Study of diaphyseal nutrient foramina of humerus

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Abstract:
Background & Objectives: To know the number, direction and common position of nutrient foramina and its variation and to determine the caliber of diaphyseal nutrient foramina. **Material and method:** The present study was conducted on 100 adult human dried humeri, of unknown age and sex, from the department of Anatomy, B. J. Medical college, Ahmedabad. The nutrient foramina were observed with the help of a hand-lens. They were identified by their elevated margins and by the presence of a distinct groove proximal to them. Only well-defined foramina on the diaphysis were accepted. **Result:** Present study found single foramen seen in 72% cases, double foramina found in 15% cases, triple foramina found in 2% cases while in 11% cases foramen was absent. In this study most common location of nutrient foramen was on the antero-medial surface (79.7%) of humerus, 51.9% were dominant foramina and 48.1% were secondary foramina.. Direction of nutrient foramen was towards the elbow i.e. away from growing end. **Conclusions:** Knowledge of this position can help the surgeons as it is the zone during surgical interventions for fractures in the middle 1/3rd of humerus. It will help to prevent intra-operative injuries in orthopedics such as fracture repair, bone grafting, vascularized bone microsurgery, intra-medullary plating etc. as well as plastic surgeries.

Keywords: Humerus, Nutrient foramina.

Introduction

Nutrient foramen has been described as the site of entrance of one or two of the larger vessels into the shafts of a long bone. Its position is fairly constant in different specimens of same bone, the tunnel into which it leads is the nutrient canal; the vessels which pass through it is called nutrient artery and vein and they convey blood to and from the yellow marrow and the substance of the shaft.[1]

Accidental ligation of nutrient artery of a long bone leads to an immediate decrease in blood flow. Disruption of nutrient artery in growing bone can result in necrosis of large portion of marrow & of inner 2/3 of cortex. Loss of circulation in terminal vessels of nutrient artery of growing bone will interfere with endochondral ossification.[2]

In a child, the nutrient arteries provide 70-80% of blood supply to long bones. When this supply is compromised, medullary bone ischemia occurs, with the metaphyses and growth plate both becoming less vascularized.[2]

Study (Kizilkanat et al. (2007) has stated that the position of the nutrient foramina was directly related to the requirements of a continuous blood supply to specific aspects of each bone, for example where there were major muscle attachments.[3] It might be that, being more bulky, stronger and more active, flexors need more blood supply compared to extensors of limbs.[4]

Clinical fracture of a long bone is usually accompanied by the rupture of the nutrient artery with variable disruption of the peripheral vessels associated with periosteal detachment.[4]

In free vascular bone grafting, the nutrient blood supply is extremely important and must be preserved to promote fracture repair, a good blood supply being necessary for osteoblast and osteocyte cell survival, as well as facilitating graft healing in the recipient.[4]

An understanding of the location, number, direction and caliber of diaphyseal nutrient foramina in long bones is very important clinically, especially in orthopedic surgical procedures such as joint replacement therapy, fracture repair, bone grafting, vascularized bone micro surgery, peripheral vascular occlusive disease, longitudinal bone growth, non-unions, transplantation and resection techniques as well as intra-medullary reaming and plating.[2]

Besides the academic aspect, detailed information of nutrient foramina may be of great importance in medico-legal practice. Sometimes

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incomplete bones, broken at one end, are sent for determination of the height of the individual. If the ratio between the total length of a bone and the distance of the nutrient foramen from any of the two ends can be established, the total length of the bone concerned can be found out and from that the height of the individual can be calculated.[2]

Knowledge of this foramina will be useful incertain surgical procedures to preserve the circulation.[5] The findings are important for the clinicians who are involved in bone graft surgical procedures.

Material and Method

The present study was conducted on 100 adult human cleaned and dried humeri. They were obtained from the Department of Anatomy, B. J. Medical College,,Ahmedabad, Gujarat. All selected bones were normal with no appearance of pathological changes. The specific age and sex characteristics of the bones studied were unknown.

Each humerus was numbered serially with a marking pen to help in identification. Their side (Left or Right) was determined. The nutrient foramina were observed in all bones with the help of a hand-lens. They were identified by their elevated margins and by the presence of a distinct groove proximal to them. Only well-defined foramina on the diaphysis were accepted. Foramina at the ends of the bone were ignored. The following data were studied on the diaphyseal nutrient foramina of each bone.

1) The Total Length (TL)

The total length (TL) of each bone was measured with the help of osteometric board and recorded closest to a millimeter. Determination of the total length of the individual bones was done between superior aspect of the head and most distal aspect of the trochlea.

2) The Distance of the foramen or foramina from the upper end of the bone (DNF)

The Distance of the foramen or foramina from the upper end of the bone was measured by means of Vernier calipers and recorded as DNF. The Range of distance of nutrient foramen from upper end and the mean of distance of nutrient foramen from upper end was obtained and recorded.

The Foraminal Index (FI) for each nutrient foramen was obtained using the formula:

FI = DNF/TL x 100

Where DNF was the distance from the proximal end of the bone to the nutrient foramina and TL was the total length of the bone. Thereafter the mean of Foraminal Index, Least Foraminal Index and the Highest Foraminal Index for each long bone was determined and recorded.

3) Total number of Nutrient Foramina

The diaphyseal nutrient foramina were observed in all the bones carefully with a hand-lens and the total number of foramina present on any surface or border was recorded. Where a bone had more than one foramen, the relative sizes of the foramina were recorded to determine, which was the main foramen and which was accessory. In bones where there was doubt as to the nature of a foramen, a fine wire was passed through it to confirm that it did enter the medullary cavity. Foramina at the ends of the bone were not taken into account.

4) The Location Of Nutrient Foramen:

All the surfaces of the bones were scrutinized in a regular order. Foramina within 1 mm from any border were taken to be lying on that border.

a) Position of foramina according to FI:
   The position of the foramina was divided into three types according to FI as follows:
   Type 1: FI up to 33.33, the foramen was in the proximal third of the bone.
   Type 2: FI from 33.33 up to 66.66, the foramen was in the middle third of the bone.
   Type 3: FI above 66.66, the foramen was in the distal third of the bone.

5) The Directions of the nutrient foramina:

There is a jingle for the direction of foramina that "To the Elbow I Go, From the Knee I Flee." The directions of the obliquity of the nutrient foramina and their canals were noted. And it was recorded as 'up' or 'down' with respect to the proximal end of the humerus.

6) Caliber of the foramen and canal:

Hypodermic needles of gauge 20 and gauge 24 were used to measure the caliber of the foramen and canal. If the size 20G passed through the nutrient foramen satisfactorily, it was classified as 'Large' sized. If the needle of size 24G passed through the foramen and size 20G did not pass through, the nutrient foramen was classified as

'Middle' sized. Both large and middle sized foramen was also categorized as being Dominant. If the needle of size 24G could not pass through the foramen it was classified as 'Small' sized or 'Secondary' nutrient foramen.

7) Photographs:

Photographs were taken by a cannon digital camera.

8) Statistical analysis:

The results were analyzed and tabulated. The range, mean and standard deviation of FI were

Image -1. Humerus with single nutrient foramen showing medium sized foramen on anteromedial surface

Result

In the present study, the total number of humerus bones examined was 100, out of which 41 were of right and 59 were of left side. Present study found single foramen seen in 72% cases, double foramina found in 15% cases, triple foramina found in 2% cases while in 11% cases foramen was absent. In this study most common location of nutrient foramen was on the anteromedial surface (79.7%) of humerus, 51.9% were dominant foramina and 48.1% were secondary foramina.. Direction of nutrient foramen was towards the elbow i.e. away from growing end. (Image 1).

Discussion

The nutrient foramina are cavities that conduct the nutrient arteries and the peripheral nerves. The major blood supply for long bones originates from the nutrient arteries, mainly during the growing period. The knowledge regarding the nutrient foramen helps to protect them during conservative operative procedures of the bone, thus to concentrate upon the viability of the fractured fragments. Accordingly, several studies have been performed on human dried bones.

Kizilkanat et al. (2007) studied human long bones of the upper and lower limbs to determine the number of their nutrient foramina. They reported a single foramen in almost all the studied humeri and observed that 62.3% of the nutrient foramina were located on the anteromedial surface of the humerus.[3]

Roopam Kumar Gupta(2008) studied on number of diaphyseal nutrient foramina in human long bone including 328 humerus. In this study, he found single foramen seen in 81.4% cases, double foramina found in 14.6% cases, triple foramina found in 2.7% cases, four foramina found in 0.3% case,>4 foramina had 0.9% cases (01 bone with 5 nutrient foramina, 01 bone with 6 nutrient foramina 01 bone with 14 nutrient foramina) He observed most common locations of nutrient foramen for each long bone was the anteromedial surface (50.11%).He noted that 57.75% were dominant foramina and 42.24% were secondary foramina and direction of nutrient foramen was towards the elbow.[2]

Sameera Yaseen Shaheen (2009) found single nutrient foramen in 60% cases, double nutrient foramen in 33.3% cases& triple nutrient foramen in 6.6% cases of humerus. She observed that of all humeral foramina, 59.09% were on the anteromedial surface, 15.9% on the medial border, 13.6% on the posterior surface close to the lateral border, 6.8% on the middle of the posterior surface and 4.5% on the posterior surface close to the medial border. She also found that 25% were dominant and 75% were secondary foramina. The nutrient foramina in all humeri examined were directed distally.[6]

B. V. Murlimanju (2011) studied morphological and topographical anatomy of nutrient foramina in human upper limb long bones. He observed, 93.8% of the humeri had single nutrient foramen, 3.1% of the humeri had double nutrient foramen and in 3.1% of the humeri the foramen was found absent. In humerii, 60.14% had foramina on anteromedial surface, 33.3% on medial surface, 3.1% on anterior border and 3.1% on posterior surface.[5]

Hemang Joshi (2011) studied the nutrient foramina in 200 human humeri. In this study, 63% cases had single foramen, 33% cases had double foramina and 4% cases had triple foramina. In this study 77% foramina were found medially; on ulnar

border & anteromedial surface, 22% foramina were on lateral border and posterior surface.[7]

Vinay. G, Arun Kumar S.(2011)studied nutrient foramina in 40 humeri, in which 92.5% had single nutrient foramen and 7.5% had double foramina. In humerii, 82.5% foramina were on anteromedial surface, 2.5% on anterior border and 22.5% on medial border. He stated that, all the nutrient foramina were directed downwards, i.e. towards elbow.[8]

Manjunath Halagatti (2011), studied nutrient foramina in dry adult humeri of south Indian subjects, study was done on 200 dry normal adult humerus bones. 80% bones had one nutrient foramen, 18% had two and 2% had 3 nutrient foramen. He found, 87% foramina were on anteromedial surface, 4% on anterolateral surface and 9% on posterior surface. 81% of foramina were larger foramina and 19% of foramina were smaller foramina. He found that the direction of nutrient foramina in this study was consistent towards the lower end.[9]

N Sanjeev Kumar (2011), studied of diaphyseal nutrient foramina in human long bones, out of 23 humerus studied, 73.9% had single nutrient foramen and 26.0% had double nutrient foramen. Out of 23 humerus, single nutrient foramen were located on the anteromedial surface in 10 bones, 5 bones at medial border and 2 at anterior border.[10]

Shanta ChandraSeKaran(2013)studied on the nutrient foramina of total 258 adult humerii. Out of this 76.7% humerii had single foramen, 20.5%had double foramina and 2.7% had three foramina. 89.92% foramina were on anteromedial surface, 1.55% were on anterolateral surface and 8.53% were on posterior surface.[11]

Sharma M (2013) studied Morphological Variations of Nutrient Foramina in upper limb long bones including 40 humeri. In his study, 70% (28 out of 40) of the humeri had a single nutrient foramen. The double foramen was observed in 25% (10 out of 40) of the cases and triple foramen was found in 5 % cases.[12]

Ukoha Ukoha Ukoha (2013), a studied nutrient foramina in 250 long bones of Nigerians (150 humeri, 50 radii and 50 ulnae). In the results, 66% of the humeri had a single foramen, 18% had double foramina and 26% had no foramen. In humerii, 90.8% of nutrient foramina were on the anteromedial surface of the bone, 1.7% were on posterior surface (in middle of surface), 0.8% were on posterior surface (close to the medial border), 5% were on posterior surface (close to the lateral border) and 0.8% were on medial border.[13]

Supriti Bhatnagar (2014), studied nutrient foramina in the upper and lower limb long bones, study analyzed the number of nutrient foramina in the diaphysis of; 70 humeri and 60 (radii, ulnae).Out of 70 humeri single nutrient foramen seen in 90%, double foramina in 7.1% and triple foramina in 1.4% of humerii.The nutrient foramina is predominant on the anterior aspect of upper limb long bones. The sizes of foramina ranged from 0.45 mm to 1.2 mm, with a mean of 0.828 mm.[14]

Mansur DI (2016) observed that 60.87% of the humeri had a single nutrient foramen, 28.85% double foramen, 6.32% triple foramen and 1.98% of humeri had four nutrient foramina where as 1.98% humeri did not have any nutrient foramina. He concluded that the majority (88.86%) of the nutrient foramina were present on the antero-medial surface, 6.52% on the anterolateral surface and 4.62% on the posterior surface of the shaft of humeri.[15]

Conclusion

Nutrient foramina allow the passage of nutrient arteries, the main blood supply to long bones. It is particularly important during active growth period, as well as during early phases of ossification. In humerus the location of nutrient foramina were found in the middle third of the anteromedial surface. Knowledge of this position can help the surgeons as it is the zone during surgical interventions for fractures in the middle 1/3rd of humerus. Knowledge of position of nutrient foramina will help to prevent intraoperative injuries in orthopedics such as fracture repair, bone grafting, vascularized bone microsurgery, intra-medullary plating etc. as well as plastic surgeries.

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