Innovations

A Comprehensive Study of Supratrochlear Foramen of Humerus and its Clinical Perspective – An Anatomical Study

[1]Adabala N. V. V. Veerraju; [2]B. Narayana Rao; [3]Pasupuleti Lakshmana Rao[3]

[1]Professor, Department of Anatomy, Konaseema Institute of Medical Sciences and Research Foundation, Amalapuram, India

[2]Professor and HOD, Department of Anatomy, Konaseema Institute of Medical Sciences and Research Foundation, Amalapuram, India

[3]Associate professor, Department of Anatomy, Andhra Medical College, Visakhapatnam, India

Corresponding author: **Pasupuleti Lakshmana Rao**

Abstract

Introduction: *The distal humerus contains the olecranon fossa and the coronoid fossa, which are partitioned by a thin bony septum that may occasionally perforate and present a supratrochlear foramen. It is not commonly mentioned about the supratrochlear foramen in standard textbooks of anatomy and orthopedics. Knowledge of the supratrochlear foramen is very essential in planning the surgical procedures involving the lower end of the humerus and preventing misinterpretation of radiographs of the elbow joint.* ***Aim:*** *The present study aims at assessing the prevalence, morphology, and morphometry of the supratrochlear foramen of the humerus in relation to size, shape, and distance from the epicondyles and margin of the trochlea.* ***Materials and methods:*** *318 dry humeri were examined, out of which 165 belonged to the right side and 153 belonged to the left side. The prevalence, degree of perforation, shape, and dimensions of the STF were recorded. The distance of the medial epicondyle, lateral epicondyle, and lower margin of the trochlea from the nearest margin of the STF was recorded. The distance between the medial and lateral epicondyles was recorded, and the TD/DMLE ratio was calculated.* ***Results:*** *The prevalence of the supratrochlear foramen observed in our study is 31.13%. The prevalence of various shapes of the STF are oval (43.43%), round (25.25%), reniform (14.14%), rectangular (7.07%), triangular (4.04%), irregular (3.03%), and sieve-like (3.03%).* ***Conclusion:*** *The supratrochlear foramen is mainly observed in primates. The STF may be an evolutionary relation between the humans and lower animals. The findings would be very helpful to anatomists, anthropologists, forensic experts, orthopedic surgeons, and radiologists in their day-to-day clinical practice. The knowledge of the STF is especially useful to orthopedic surgeons in surgical prelude of the supracondylar fractures of the humerus like intramedullary nailing.*

Key words: *Supratrochlear foramen, humerus, intramedullary nailing, septal aperture, translucency.*

Abbreviations used: STF = Supratrochlear foramen, TD = Transverse diameter, VD = Vertical diameter, DMLE = Distance between medial and lateral epicondyles

Introduction

The supratrochlear foramen is a common atypical variant seen in the distal humerus which was not given much importance in standard reference books of orthopedics and anatomy. Usually vessels and nerves pass through foramina, but no important structure passes through the supratrochlear foramen. The lower end of the humerus contains the olecranon fossa and the coronoid fossa, which are partitioned by a thin bony septum covered by synovial membrane in the living (1). Occasionally, the plate of bone may show a perforation, which is known as the supratrochlear foramen or intercondylar foramen (2).

The supratrochlear foramen was first described by Meckel in 1825 (3). It was referred to as septal aperture by Hrdlicka (4). In previous studies, different shapes of the supratrochlear foramen were described by various authors. The most common shapes observed were oval, round, reniform, rectangular, triangular, irregular, sieve-like, etc. The supratrochlear foramen is also observed in some lower animals like hyenas, dogs, apes, and other primates (5). Functionally, the presence of a supratrochlear foramen results in overextension of the elbow in animals, which helps to tear the meat of the prey. Darwin contemplated the STF in humans as a feature to suggest the evolution of humans from primates (6).

According to Hirsh (1972), the supratrochlear septum was intact up to the age of seven years and is lined by synovial membrane (7). Later, in some individuals, due to various reasons, the septum may undergo degeneration or get absorbed to form the supratrochlear foramen (8). T-Box5 (TBX) genes play an important role in the development of the supratrochlear foramen in postnatal life. They act at the molecular level and regulate the synthesis of TBX proteins, which are critical in the development of the heart and the limbs in foetal life (9).

Several studies have found that there is an association between the supratrochlear foramen and the narrowing of medullary canal at the distal humerus (10). A fracture in supracondylar region of the humerus is a common problem among children and is treated by retrograde intramedullary nailing through both medial and lateral epicondyles or through the lateral epicondyle only. The existence of a supratrochlear foramen and a narrow intramedullary canal can compromise the surgical procedure. Hence the knowledge of the presence of the supratrochlear foramen is very important to plan surgical procedures for fracture of the distal end of the humerus (11). The incidence of

supratrochlear foramen varies widely in different races, between 0.3 and 58% (12).

In radiological examination, the presence of the supratrochlear foramen may be misinterpreted as a cystic or osteolytic lesion (13). Our present anatomical study aims to find the prevalence, morphology, and morphometry of supratrochlear foramen in the Konaseema region of Andhra Pradesh, India. The comprehensive knowledge of the supratrochlear foramen might be beneficial to the orthopedic surgeons, anatomists, radiologists, and anthropologists in day to day clinical practice.

Materials and methods

A cross-sectional study is carried out on 318 unpaired humeri from the bone bank of the Department of Anatomy, Konaseema Institute of Medical Sciences and Research Foundation, Amalapuram, Andhra Pradesh, between November 2024 and March 2025. The age and sex of the humeri are unknown. Of these humeri, 165 belonged to the right side and 153 belonged to the left side. Broken bones and bones with pathological changes are discarded from the study.

The prevalence of supratrochlear foramen was observed in both right and left humeri and was recorded as present or absent. The shape of the supratrochlear foramen was observed and classified as oval, round, triangular, rectangular, reniform, sieve-like, and irregular (figure-1).

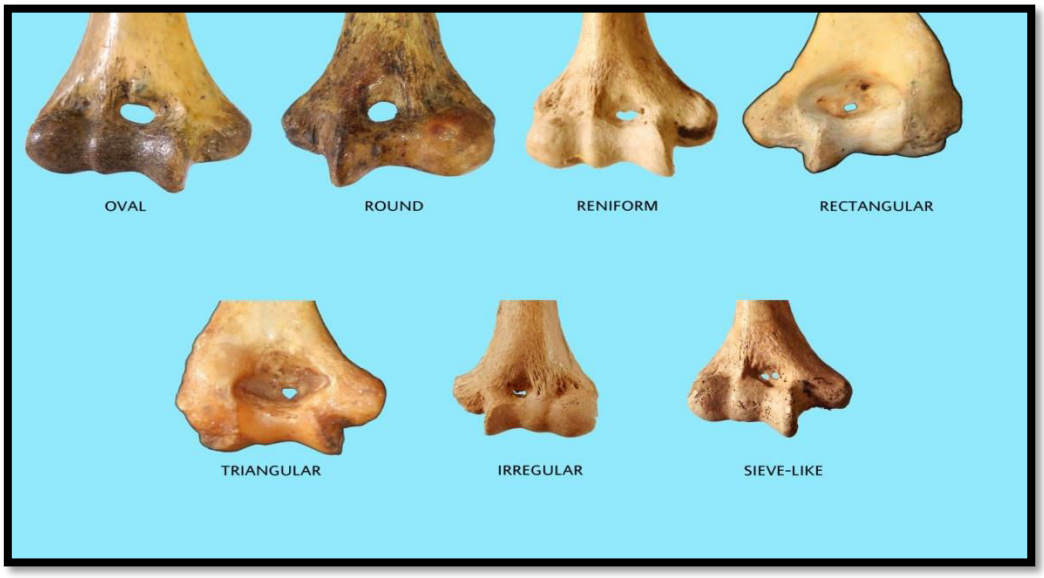

Figure 1: Various shapes of the supratrochlear foramen

Degree of perforation of bony septum was classified as opaque septum, translucent septum, translucent septum with foramen, and complete foramen without septum (figure-2). The translucency of the bony septum was observed by placing the lower end of the humerus against an illuminated X-ray lobby.

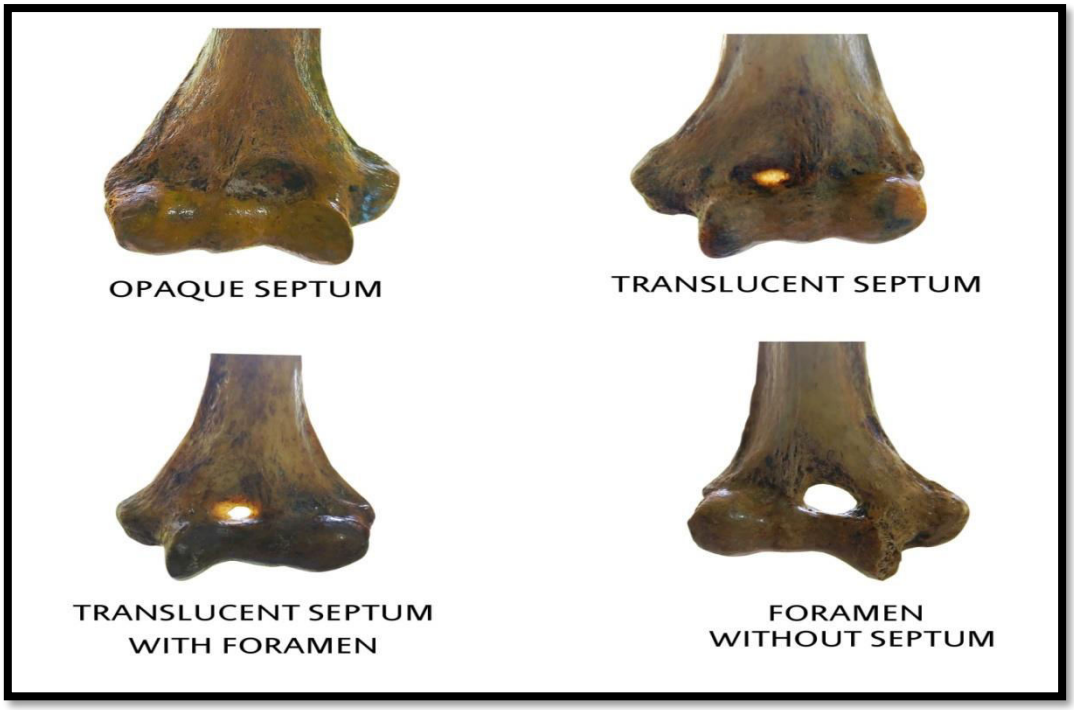

Figure 2: Degree of perforation of the supratrochlear septum seen against illumination of X-ray lobby

Morphometric parameters were measured using a digital vernier caliper. Sieve-like foramina were not measured. All the parameters were recorded in millimeters and were tabulated. The following parameters of the supratrochlear foramen were observed and recorded (figure-3).

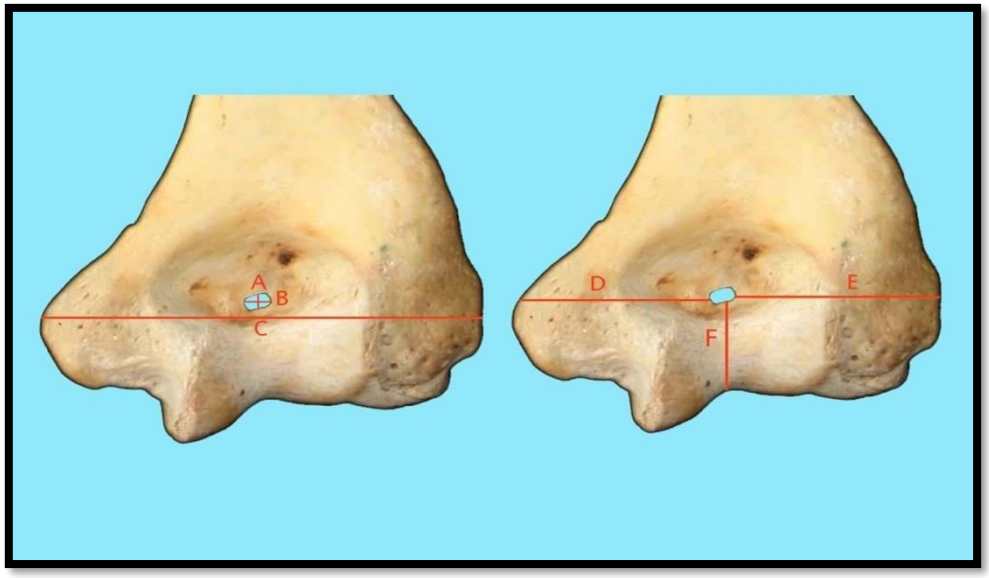

Figure 3: Various metric parameters of the STF recorded in present study

A. Vertical diameter of the STF (VD)
B. Transverse diameter of the STF (TD)
C. Distance between medial and lateral epicondyles (DMLE)
D. Distance between the nearest STF margin and the medial epicondyle
E. Distance between the nearest STF margin and the lateral epicondyle
F. Distance between the nearest STF margin and the lower margin of the trochlea.
G. The ratio between TD and DMLE.
Statistical analysis of the data obtained was done using SPSS Version 21.

Results

Among the 318 humeri studied, 165 belonged to the right side and 153 belonged to the left side. 99 humeri out of 318 (31.13%) showed the presence of the supratrochlear foramen. The prevalence of the STF recorded in the right and the left humeri are tabulated in table 1. Out of 99 humeri that showed the presence of the STF, 47 belonged to the right side (28.48%) and 52 belonged to the left side (33.98%). Hence the prevalence of the STF is more common in the left humeri compared to the right humeri.

Table 1: Prevalence of supratrochlear foramen in the humerus bone

Side	STF Present	Percentage (%)
Right (n=165)	47	28.48
Left (n=153)	52	33.98
Total (n=318)	99	31.13

The supratrochlear foramen exhibited various shapes, like oval, round, reniform, triangular, rectangular, irregular, and sieve-like. The prevalence of the various shapes of the STF recorded in the right and the left humeri are tabulated in table 2. The prevalence of various shapes of the STF are oval (43.43%), round (25.25%), reniform (14.14%), rectangular (7.07%), triangular (4.04%), irregular (3.03%), and sieve-like (3.03%).

Table 2: Prevalence of various shapes of supratrochlear foramen of humerus

Shape of the STF	Right side (n=47)	Left side (n=52)	Total (n=99)	Percentage (%)
Oval	19	24	43	43.43
Round	12	13	25	25.25
Triangular	1	3	4	4.04
Rectangular	3	4	7	7.07
Reniform	8	6	14	14.14
Irregular	3	0	3	3.03
Sieve like	1	2	3	3.03

The degree of perforation of the bony septum was recorded and tabulated in table 3. Among the 165 right humeri examined, 36 showed an opaque bony septum (21.82%), 82 showed a translucent bony septum (49.69%), 18 showed a translucent bony septum with a supratrochlear foramen (10.91%), and 29 showed a supratrochlear foramen without any bony septum (17.58%). Among the 153 left humeri examined, 28 showed an opaque bony septum (18.30%), 73 showed a translucent bony septum (47.71%), 20 showed a translucent bony septum with a supratrochlear foramen (13.07%), and 32 showed a supratrochlear foramen without any bony septum (20.92%).

Table 3: Degree of perforation of bony septum

Type	Right side	Percentage	Left side	Percentage
Opaque septum	36	21.82%	28	18.30%
Translucent septum	82	49.69%	73	47.71%
Translucent septum with foramen	18	10.91%	20	13.07%
Foramen	29	17.58%	32	20.92%
Total	165	100%	153	100%

Various metric parameters of the supratrochlear foramen were studied, recorded, and tabulated in Table 4. The mean vertical diameter (VD) of the STF in the right humerus is 3.51±1.70 mm compared to 4.03±2.15 mm in the left humerus with a p-value of 0.185, which is statistically not significant. The mean transverse diameter (TD) of the STF in the right humerus is 5.78±2.49 mm compared to 5.98±2.57 mm in the left humerus, with a p-value of 0.697, which is statistically not significant. The mean distance between the medial and lateral epicondyles (DMLE) of the humerus in the right humerus is 53.87±3.86 mm compared to 55.01±4.11 mm in the left humerus, with a p-value of 0.158, which is statistically not significant. The mean distance between the nearest STF margin to the medial epicondyle in the right humerus is 24.49±2.83 mm compared to 23.87±3.02 mm in the left humerus, with a p-value of 0.295, which is statistically not significant. The mean distance between the nearest STF margin to the lateral epicondyle in the right humerus is 25.83±2.86 mm compared to 26.17±2.54 mm in the left humerus, with a p-value of 0.542, which is statistically not significant. The mean distance between the nearest STF margin to the lower margin of the trochlea in the right humerus is 14.12±1.72 mm compared to 13.96±1.78 mm in the left humerus with a p-value of 0.642, which is statistically not significant. The ratio between TD and

DMLE in the right humerus is 0.11±0.04 mm compared to 0.11±0.05 mm in the left humerus with a p-value of 0.873, which is statistically not significant.

Table 4: Average diameter and distance of the STF margin from key points in millimeter

Parameter	Right		Left		P value
	Mean	Standard deviation	Mean	Standard deviation	
Vertical diameter (VD) of the STF	3.512	1.702	4.031	2.152	0.185
Transverse diameter of the STF (TD)	5.778	2.491	5.977	2.570	0.697
Distance between medial and lateral epicondyles (DMLE)	53.872	3.863	55.012	4.110	0.158
Distance between STF margin to medial epicondyle	24.495	2.833	23.875	3.022	0.295
Distance between STF margin to lateral epicondyle	25.834	2.859	26.168	2.543	0.542
Distance between STF margin to lower margin of trochlea	14.124	1.727	13.960	1.783	0.642
Ratio between TD and DMLE	0.107	0.045	0.108	0.046	0.873

Discussion

The distal humerus presents lateral and medial epicondyles, which give attachment to the common extensor and flexor group of muscles of the forearm. The lower end of the humerus presents three fossae called the coronoid fossa, radial fossa, and olecranon fossa and enters into the formation of the elbow joint by articulating with the ulna and the radius bones of the forearm (14). The distal end of the humerus plays an important role in orthopedics in the preoperative surgical planning of the supracondylar fractures and also in anthropology to identify the evolutionary origin of human beings from primates (15). Various foramina present in lower animals and humans permit passage of neurovascular structures, but the supratrochlear foramen does not allow passage of any significant structures in humans.

Various theories have been proposed to explain the development of the supratrochlear foramen in lower animals and human beings. Glanville EV proposed a mechanical theory that the STF is formed due to the articulation between the humerus and ulna in extreme flexion and extension. The appearance of the supratrochlear foramen can be due to physiological origin of the elbow joint, and different shapes of the STF can be due to articulating surfaces (16). Koyun, N., proposed that an inherited trait leads to the formation of the supratrochlear foramen (17). Sunday. OO proposed that the prehistoric ancestors carried heavy tools for their basic needs like cultivation. The intermittent pressure caused by the olecranon and coronoid process of the ulna progressively resulted in the disappearance of the bony supratrochlear septum and in the formation of the supratrochlear foramen (18). Chapman DL proposed that the pressure by the olecranon process may be a strengthening factor, but the inadequate blood flow to the supratrochlear bony septum results in deterioration and leads to the formation of the STF. This is supported by the fact that the STF was not present at birth and is developed after seven years of age. Later the supratrochlear septum may get absorbed to form the STF due to decreased blood flow (19).

The prevalence of the supratrochlear foramen varies widely in varied populations and result from genetic factors and everyday activities. The STF is more commonly observed on the left side when compared to the right side due to the robust and gracile nature of the right-side bones (20). The prevalence of the STF varies widely in various populations, from 0.3% to 60%, and the prevalence observed in the present study compared to previous studies is recorded in table 5. The prevalence of the STF in present study is 31.13%. Mecalister conducted a study and recorded a prevalence of 57% among the population of Libya (21). The prevalence of the STF is very low in the Greek population (22). Lamb et al. observed that the STF is predominantly observed on the left side, especially in ancient people and adolescents (23). The prevalence observed in the present study is similar to the study of Lamb et al.

Table 5: Comparison of prevalence of the STF in various studies

Author	Population	Prevalence (%)
Present study	Andhra Pradesh, South India	31.13
Sangeetha et al, 2017	North India	30.05
Chagas et al, (2016)	Brazil	22.5
Joshi et al, (2016)	Western India	35.88
Sunday.OO et al, (2014)	Nigeria	27.7
Krishnamurthy et al, (2011)	Mexico	38.7
Singhal and Rao et al (2007)	South India	28.0

Ozturk et al, (2000)	Egypt	7.9
Kate and Dubay et al, (1970)	Central India	32.0
Chatterjee et al, (1968)	Eastern india	27.4
Glanville et al, (1967)	Europe	6.0
Ming-Tzu et al, (1935)	China	17.5
Akabori et al, 1934	Japan	18.1
Hrdlicka et al, (1932)	Germany	8.8
Hirsh et al, (1927)	Native America	58

Various shapes of the supratrochlear foramen described are oval, round, reniform, quadrangular, triangular, irregular, and sieve-like (24). The formation of various shapes of the STF may depend on mechanical activity, level of degeneration, and the differences in race. The literature available revealed the most common shape of the STF is oval, and the least common shape is sieve-like. The prevalence of remaining shapes depends on the level of absorption of the supratrochlear septum. Results obtained in our present study are similar to studies conducted by previous authors showing a higher incidence of oval shape (43.3%), followed by round (25.25%), reniform (14.14%), triangular (7.07%), irregular (3.03%), and sieve-like (3.03%). The prevalence of various shapes observed by previous authors compared with the present study is recorded in table 6.

Table 6: Comparison of prevalence of STF in various studies categorized according to shapes

Author	Oval	Round	Reniform	Sieve	Triangular	Rectangular	Irregular	Total prevalence
Present study (2025)	43.43 %	25.25 %	14.14 %	3.03 %	4.04%	7.07 %	3.03%	31.13%
Sorrathron Boonchan et al. (2022)	43.70 %	16.5 %	8.74 %	3.88 %	3.88%	4.85%	18.45 %	16.10%
Deshmukh et al. (2018)	45%	50%	-	-	-	-	5%	16.39%
Shivaleela et al. (2016)	42.10 %	47.37 %	-	-	-	-	10.52 %	26.76%
Mathew et al. (2016)	51.67 %	21.67 %	11.66 %	8.33 %	5%	1.67%	-	24.59%
Li et al. (2015	70.37 %	14.81 %	-	-	7.41%	7.41%	-	10.3%

In our present study, the mean value of the transverse diameter and vertical diameter of the supratrochlear foramen are 5.78 mm and 3.51 mm on the right side and 5.98 mm and 4.03 mm on the left side. The results obtained in our study are consistent with results obtained by previous authors and are recorded in Table 7. The transverse and vertical diameter of the supratrochlear foramen varies depending upon the shape, absorption, and vascular insufficiency of the lower end of the humerus.

Table 7: Comparison of various parameters related to STF with previous studies

Author	Vertical diameter of STF		Transverse diameter of STF		STF to medial epicondyle		STF to lateral epicondyle	
	Right	Left	Right	Left	Right	Left	Right	Left
Present study	3.51 ± 1.70	4.03 ± 2.15	5.78 ± 2.49	5.98 ± 2.57	24.49 ± 2.83	23.87 ± 3.03	25.83 ± 2.86	26.17 ± 2.54
Bahsi et al. (2019)	4.81 ± 1.38	4.82 ± 1.33	6.55 ± 2.84	5.64 ± 1.96	25.00 ± 3.07	24.73 ± 3.04	26.19 ± 2.64	26.91 ± 1.97
Bokhari et al. (2018)	3.80 ± 1.24	3.20 ± 1.19	5.20 ± 2.69	4.90 ± 2.75	21.7 ± 0.45	25.3 ± 0.24	27.4 ± 3.0	26.2 ± 2.8
Deshmukh at al. (2018)	4.2 ± 3.1	4.3 ± 1.7	5.3 ± 2.7	6.7 ± 2.3	24.1 ± 2.2	23.7 ± 2.4	16.9 ± 5.5	24.3 ± 2.2
Joshi et al. (2016)	3.75 ± 1.48	4.68 ± 1.43	5.50 ± 2.89	6.48 ± 2.47	24.7 ± 3.3	25.2 ± 3.2	24.7 ± 1.9	25.7 ± 1.7
Mathew et al. (2016)	3.82 ± 1.07	3.37 ± 1.25	5.24 ± 1.76	4.88 ± 1.63	24.91 ± 2.93	24.39 ± 3.15	27.2 ± 2.95	26.92 ± 2.46
Erdogmus et al. (2014)	2.72 ± 0.0	4.26 ± 0.0	6.52 ± 0.0	6.7 ± 2.2	24.70 ± 1.95	23.93 ± 2.65	26.65 ± 0.68	26.92 ± 1.28

The distance between the nearest margins of the STF and medial epicondyle and lateral epicondyle are recorded and compared with studies by previous authors, as documented in table 7. The results obtained in our present study are consistent with results obtained in previous studies conducted by Bashi et al., Bokhari et al., Deshmukh et al., Joshi et al., Mathew et al and Erdogmus et al.

The measurement of transverse and vertical diameters for assessing the size of the STF can lead to confounding bias due to variations in the size of the humeri. Large sized humeri are likely to have large sized STF. Hence the ratio of transverse diameter (TD) and distance between medial and lateral epicondyles (DMLE) was taken into account to eliminate the bias in calculation of the size of the supratrochlear foramen. Not much literature is available for comparison of the ratio between TD and DMLE in previous studies about the STF. An additional metric parameter, i.e., the distance between the nearest margin of the STF and the lower margin of the trochlea, was recorded to increase the precision of

identifying the anatomical position of the STF. It would be helpful in preoperative planning of a surgical procedure.

Though not clearly mentioned in the textbooks of anatomy, the supratrochlear foramen exhibits variations in shape and size, which makes its presence highly significant in clinical practice. The STF can increase the local stress and alter the pattern and stability of fractures (25). Understanding the clinical significance of the supratrochlear foramen helps in the precise diagnosis and planning of the orthopaedic surgical procedures. Supracondylar fractures constitute 17% of paediatric trauma. The STF influences the surgical management of supracondylar fractures of the humerus, which are treated by retrograde intramedullary nailing (26). The STF can alter the pattern of the fracture, as the medullary canal may be narrowed down. The presence of the STF can restrict the placement of the nail or cause intraoperative complications. The STF can affect the entry point and path of the intramedullary nail. Hence requires careful preoperative planning for surgery.

According to De Wilde et al, the supratrochlear foramen appears radiolucent and is seen as a 'pseudo-lesion' in a radiograph of the upper limb. Hence it can mimic a cyst or a lytic lesion on a radiograph, which can lead to confusion and misinterpretation (27). Hence, knowledge of variations in the anatomy of the supratrochlear foramen is essential for accurate interpretation of radiological images.

The supratrochlear foramen can be a potential site for median nerve entrapment or compression. Although the STF doesn't contain any structures, occasionally the median nerve gets entrapped in the STF and presents symptoms like pain, numbness, and weakness in the hand.

As the supratrochlear foramen shows a wide range of racial differences, it can be used to identify the race of an individual and can be a useful parameter in forensic medicine and anthropology. The link of the STF as an evolutionary trait is helpful for dating the specimens by an anthropologist.

Conclusion

The supratrochlear foramen is a common variant observed in the distal humerus. The STF is familiar to anatomists and anthropologists but not very familiar to clinicians. The standard textbooks of clinical practice have not described the importance of the STF in detail. The knowledge of the STF is very essential in academic sessions of the anatomists, medicolegal investigations by forensic science experts, evaluations to establish a relationship between humans and primates, and dating the specimens by anthropologists. The knowledge of the STF is crucial to orthopaedic surgeons for preoperative planning to choose an intramedullary nailing in supracondylar fractures of the humerus. The knowledge of the supratrochlear foramen is beneficial to radiologists for the interpretation of radiographs and CT scans of the distal end of the humerus to differentiate osteolytic and cystic lesions.

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