










# Supratrochlear foramen: morphology and clinical-surgical implications

## Forame supratroclear: morfologia e implicações clínico-cirúrgicas



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### Abstract

The supratrochlear foramen is an anatomical variation of the humerus bone that connects the olecranon fossa with the coronoid fossa. Considering the scarce data about this variation in the Brazilian population, its morphological and morphometric aspects may vary depending on the ethnic group. **Objective:** To investigate the morphology and frequency of the supratrochlear foramen in Brazilian human bones and its association with laterality and describe its clinical-surgical repercussions. **Methods:** This cross-sectional and prospective study analyzed a convenience sampling of 51 human humeri bones from a collection belonging to a higher education institution. **Results:** A total of 21.9% of the humeri presented supratrochlear foramen, and the oval shape was the most predominant. Although it was more frequent on the left side, no significant association was observed between the presence of the supratrochlear foramen and laterality.

**Keywords:** Surgery; Orthopedic procedures; Humerus; Anatomy variation.

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## Resumo

O forame supratroclear é uma variação anatômica do osso úmero que comunica a fossa do olecrano com a fossa coronoide. Considerando o escasso número de dados desta variação na população brasileira, haja vista que seus aspectos morfológicos e morfométricos podem variar dependendo do grupo étnico. **Objetivo:** investigar a morfologia e frequência do forame supratroclear em ossos humanos brasileiros e sua associação com a antimeria, bem como descrever suas repercussões clínico-cirúrgicas. **Métodos:** Trata-se de um estudo do tipo transversal, observacional e prospectivo, com amostragem do tipo não probabilístico por conveniência, o qual analisou 51 úmeros humanos de um acervo pertencente a uma instituição de ensino superior. **Resultados:** Foi observado que 21,9% dos úmeros apresentaram o forame supratroclear, sendo a forma oval a mais predominante. Apesar de ter sido mais frequente no lado esquerdo, não foi observada associação estatística significativa entre a presença do forame supratroclear e a antimeria.

**Palavras-chaves:** Cirurgia; Procedimentos ortopédicos; Úmero; Variação anatômica.

## INTRODUCTION

The coronoid fossae and olecranons in the distal epiphysis of the humeri are separated by a thin bone plate called supratrochlear septum, whose thickness is between 0.5 mm and 1 cm<sup>1,2</sup>. In some cases, especially after seven years of age, this region can be perforated and generate the supratrochlear foramen (STF)<sup>3</sup>.

The factors leading to the emergence of this anatomical variation have not been defined yet; however, the mechanical stress during flexion and extension at a high range of motion and genetic factors, mainly related to T-box genes, may be involved. This is possible because genes from the TBX family control the synthesis of T-box proteins, which are crucial for the development of limbs and affect postnatal development. Also, the supratrochlear septum remains intact and covered by synovial membrane until seven years of age; thus, perforations may occur only after this period<sup>4</sup>.

Knowledge of the anatomical aspects of the STF is important in the preoperative period and during procedures to correct supracondylar fractures (e.g., intramedullary nail fixation), which are common in the pediatric group<sup>1,5</sup>. STF is relevant in this mechanism since it narrows the medullary canal in the distal epiphysis of the humerus and may lead to misinterpretations of radiographic examinations due to its radiolucency, which can be confused with osteolytic or cystic lesions<sup>6,7</sup>.

Septal foramens have been observed in most mammalian species, with a slightly high prevalence among platyrrhine and pongid primates. Darwin considered the presence of this foramen in humans as one of the evolutionary characteristics of primates, and it was a source of study for anthropologists<sup>8</sup>.

In this context, and considering that this anatomical variation can be confused with an

osteolytic lesion on radiographic images<sup>9</sup>, the present study aimed to (1) investigate the morphology and frequency of the STF in Brazilian human bones and its association with laterality and (2) describe the clinical-surgical repercussions of this structure.

## METHODS

This cross-sectional and prospective study was conducted at the Department of Anatomy of the Federal University of Pernambuco (Brazil) in February 2023. A convenience sampling of sixty-six human humeri from the collection of cadaveric parts of the department (32 were from the right and 34 from the left side) was analyzed without distinction of biological sex, age, population, and height. Bones could not be identified as belonging to the same individual.

The human humerus bones with anatomical variations of the distal epiphysis were included in the study since bone integrity could interfere with the evaluation. Fifteen human humeri were excluded because they were not in good condition (e.g., fragmentation and severe wear), which could affect the evaluation of anatomical variations.

Therefore, the study was divided into three stages: (1) selection of human humerus bones among bones in the collection, (2) morphological analysis of the distal epiphysis of the bones, and (3) identification of the STF in the distal epiphyses of the bones.

After analysis, 51 human humerus bones were included to study the frequency and morphology of the STF. Data were analyzed using the Predictive Analytics Software (PASW® Statistics), version 17.0. A descriptive analysis was conducted, and results were presented as absolute and relative values. The Chi-square test was applied to verify the associations between variables. Significance was set at 5%, and a confidence interval of 95% and maximum variability of 0.5 were used.

## RESULTS

Of the 51 human humeri included in the study, 47.1% (n = 24) were from the right and 52.9% (n = 27) from the left side. A total of 21.6% (n = 11) of bones presented STF, whereas 78.4% (n = 40) did not. Regarding laterality, of the 24 bones from the right side, 9.8% (n = 5) presented STF, whereas 37.3% (n = 19) did not present this anatomical variation. Of the 27 left humerus bones, 11.8% (n = 6) presented STF, whereas 51.2% (n = 21) did not present the anatomical variation (Figure 1).

**Figure 1.** Right and left humerus bones with and without anatomical variation (supratrochlear foramen). **A:** Right humeri without supratrochlear foramen; **B:** Left humeri without supratrochlear foramen; **C:** Right humeri with supratrochlear foramen; **D:** Left humeri with supratrochlear foramen.



Regarding the morphological analysis, an opening was observed in the distal epiphysis of the humerus connecting the olecranon fossa with the coronoid fossa. The shape of the STF varied between the right and left humeri. Three types of shapes were observed: oval, round, and triangular (Figures 2 and 3). The oval shape was observed in 45.4% ( $n = 5$ ) of humerus bones, with 36.4% ( $n = 4$ ) on the left and 9.1% ( $n = 1$ ) on the right side. The incidence of the round shape was 36.4% ( $n = 4$ ), with 18.2% ( $n = 2$ ) on the left and 18.2% ( $n = 2$ ) on the right side. The incidence of the triangular shape was 18.2% ( $n = 2$ ) and was present only on the right side (Table 1).



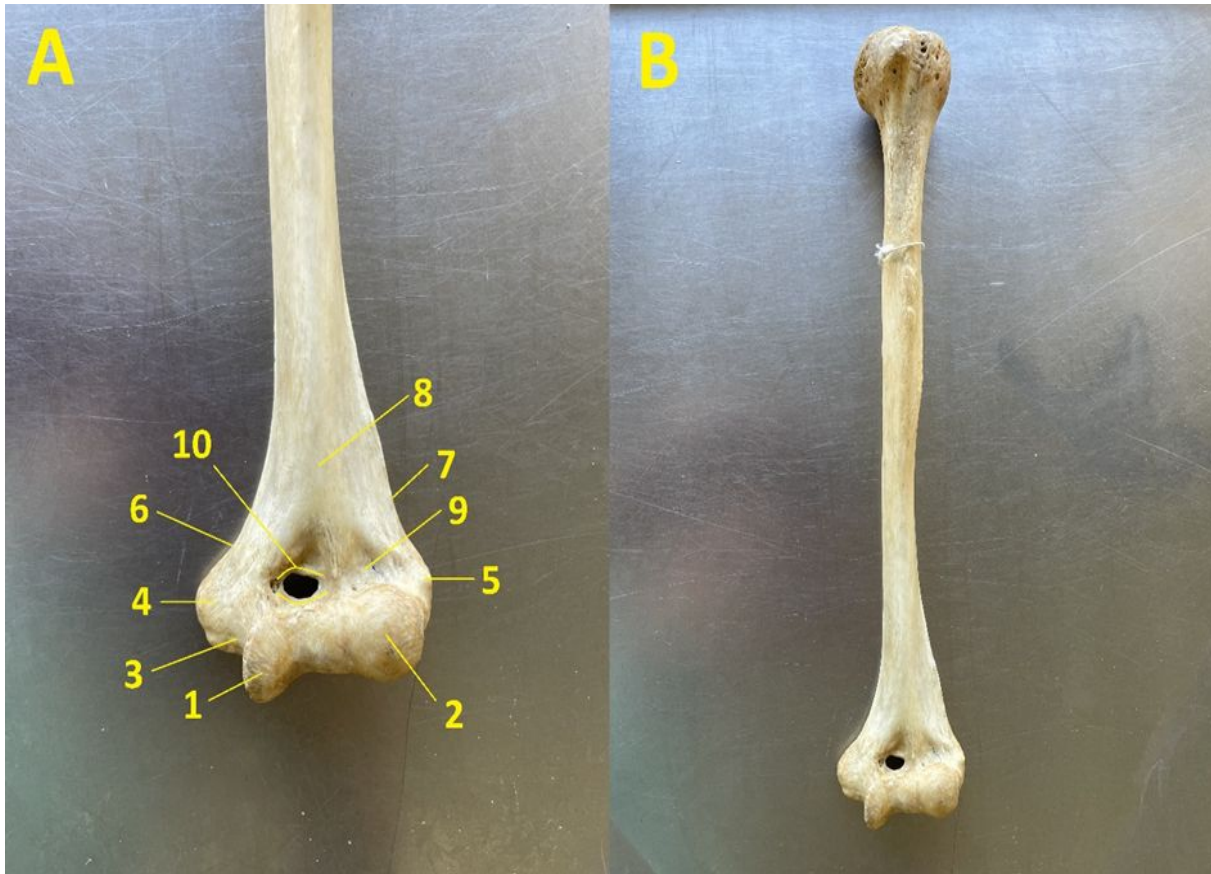
**Table 1.** Incidence of different forms of STF (n = 11)

Shape	Right		Left		Total	
	N	%	N	%	N	%
Oval	1	9.1	4	36.4	5	45.4
Round	2	18.2	2	18.2	4	36.4
Triangular	2	18.2	0	0.00	2	18.2

STF: supratrochlear foramen

**Figure 2.** Different shapes of the supratrochlear foramenAnterior view. **A:** Triangular; **B:** Oval; **C:** Round

**Figure 3.** Supratrochlear foramen in the right humerus **A:** Distal epiphysis of the right humerus, anterior view; **B:** Right humerus, anterior view; **1:** Trochlea; **2:** Capitulum; **3:** Groove for ulnar nerve; **4:** Medial epicondyle; **5:** Lateral epicondyle; **6:** Medial supracondylar ridge; **7:** Lateral supracondylar ridge; **8:** Anteromedial face; **9:** Radial fossa; **10:** Supratrochlear foramen (in the center of the coronoid fossa).



A contingency table was constructed to assess the associations between laterality and the presence of STF. The Chi-square test was used to assess whether distributions were statistically different; assumptions were met, including the expected frequency of more than five in each cell of the contingency table. The Chi-square test value was 0.014, and the p-value was 0.904, demonstrating that differences regarding the presence of STF were not statistically significant between the right and left sides. Last, the Phi value approached zero, revealing that STF occurs independently of laterality (Table 2)

**Table 2.** Distribution of the supratrochlear foramen according to laterality (contingency table)

Anatomical variation	Laterality		Total
	Right	Left	
Without foramen			
Absolute frequency	19	21	40
Expected frequency	18.8	21.2	40.0
Total percentage	37.3%	41.2%	78.4%
Adjusted residuals	0.1	- 0.1	
With foramen			
Absolute frequency	5	6	
Expected frequency	5.2	5.8	11.0
Total percentage	9.8%	11.8%	21.6%
Adjusted residuals	- 0.1	0.1	
Total			
Absolute frequency	24	27	51
Expected frequency	24.0	27.0	51.0
Total percentage	47.1%	52.9%	100.0%

Chi-square test value = 0.014; p = 0.904;

Likelihood ratio = 0.015, and Phi = 0.017.

It is important to highlight that the statistical analysis of this study did not consider the biological sex, age, population, and height due to the absence of these data in the collection of cadaveric parts of the Department of Anatomy of the higher education institution.

## DISCUSSION

The STF, also called intercondylar, olecranon, or epitrochlear foramen, is an anatomical variation located in the distal epiphysis of the humerus bone due to perforation and opening of the supratrochlear septum<sup>8</sup>. This anatomical variation is located above the humeral and intra-articular epiphyseal line in the olecranon fossa and below the reflex line of the synovial membrane<sup>5</sup>.

The incidence of STF varies between 0.3% and 60% worldwide, with approximately 6.9% in the American population<sup>1</sup>. This anatomical variation is more common in black and female individuals and is present mostly in the left humerus. Nevertheless, bilaterality can also be observed, as demonstrated in a study conducted with 32 pairs of humeri from 32 individuals; 18.8% had STF in the left and right sides<sup>6</sup>. In a meta-analysis including 62 studies (n = 20,388 humeri), the overall prevalence of STF was 21.9% (95% confidence interval [CI]: 18.6% to 25.3%). STF was present in 26.6% (95% CI: 21.5% to 31.9%) of 6,866 left humeri and in 19.4% (95% CI: 15.3% to 23.8%) of 6,860 right humeri in 41 studies; analyses were statistically significant. Moreover, STF was present in 21.9% (95% CI: 13.5% to 31.8%) of the female sample and 12.1% (95% CI: 7.4% to 17.6%) of the male sample; this difference was also statistically significant<sup>9</sup>. This finding cor-

roborates with the present study, which found an incidence of 21.6%. However, no difference was observed regarding laterality, which could be explained by the sample size, the anthropological characteristics of the population, and the fact that bones were not from the same individual. In our study, associations with age, biological sex, population, and height were not performed.

This meta-analysis included only six studies from America (Brazil and the United States), whereas 28 were conducted in South Asia. STF is a common anatomical variation among the general population, although predisposition is higher in individuals from Africa<sup>9</sup>. These data reinforce the importance of the present study, given the scarce data on the Brazilian population and the existence of different prevalence rates according to ethnic groups.

During embryonic development, the supratrochlear septum is not perforated, but incomplete ossification of this structure during adolescence or early adulthood may lead to the formation of the STF<sup>3</sup>. Although its origin is not well clarified, two theories are present in the literature: (1) mechanical origin, which explains the perforation mechanism through movements of flexion and extension at high range of motion, weakness of triceps and biceps muscles, and laxity of the involved ligaments; and (2) genetic component, especially T-box genes, which are involved in the postnatal development of limbs<sup>4,8,10</sup>.

Another important fact about STF is its association with other anatomical variations (e.g., supracondylar process and Struther's ligament), increasing the risk of neurovascular compression, affecting the median and radial nerves and the brachial artery, and leading to a clinical picture related to regions innervated and irrigated by these structures<sup>8</sup>.

The supracondylar fractures represent approximately 17% of pediatric traumas, and retrograde intramedullary nailing is the basis of treatment. As STF is associated with a narrow medullary cavity, the antegrade route may be preferred. Thus, knowledge regarding its presence helps to decide the surgical approach<sup>8,11</sup>. The olecranon opening has also been reported to predispose low-energy fractures of the distal humerus<sup>9</sup>.

We highlight the lack of epidemiological data about the individuals as a limitation of the study. Future studies should consider the inclusion of age, biological sex, population, and height and use the right and left humerus bones from the same individual so possible patterns of anatomical variation can be observed.

## CONCLUSION

The present study analyzed the morphology and frequency of the STF in Brazilian human bones, its association with laterality, and its clinical-surgical implications. The data analyzed showed the presence of STF in 21.9% of the humeri studied, with the oval shape being the most predominant. Despite being more frequent on the left side, no significant associations were observed between the presence of STF and laterality.



Considering the clinical-surgical implications addressed, the study also provided a theoretical basis for assisting specialists (e.g., orthopedists and radiologists) in the preoperative period, during surgical procedures, or while interpreting images of the humerus. Therefore, in-depth knowledge about the topic is essential to improve the ability to perform differential diagnoses and provide appropriate treatments; thus, ensuring accurate and efficient decision-making and avoiding complications.

Last, we reinforce the lack of studies regarding the topic in the Brazilian population, given that the incidence of STF and morphological and morphometric aspects may vary according to population, ethnic group, and regions of the country. Future studies including age, biological sex, population, and height are needed to improve the understanding of anatomy and its variations in the Brazilian population.

## CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

## AUTHOR CONTRIBUTIONS

**TJMSV**: writing of the original draft and review and editing; **IFGG**: writing of the original draft and review and editing; **ACCS**: writing (review and editing); **LLD**: writing (review and editing); **CBAM**: writing (review and editing); **RCFC**: resources, supervision, and writing (review and editing); **PFAP**: conceptualization, data curation, investigation, methodology, project administration, resources, supervision, writing of the original draft, and review and editing. All authors approved the final version.

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