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Original Research

Morphology and Topography of the Nutrient Foramina in the Shoulder Girdle and Long Bones of the Upper Extremity

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ABSTRACT

Objective: The most principal nutrition source of a bone is nutrient arteries. They are important at every stage of bone development. A nutrient artery enters a bone through the nutrient foramen, the largest hole on the outer surface of the bone. The foramen is important both morphologically and clinically.

Methods: A total of 414 adult human dry bones were investigated in this study to identify topographic and morphological features of nutrient foramina in the scapula, clavicle, humerus, radius and ulna. Nutrient foramina were examined with a hand lens. Their dimensions and directions were determined with a 21-gauge needle, and thus major foramina were detected. Positions of nutrient foramina were noted according to surfaces of the bones, and to segments separated as proximal, middle and distal by calculating foraminal index.

Results: A single nutrient foramen was found in 71% of our samples. We observed that 94.2% of foramina in the clavicle, 89.3% of foramina in the humerus, 51.3% of foramina in the radius, and 67.7% of foramina in the ulna were located in the middle 1/3 segment of the bones.

Conclusion: On account of pathologies associated with the nutrient foramen, our findings may be helpful for surgeons to design applications performed in the region. In addition, we think that our data by contributing to the literature may be a resource for clinicians due to the importance of the nutrient foramen for surgical procedures.

Keywords: Nutrient foramen, nutrient arteries, foraminal index, upper limb, long bone

INTRODUCTION

Bones are the structures that form the passive element of the movement system and form the skeleton in the human body. Bone tissue is a vascularized type of dense connective tissue [1, 2]. Bones are supplied by the nutrient, metaphyseal, epiphyseal, and periosteal artery [1]. The most prominent nutrition of the bone is provided by the nutrient artery, and this artery is an independent branch of the adjacent arteries located outside the periosteum [3]. During the prenatal and postnatal development of the bone, the nutrient artery is essential for the development of the diaphysis and epiphyseal cartilage [4]. The nutrient artery enters the bone through the nutrient foramen (FN), the largest foramen on the outer surface of the bone [5]. The entry site of the nutrient artery into the bone tissue was first described by Havers in 1691 [6]. FNs are the external opening of the nutrient canal and are distinguished from other foramen on the bone surface by the presence of a prominent vascular groove [7]. The nutrient artery enters the bone tissue through these holes called the nutrient foramen and feeds the bone along the length of the bone through channels called nutrient canal [8].

FN examined in the presented study has both morphological and clinical significance. The vascular system of bone is closely associated with some pathologies such as fracture healing or acute hematogenic osteomyelitis [4]. Healing is delayed in stress fractures due to the accompanying rupture of the nutrient artery [9]. Especially during puberty, the nutrient artery provides 70-80% of the nutrition of the bones. When bone nutrition is compromised, less vascularization of the epiphyseal plate results in medullary bone ischemia [7]. In free vascularized bone grafts, it is very important to protect the nutrient artery entering the bone from the FN. It is important to analyze the anatomy of FN in microsurgery, vascularized bone transplants, joint replacement treatments, and reconstructive surgeries. The nutrient artery should be preserved in order to maintain the presence of osteocytes and osteoblasts that have an effect on the healing process and the union of the bone graft, which is ideal for free transplantation [4, 9]. By knowing the location and variations of the FN, the placement of the internal fixation devices can be made appropriately [5]. Inappropriate treatment or poor surgical techniques may cause rupture of the FN or nutrient artery. This leads to additional interventions that need to be repeated [10, 11]. Detailed data on bone nutrition are always important in the development of new transplantation and resection techniques in orthopedics [4]. Therefore, understanding the topography of FN located on the surfaces of bones is critical to the success of surgical procedures and outcomes.

The aim of this study is to understand the topography and morphology of FN on the surfaces of bones. This region contributes to surgical procedures and increases the success of surgical results. For this purpose, to determine, examine and observe the number, location, size and direction of FN in human shoulder girdle bones and upper extremity long bones.

Main Points;

- Detailed knowledge of vascularization in upper extremity bones
- Determination of safe area in orthopedic surgery
- To preserve FN, reduce complications and increase the success rate of surgical intervention

MATERIALS AND METHODS

A total of 414 adult human dry bones (clavicle (61), scapula (59), humerus (103), ulna (89), radius (102)) from XXX University Faculty of Medicine, Department of Basic Medical Sciences and Anatomy were included in the study. Those with major abnormality of dry bones of unknown age and sex were excluded from the study.

Considering the following data, FNs in the diaphysis of each bone were studied:

Number and Location of FN

FNs were observed using a 90 mm handpiece so as not to miss the smallest FN. In order to determine the FN topography on the bones in detail, surfaces were determined in each bone. Their positions relative to the determined surfaces were noted.

Foraminal index (FI)

FI was calculated for the location of the FN in other bones except the scapula, and their segmental location was determined. FI was calculated with the Hughes formula, which is widely used in the literature [12].

FI= (PM/LB)×100

(PM: distance from the proximal point of the bone to the Major FN (MFN), LB: Length of the bone)

PM was measured with a digital caliper with an accuracy of 0.01 mm.

Determination of the total length of the bone

Total bone length was measured manually with a mechanical steel caliper [13]. How bone length measurements are made is shown in Figure 1.

Segmental calculation to foraminal index

FI was used to identify segments of long bones. The location of the FN relative to the FI has been divided into three sub-segments as indicated below [5].

- Tip I: FI≤33.33, in the proximal third of the bone.
- Tip II: FI 33.33-66.66, in the middle third of the bone.
- Tip III: FI ≥66.66, in the distal third of the bone.

FN Size and Direction

MFN was determined by calibrating the foramen with a hypodermic needle not smaller than the size 21, by including well-defined FNs in the diaphysis part of the bone [4]. Foramen where the needle could not enter were considered as secondary

FN and were not included in the calculation of FI. A rigid wire was passed through the FN opening, and its direction was determined and then confirmed with a hypodermic needle (Figure 2).

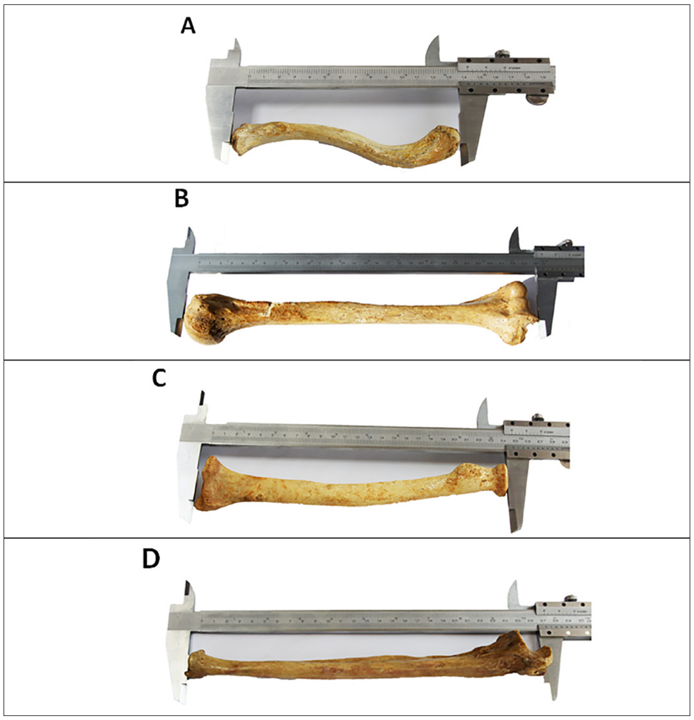

Figure 1. Measurements of the bone lengths (clavicle, humerus, radius and ulna respectively)

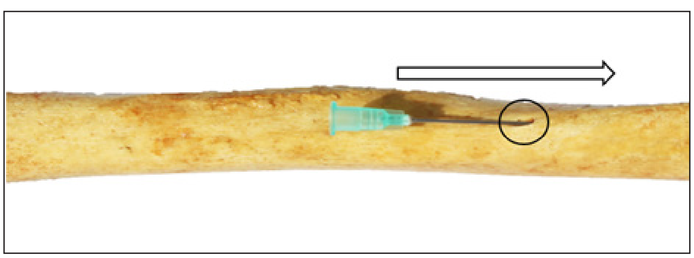

Figure 2. Detection of FN

Photographing

Photos were taken using Canon eos 700d camera and canon zoom lens ef-s 18-135mm lens. The bone photos taken were cleaned with Adobe Photoshop CS6 program.

Statistical Analysis

Whether the obtained data were suitable for normal distribution was evaluated with Shapiro wilk and Kolmogorov smirnov tests. Sample T-Test (Independent samples t test) was used to compare the variables with normal distribution in two independent groups. The Man Whitney U test, which is a non-parametric test, was used for the variables that did not fit the normal distribution. For numerical variables, mean±standard deviation values were given in descriptive statistics. SPSS statistics 20.0 package program was used for all statistical analyses. P<0.05 was considered significant.

RESULTS

Number of FN

The FN numbers detected in the shoulder girdle and upper extremity bones are given in Table 1 in detail. The mean number of FN in the scapula was 3.92 ± 1.38, and the mean number of FN in the clavicle was 1.68 ± 0.78. The mean number of FN in the humerus was 1.59 ± 0.91, the mean number of FN in the radius was 1.06 ± 0.22, and the mean number of FN in the ulna was 1.16 ± 0.47. When the number of FNs was compared between the parties, there was no statistically significant difference between the parties in any of the bones (p>0.05) (Table 1).

Total Bone Length

The mean length values of the 4 bones (clavicle, humerus, radius and ulna) examined are given in Table 2. When the bone lengths were compared between the sides, it was found that the radius of the right side was significantly larger than the left (p=0.002). There was no statistically significant difference in other bones (p>0.05) (Table 2).

PM, Distance from the proximal point of the bone to the Major FN (MFN)

PM values of the examined bones are given in Table 3. While the PM value of the right radius was significantly higher than the left (p=0.008), no statistically significant difference was found between the PM values of the other bones (p>0.05) (Table 3).

Foraminal Index

FI values of the examined bones are given in Table 4. There was no statistically significant difference between the parties in terms of FI (p>0.05) (Table 4).

Location of FN

Segmental position of the FN according to the FI

Position of the MFN are given in Table 5. FNs detected in the clavicle, humerus, radius and ulna were mostly found in the middle third of the bone (Table 5). The positions of the FNs by segment were verified by calculating FI. Of the 198 MFNs examined according to FI, 38 (19.1%) were Type I, 152 (76.7%) were Type II, and 8 (4%) were Type III.

Table 1 Comparison of FN number characteristics for right and left sides in shoulder girdle and upper extremity bones

Shoulder Girdle and Upper Extremity Long Bones	N		Number of FN	Mean ±SD (mm)	p
Scapula	R	30	111	3.72 ± 1.43	0.197
	L	29	116	4.12 ± 1.33	
Clavicle	R	31	43	1.48 ± 0.73	0.050
	L	30	47	1.88 ± 0.83	
Humerus	R	52	78	1.59 ± 1.01	0.507
	L	51	75	1.60 ± 0.81	
Radius	R	49	45	1.02 ± 0.14	0.093
	L	53	50	1.11 ± 0.31	
Ulna	R	38	35	1.20 ± 0.55	0.664
	L	51	52	1.13 ± 0.40	

N: Number of bones, SD: Standard deviation, R: Right, L: Left

Table 2 Findings of the comparison of bone lengths for the right and left sides of the bones

Bones	Side	N	Mean ±SD (mm)	p
Clavicle	R	31	140.33 ± 2.49	0.982
	L	30	140.42 ± 3.17	
Humerus	R	52	304. 39 ± 20.04	0.838
	L	51	303.54 ± 20.22	
Radius	R	49	241.28 ± 16.47	0.002*
	L	53	229.41 ± 18.14	
Ulna	R	38	249.64 ± 18.96	0.542
	L	51	246.80 ± 19.60	

N: Number of bones, SD: Standard deviation, R: Right, L: Left

* There is a statistically significant difference (p<0.05).

Table 3 Comparison of PM for right and left sides in bones

Bones	Side	N	Mean ±SD (mm)	p
Clavicle	R	31	74.17 ± 12.92	0.343
	L	30	77.67 ± 13.69	
Humerus	R	52	172.49 ± 23.17	0.243
	L	51	166.68 ± 25.26	
Radius	R	49	85.09 ± 12.84	0.008*
	L	53	78.43 ± 9.34	
Ulna	R	38	98.37 ± 19.42	0.084
	L	51	91.42 ± 12.41	

N: Number of bones, SD: Standard deviation, R: Right, L: Left, PM: Distance from the proximal point of the bone to the Major FN

* There is a statistically significant difference (p<0.05).

Table 4. Findings of the comparison of FI values for the right and left sides of the bones

Bones	Sides	N	Mean ±SD (mm)	p
Clavicle	R	31	52.80 ± 7.55	0.436
	L	30	54.50 ± 7.84	
Humerus	R	52	56.68 ± 5.56	0.181
	L	51	54.87 ± 7.33	
Radius	R	49	34.93 ± 4.01	0.578
	L	53	35.18 ± 4.60	
Ulna	R	38	37.36 ± 5.98	0.882
	L	51	37.17 ± 4.40	

N: Number of bones, SD: Standard deviation, R: Right, L: Left, FI: Foraminal index

Table 5. Position of MFNs relative to segments in bones (numbers and percentages)

Bone	MFN	Proximal 1/3(%)	Middle 1/3 (%)	Distal 1/3 (%)
Clavicle	52	-	49 (94.2%)	3 (5.7%)
Humerus	47	-	42 (89.3%)	5 (10.6%)
Radius	37	18 (48.6%)	19 (51.3%)	-
Ulna	62	20 (32.2%)	42 (67.7%)	-

MFN: Major FN

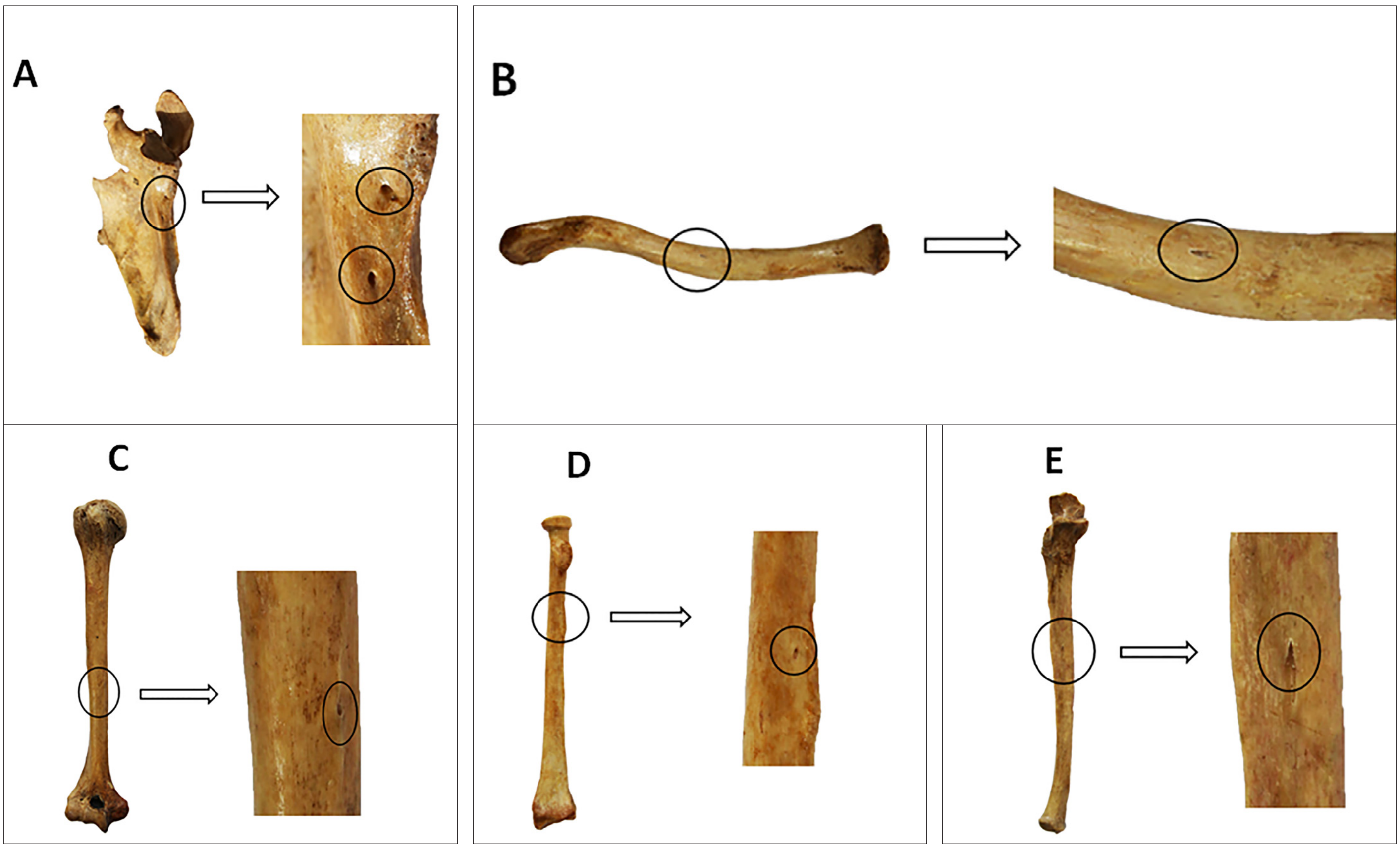

Figure 3. A-E. Determination of the FN position in relation to the bone surface (scapula, clavicle, humerus, radius and ulna respectively)

The position of the FN relative to the surfaces determined in the bone

Of the 227 FNs found in the scapula, 52 (22.9%) are in the fossa subscapularis, 43 (18.9%) are in the supraspinous fossa, 54 (23.7%) are in the infraspinous fossa, 78' i (34.3%) were found in the peri-glenoid (Figure 3A). In the clavicle, 32 (35.5%) of a total of 90 FNs were found in inferior surface, 2 (2.2%) in superior surface, and 56 (62.2%) in posterior surface (Figure 3B). Of a total of 153 FNs found in the humerus, 18 (11.7%) were found in 96 (62.7%) anteromedial surface, 9 (5.8%) in anterolateral surface, and 3 (1.9%) were seen in anterior surface and 26 (16.9%) were in posterolateral surface (Figure 3C). While 62 (65.2%) of a total of 95 FNs found in the radius were found in anterior surface, 17 (17.8%) were in anteromedial surface, and 16 (16.8%) were in anterolateral surface, FN in posterior surface was not observed (Figure 3D). While 64 (73.5%) of a total of 87 FNs found in ulna samples were observed in anterior surface, 4 (4.5%) were in anteromedial surface, and 19 (21.8%) were in anterolateral surface, it was not observed in posteromedial surface (Figure 3E).

Table 6. Comparison of literature on FN in humerus

Study	N	Number of FN						Location of FN								FI
		0	1	2	3	4	5	AS	AMS	ALS	PS	PLS	AB	MB	LB	
Ukoha et al. [4]	150	39	99	12	-	-	-	-	109	-	9	-	-	1	-	56.28
Kızılkanat et al. [9]	101	2	69	22	7	1	-	30	99	2	25	1	-	-	-	46.46
Mysorekar et al. [42]	180	-	104	69	4	2	-	-	207	-	50	-	-	-	-	-
Campos et al. [32]	36	-	27	9	-	-	-	-	36	1	7	-	-	-	-	57.73
Güner et al. [30]	50	15	33	2	-	-	-	-	31	1	3	-	-	-	-	55.7
Pereira et al. [20]	174	-	154	20	-	-	-	-	173	-	8	-	8	-	5	55.2
Solanke et al. [12]	100	4	92	4	-	-	-	-	67	-	1	-	-	32	-	-
Mansur et al. [24]	253	5	154	73	16	5	-	-	327	17	24	-	-	-	-	55.20
Ruthwik et al. [17]	80	1	50	23	6	-	-	-	43	2	14	-	2	37	1	51.50
Caroll et al. [31]	71	-	48	20	3	-	-	-	74	1	25	-	-	-	-	-
Şendemir et al. [16]	29	1	22	4	2	-	-	-	29	2	5	-	-	-	-	54.6
Öztürk et al. [23]	114	-	90	24	-	-	-	-	102	2	22	-	2	10	-	57.32
Khandve et al. [27]	80	1	77	32	-	-	-	-	44	-	4	-	3	78	-	-
Joshi et al. [28]	200	-	126	66	8	-	-	2	60	-	-	-	-	96	-	-
Present study	**103**	**7**	**59**	**24**	**8**	**3**	**2**	**3**	**96**	**9**	**18**	**26**	**-**	**-**	**-**	**55.77**

AS: Anterior surface, AMS: Anteromedial surface, ALS: Anterolateral surface, PS: Posterior surface, PLS: Posterolateral surface, AB: Anterior border, MB: Medial border, LB: Lateral border, N: number of bones, FI: Foraminal index

Table 7. Comparison of literature on FN in radius

Study	N	Number of FN				Location of FN								FI
		0	1	2	3	AS	AMS	ALS	PS	PLS	AB	MB	LB	
Ukoha et al. [4]	50	16	34	-	-	32	-	-	-	-	2	-	-	33.74
Kızılkanat et al. [9]	93	-	92	2	-	30	24	40	3	-	-	-	-	33.52
Murlimanju et al. [2]	72	3	68	1	-	-	52	-	-	-	4	10	4	34.4
Mysorekar et al. [42]	180	4	168	8	-	80	-	-	-	-	17	38	29	-
Campos et al. [32]	33	-	33	-	-	33	-	-	-	-	-	-	-	36.34
Shulman et al. [15]	164	2	161	3	-	135	-	-	-	4	-	-	25	-
Güner et al. [30]	50	12	37	1	-	33	-	-	-	-	1	2	3	35.9
Longia et al. [25]	200	-	190	8	2	194	-	-	-	-	2	6	10	-
Parmar et al. [22]	60	-	60	-	-	60	-	-	-	-	-	-	-	36
Solanke et al. [12]	80	3	77	-	-	59	-	-	-	-	1	9	8	34.36
Pereira et al. [20]	157	-	156	1	-	115	32	5	5	-	-	-	-	35.7
Akbari et al. [33]	63	-	63	-	-	52	-	-	-	1	9	-	1	36.14
Patel et al. [21]	40	-	44	-	-	44	-	-	-	-	-	-	-	38.3
Present study	**102**	**13**	**83**	**6**	**-**	**62**	**17**	**16**	**-**	**-**	**-**	**-**	**-**	**34.93**

AS: Anterior surface, AMS: Anteromedial surface, ALS: Anterolateral surface, PS: Posterior surface, PLS: Posterolateral surface, AB: Anterior border, MB: Medial border, LB: Lateral border, N: number of bones, FI: Foraminal index

Table 8. Comparison of literature on FN in ulna

Study	N	Number of FN				Location of FN								FI
		0	1	2	3	AS	AMS	ALS	PS	PLS	AB	MB	LB	
Ukoha et al. [4]	50	11	39	-	-	39	-	-	-	-	-	-	-	36.70
Kızılkanat et al. [9]	102	-	101	1	-	34	26	21	2	-	-	-	-	38.84
Shulman et al. [15]	164	1	149	14	-	136	-	-	-	-	4	-	24	-
Murlimanju et al. [2]	75	-	75	-	-	65	-	-	-	-	-	8	2	34.4
Mysorekar et al. [42]	180	2	168	10	-	137	-	-	-	-	-	32	19	-
Campos et al. [32]	33	-	30	3	-	33	-	-	-	-	-	-	-	36.81
Longia et al. [25]	200	-	190	8	2	194	-	-	-	2	-	6	10	-
Güner et al. [30]	50	9	41	-	-	38	-	-	-	-	-	2	1	38.3
Pereira et al. [20]	146	-	144	2	-	120	9	17	-	-	-	-	-	37.9
Solanke et al. [12]	80	3	77	-	-	59	-	-	-	1	-	9	8	36.52
Parmar et al. [22]	60	-	58	2	-	35	-	-	-	5	-	4	2	32.7
Priya et al. [19]	200	-	188	12	-	158	-	-	-	-	2	33	19	35.83
Patel et al. [21]	40	-	40	-	-	35	-	-	-	5	-	-	-	34.77
Kumari et al. [26]	100	3	92	10	-	71	-	-	-	-	-	18	13	36.19
Present study	**89**	**14**	**65**	**6**	**3**	**64**	**4**	**19**	**-**	**-**	**-**	**-**	**-**	**37.56**

AS: Anterior surface, AMS: Anteromedial surface, ALS: Anterolateral surface, PS: Posterior surface, PLS: Posterolateral surface, AB: Anterior border, MB: Medial border, LB: Lateral border, N: number of bones, FI: Foraminal index

Table 9. Comparison of literature on FN in clavicle

Study	N	Number of FN					Location of FN				FI
		0	1	2	3	4	AS	PS	IS	SS	
Rai et al. [5]	40	-	17	21	2	-	-	31	23	-	48.01
Murlimanju et al. [2]	52	2	20	23	7	-	-	36	29	1	44.72
Sinha et al. [13]	100	-	72	20	8	-	-	41	95	-	60.22
Hussain et al. [29]	60	-	22	30	6	2	12	66	30	-	51.41
Sinha et al. [14]	50	-	35	12	3	-	-	38	28	2	52.25
Tanna et al. [11]	50	-	21	26	3	-	-	31	30	-	49.01
Malukar et al. [8]	100	1	68	21	8	2	-	80	60	2	-
Present study	**61**	**6**	**28**	**16**	**8**	**1**	**-**	**56**	**32**	**2**	**53.65**

AS: Anterior surface, PS: Posterior surface, SS: Superior surface, IS: Inferior surface, N: number of bones, FI: Foraminal index

Directions of FN

It was seen that 242 (56.9%) of the FNs were oriented to the distal direction, and 183 of them were oriented to the proximal direction. Of 90 FNs in the clavicle, 2 (2.2%) were in the proximal direction and 88 (97.7%) were in the distal direction. 153 (100%) FN in the examined humeral samples were in the distal direction. It was observed that all 95 FNs in the radius were in the proximal direction. Only 1 (1.1%) of 87 FNs in the ulna were in the distal direction, and 86 (98.8%) were in the proximal direction.

DISCUSSION

FN, the external opening of the nutrient canal, has a specific location for each bone and may show variation. The factors that create these variations are the growth rates at both ends of the bone and the remodeling of the bone [5]. Hughes H. observed that foramen variation was most common in the femur, and rarely in the radius bone in the upper extremities, but was very rare in other bones [2]. Comparison of our study findings with the literature is given in Table 6-9 [2, 5, 8, 9, 11-33].

Nutrient artery plays an important role in the nutrition of bones by feeding 2/3 of the bone and the entire medulla. Due to the important role of FNs in the nutrition and growth of bones, the nomenclature “nutrient”, which means “nutritive, high nutritional value, building material”, has been made [8]. Having an important role in both prenatal and postnatal periods, a. nutricia also supports the formation of callus at the fracture site [34]. Healing of fractures depends on blood circulation as in all wounds [4]. Fractures may be accompanied by rupture of the nutrient artery. Especially in long bones, stress fractures associated with periosteal detachment, disruption of peripheral arteries, nutrient artery rupture, and soft tissue damage are also observed in such fractures [9].

In a study of the scapula, one of the bones of the shoulder girdle, Donders et al. [34] stated that the spine of scapula and the peri-glenoid are the thickest and most voluminous parts of the scapula. Therefore, they assumed that the nutrient artery provided the nutrition of these regions the most, and they reported that this assumption was consistent with their findings. The weakest point of the clavicle is the lateral 1/3 and middle 1/3 of the bone. Clavicula fractures constitute 2.6-12% of all fractures and 44-66% of shoulder-related fractures [35]. Humerus fractures are seen with a frequency of 1-7% among all fractures [36]. Thirty percent of the fractures are seen in the proximal 1/3, 60% in the middle 1/3 and 10% in the distal 1/3 [37]. Particularly proximal humerus fractures are among the most common fractures and constitute approximately 3% of upper extremity fractures [38]. Radius fractures constitute 20% of the cases with fracture development and 75% of all fractures in the forearm region [39]. Since methods such as plated osteosynthesis and intermedullary nailing can cause soft tissue damage and infection in fracture repair surgery, stabilization can be achieved with open reduction and internal fixation methods [38, 40]. In particular, open reduction is a method that requires the surgeon to pay attention to the area of FN. Avoiding a limited area containing the FN ensures a good result [41]. The circulation of bone fragments must be preserved in this type of surgical technique for a low complication rate. Therefore, orthopedic surgeons’ awareness of the nutrient artery and its entry point in the bone helps in treating broken bone. With the developments in bone fixation techniques and increasing patient demands, bone fractures are treated more surgically rather than conservatively. This situation is associated with high cost and complication risks [10].

It is known that good circulation is required for free vascular bone grafting. In the humerus, the nutrient originates from the brachial artery or the deep brachial artery. The radius receives the nutrient artery from the anterior interosseus artery or the posterior interosseous artery. In the ulna, the nutrient artery originates from the ulnar artery [42, 43] Nutrient artery may also be caused by posterior interosseus artery in the radius, which may explain the FN in the posterior facies of the radius. The anterior interosseus artery is an important artery in transplantation and reconstruction to reduce the rate of pseudoarthrosis in the radius and ulna Kızılkanat et al. [37] directly related the delay in union of the bone or nonunion of the bone in the distal part of the ulna and radius of the bone after trauma, with the lack of nutrient artery entering the bone from this region. In our study, FN was not found in the distal 1/3 of the radius and ulna. “Bhatnagar et al. [44] stated that Geibel et al. reported that FN in both radius and ulna and facies posterior is not common, therefore dorsal placement of the plate should be preferred during the operative procedure.” In our study, it was found that FN was most concentrated in the anterior facies in both the radius and ulna. Knowing the circulation of the bone in free vascularized bone grafts facilitates the preservation of osteocytes and osteoblasts in the graft and the healing of the graft in the new recipient [45]. Recent results confirm the hypothesis that vascularized bone graft and joint allograft survival are strongly dependent on blood circulation. The exact topography of the FN must be known to preserve the diaphyseal vascularization of the recipient in the allograft.

Limitations

Difficulties in knowing the features of dry bones such as age, sex, or race have been reported in the literature [46]. The limitation of the study is that information about the age, sex, and race the examined dry bones is not known.

CONCLUSION

Detailed knowledge of vascularization in bones has been a decisive factor for the success of new techniques in orthopedics.

This study provided additional information on the morphology and topography of FN in the shoulder girdle bones and upper extremity long bones. Determination of safe area in orthopedic surgical procedures; It will help to preserve FN, reduce complications and increase the success rate of surgical intervention. It is thought that this study will contribute to the literature in surgical procedures.

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