ORIGINAL ARTICLE

DIAPHYSEAL NUTRIENT FORAMINA IN DRIED HUMAN ADULT LONG BONES OF UPPER AND LOWER LIMBS IN PAKISTAN

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ABSTRACT

Background: The circulation of blood in the bones is necessary for osteogenesis, maintenance of bone vitality, bone growth and repair of fracture and other injuries. The nutrient foramina are holes that allow blood vessels to pass through the bone cortex.

Methodology: This was a cross-sectional study conducted from February 2013-Sep-tember 2013, at the department of Anatomy, Ayub Medical College (Osteology Sec-tion), Abbottabad and Department of Anatomy, Khyber Medical College (Osteology Section), Peshawar with the due consents of the heads of the institutions. The aim of the present study was to observe the diaphyseal nutrient foramina in the human upper and lower limb long bones. This study was done on 180 human long bones, consisting of humerii, radii, ulnae of upper limb and femora, tibiae and fibulae of lower limb bones with 30 bones each..

Results: Our study was conducted on 180 long bones of upper and lower limbs. More than 80% of the long bones of upper and lower limbs had single nutrient foramen, whereas occurrence of double nutrient foramina was around 18%. Direction of nutrient foramina in case of humerus was distal, where as in cases of radius and ulna direction was proximal. In case of femur direction of nutrient foramina was proximal where as in cases of tibia and fibula most of nutrient foramina were directed distally.

Conclusion: The present study has provided additional information on the morphology, foramina index and topography of the nutrient foramina in the upper and lower limb long bones. The anatomical data is important to the clinicians as the micro-vascular bone transfer is becoming popular.

Key Words: Nutrient foramina, bone vitality, humerii, radii, ulnae, femo-ra, tibiae, fibulae, bone cortex.

This article may be cited as: **Afzal E, Masood A, Sherin F, Ullah N. Diaphyseal nutrient foramina in dried human adult long bones of upper and lower limbs in pakistan. Adv Basic Med Sci. 2017; 1(1): 30-34.**

INTRODUCTION

The circulation of blood is necessary for the osteogenesis, maintenance of bone vitality, bone growth and repair of fracture and other injuries[1]. The long bones are usually supplied by three sources: epiphy-seal-metaphyseal vessels at the ends of bones, one or more arteries that enter the diaphysis, the nutrient arteries and the periosteal vessels[2]. The six groups of arteries that supply the long bones are proximal epiph-yseal, proximal metaphyseal, diaphyseal nutrient, distal metaphyseal, distal epiphyseal and periosteal arteries. The adjacent groups of arteries anastomose freely with each other so that if an infarction occurs due to failure of one group the other group can easily compensate for it[3] . Blood supply to the diaphyseal cortex gets 10% of its blood supply by nutrient artery and 90% of blood supply to marrow is also done by nutrient artery. The nutrient arteries divide into ascending and descending branches after they enter the diaphysis. The lateral branches radially extend outwards from the endosteal surface towards the diaphyseal cortex, supplying the Haversian canals and thus supplying the cortex. The blood flows by entering the endosteal sur-face of the cortex from the nutrient medullar system and leaving through the periosteal surface[4]. The ends of the bones are supplied by the terminal branches of the main ascending and descending branches of the nutrient artery.

These blood vessels enter the epiphysis and metaphysis through small foramina. These foramina are called the nutrient foramina. These arteries branch into Hunter's "vascular circle" that penetrates into the epiphyseal-metaphyseal area where these vessels are arranged like the spokes of wheel. The vessels af-ter entering the bone forms capillary arcades, which loops beneath the articular cartilage. There is inflow of blood from the outside to the inside of bone and this system anastomose with the nutrient artery system[4].

The vascular arrangement in cancellous bone is very important because 80% of remodeling activity in mature bone occurs in cancellous bone. The marrow fills up the spaces in the cancellous bone. The vascular supply plays an important role in calcium homeosta-sis also. The venous drainage occurs at the ends of long bones. The small venules travel in the cortex and drains periosteally and endosteally. The central med-ullary sinus and periosteal venous system are connect-ed by large veins[4].

A major contributor to the vascularity of the bone is the periosteum, which is a fibro-elastic covers the bone surface. The periosteal activity influenc-es the behavior of the entire bone5. Maintenance of the shape of the bone is dependent on the periosteal membrane. Physiological division of electro-chemi-cal potential and metabolic ion exchange, difference across its structure5.

The pre-lymphatic system of bone discharges pro-teins and other substances from the interstitial fluid system into the periosteal veins. The specific contri-bution of the periosteum towards the peripheral med-ullary arterial blood is as far as the exterior 1/3rd of cortex at the places of facial attachments of 20%[6].

The important source of blood when the nutrient medullary blood supply is damaged or suppressed is by the endothelial tubes in the bone originating from the arterioles of the periosteum. Researchers have shown the ability of the periosteal circulation to act as com-pensatory blood supply when blood flow is disrupted by maintaining the outer cortex vascularity and following reversal of the centrifugal direction, to re-vascularize the cortex when there is compromise of the medul-lary blood supply. It is shown that there is a network of arteries similar to the network of nutrient arteries that is present in the layers of the periosteum contin-uous with the intra-cortical circulation. Oni and Gregg showed that periosteal afferent vessels can penetrate the cortex and the marrow cavity from the outer sur-faces by the creation of a diaphyseal segment. At the location of the cut new sub-periosteal bone formation and cartilage were observed. The cortical vessels in the segment were not perfused and no new bone formation was seen suggesting that periosteal circulation is essential for the normal functioning of medullary circulation[7]. Some researchers have demonstrated cortical and medullary revascularization via longitudinal cortical vascular channels (Davies, et al.,2005). The overall blood supply to the bones cannot be affected if the nutrient artery is damaged as the periosteal and medullary circulation can supply blood to the diaphy-sis[8]. After the interruption of the periosteal supply, the afferent vessels from nutrient artery were able to penetrate the cortex. There was rapid restoration of the periosteal blood supply after damage, but it was not understood whether it was due to formation of a new blood vessel or there was increase in the perfusion in the pre-existing vessels[9]. The diaphysis of the cortex was also supplied blood potentially by the periosteal and medullary circulations[3]. The circulation of blood in the bone helps in mineral metabolism, haematopoi-esis and mobilization of bone cells in bone and bone marrow. It is also important for the vitality of bone, osteogenesis and for the growth and repair of bone.

Nutrient Canal

All the bones possess small or large foramina that are for the entrance of the blood vessels. These foramina are known as the "Nutrient Foramina", and these are larger in size particularly in the long bone shafts where these lead into a nutrient canal, leading in medullary cavity[10]. Nutrient arteries and veins pass through these canals. These nutrient canals are found in both long and irregular bones. In long bones these foramina are found in the shaft while in irregular bones these are found at other locations.

It has been suggested that the direction of the nutrient foramina is determined by the growing end of the bone, which grows faster than the non-growing end. The nutrient vessels move away from the growing end of the bone. Regarding the direction of nutrient foramina, variations have been observed. This study was aimed to determine the direction, size, obliquity, position and number of nutrient foramina in human adult long bones of upper and lower limbs.

RESULTS

Humerii

Number: Out of 30 humerii examined 67% had a single nutrient foramen and 30 had double nutrient foramina, whereas 3.3% had 3 foramina.

Direction: In all humerii nutrient foramina were di-rected distally.

Table 1: Number of diaphyseal nutrient foramina seen in long bones of upper limb

Bone	Number of bone	Number of Foramina	Percentage
Humerus (n=30)	20	1	66.6%
	9	2	30.3%
	1	3	3.3%
Radius (n=30)	30	1	100%
Ulna (n=30)	26	1	86.6%
	4	2	13.3%

Table 2: Direction and position of diaphyseal nutrient foramina in long bones of upper limb

Bone	Number of bone			Number of Foramina
	Type-1	Type-2	Type-3	
Humerus	4(9.09%)	38(86.36%)	2(4.5%)	Distally
Radius	15(50.0%)	15(50.0%)	-	Proximally
Ulna	10(31.25%)	22(67.7%)	-	Proximally

Table 3: Number of diaphyseal nutrient foramina seen in long bones of lower limb

Bone	Number of Bone	Number of Foramina	Percentage
Femur (n=30)	14	1	46.6%
	16	2	53.4%
Tibia (n=30)	30	1	100%
Fibula (n=30)	26	1	81.29%
	4	2	18.75%

Table 4: Direction and Position of the nutrient foramina in long bones of lower limb

Bone	Position			Direction
	Type-1	Type-2	Type-3	
Femur	10(20.8%)	38(79.16%)	-	Proximally
Tibia	25(83.3%)	5(16.6%)	-	Distally
Fibula	-	35(97.2%)	1(2.7%)	28 Distally 8 Proximally

Radii

Number: In all the 30 radii examined, 100% had a single nutrient foramen. Direction: In all radii examined nutrient foramina were directed proximally.

Ulnae

Number: Out of 30 ulnae examined, 86.6% had a single nutrient foramen whereas 13.3% had double nu-trient foramina. Direction: In all the ulnae examined, the nutrient foramina were directed proximally.

Femora

Number: Out of 30 femora examined, 46.6% had a single nutrient foramen and 53.4% had double nutrient foramina. Direction: In all the femora, the nutrient foramina were directed proximally.

Tibiae

Number: All the 30 tibiae examined had a single nu-trient foramen. Direction: In all tibiae examined, the nutrient foramina were directed distally.

Fibulae

Number: Out of 30 fibulae examined, 81.25% had a single nutrient foramen, while 18.73% showed double nutrient foramina.

Direction: Out of the 36 nutrient foramina seen in the fibulae, 77.71% were directed distally while 22.2% were directed proximally.

DISCUSSION

The nutrient canal or the nutrient foramen has a particular position for each bone. There is a jingle for the direction of the nutrient foramina. “It seeks the elbow and flees the knee.” This means that in the upper limb it is directed towards the elbow (directed towards the upper ends of radius and ulna and lower end of humerus), while it is directed away from the knee in the lower limb (directed towards the lower ends of tibia and fibula and upper end of femur). The reason for this is that one end of the bone grows faster than the other.

Number of Nutrient Foramina

According to studies, humerus usually has two nu-trient foramina (42%) and they occur just below the middle part of the bone or in the radial groove, or usually in both these locations. However we observed the double nutrient foramina of humerus in 30.3% of the cases.

A study conducted showed the occurrence of double nutrient foramina in humerus to be 13%. In our study the occurrence of double foramina was 30.3% which is higher than the studies conducted showed the pres-ence of triple nutrient foramina in our study was 3.3% in the humerii... In our study we did not observe any humerus without nutrient foramina. Others reported the presence of four nutrient foramina in the humerii (1%). In our study we did not observe any humerus that had four nutrient foramina.

In the present study on the radii, we observed that all the 30 radii had a single nutrient foramen. Previous studies conducted also reported a single nutrient fora-men in the majority of the radii (90%). Previous studies conducted also showed the absence of nutrient fora-men in the radii but in our study we did not observe any radii which showed no nutrient foramina.

In the present study, the majority of ulnae we ex-amined showed single nutrient foramen (86.6%) and (13.3%) showed double nutrient foramina.. similar to the ones in this study for the presence of a single nu-trient foramen and they reported 9% of the bones with two nutrient foramina.

Study conducted showed that all the ulnae he ex-amined had a single nutrient foramen. These results are not in accordance with the present study in which we observed a single nutrient foramen in (86.6%) of the ulnae examined and (13.3%) showed double nu-trient foramina. Studies conducted the presence of three foramina in (1%) of the bones he examined. In the present study, out of 30 femora examined, (46.6%) showed a single nutrient foramen and (53.4%) showed a double foramina. Previous studies conducted showed the presence of single nutrient foramen in the major-ity of the femora they examined. Studies conducted; showed the presence of three nutrient foramina in a few bones they examined. In the present study we did not observe any femora with three nutrient foramina. In some studies conducted, they observed more than six nutrient foramina in some of the femora they ex-amined.

Some studies conducted showed the absence of nu-trient foramina in some of the femora they examined. The present study conducted upon the tibia showed that the entire tibia had a single nutrient foramen. In the present study 81.29% of the fibulae had one nutrient foramen, while 18.7% of the fibulae had two nutrient foramina. In a study conducted almost all the fibulae had at least one nutrient foramen, while 0.8% had two nutrient foramina. In our study the incidence of two nutrient foramina is more (18.7%) than their studies.

Direction of Nutrient Foramina

In our present study the nutrient foramina were di-rected away from the growing end of the humerus. A study conducted also showed the same results.

The direction of nutrient foramina in radii exam-ined in our study was proximal. The ulnae examined in our study had the nutrient foramina in proximal di-rection. Our study is in accordance with other studies, who stated that the nutrient foramina on the shaft of ulna entered obliquely and were directed towards the elbow.

In our study on femora, all the nutrient foramina were directed proximally away from the growing ends. In other studies, the nutrient foramina are directed distally in 1% and 0.5% of femora respectively.

Our study confirmed the previous studies conducted on tibiae suggesting that the nutrient foramina were directed away from the knee study confirmed our re-sults. On the other hand study showed that nutrient foramina were directed towards the knee in 3.5% of the examined tibiae.

In studying fibulae the direction of nutrient foram-ina was distal in 77.1%, while proximal direction was seen in 22.2% of fibulae. In study conducted by Longia, et al., (1980) he reported nutrient foramina having a proximal direction in 9.5% of fibulae examined in study showed variations in the direction of nutrient foramina in fibula only.

CONCLUSION

The present study has provided additional informa-tion on the morphology, foraminal index and topogra-phy of the nutrient foramina in the upper and lower limb long bones. The anatomical data is important to the clinicians as the micro-vascular bone transfer is becoming popular.

The exact position and distribution of the nutrient foramina in bone diaphysis is important to avoid any damage that may occur to the nutrient vessels during surgical procedures.

Our study confirmed the previous reports regarding the number and position of the nutrient foramina in the human long bones of the upper and lower limbs. It also provides important information to the clinical significance of the nutrient foramina. Accordingly, an understanding of the characteristic morphological fea-tures of the nutrient foramina by the orthopaedic sur-geons is recommended. Exact position and distribution of the nutrient foramina in bone diaphysis is important to avoid damage to the nutrient vessels during surgical procedures.

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