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Morphometric Analysis of the Sella Turcica and Sphenoid Sinus: A Retrospective Cross-Sectional Study

Análisis Morfométrico de la Silla Turca y Seno Esfenoidal: Un Estudio Transversal Retrospectivo

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SUMMARY: This study evaluated the effects of ethnicity, sex, and age on the linear dimensions of the sella turcica (ST) and the pneumatization patterns of the sphenoid sinus (SS). In this cross-sectional retrospective study, we examined digitally standardized computed tomography scans of 100 Jordanians. These study participants comprised 50 men and 50 women, and their age ranged from 23 years to 77 years. We assessed linear ST dimensions and SS pneumatization patterns and correlated this data to age and sex. Furthermore, we compared the data with different ethnic groups from previous studies. The mean (standard deviation [SD]) length, diameter, width, and depth of the ST were 9.98 (1.89) mm, 12.45 (2) mm, 11.96 (1.76) mm, and 8.38 (1.63) mm, respectively. The mean (SD) interclinoid diameter was 8.84 (2.03) mm. These measurements were not significantly correlated with sex or age. With regards to pneumatization patterns of the sphenoid sinus, the conchal type was observed in 2 % of the study participants. Presellar involvement was observed in 30 % of the patients. The sellar and postsellar type was observed in 66 % and 2 % of patients, respectively. In our study, ST measurements did not differ significantly between the sexes. Pneumatization patterns of the SS differed from the patterns reported for other races. The findings of this study could assist neurosurgeons, orthodontists, and forensic medical investigators in diagnosing and planning treatment for pituitary gland pathologies.

KEY WORDS: Sella turcica; Computed tomography scan; Morphometry; Sphenoid Sinus; Pneumatization.

INTRODUCTION

The sella turcica (ST) is a saddle-shaped fossa in the body of the sphenoid bone. It is bounded anteriorly by the tuberculum sellae and posteriorly by the dorsum sellae. It projects four clinoid processes, i.e., two anterior and two posterior processes. The anterior clinoid processes are formed by the medial and anterior prolongations of the lesser wing of the sphenoid bone, and the terminations of dorsum sellae exist in the form of posterior clinoid processes. Furthermore, the ST lies in the middle cranial fossa located on the intracranial surface of the body of the sphenoid sinus (SS) bone, and it houses the pituitary gland (Pisaneschi & Kapoor, 2005; Taner *et al*., 2019). Clinical conditions can alter the shape and size of the ST. Knowledge regarding the standard dimensions and shape of the ST is crucial to identify abnormalities that may reflect underlying pathologies (Pisaneschi & Kapoor, 2005; Hasan *et al*., 2016; Taner *et al*., 2019).

According to earlier analyses, the normal range of the ST is 11–16 mm in length and 8–12 mm in routine bilateral radiographs of skulls (Hasan *et al*., 2016). Previous studies have shown significant anatomical variations in the shape and size of the ST among different age and ethnic groups (Alkofide, 2007; Hasan *et al*., 2016). Therefore, establishing normal standards will assist in the process of eliminating any anomaly in such a vital region.

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To the best of our knowledge, no such findings have been established in Jordanian populations using computed tomography (CT) scans. Therefore, the aims of our study were as follows:

1. To determine sex- and age-related morphological shape and size of the ST in the Jordanian population.
2. To compare the morphological size of the ST in the present study with global data.

This work is reported in line with the Strengthening the Reporting of Cohort Studies in Surgery (STROCSS) guidelines (Agha *et al*., 2019).

MATERIAL AND METHOD

Participants and CT imaging. We conducted a retrospective study of Jordanian patients who underwent a CT scan for reasons other than craniofacial pathology at the Radiology Department of a Public Hospital. We collected CT images from a CT database. CT scans from 100 individuals (50 men and 50 women) with an age range of 24–77 years were obtained. We divided the data by sex, and then for each sex, we further stratified the data by age group. Only CT scans with maximum ST clarity were included. All patients were clinically healthy with no craniofacial or maxillofacial abnormalities.

High-resolution helical scans were obtained with the Brilliance 16 CT scanner system (Philips Healthcare, Amsterdam, Netherlands). The dosing protocol consisted of 120 kVp and 25–75 mA. The CT resolution was as follows: 1.00 mm thickness and 1.00 mm spacing. The data were collected and stored in Excel 2007 (Microsoft Corporation, Redmon, WA, USA). Statistical analysis was performed using the Statistical Package for Social Scientists (SPSS) version 17 (IBM, Armonk, NY, USA).

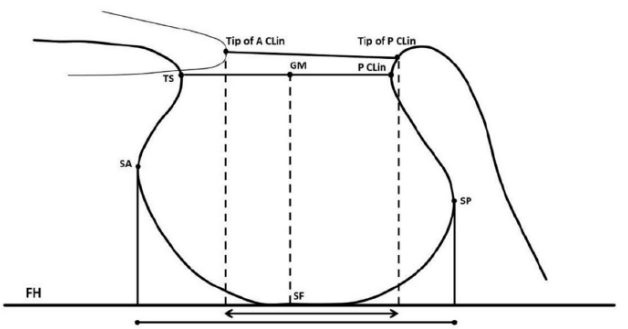

Fig. 1. Sella turcica (ST) measurements: A Clin, anterior clinoid process; P Clin, posterior clinoid process; TS, tuberculum sellae; SA, most anterior point of the ST; FH line, line parallel to the Frankfurt horizontal line; GM, ST median point; SF, ST floor; SP; most posterior point of the ST (based on Anderdaki *et al*., 2007 with modifications) (Abu Ghaida *et al*., 2017).

The inclusion criteria were as follows: (1) patients aged 24 years to 77 years old; (2) patients with no history of craniofacial, plastic, or reconstructive surgery; and (3) high-quality CT volumetric data with ST closeness were available. We only included adult patients because ST dimensions are known to develop until skeletal maturation (Alkofide, 2007). The exclusion criteria were as follows: (1) patients with a history of previous craniofacial plastic or reconstructive surgeries or deformities; (2) patients with a history of craniofacial trauma; and (3) the available CT scan images had a poor resolution.

All participants provided written informed consent. This study was approved by the Ethical Committee of the Hospital, which complies with the Declaration of Helsinki guidelines. The data were divided into three groups, based on the participants' age: young adults (24–39 years), middle-aged adults (40–59 years), and older adults (60–77 years).

Measurements. A single operator performed all measurements. All linear dimensions were repeated twice. After the first dimensions were completed, the results were blinded to the observer before the second measurements to minimize examiner bias. The average of the two readings of each measurement was considered for the final statistical analysis. The obtained images were reconstructed into 1-mm thick CT images and analyzed on a preset bone window setting using a width of 2500 Hounsfield units (HU) and length of 350 HU.

The following measurements were obtained, as illustrated in Figure 1: (1) length of the ST (i.e., the line drawn from the tuberculum sellae to dorsum sellae); (2) ST diameter (i.e., the line drawn from the tuberculum sellae to the most posterior point inside the hypophyseal fossa); (3) ST width (i.e., the largest anteroposterior dimension measured parallel to the Frankfurt horizontal line [FH] from the ST posterior to the ST anterior); (4) depth of the ST (i.e., the line drawn from the length to the deepest point of the hypophyseal fossa); and (5) interclinoid diameter (i.e., the distance from the tip of the anterior clinoid to the tip of the posterior clinoid). We also examined and classified the pneumatization patterns of the SS into four categories as follows: (1) conchal, (2) presellar, (3) sellar, and (4) postsellar (Fig. 2).

Statistical analysis. All data were analyzed using SPSS software 22.0 (IBM, Armonk, NY, USA). General descriptive statistics were calculated for each parameter. All values are

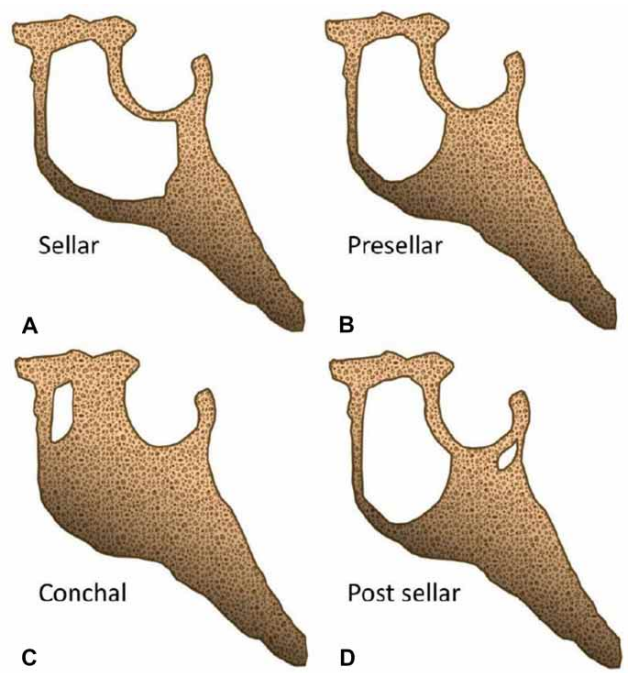

Fig. 2. Pneumatization patterns of the sphenoid sinus: A, conchal; B, presellar; C, Sellar; and D, postsellar, based on Pirinc *et al.* (2019).

expressed as the mean (SD), and linear dimensions are reported in millimeters. The Student's t -test was used to calculate the mean differences in the measured dimensions between the sexes, whereas the correlation between the ST dimensions and age was investigated by using Pearson's correlation coefficient. Statistical significance was set at $P < 0.05$.

RESULTS

Table I shows the values obtained for the linear dimensions of the overall sample and the male and female groups, whereas Table II shows the differences between the three age groups. Independent sample t-tests comparing the measurements between the sexes and age groups showed no significant difference ($P > 0.05$).

Morphometry of the ST. The length of the ST ranged from 4 mm to 14.3 mm in men and from 7.2 mm to 13.8 mm in women, with a mean SD) length of 9.95 (2.24) mm and 9.97 (1.49) mm in men and women, respectively. The diameter ranged from 1.19 mm to 16.5 mm in men and 7.8 to 16 mm in women, with a mean (SD) of 12.34 (2.41) mm and 12.55 (1.50) mm in men and women, respectively.

The width of the ST ranged from 7.3 mm to 16 mm in men and 8.3 mm to 16.9 mm in women, with a mean (SD) of 11.74 (1.81) mm and 12.17 (1.70) mm in men and women, respectively. Furthermore, the depth ranged from 4.6 mm to 13.8 mm in men, with a mean (SD) of 8.45 (1.83) mm. In women, the depth ranged from 5.4 to 13.4 mm with a mean (SD) of 8.31 (1.41) mm. The interclinoid diameter ranged from 2.6 mm to 13.9 mm in men, with a mean (SD) diameter of 8.22 (2.22) mm. In women, the interclinoid diameter ranged from 3.9 mm to 13.5 mm, with a mean (SD) diameter of 8.86 (1.84) mm.

When comparing age groups (Table II), we divided our sample into young adults (24–39 years), middle-aged

Table I. Mean dimensions of the sella turcica, based on sex.

Variable	Mean (SD) Distance (mm)			P-value
	Total (100)	Men (50)	Women (50)	
Length	9.98 (1.89)	9.95 (2.24)	9.97 (1.49)	0.5
Diameter	12.45 (2.00)	12.34 (2.41)	12.55 (1.50)	0.32
Width	11.96 (1.76)	11.74 (1.81)	12.17 (1.70)	0.13
Depth	8.38 (1.63)	8.45 (1.83)	8.31 (1.41)	0.35
Interclinoid diameter	8.84 (2.03)	8.22 (2.22)	8.86 (1.84)	0.46

The P values reflect the results of the independent sample t-test. SD, standard deviation

Table II. Mean dimensions of the ST, based on age group (young adults: 23–39 years; middle-aged adults: 40–59; and older adults: 60–77 years)

Variable	Mean distance (mm)				P-valu
	Total (100)	Young adults (n = 45)	Middle-aged adults (n = 41)	Older adults (n = 14)	
Length	9.98	9.84	10.01	10.32	*0.765*
Diameter	12.45	12.17	12.62	12.83	*0.447*
Width	11.96	11.53	12.17	12.67	*0.09*
Depth	8.38	8.1	8.63	8.54	*0.299*
Interclinoid diameter	8.84	8.84	8.72	9.17	*0.782*

ST, sella turcica

adults (40–59 years), and older adults (60–77 years). All dimensions were smaller for the young adult group, except for the interclinoid distance, which was larger. The differences were not significant.

Pneumatization patterns of the SS. With regard to pneumatization patterns, four different patterns were observed radiologically (Fig. 1 and Table III): type A (2 %), type B (30 %), type C (66 %), and type D (2 %). Table IV presents the pneumatization patterns of the SS observed by many authors, compared to our findings.

Table III. Pneumatization patterns of the sphenoid sinus, based on sex.

Pneumatization type	Total (%)	Men	Women
	(n = 100)	(n = 50)	(n = 50)
Type A (conchal)	2%	1	1
Type B (presellar)	30%	16	14
Type C (sellar)	66%	32	34
Type D (postsellar)	2%	1	1

Table IV. Comparison of the ST length, depth, and diameter between Chinese and Nepalese populations [6]

	No. of participants	ST length N (SD)	Depth N (SD)	Diameter N (SD)
Present study	100	9.98 (1.89)	8.38 (1.63)	12.45 (2.00)
Chinese	94	9.30 (2.090)	7.2 (1.463)	10.9 (1.539)
Nepalese	94	10.90 (1.497)	6.88 (1.214)	9.96 (1.263)

SD, standard deviation; ST, sella turcica.

DISCUSSION

The ST is a saddle-shaped fossa located in the body of the SS bone. It is bound anteriorly by the tuberculum sellae and posteriorly by the dorsum sellae, and projects four clinoid processes (i.e., two anterior and two posterior processes). Furthermore, the ST is located in the middle cranial fossa on the intracranial surface of the body of the SS bone, and it houses the pituitary gland (Pisaneschi & Kapoor, 2005; Hasan *et al*., 2016; Taner *et al*., 2019).

Changes in the shape and size of the ST are indicative of pituitary pathologies (Pressman, 2017). Several clinical conditions can alter the shape and size of the ST, which includes pituitary tumors, hypopituitarism, Sheehan's syndrome, Turner syndrome, Kallmann syndrome, and Down syndrome (Hasan *et al*., 2016; Taner *et al*., 2019). Population-specific knowledge of the normal dimensions and shape of the ST is thus crucial for determining and exploring abnormalities that may reflect underlying pathologies.

Alkofide (2007) analyzed the linear dimensions of the ST in the Saudi population. His study demonstrated an overall average ST length of 10.7 mm and 11.0 mm, and average diameter of 14.0 mm and 13.9 mm in women and men, respectively, with an average depth of 9.1 mm for both sexes.

To the best of our knowledge, the measurements and normal values for ST dimensions vary and can be conflicting. On average, the reported values for the ST length were between 5 mm and 16 mm, and ST depth ranged from 4 mm to 12 mm (Chilton *et al*., 1983; Hasan *et al*., 2016). Our results were similar to these ranges. Slight differences were noted for length (4–14.3 mm) and depth (4.6–13.8 mm). The reasons for the variation in results may be because of several contributing factors, including variation in the composition of the study groups in age, sex, or race, among other factors (Hamberger *et al*., 1961). Different studies may also use different radiological and measurement techniques or use disparate landmarks to define the exact dimensions. Additionally, some studies do not consider sex, which may affect the interpretation of the results (Hamberger *et al*., 1961).

With regard to the pneumatization patterns of SS, the predominant pneumatization pattern was the sellar type (66 %). Our findings were higher than those reported in Nigeria, Turkey, and Iraq (Hamberger *et al*., 1961). The frequency of the presellar type was 33 % in the current study, which was higher than that reported in two Nigerian studies (Hamberger *et al*., 1961). The conchal type had a low prevalence (2 %), which was lower than that previously documented (Hiremath *et al*., 2018; Bilgir & Bayrakdar, 2021; Ominde *et al*., 2021). The conchal type was absent in the populations studied by Hiremath *et al*. (2018) and Abdalla (2020). The frequency of the postsellar type observed in our study was much lower than that reported in Iraqi and Turkish populations (Abdalla, 2020; Bilgir & Bayrakdar, 2021).

CONCLUSIONS

Based on our results, sex and age group differences were statistically insignificant for all linear measurements of the ST. Our findings also demonstrated a gradual increase in all ST linear dimensions with advancing age. Our results suggest that SS pneumatization patterns vary between different ethnic groups, which necessitates further studies among different demographic populations.

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RESUMEN: Este estudio evaluó los efectos de la etnia, el sexo y la edad sobre las dimensiones lineales de la silla turca y los patrones de neumatización del seno esfenoidal (SE). En este estudio retrospectivo transversal, examinamos tomografías computarizadas estandarizadas digitalmente de 100 jordanos. Los participantes del estudio comprendían 50 hombres y 50 mujeres entre los 23 y los 77 años de edad. Evaluamos las dimensiones lineales del SE y los patrones de neumatización del SE y correlacionamos estos datos con la edad y el sexo. Además, comparamos los datos con diferentes grupos étnicos de estudios previos. La media (desviación estándar) de la longitud, el diámetro, el ancho y la profundidad del SE fueron 9,98 (1,89) mm, 12,45 (2) mm, 11,96 (1,76) mm y 8,38 (1,63) mm, respectivamente. El diámetro interclinoideo medio era de 8,84 (2,03) mm. Estas medidas no se correlacionaron significativamente con el sexo o la edad. Con respecto a los patrones de neumatización del seno esfenoidal, el tipo conchal se observó en el 2 % de los participantes del estudio. Se observó afectación preselar en el 30 % de los pacientes. El tipo selar y postsillar se observó en el 66 % y el 2 % de los pacientes, respectivamente. En nuestro estudio, las medidas del SE no difirieron significativamente entre los sexos. Los patrones de neumatización de la silla turca diferían de los patrones informados para otras razas. Los hallazgos de este estudio podrían ayudar a los neurocirujanos, ortodoncistas e investigadores médicos forenses en el diagnóstico y el tratamiento de las patologías de la hipófisis.

PALABRAS CLAVE: Silla turca; Tomografía computarizada; Morfometría; Seno esfenoidal; Neumatización.

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