52%)	-
Fibula	-	64(96.96%)	2(3.03%)
Clavicle	4(6.1%)	61(92.4%)	1(1.5%)

Discussion
Number of Nutrient Foramina:-
In the present study, single nutrient foramen has a higher percentage (90%) in the humerus, compared to that of double (7.1%) and triple foramina (1.4%) respectively. Many studies reported high percentage of single nutrient foramen approximately similar to that of the present result (Shulman et al, 1959; Mysorekar, 1967;). Some studies reported less percentage (50 to 75%) of a single nutrient foramen (Longia et al., 1980; Nagel, 1993).On the other hand some researchers found double nutrient foramen in 8.6% (Shulman et al, 1959), 20% (Nagel, 1993).

In the present study all the radius examined had a single nutrient foramen. The same finding was reported by Forriol Campos et al. (1987) and Nagel (1993). In other studies, the majority of radius were found to have a single nutrient foramen (Longia et al., 1980; Kizilkanat et al.,2007).

In the present study 96% of ulnae examined had a single nutrient foramen and 1.66% no nutrient foramina. Double nutrient foramina were observed in the 3.3% of the ulnae examined. Other studies reported a single nutrient foramen in more than 91% of ulnae(Longia et al., 1980; Forriol Campos et al., 1987;). Some researchers found double nutrient foramen in few ulnae (Shulman, 1959;),

In this study, 55% of the femora examined had single nutrient foramina, while 43.37% had two nutrient foramen and 1.66% had no nutrient foramina.

Many studies reported that the majority of femora studied had a single foramen in most specimens (Lutken, 1950; Motabagani, 2002;), while some authors stated that the majority of femora studied had double nutrient foramina (Mysorekar, 1967; Collipal,2007). Like the present study some researchers found three nutrient foramina in small number of femur (Gumusburun et al., 1994; Collipal, 2007). On the other hand some studies found nutrient foramen upto 6 to 9 (Sendemit and cimen, 1991), while some studies found the absence of nutrient foramina (Mysorekar, 1967; Motabagoni, 2002).

In this study, 95% of the tibiae examined had a single nutrient foramen. Double nutrient foramina were observed in 5% of tibia examined. The present study is very similar with previous studies as they reported the presence of a single nutrient foramen in at least 90% of the tibiae, they also reported the presence of double nutrient foramina in some of the tibiae (Mysorekar, 1967; Longia et al., 1980;).

In the fibulae studied, 90% of the bones presented a single nutrient foramen, while 10% of the bones possessed double nutrient foramina. Similar data had been reported by Mysorekar (1967), Longia et al. (1980), Guo (1981), , while Mckee et al. (1984) reported fibulae with three nutrient foramina. On the other hand, Gumusburun et al. (1994) and Kizilkanat et al. (2007) reported fibulae with no nutrient foramina.

In this study 90% of the clavicle had a single nutrient foramen, while 6 (10%) had two foramina. Our findings are very similar to Longia et al. 1980 who found most of the single nutrient foramen in comparison to less double nutrient foramen. On the other hand some researchers found more double (44.2) nutrient foramen in comparison to single (38.5) nutrient foramen (Urlimanju BV et al. 2011)

Location of Nutrient Foramina:-
In the present study, 90.7% of the nutrient foramina were located along the whole middle third of the humerus, with the foramen index ranging between 38.88% to 73.21% of the bone length. The same location of the nutrient foramina were founded by different researchers (Mysorekar, 1967; Longia et al., 1980;).

In the present study, 56.6% of the total nutrient foramina were distributed in the middle third of the radius and 43.3% were in the proximal third, with the foramen index ranging between 26.72 and 46.64% of the bone length. The present study is very close to the study of Mysorekar (1967). On the other hand, some reports such as those of Shulman (1959), and Kizilkanat et al. (2007) stated that the majority of nutrient foramina were located in the proximal third of the bone.

In this research we found in ulna majority of the nutrient foramina 62.5% were in the middle third and 37.5% were in the proximal third of the bone, with the foramen index ranging between 28.38 and 49.56% of the bone length. No nutrient foramina were found in the distal third of the ulna. Reviewing the literatures, some authors reported that the majority of nutrient foramina were located in the middle third (Mysorekar, 1967) while others stated that most of foramina were in the proximal third (Shulman, 1959; Longia et al., 1980). However, all authors agreed that there were no nutrient foramina in the distal third of the ulna.

The blood supply to the sites of muscle attachment to the proximal half of the radius and ulna is directly reinforced by the nutrient arteries. There are, however, no significant muscle attachments to the distal half of the radius and ulna, corresponding to a general lack of nutrient foramina. Delayed or nonunion in the middle or lower diaphysis following trauma may be directly related to the absence of the nutrient arteries entering the bones in these areas (Kizilkanat et al., 2007). The posterior surface of both radius and ulna often lack nutrient foramina especially in the middle and dorsal diaphysis. That is why the dorsal localization for the plate is preferred during operative procedure (Giebel et al., 1997).

In the present study, most of the nutrient foramina (83.5%) were located along the middle third of the femur; the rest were in the proximal third, with no foramina detected in the distal third of the femur. These results are similar to the findings of Laing (1953), Mysorekar (1967),.

In the present study, 90.47% of the nutrient foramina in the tibiae were in the proximal third, with the foramen index ranging between 27.35 and 45.97% of the bone length. Nutrient foramina were located in the middle third in the rest of the tibiae examined (9.52%). There were no foramina in the distal third. Our findings are similar to previous findings. In previous studies researchers found most of the nutrient foramina in proximal third of the tibia (Mysorekar, 1967; Longia et al., 1980;).

On the other hand, Kizilkanat et al. (2007) found that most of nutrient foramina were located in the middle third of the bone length.

The areas or regions with a good blood supply are more rapidly healed than those with a poor blood supply. Because of the absence of nutrient foramina in the distal third of the tibia, fractures in that region tend to show delayed union or malunion (Trueta, 1974).

In the present study most of the nutrient foramina of the fibula were situated in the middle third of the bone (96.96%), with a foramen index ranging between 25% and 65.21% of the bone length. The rest of the nutrient foramina (3.03%) were located in the distal third of the bone. These results were similar to most of the previous studies (Mysorekar, 1967; Mckee et al., 1984;). Some researcher reported that the majority of the foramina were located on proximal third of the bone (Guo et al., 1981)

Knowing the variations in the distribution of the nutrient foramina is important preoperatively, especially regarding the fibula used in bone grafting. In the majority of the specimens, the nutrient foramina were located in the middle third of the fibula, which is the segment that must be used for the transplant, if one desires that the implant include endosteal vascularization and peripheral vascularization (Mckee et al., 1984; Collipal et al., 2007).

In the present research 92.4% nutrient foramina were found at the middle 1/3 part of clavicle with the foramina index ranging from 30% to 76.92%, 6.1% nutrient foramina at the lateral 1/3 part and 1.5% at the medial 1/3 part of the clavicles. It is very important that the nutrient blood supply is preserved in free vascularized bone grafts so that the osteocytes and osteoblasts in the graft survive, and the healing of the graft to the recipient bone is facilitated with the usual replacement of the graft by creeping substitution (Gumusburun et al., 1996).

Conclusion

The study confirmed previous reports regarding the number and position of the nutrient foramina in the long bones. The analysis on the nutrient foramina distribution indicates that they are located predominantly on the anterior surface in long bones of the lower limbs, which corroborates with previous results on the localization of nutrient foramina in the flexor surface of those bones.

It also provided important information to the clinical significance of the nutrient foramina. Accordingly, a well understanding of the characteristic morphological features of the nutrient foramina by orthopaedic surgeons is recommended.

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