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Humerus, Radius ve Ulna’daki Foramen Nutricium’ların Sayı ve Lokalizasyonlarının İncelenmesi

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Özet

Amaç: Kemiğe kan sağlayan a. nutricia’nın seyrettiği foramen nutricium (FN) önemli bir role sahiptir. Bu çalışmada, humerus, radius ve ulna kuru kemiklerinde FN sayısı, konumları ve vertical çapları araştırıldı.

Gereç ve yöntem: Trakya Üniversitesi Tıp Fakültesi Anatomi Anabilim Dalı’nda bulunan ve eğitim amaçlı kullanılan 64 humerus, 37 radius ve 26 ulna kuru kemiği üzerinde ölçüm yapıldı. FN yeri, sayısı ve vertical çapları ölçüldü. Kemiğin proksimal ucu ile FN arasındaki mesafenin kemiğin toplam uzunluğuna bölünmesiyle hesaplanan foraminal indeks (FI), FN çapı 0,5 mm’den büyük olan her bir kemik için hesaplandı.

Bulgular: Humerus kemiklerinin %81’inde FN’un tek sayıda olduğu görüldü. Humerus kemiklerinin %80’inde FN anteromedial yüzeyde yer almaktaydı. Humerus kemiklerinde FN’nin ortalama vertikal çapı 1,20±0,27 mm ölçüldü ve ortalama FI %55,47 olarak bulundu. Radius kemiklerinde FN’un diğer ölçüm yapılan kemiklere göre daha az olduğu ve anterior yüzeyde bulunduğu görüldü. Radius kemiklerinde FN’nin ortalama vertical çapı 0,98±0,24 mm ölçüldü ve ortalama FI değeri %34,60 olarak bulundu. Ulna kemiklerinin %92’sinde tek FN bulunduğu görüldü ve %89’unda FN kemiğin ön yüzünde yer almaktaydı. Ulna kemiklerinde ortalama vertical FN çapı 1,24±0,32 mm olarak ölçüldü ve ortalama FI değeri %37,16 olarak belirlendi.

Sonuç: FN’nin konumu, sayısı ve morfometrik özelliklerinin bilinmesi, uzun kemik kırıklarının iyileşmesinde ve ekstremite üzerindeki tüm cerrahi veya ortopedik prosedürlerde kemiğin beslenmesi açısından kritik öneme sahiptir.

Anahtar Kelimeler: *humerus, radius, ulna, foraminal indeks, foramen nutricium*

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Examination of the number and localization of nutrient foramen in the humerus, radius, and ulna

Abstract

Objective: Nutrient foramen (NF) plays a critical role in the nutrient artery that supplies blood to the bone. This study investigates the number, location, and vertical diameter of nutrient foramina in the dry bone of the humerus, radius, and ulna.

Materials and Methods: 64 humerus, 37 radius, and 26 ulna dry bones used for educational purposes were morphometrically studied at Trakya University Faculty of Medicine, Department of Anatomy. The location, number, and vertical diameter of the nutrient foramina were measured. For each bone with NF diameter greater than 0.5 mm, the foraminal index (FI) was calculated by dividing the distance between the proximal end of the bone and the NF by the total length of the bone.

Results: The number of FN was found to be single in 81% of the humerus bones. In 80% of the humerus bones, the NF was located on the anteromedial surface. The mean vertical diameter of the NF in the humerus bones was 1.20±0.27 mm, and the mean FI was calculated to be 55.47%. It was found that NF was smaller in radius bones than in the other bones measured and was located on the anterior surface. The mean vertical diameter of NF was 0.98±0.24 mm and the mean value of FI was 34.60% in radius bones. The number of NF was single in 92% of ulna bones and in 89% it was located on the anterior surface. The mean vertical diameter of NF was 1.24±0.32 mm and the mean value of FI was 37.16% in ulna bones.

Conclusion: Knowledge of the location, number, and morphometric characteristics of NF is critical for bone nutrition in healing long bone fractures and in all surgical or orthopedic procedures of the upper extremity.

Keywords: *humerus, radius, ulna, foraminal index, nutrient foramen*

Introduction

Bones are the building blocks of the human skeleton, forming the basic structure of the human body and its mechanisms of movement and support. Bones are calcified connective tissues. Bones provide support to the body. Individually or in groups, all bones form an important structure for attaching ligaments, muscles, and protecting organs. Bones serve as storage for many minerals needed by the human body, especially calcium. Bone marrow is formed by the red marrow, which produces various types of blood cells, including red blood cells, white blood cells, and platelets. In addition, bones protect vital organs and soft tissues in the human body (1).

The diaphyseal parts of the long bones are supplied by the nutrient artery (NA). The NA is the main blood supply to a long bone and is especially important during the active growth phase of the embryo and fetus and during the early phase of ossification. The NA enters the individual bones obliquely through a nutrient foramen (NF). These arteries reach the bone marrow from the bone cortex through oblique channels. The nutrient foramen (NF), the outer openings of these channels, are located in the shaft of the bones and are important for the nutrition of the long bones (2-5).

It is suggested that differences in the location and number of nutrient foramen in bones may be related to embryological developmental stages. According to Digby's theory, NA shapes NF development. He explained this idea in terms of the obliquity of the NF sections in the bones. He noted that the presence of nutrient foramina in the bones before the fourth month of fetal life and the shape of the NF adapt to it as the bone lengthens. He reported that when two nutrient foramina are present and these two nutrient foramina are located at different entry flanks into the bone, they converge at the same location in the medullary cavity as the bone lengthens (6).

The blood supply to the NF is very important for both the development of long bones and the healing of fractures. Knowledge of the topography of the NF is very important in surgical procedures to protect the blood supply. NF is known to play a role in non-healing or delayed healing of fractures of the humerus, radius, and ulna. The foraminal index (FI) is calculated by dividing the distance between the proximal end of the bone and the NF by the total length of the bone. Therefore, information on the number and location of NF is useful for physicians providing appropriate treatment (3-5,7,8).

Studies have shown that the number and location of NF are highly variable in long bones (3,9). In this study, the number of NF, their location, and the diameters of the entry holes in the humerus, radius, and ulna were analyzed.

Materials and methods

Seventy-two humerus, fifty-four radius, and thirty-four ulna dry bones used for educational purposes at the Trakya University Faculty of Medicine, Department of Anatomy, were morphometrically examined in accordance with the ethical rules of the university. These bones were known to belong to the Turkic Caucasian population, but age and sex were unknown. The bones with gross pathological deformities were excluded from the study.

In this study, the number of NFs in arm and forearm bones and their location on the bone body was macroscopically observed. A digital caliper was used for the measurements, which has a measurement accuracy of 0.01 mm. The length of the bones and the width of the entrance holes were measured by the same author to avoid inter-observer variability. Measurements were repeated three times on consecutive days, and average values were calculated. NF patency was confirmed with a 24-gauge needle inserted through each foramen. The foraminal index (FI) is the distance of NF from the proximal end of the bone (PE) divided by the total length (TL) of the bone (1, 9). The formula of FI is as follows;

FI (%) = (PE/ TL) * 100

The total length (TL) of each bone was measured between the most proximal and distal points of the bone. The distance of NF from the proximal end of the bone (PE) was measured between the most proximal point of the bone and the most proximal point of the NF entrance hole. Bones with NF diameters less than 0.5 mm were not included in the measurements and calculation of FI.

The NF diameter and PE length measurements are shown in Figure 1, Figure 2, and Figure 3 for the humerus, radius, and ulna, respectively.

Figure 1. a. measurement of NF diameter and distance to the proximal end of the humerus. b. measurement of the diameter of NF and the distance from the proximal end of the radius. c. measurement of the diameter of the NF and the distance from the proximal end of the ulna.

Figure 2. Macroscopic image of a NF of the humerus with a 24-G cannula in it.

The statistical data analysis was carried out using SPSS 22. 0 (Statistical Package for the Social Sciences). The descriptive statistical analysis was performed through frequency tables and the calculation of the central tendency and variability measures (distance, mean and standard deviation).

Results

In this study, measurements were made on the humerus, radius, and ulna on both the right and left sides. It was known that these bones belonged to the Turkish Caucasian population, and no information on age and sex was available. Therefore, the measurement results were reported for each bone, whether from the right or left side. No bone without NF was observed in our laboratory, but those with an NF diameter of less than 0.5 mm were not included in the calculations.

In our laboratory, 64 of 72 humerus bones were found to have NF diameters greater than 0.5 mm. Of these bones, 32 were right humerus and 32 were left humerus. Eighty percent of these humerus bones were found to have single NF and 20% had double nutrient foramina. Fifty-one of these nutrient foramina were located on the anteromedial surface, 10 on the posterior surface, 10 on the medial margin, 1 on the anterolateral surface, 1 on the anterior margin, and 1 on the lateral margin.

In our laboratory, 37 of 54 radius were found to have NF diameters greater than 0.5 mm. Of these bones, 17 were right radius and 20 were left radius. NF was found to occur singly in all radius bones and was located on the anterior surface.

In our laboratory, 26 of the 34 ulnae were found to have NF diameters greater than 0.5 mm. Fourteen of these bones were located on the right ulna and 12 on the left ulna. Single NF was found in 92% of the ulna bones and double nutrient foramina in 8%. Twenty-three of these nutrient foramina were located on the anterior surface and three were on the medial margin.

The NF diameters, the distance of the nutrient foramina from the proximal end of the bone (PE), the total length of the bone (TL), and the mean FI data of the bones examined morphometrically are shown in Table 1. The number and topographic distribution of foramina in the upper limb bones is shown in Table 2.

Bone	Number of bones	NF diameter (mm) (mean±sd)	PE (cm) (mean±sd)	TL (cm) (mean±sd)	FI (%) (mean±sd)
Humerus	64	1,20±0,27	17,18±2,48	30,98±2,23	55,47±6,99
Radius	37	0,98±0,24	7,95±1,09	22,99±1,23	34,60±4,59
Ulna	26	1,24±0,32	9,33±1,40	25,09±1,51	37,16±4,93

NF: nutrient foramen, **PE:** the distance of the nutrient foramina from the proximal end of the bone, **TL:** total length of the bone, **FI:** foraminal index

Table 1. NF-related morphometric parameters of humerus, radius, and ulna.

Bone	Number of bones	Number of NF		Location of NF							
		1	2	AMS	PS	MM	ALS	AM	LM	AS	MS
Humerus	64	51	13	51	10	10	1	1	1	-	-
Radius	37	37	-	-	-	-	-	-	-	37	-
Ulna	26	24	2	-	-	-	-	-	-	23	3

NF: nutrient foramen, **AMS:** anteromedial surface, **PS:** posterior surface, **MM:** medial margin, **ALS:** anterolateral surface, **AM:** anterior margin, **LM:** lateral margin, **AS:** anterior surface, **MS:** medial surface, **FI:** foraminal index

Table 2. Number and topographical distribution of NF on arm and forearm bones

Figure 1.

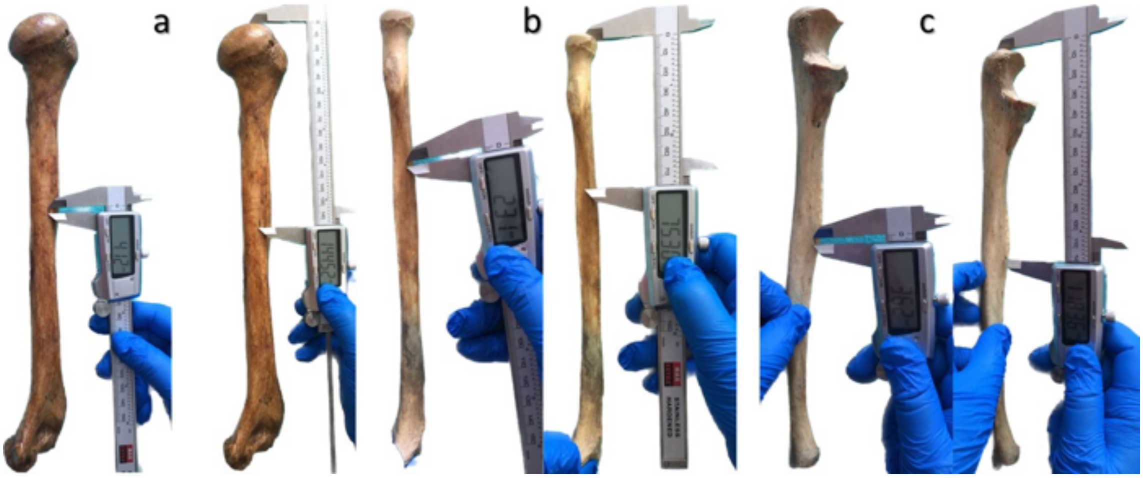

Figure 2.

Discussion

According to the results of this study, the probability of a single NF in the arm and forearm bones is 80%, 100%, and 92% for the humerus, radius, and ulna, respectively. In this study, no more than two nutrient foramina were found in any of the bones examined. Uzuner et al. also found no more than two nutrient foramina in humerus bones in their study (11). Kizilkanat et al. reported that they detected 3-4 nutrient foramina in 8.1% of humerus bones, but also examined nutrient foramina smaller than a 24-gauge hypodermic needle (6). In this study, nutrient foramina were most frequently found on the anteromedial surface and least frequently on the anterolateral surface, lateral margin, and anterior margin of the humerus. These results are consistent with studies in the literature (2,6,12-17).

In all radius bones, a single NF was located on the anterior surface. Korkmaz et al. reported in their review study that they did not find any NF location other than the anterior surface in any of the 1356 radial bones in a total of 14 articles (2). Kızılkanat et al. found NF in 99%, Perreira et al. found NF in 99%, and Uzuner et al. found NF in all the radius bones they studied (6, 12, 18). Kızılkanat et al. reported that 41.5% of the radius bones had NF on the anterolateral surface and 29.8% on the anterior surface (6). Murlimanju et al. reported that 94.4% of the radius bones had a single NF, and mostly on the anterior surface (17). These findings are consistent with the results of this study.

The presence of NF greater than 0.5 mm in diameter was observed in 26 ulna bones examined in this study. 11.5% of the nutrient foramina were located on the medial surface and 88.5% on the anterior surface. Korkmaz et al. reported in their review study that they did not find any location other than the anterior surface in any of the 1368 ulna bones in 14 articles of NF (2). Kızılkanat et al. found NF in 99% of ulna bones, Perreira et al. in 99%, Uzuner et al. and Murlimanju et al. in all the bones they studied (6, 12, 17, 18). Murlimanju et al. reported that 65 of 75 ulna bones had a single NF on the anterior surface (17). The results of these studies are compatible with the findings obtained in this study on ulna bones.

The results of this study indicate that the number and location of nutrient foramina detected in the humerus, radius, and ulna are generally consistent with the literature. One of the limitations of this study was the lack of information on the sex and age of these bones in our laboratory.

In addition to studies showing that vascular damage to the feeding arteries as a local factor negatively affects fracture healing, there are also studies indicating that NF damage is not a risk factor in arm and forearm fractures (2,18,19). The NA enters the humerus near the distal end of the bone. Damage to the NA in this part of the humerus has been reported to cause union problems (9,20).

Knowledge of the location, number, and variations of the NA, which plays an important role in nourishing the long bones, and the NF where these arteries reach the medullary canal is important for physicians planning interventional and surgical treatments in these regions, both during surgery and during postoperative follow-up. The detection of nutrient foramina is of paramount importance to surgeons during fracture reduction and surgical procedures such as bone grafting and microsurgical bone grafting. The authors of this study believe that the data obtained from this study will be useful to clinicians when performing interventional treatments on the upper extremity.

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