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An anatomical study of the supratrochlear foramen of the Jining population

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Background/aim: The supratrochlear foramen (STF) is an important variation in the lower end of the humerus where the septum separating the coronoid and olecranon fossa is perforated. There are no studies in the literature on the STF of the Jining population. This study will make a contribution to anatomy and anthropology by adding new data.

Materials and methods: STF was studied in detail in 262 adult dried humeri of unknown sex and age. The topographical anatomy of the STF was studied, morphometric measurements were taken, and the specimens were photographed with a digital camera.

Results: The prevalence of the STF was 10.3%, with 18 cases on the left side and 9 cases on the right side. The STF occurred in 4 shapes: oval, 19 cases; round, 4 cases; triangular, 2 cases; and rectangular, 2 cases. The mean transverse diameter of STF was 4.47 mm and 3.26 mm on the left and right sides, respectively; the mean vertical diameter of STF was 5.07 mm and 3.56 mm on the left and right sides, respectively; and the average surface area of STF was 13.1 mm^2 and 18.43 mm^2 on the left and right sides, respectively.

Conclusions: The STF of the Jining population was more common on the left side, with oval being the most common shape. The two sides did not show any statistically significant differences. The findings of this study may be of clinical significance to surgeons and osteologists and may have anthropological or forensic importance.

Key words: Humerus, supratrochlear foramen, septal aperture

1. Introduction

The olecranon and the coronoid fossa are separated by a thin plate of bone, which may become perforated in some cases to give rise to a foramen known as a "septal aperture" or "supratrochlear foramen" (STF) (1). The STF of the humerus was first described about 200 years ago by Meckel (1). Since then, it has been studied by other authors in many species, including dogs, hyenas, cattle, and the primates (2,3).

The frequency of STF among human populations can vary greatly. It seems to be more frequent in females and on the left humerus, but it can vary significantly between ethnic groups as well as individuals of the same ethnicity (4).

It is suggested that the humerus is not perforated at the embryonal stage. The thin plate of bone between the olecranon and coronoid fossa is always present until the age of 7 years. The foramen usually develops in adolescence or, more frequently, in adulthood, due to incomplete ossification, intralamellar space enlargement, and gradual septum absorption (5). The person may be able to overextend the elbow joint with this STF (6). Humerus bones with STF at the fossa coronoidea were observed to have a narrow canal and anterolateral compressed surface at the distal end (7,8).

The aim of this study was to determine the prevalence of the STF in the Jining population. Radiologists should be aware of the occurrence of this foramen because it may be misinterpreted as an osteolytic lesion. Being aware of the various shapes and dimensions may help avoid misdiagnosing radiographs. The results, compared to the previous anatomical data in other races and populations, might be useful to orthopedic surgeons and radiologists in day-to-day clinical practice.

2. Materials and methods

2.1. Specimens and measurements

A total of 262 adult dried humeri (left side 125, right side 137) of unknown sex and age, free of pathological changes and from the Jining area, were obtained from the Department of Anatomy, Jining Medical University,

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Shandong, China. Three observers observed the specimens and differentiated between a true STF and postmortem damage. The presence of a STF was noted; its shape was observed and divided into 4 types (oval, round, triangular, and rectangular). The transverse diameter (TD) and vertical diameter (VD) of the STF and the distance between the medial and lateral epicondyles (DMLE) were measured 3 times, respectively, by each observer, and the mean measurement was used. All measurements were obtained by a vernier caliper with a minimum scale of 0.01 mm. The study was authorized by the Ethical and Legal Committee of Jining Medical University according to the ethical principles of medical research involving human subjects.

2.2. Statistical evaluation

Side differences of the TD, VD, and surface area of STFs were compared with the unpaired Student's t-test. The level of significance was set at $P < 0.05$.

3. Results

3.1. Prevalence and shapes of STF in the Jining population

Of the 262 humeri studied, 27 (10.3%) cases showed the presence of a STF. One STF was present in 18 (6.9%) cases on the left side and in 9 (3.4%) cases on the right side. The STF was oval in 19 cases (Figure 1A), round in 4 cases (Figure 1B), rectangular 2 in cases (Figure 1C), and triangular in 2 cases (Figure 1D).

3.2. Measurements of STF in the Jining population

The mean transverse diameter of the STF was 4.47 mm (range: 1.12–8.04 mm) and 3.26 mm (range: 1.13–5.0 mm) on the left and right sides, respectively. The mean vertical diameter of the STF was 5.07 mm (range: 1.12–8.35 mm) and 3.56 mm (range: 1.15–4.99 mm) on the left and right sides, respectively. The average surface area of STF was 13.1 mm^2 (range: 1.13–34.25 mm^2) and 18.43 mm^2 (range: 1.01–32.71 mm^2) on the left and right sides, respectively. Differences between the two sides were not significant (Table 1). The ratio of TD to DMLE ranged from 0.02 to 0.147 on the left side and 0.021 to 0.135 on the right side.

4. Discussion

4.1. Prevalence of STF in other populations and comparison with the present study

The prevalence of the STF in the human population varies from 0.3% to almost 60% worldwide (Table 2). Studies have shown that the STF was more common among

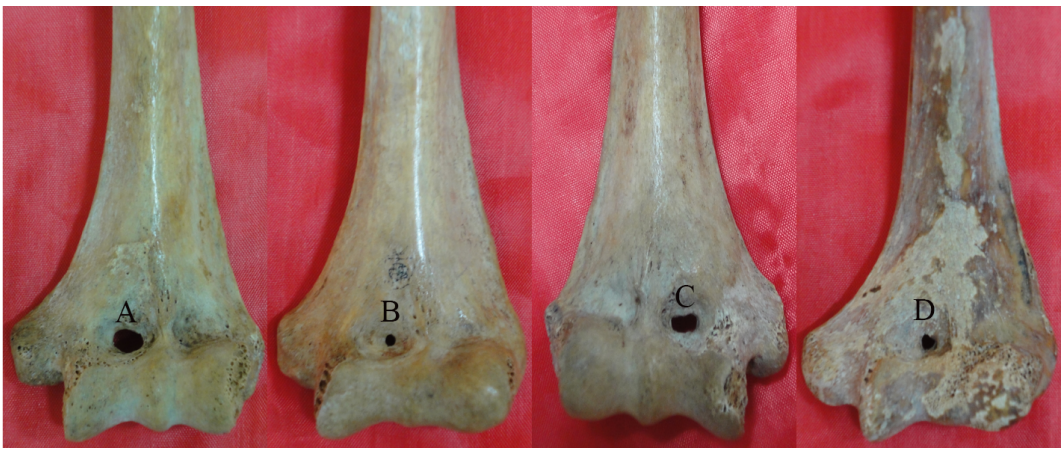

Figure 1. Distal end of the humeri showing the various shapes of the STF. **A**) Oval; **B**) round; **C**) rectangular; **D**) triangular.

Table 1. Measurements of the supratrochlear foramen (mean ± standard deviation).

Measurements	Left side	Right side	P-value	t
TD (mm)	4.47 ± 2.27*	3.26 ± 1.15*	0.523	–0.648
VD (mm)	5.07 ± 2.26†	3.56 ± 1.30†	0.539	–0.623
Surface area (mm^2)	13.10 ± 10.35‡	18.43 ± 8.65‡	0.429	–0.804
DMLE (cm)	5.38 ± 0.37	5.46 ± 0.39	-	-
Ratio of TD to DMLE	0.083 ± 0.041	0.093 ± 0.039	-	-

TD: Transverse diameter; VD: vertical diameter; DMLE: distance between the medial and lateral epicondyles.
*: $P > 0.05$, relative between the two sides; †: $P > 0.05$, relative between the two sides; ‡: $P > 0.05$, relative between the two sides. Differences between the two sides were not significant (unpaired Student's t-test).

Table 2. Prevalence of the supratrochlear foramen in different populations.

Authors and sample numbers	Population	Prevalence (%)
Kate and Dubey (1)	Central Indians	32
Macalister (4)	Libyans	57
Hirsh (9)	White Americans	4.2
Hirsh (9)	African Americans	21.7
Hirsh (9)	Native Americans (Arkansas)	58
Glanville (10)	Africans	47
Glanville (10)	Europeans	6
Papaloucas et al. (11)	Greeks	0.304
Öztürk et al. (12)	Egyptians	7.9
Chatterjee (13)	Eastern Indians	27.4
Singh and Singh (14)	North Indians	27.5
Çimen et al. (15)	Turks	12
Akabori (16)	Koreans	11
Akabori (16)	Ainus	8.8
Akabori (16)	Japanese	18.1
Singhal and Rao (17)	South Indians	28
Ming-Tzu (18)	Chinese	17.5
Krishnamurthy et al. (19)	Indians (Telangana region)	23
Krishnamurthy et al. (19)	Mexicans	38.7
Krishnamurthy et al. (19)	Eskimos	18.4
Hrdlicka (20)	Australians	46.5
Hrdlicka (20)	Italians	9.4
Hrdlicka (20)	Germans	8.8
Hrdlicka (20)	Irish	1.6% (M); 7.37% (F)
Benfer and McKern (21)	American	6.9
Nayak et al. (22)	Indians	34.4

M: Male; F: female.

ancient human populations and less frequent in modern populations, especially in modern Europe. The frequency of the STF appears to have decreased considerably since the Paleolithic and even the Neolithic times (9).

The low prevalence of the STF in the Jining population in comparison to other Asian populations was an interesting finding in our series. It was very close to the prevalence in the Korean population (16). It should be mentioned that the bones obtained from our department belonged to individuals from Jining; Jining is a small city with a majority of local residents. The Japanese population in the Kyusu district had a prevalence of 18.1% (16,17), with a higher frequency of 20.6% in females and a lower frequency of 13.5% in males. Among Indians, a prevalence of 32% was found in Central India, whereas a lower prevalence was reported among South (28%), North (27.5%), and East Indian (27.4%) population groups, as reviewed by Singhal and Rao (17). According to Ming-

Tzu (18), the incidence in the overall Chinese population was 17.5% with a significant difference between males and females (6.9% and 27.3%, respectively).

4.2. Causes of the STF

There is no clear agreement about the occurrence of STF. Some authors argued that the occurrence of the foramen was attributed to atrophy of the bone after ossification, including the impact of pressure in cases of extension of the arm in a straight-line direction. Due to posture during tearing, the STF may be present in animals such as dogs, pigs, and hyenas. Darwin (19) considered this foramen in humans as one of the characteristics that showed human's close relationship to lower forms of species.

The coronoid and olecranon process of the ulna may potentially impinge on the humerus septum during hyperflexion and hyperextension of the elbow joint. However, Hrdlicka (20) asserted that intermittent pressure would result in hyperemia and simultaneous strengthening of the bony septum. He argued that the STF was largely inherited and its expression was inhibited in more robust humeri.

Anthropologists have argued that the STF was present more frequently in ancient primitive populations than in contemporary populations. Human ancestors predominantly lived on agriculture and created and used tools. Occasionally they needed to hunt and climb trees or rocks to avoid danger. The range and frequency of elbow movements was much higher in ancient people than in modern humans. The intermittent pressure of ulna olecranon and the coronoid process on the septum of the humerus could potentially lead to bony resorption and to the formation of the STF (23). This phylogenetically significant feature of the STF is in recession and will eventually disappear in modern humans due to the limited range of elbow movements.

If mechanical stress is the causative agent, then the STF should be more frequent on the right side. However, the research revealed a higher frequency on the left side. This is due to the fact that the STF is a phylogenetic characteristic feature found in primates and is suppressed by the stronger limb and exhibited in the weaker limb.

In the present study, the prevalence of the STF was higher on the left side. This result was consistent with earlier reports (12,13,16), although it was different from the result found by Nayak and Das (22), who found that the STF was more common on the right. Recent studies by Ndou et al. (24) and Mahajan et al. (25) showed an incidence of STF in 32.5% and 26% of the humeri, respectively. This incidence was higher than in our study, which showed an incidence of 10.3%. It was mentioned that the 384 humeri were obtained from the bone bank in Mangalore, India (14). Most of the local residents of Jining are of the Han nationality. It might be that regional and ethnic differences lead to the different results. Range of joint motion and prevalence of joint hypermobility in the left upper limb is somewhat greater than in the right, which results in a greater prevalence of STFs in the left humerus.

4.3. New findings of the present study

Although it may have an irregular shape (24) or be a sieve (26,27), the STF predominantly occurs in 3 shapes: oval, round, and triangular, with oval being the most common shape (28–30). This study noted the rectangular shape of the STFs, which was seldom described previously. Factors influencing the shape of the STF still remain to be determined. Further studies may be needed to establish the relationship between the shape of the olecranon process of the corresponding ulna and that of the STF.

4.4. Clinical significance of STF

Supracondylar fractures account for 17% of all injuries in the pediatric age group (31). Intramedullary fixation is a popular method of treatment of traumatic injuries and pathological fractures. There is much controversy about the route of pin entry in cases with STFs, because the STF is always associated with the narrow medullary canal at the distal end of the humerus. Therefore, in cases of humeral fractures of the STF, it is better to perform an antegrade nailing rather than a retrograde one (32). Sometimes the elbow joint is badly fractured and needs scanning by computed tomography. The images of the structures are obtained by multiplanar reconstruction. The ratio of TD to DMLE could provide radiologists with enough data to reduce errors in diagnosing defects or cystic lesion.

In conclusion, the prevalence of the STF in the Jining population was determined for the first time. Additionally, the rectangular shape of the STF, which was seldom described previously, was identified. Beyond the findings above, the etiology of the STF needs further studying.

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