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ORIGINAL ARTICLE

Anatomical Study of the Supratrochlear Foramen on the Distal Humerus

Distal Humerus'ta Bulunan Supratrochlear Foramen ile İlgili Anatomik Çalışma

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ABSTRACT

Aim: Supratrochlear foramen (STF) is the variation of the distal part of the humerus. The aim of this study is to reveal the frequency, morphology and morphometry of the STF in Turkish population and emphasize the importance of knowing the presence of the STF in intramedullary nailing for supracondylar fractures for orthopedists and distinguishing it from an osteolytic and cystic lesion for radiologists.
Materials and Methods: This study was performed with 116 dry humeri (61 right, 55 left). The translucent and opaque bony lamina between the coronoid fossa and the olecranon fossa and STF on the humerus were noted. STF was classified as oval, round, irregular, triangular, rectangular, sieve like, reniform, hourglass shaped. The frequency and morphometry of the STF were also evaluated.
Results: The translucent type 88 (75.9%) bony lamina was found mostly between the coronoid and olecranon fossa. STF was detected on 19 (16.4%) humeri, 13 of them were on the left humeri and 6 of them were on the right humeri. The shape of the 16 of 19 STF were oval shaped. The mean values of the transverse and vertical diameter of STF, distance between the most medial points of the STF and medial epicondyle, the most lateral points of the STF and lateral epicondyle, distance between the most distal point of the STF and the lower edge of the trochlea humeri were found as 4.41±2.34 mm, 3.1±0.85 mm, 26.65±3.82 mm, 27.94±3.34 mm, 14.62±1.9 mm respectively.
Conclusion: There are few studies on STF in Turkish population and we believe that this clinically important variation will contribute to anatomists, especially radiologists and orthopedists in terms of awareness and knowing the frequency, morphology and morphometry of STF.

Keywords: Humerus, supratrochlear foramen, anatomy, variation.

ÖZ

Amaç: Supratrochlear foramen (STF), humerusun distal bölümü ile ilişkili bir varyasyonudur. Bu çalışmanın amacı, Türk toplumunda STF'nin sıklığını, morfolojisini ve morfometrisini ortaya koymak ve STF varlığının bilinmesinin suprakondiler kırıklarda intramedüller çivilemede ortopedistler, osteolitik ve kistik lezyonlardan STF'yi ayırmada radyologlar için önemli olduğunu vurgulamaktır.
Gereç ve Yöntem: Bu çalışma 116 kuru humerus (61 sağ, 55 sol) ile yapıldı. Fossa coronoidea fossa olecrani arasındaki yarı saydam ve opak kemik lamina ve STF bulunan humerus'lar not edildi. STF; oval, yuvarlak, düzensiz, üçgen, dikdörtgen, elek benzeri, böbrek şekilli, kum saati şeklinde sınıflandırıldı. STF'nin bulunma sıklığı ve morfometrisi değerlendirildi.
Bulgular: Fossa coronoidea fossa olecrani arasındaki kemik lamina en çok yarı saydam tip olarak bulundu 88 (%75,9). STF 19 (%16,4) humerus'ta tespit edildi ve bunların 13'ü sol humerusta, 6'sı sağ humerusta idi. Ondokuz STF'nin 16'sı oval şekilli idi. STF'nin transvers ve vertikal uzunluğu, STF'nin en medial noktası ile epicondylus medialis'in en medial noktası arasındaki mesafe, STF'nin en lateral noktası ile epicondylus lateralis'in en lateral noktası arasındaki mesafe ve STF'nin en distal noktası ile trochlea humeri'nin alt kenarı arasındaki mesafe ortalama olarak sırasıyla 4,41±2,34 mm, 3,1±0,85 mm, 26,65±3,82 mm, 27,94±3,34 mm, 14,62±1,9 mm olarak bulundu.
Sonuç: Türk toplumunda STF ile ilgili az sayıda çalışma bulunmaktadır ve klinik açıdan önemli olan bu varyasyonun anatomistlere, özellikle radyologlara ve ortopedistlere STF'nin farkındalığı, sıklığı, morfolojisi ve morfometrisinin bilinmesi açısından katkı sağlayacağı düşünülmektedir.

Anahtar Kelimeler: humerus, supratrochlear foramen, anatomi, varyasyon

Introduction

The humerus is the longest and widest bone of the upper extremity. At its distal end, coronoid fossa and radial fossa are located anteriorly and olecranon fossa posteriorly (1). Coronoid fossa and olecranon fossa are separated from each other by a thin bony lamina and which may be perforated in some cases and this variation is known as the supratrochlear foramen (STF) (2). STF; It has also been named by various names such as intercondyloid foramen, septal aperture, epitrochlear foramen, olecranon perforation and supracondyloid foramen (3, 4). It can be oval, round, triangular, irregular, sieve like, reniform, rectangular and hourglass shaped (5-7). This variation has also been described in different researches in dogs, hyenas and other primates. (8, 9). The aim of this study is to reveal the frequency, morphology and morphometry of the supratrochlear foramen in Turkish population and emphasize the importance of knowing the presence of the STF in intramedullary nailing for supracondylar fractures for orthopedists and distinguishing it from an osteolytic and cystic lesion for radiologists.

Materials and Methods

This study was performed with 116 dry humeri (61 right, 55 left) in the Department of Anatomy, Faculty of Medicine, Hacettepe University. The humeri with fractures or

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pathological changes were not included in the study. The age and gender of humeri were unknown. By using a light source of mobile phone, the translucent and opaque bony lamina between the coronoid fossa and the olecranon fossa were evaluated. It was defined as translucent if the light reflected from this bony lamina and as opaque if it did not. The shape of the STF was classified observationally by three authors (MÜ, LK, BEG) in accordance with the shape types (oval, round, triangular, irregular, sieve like, reniform, rectangular and hourglass shaped) determined in the literature (5-7).

Parameters:

1) Transverse diameter of the STF: the distance between the most medial and most lateral points of the STF (TD) (5)

2) Vertical diameter of the STF: the distance between the most proximal and the most distal points of the STF (VD) (5)

3) Distance between the most medial point of the STF and the most medial point of the medial epicondyle (DME) (10)

4) Distance between the most lateral point of the STF and the most lateral point of the lateral epicondyle (DLE) (10)

5) Distance between the most distal point of the STF and the lower edge of the trochlea humeri (DTH) (6)

6) Epicondylar breath: the distance between the most medial point of the medial epicondyle and the most lateral point of the lateral epicondyle (EB) (11)

7) Maximum humeral length: distance from the most proximal point of the head of the humerus to the most distal point of the trochlea humeri (MHL) (12)

8) Height of the coronoid fossa: the distance between the most proximal and the most distal points of the coronoid fossa (HCF)

9) Distance between the coronoid fossa and the trochlea humeri: the distance between the most proximal point of the coronoid fossa and the most distal point of the trochlea humeri (CFTH)

The measurements which were made with a tape measure and a 0.01 mm precision Vernier caliper are demonstrated in Figure 1. and Figure 2. and. All morphometric measurements were decided by three authors (MÜ, LK, BEG) and measured twice by one author (MÜ) and mean values were recorded.

Statistical analysis

Statistical analyses were performed using SPSS software version 20 (IBM Corporation, Armonk, NY). The visual (histograms, probability plots) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk's test) were used to determine whether the parameters were normally distributed or not. Morphologic and morphometric properties were presented by using cross tabulations. An overall 5% Type 1 error level was accepted to infer statistical significance.

Ethics Committee Approval

Ethic approval was obtained from the Hacettepe University non-interventional clinical researches ethic committee (date: 21/12/2021 number: 2021/21-29).

Results

When the bony lamina between the coronoid fossa and the olecranon fossa was examined, it was mostly found as translucent type 88 (75.9%). While STF was detected on 19 (16.4%) humeri, 13 of them were on the left humeri and 6 of them were on the right humeri (Table 1.). STFs detected on the right and left humeri were generally found in oval shape (Table 2.). The mean values of the MHL, HCF, CFTH and EB on humerus with STF were 321.7±24.8 mm, 12.70±2.60 mm, 32.95±4.68 mm, 57.66±6.31 mm, respectively (Table 3.). Moreover, the mean values of the TD, VD, DME, DLE, DTH of the STF were found as 4.41±2.34 mm, 3.1±0.85 mm, 26.65±3.82 mm, 27.94±3.34 mm, 14.62±1.9 mm respectively (Table 4.).

Table 1. Frequency of the STF, translucent and opaque bony lamina

Side	STF n (%)	Translucent n (%)	Opaque n (%)	Total (n)
Right	6 (9.8)	48 (78.7)	7 (11.5)	61
Left	13 (23.6)	40 (72.7)	2 (3.7)	55
Total	19 (16.4)	88 (75.9)	9 (7.7)	116

STF: supratrochlear foramen, n: number

Table 2. Shape of STF

Side	Oval (n)	Round (n)
Right	6	0
Left	10	3
Total	16	3

STF: supratrochlear foramen, n: number

Table 3. Measurements of the STF+ and STF- humerus

Parameters	STF+	STF-	
		Opaque	Translucent
MHL (mm)	321.7±24.8	337.8±26.4	318.1±23.0
HCF (mm)	12.70±2.60	12.37±2.34	11.61±2.48
CFTH (mm)	32.95±4.68	35.77±5.05	32.65±3.67
EB (mm)	57.66±6.31	61.18±3.72	58.58±4.82

MHL: maximum humeral length, HCF: height of the coronoid fossa, CFTH: distance between the coronoid fossa and the trochlea humeri, EB: epicondylar breadth, STF: supratrochlear foramen

Table 4. Measurements of the STF

Parameters	**Right**	**Left**	**Total**
TD (mm)	3.39±0.94	4.88±2.66	4.41±2.34
VD (mm)	2.62±0.61	3.33±0.87	3.1±0.85
DME (mm)	28.08±3.64	26±3.85	26.65±3.82
DLE (mm)	30.63±3.8	26.7±2.33	27.94±3.34
DTH (mm)	14.93±2.12	14.26±1.88	14.62±1.9

TD: transvers diameter of the STF, VD: vertical diameter of the STF, DME: Distance between the most medial point of the STF and the most medial point of the medial epicondyle, DLE: distance between the most lateral point of the STF and the most lateral point of the lateral epicondyle, DTH: Distance between the most distal point of the STF and the lower edge of the trochlea humeri, STF: supratrochlear foramen

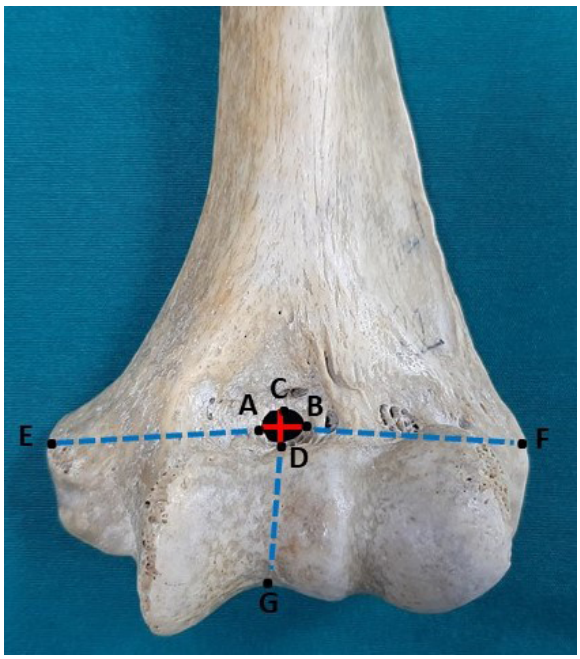

Figure 1. A: the most medial point of STF, B: the most lateral point of STF, C: the most proximal point of STF, D: the most distal point of STF, E: the most medial point of medial epicondyle, F: the most lateral point of lateral epicondyle, G: inferior margin of trochlea humeri, A-B: transvers diameter of STF, C-D: vertical diameter of STF, A-E: distance between the most medial point of STF and the most medial point of medial epicondyle, B-F: distance between the most lateral point of STF and the most lateral point of lateral epicondyle, D-G: distance between the most distal point of STF and inferior margin of trochlea humeri, STF: supratrochlear foramen

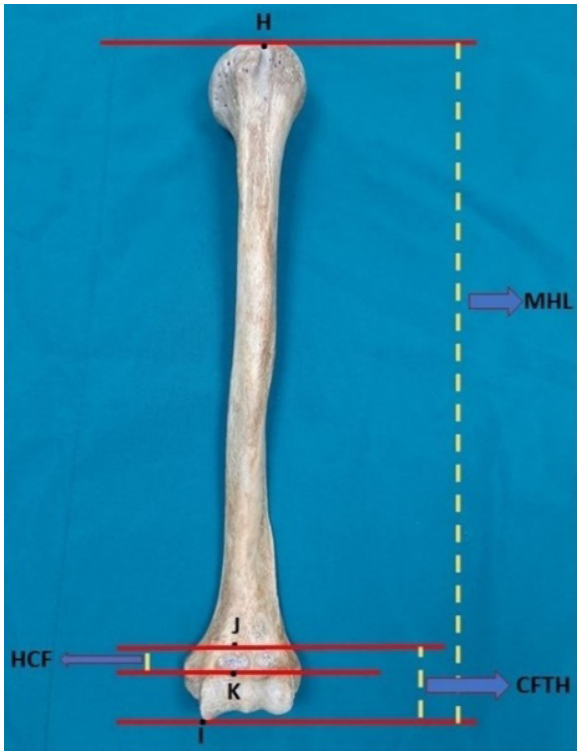

Figure 2. H: most proximal point of head of humerus, I: most distal point of trochlea humeri, J: most proximal point of coronoid fossa, K: most distal point of coronoid fossa, H-I: maximum humeral length (MHL), J-I: Distance between the coronoid fossa and the trochlea humeri (CFTH), J-K: Height of the coronoid fossa (HCF)

Table 5. Shape of the STF in the previous studies and this study

Study	Side	Oval (n)	Round (n)	Irregular (n)	Triangular (n)	Rectangular (n)	Sieve like (n)	Reniform (n)	Hourglass (n)
Erdogmus et al. (5)	R	3	1						
	L	10	1		2		1		
Mathew et al. (6)	R	8	5		2	1	1	1	
	L	23	8		1		4	6	
Li et al (24)	Total	19	4		2	2			
Jadhav and Zambare (13)	R	27	6	6					
	L	25	7	6					
Singhal and Rao (28)	R		2						
	L				1				
Ravindra et al. (10)	R	4	1	1					
	L	5	9						
Bahşi (19)	R	3	5					3	
	L	6	5						
Nayak et al. (29)	Total	23	7		2				
Nayak et al. (7)	Total	1		7	1	2			1
Bhanu and Sankar (2)	R	9	4						
	L	17	7						
Shivaleela et al. (25)	R	6	8	2					
	L	10	10	2					
Bokhari et al. (14)	R	8	2	1			2		
	L	11	3	4	1		2		
Patel et al. (26)	Total	125	6		2				
Arunkumar et al. (27)	Total	71	2		3				
Mayuri et al. (43)	Total	15	13		2		1		
Dang et al. (16)	R	4	8						
	L	8	10						
Adibatti and Asha (31)	Total	8	2						
Jayakumar and Vimala (22)	R	10	4				1	2	
	L	11	11				2	2	
Agrawal et al. (15)	R	8	4	1					
	L	11	6	1					
This study	R	6							
	L	10	3						

R: right, L: left, n: number, STF: supratrochlear foramen

Table 6. Morphometry and frequency of the STF in the previous studies and this study

Study	Population	Sample size (N)	STF (%)	Side	STF (n)	Translucency (n)	Opacity (n)	TD (mm)	VD (mm)	DME (mm)	DLE (mm)	DTH (mm)
Erdogmus et al. (5)	Türkiye	166 (85 R, 81 L)	10.8	R (M/F)	6	17	62	6.52/5.34	2.72/4.59	30.56/24.70	29.54/26.65	
				L (M/F)	12	17	52	6.70/5.64	4.26/3.92	28.97/23.93	28.68/26.92	
Mathew et al. (6)	India	244 (114 R, 130 L)	24.59	R	19	70	25	5.24	3.82	24.91	27.2	14.29±1.58
				L	41	69	20	4.88	3.37	24.39	26.92	14.41±1.62
Li et al. (24)	China	262 (137 R, 125 L)	10.3	R	9			3.26	3.56			
				L	18			4.47	5.07			
Jadhav and Zambare (13)	India	222 (113 R, 109 L)	34.68	R	39	51						
				L	38	54						
Singhal and Rao (28)	India	150 (78 R, 72 L)	28	R	22	99	9	6.92	4.64			
				L	20							
Ravindra et al. (10)	India	122 (54 R, 68 L)	16.3	R	6	35	13	5.3	4.2	24.1	23.7	
				L	14	43	11	6.7	4.3	16.9	24.3	
Bahşi (19)	Türkiye	108 (56 R, 52 L)	20.37	R	11	30	15	6.55	4.81	25.0	26.19	
				L	11	27	14	5.64	4.82	24.73	26.91	
Nayak et al. (29)	India	384 (164 R, 220 L)	34.3	R	73	54		5.99	3.81	28		
				L	59	89		6.55	4.85	26.1		
Nayak et al. (7)	India	60 (28 R, 32 L)	20	R	5	11		5.0	3.2	23.58	25.16	
				L	7	12		6.57	5.28			
Bhanu and Sankar (2)	India	121 (49 R, 72 L)	30.58	R	13	27	6	6.68	5.75			
				L	24	42	9	6.92	4.86			
Shivaleela et al. (25)	India	142 (72 R, 70 L)	26.7	R	16	36	20	4.50	3.88			
				L	22	32	16	3.32	3.68			
Krishnamurthy et al. (33)	India	180 (84 R, 96 L)	23	R				5.26	4			
				L				6.5	4.70			
Hamzehtofigh et al. (30)	Iran	57 (27 R, 30 L)	6.8	R	2			2.60±2.68	1.75±1.76			
				L	2			0.57±0.31	0.55±0.07			
Bokhari et al. (14)	Pakistan	200 (103 R, 97 L)	17	R	12	125	41	5.2± 2.69	3.8± 1.24	21.7± 0.45	27.4± 3.0	
				L	22			4.9 ± 2.75	3.2± 1.19	25.3±0.24	26.2± 2.8	
Patel et al. (26)	India	565 (279 R, 286 L)	23.5	R	53	126	100	7.31±1.77	4.77±1.15			
				L	80	101	105	7.03±1.49	4.90±1.68			
Arunkumar et al. (27)	India	355 (188 R, 167 L)	21.4	R	37	106	45	5.67±1.71	3.9± 1.32			
				L	39	76	52	5.39±1.57	3.84±1.2			
Mayuri et al. (43)	India	76	40.78	R	12							
				L	19							
Dang et al. (16)	India	100 (46 R, 54 L)	30	R	12	18	16	5.14±1.165	3.79±0.68			
				L	18	12	24	5.21±2.13	3.94±1.40			
Chagas et al. (23)	Brazil	330 (145 R, 185 L)	22.5	R	28	73	44	2.365±1.396	2.778±2.197			
				L	46	63	76	2.332±1.234	2.780±2.050			
Adibatti and Asha (31)	India	100	10	R	4	6						
				L	6	9						
Cibikkarthik et al. (32)	India	40	17	R				3.89±0.68	6.84±0.59			
				L				3.71±0.31	6.52±0.77			
Jayakumar and Vimala (22)	India	156 (72 R, 84 L)	27.5	R	17			7	4.5	26.2	27.2	
				L	26			10	7.5	25.3	27.1	
Mahajan (21)	India	100 (50 R, 50 L)	26	R	11	35	4					
				L	15	27	8					
Agrawal et al. (15)	India	135 (69 R, 66 L)	31/135	R	13	7		6.35±1.57	4.16±0.673			
				L	18	15		6.49±1.375	4.88±0.694			
Silva et al (20)	Brazil	141 (72 R, 69 L)	19.8	R	11	110	3	4.853±2.934	3.653±1.983			
				L	17			5.427±2.540	3.492±1.746			
Papaloucas et al. (18)	Greece	1312	0.304	M								
				F	0.568%							
Akabori (3)	Japan	436	12.7 (M)/ 30.1 (F)	M	38							
				F	41							
Hirsh (17)	Indian		58	R								
				L								
This study	Türkiye	116(61 R, 55 L)	16.3	R	6	48	7	3.39±0.94	2.62±0.61	28.08±3.64	30.63±3.8	14.93±2.12
				L	13	40	2	4.88±2.66	3.33±0.87	26±3.85	26.7±2.33	14.26±1.88

R: right, L: left, M: male, F: female, n: number, STF: supratrochlear foramen, TD: transvers diameter of the STF, VD: vertical diameter of the STF, DME: Distance between the most medial point of the STF and the most medial point of the medial epicondyle, DLE: distance between the most lateral point of the STF and the most lateral point of the lateral epicondyle, DTH: Distance between the most distal point of the STF and the lower edge of the trochlea humeri

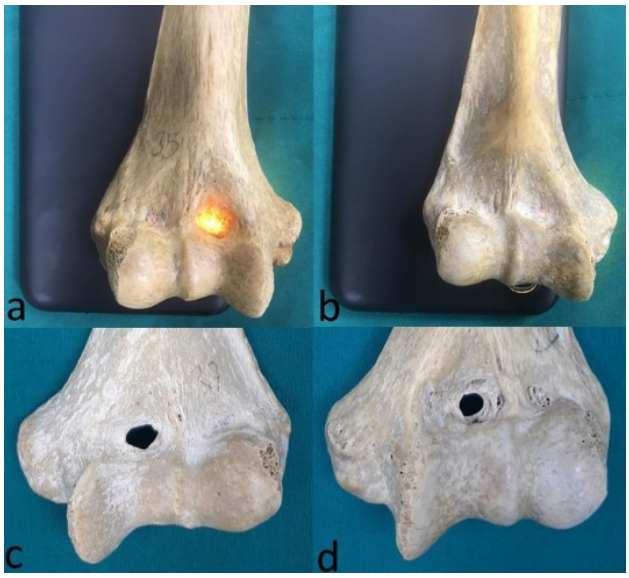

Figure 3. a) The translucent coronoid olecranon septum, b) The opaque coronoid olecranon septum, c) Oval shaped STF, d) Round shaped STF, STF: supratrochlear foramen

Discussion

STF is formed as a result of perforation of the bony lamina between the coronoid fossa and the olecranon fossa at the distal end of the humerus. This foramen may show variations in shape. Consistent with the studies of Erdogmus et al. (5), Mathew et al. (6), Jadhav and Zambare (13), Bhanu and Sankar (2), Bokhari et al. (14), Agrawal et al. (15) on STF shape variations, oval-shaped STF was found frequently in this study, while in the study of Dang et al. (16), round-shaped STF and in the study of Nayak et al. (7), irregular-shaped STF was detected more frequently (Table 5.). In this study, no shape types of STF other than oval and round was observed.

The frequency of STF may vary according to the geographical regions. STF was found as 58% in the study conducted by Hirsh in the Indian population (17), while it was found at least as 0.304% in the study of Papaloucas et al. in the Greek population (18). In Turkish population, the frequency of STF (16.4%) was found less than in the study of Bahşi et al.(20.37%) (19) and more than Erdogmus et al. (10.8%) (Table 6.) (5).

The frequency of STF may differ in the right and left humerus. Consistent with this study, while STF is generally detected on the left humerus in the literature (2, 5-7, 10, 13-16, 19-27), Singhal and Rao (28), Nayak et al. (29) and Hamzehtofigh et al. (30) found it more common on the right humerus (Table 6.). Studies in the literature on STF frequency, morphology and morphometry and this study are summarized comparatively in Table 6.

The minimum and maximum mean values of the TD, VD, DME, DLE in the previous studies were ranged between 0.57±0.31 mm/7.31±1.77 mm, 0.55±0.07 mm/6.84±0.59 mm, 16.9 mm/30.56 mm, 23,7 mm/29.54 mm respectively. While the mean values of the TD, VD, DME are among the values found in previous studies, DLE measurement of right side humerus is higher than the literature values in our study (2, 5, 6, 10, 14-16, 19, 20, 22-33). The present study found the mean value of the DTH (right: 14.93±2.12mm / left: 14.26±1.88 mm) similar to the study of Mathew et al (right: 14.29±1.58 mm / left: 14.41±1.62 mm) (Table 6.) (6).

There are various theories that STF may occur as a result of pressure due to excessive hyperextension of the elbow joint (34), resorption of the anterior edge of the septum between the olecranon fossa and coronoid fossa (35), compression of the olecranon process (17) and calcium metabolism differences (36). STF is more common in women, and it is thought that this may be due to higher joint hypermobility in women (37) and the fact that the elbow joint is more inverted (38). In this study, the relationship between STF and gender could not be evaluated because the gender of the bones was unknown.

In the literature, while there is no study showing that any neurovascular structure passes through the STF, Roaf described a case in 1957 where the median nerve extended to the foramen and reported that this patient had complaints of pain and weakness in the left hand (39).

STF can be confused with some clinical conditions. It appears as a radiolucent area on X-ray images, and this image resembles an osteolytic and cystic lesion. For this reason, radiologists should be aware of this variation (40). STF is also associated with narrow medullary canal and anterior angulation, so caution is required in the preoperative evaluation of supracondylar fractures of humerus (41, 42). Supracondylar fractures of the humerus constitute approximately 17% of pediatric traumas. Retrograde intramedullary nailing is applied in such fractures. Since STF is known to be associated with a narrow medullary cavity, the antegrade route may be preferred. Therefore, knowing the presence of the STF may be helpful in deciding the surgical course of the fracture repairing (6). Moreover, in the anthropological science, it is accepted that the STF is more common in primitive populations than in contemporary humans. It is thought that this variations, which is phylogenetically important, is less common in modern populations because of more limited elbow movements (24).

Conclusion: STF was detected on 19 (16.4%) of humeri, and most of them were in the left humeri and oval shaped. There are few studies on STF in Turkish population. We believe that this clinically important variation will contribute to anatomists, especially radiologists and orthopedists, in terms of awareness and knowing the frequency, morphology and morphometry of STF.

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