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Original Research Article

Morphometry of Sella Turcica in Libyan Populations Using Computed Tomography

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Abstract: Introduction: The Sella Turcica (ST) is a saddle-shaped structure in the sphenoid bone, and it houses the pituitary gland within the pituitary fossa. The primary imaging technique for studying the morphometry of the ST is computed tomography (CT). The purpose of this study is to measure the dimensions of ST and their relationship with age and gender in Libyan subjects who live in Benghazi using CT scans. Material and method: A cross-sectional study was carried out from September 2023 to December 2024. The information was collected from 181 randomly chosen head CT scans of patients who came to the Benghazi Medical Center (BMC) and Aljalla Teaching Hospital. Patients are male and female Libyan patients (67 women and 114 men) aged 18 and above. Two calibrated examiners examined each scan. The data collected was analyzed statistically, and results were obtained. Results: The study sample included 181 participants, with 63% being male (114) and 37% female (67). Participants were divided into four age groups: Group I (ages 18-30, 17.1%, n=31), Group II (ages 31-40, 16.6%, n=30), Group III (ages 41-50, 17.7%, n=32), and Group IV (ages over 50, 48.6%, n=88). The average measurements of the sella turcica in the study group were 10.7 mm in length, 8.7 mm in depth, and 12.9 mm in AP diameter. For male participants, the measurements were 10.8 mm in length, 8.62 mm in depth, and 13.00 mm in AP diameter. For female participants, the measurements were 10.5 mm in length, 8.73 mm in depth, and 12.7 mm in AP diameter. No significant difference in sella turcica dimensions was found between genders (p > 0.05). However, there was a significant difference in mean sella length and AP diameter across the four age groups. This was mainly due to Group I (ages 18-30) having a smaller mean sella length (9.7 mm) and AP diameter (12.1 mm) compared to the other age groups. There was no significant difference in sella depth among the age groups. Conclusion: The findings of this research could have important clinical implications for surgeons and medical professionals. Increased understanding of potential anatomical variations in the sella turcica may impact surgical planning and patient outcomes. Additionally, this study is expected to be a reference for future research studies related to neuroanatomy, contributing to advancing diagnostic techniques, treatment options, and overall patient care in Benghazi.

Keywords: Sella turcica; hypophyseal fossa; morphometry; tuberculum sellae; diaphragma sellae.

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INTRODUCTION

The sella turcica (ST) is a saddle-shaped depression located in the base of the skull at the middle part of the sphenoid bone; it contains the pituitary gland (master gland), which makes this structure of clinical significance [1]. The bony part of ST is mainly formed by the body of the sphenoid, and it consists of the floor, anterior wall, posterior wall, and lateral wall. The floor of ST contains the hypophyseal fossa, which houses the pituitary gland. The anterior wall of ST (i.e., tuberculum sellae) has two lateral angles known as the middle clinoid processes that serve as attachment points of the diaphragma sellae. The diaphragma sellae is a circular

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horizontal sheet of dura mater that covers the entire roof of ST, except the central area that allows the passage of the infundibulum and pituitary stalk. In the past, this structure served as an important landmark for pituitary gland tumors, where surgeons did craniotomy procedures, but now the trans-sphenoidal approach is the first option. The posterior wall of ST (*i.e.*, dorsum sellae) has posterolateral projections called the posterior clinoid processes. These processes give attachments to the diaphragma sellae and the tentorium cerebelli. The lateral wall of ST is formed by the medial surfaces of the greater wings of the sphenoid bone, and directly lateral to it lie the cavernous sinuses and the internal carotid arteries [2]. With this information above, especially of the trans-sphenoidal approach, which is done through the ST, it is very important to know the variation of ST dimensions, especially in pituitary gland tumors, which require hypophysectomy [2]. Consequently, there is a close link between the pituitary gland and the ST. Furthermore, the pituitary gland develops more quickly than the ST. For this reason, the pituitary gland's development is finished before the ST is finished. The shape of the ST will also be impacted by any pathology that develops in the pituitary gland during this stage [3]. Thus, understanding the sella turcica's morphology is important for the identification of pituitary gland abnormalities and other diseases, as well as for assessing craniofacial morphology [4]. Significant differences in the sella dimension measurements for gender and race have been documented, and these differences are influenced by genetics and local factors [5, 7]. The empty sella syndrome, a disorder marked by a partially or fully empty ST, has been examined in another published study [8]. The ST can be evaluated using computed tomography (CT) or X-ray. Both of these are commonly used diagnostic imaging techniques that use ionizing radiation to provide pictures of the inside organs. Although CT provides benefits like the ability to identify anomalies and create finely detailed 3D images, it also has disadvantages, including increased radiation exposure, longer operation times, and greater costs as compared to X-rays. Although numerous research studies have been carried out in different countries, the ST dimension in African people, especially in Libya, is not well understood. Therefore, it is important to collect normative data that will be necessary in an African population. This research aims to measure the

dimensions of ST in Libyan adults who live in Benghazi using CT scans and to determine the effect of age and gender on the dimensions of ST.

MATERIALS AND METHODS

Participants and CT imaging:

This cross-sectional study involves skull CT scans from a randomly selected group of patients who presented to Benghazi Medical Center (BMC) and Aljalla Teaching Hospital from September 2023 to December 2024. Patients are male and female Libyan patients (67 women and 114 men) aged 18 and above. Patients under 18 years old have not been included in this study since ST dimensions are known to develop until skeletal maturity [9].

Inclusion criteria:

- 1. The study included head CT scan images that showed the mid-sagittal section of the sella turcica with optimal clarity and complete age and sex documentation.
- 2. Patients in the age group of 18-93 years.

Exclusion criteria include the following:

- 1. Patients with any pathologies that will likely affect the dimensions of the ST.
- 2. Patients with craniofacial fractures or who have undergone craniofacial surgeries.
- 3. Poor-resolution CT scans.

Measurements and Data Collection:

The skull CT scans will be visualized in the mid-sagittal section via the software RadiAnt DICOM Viewer 2021, following Silverman and Kisling's methods. [10, 11] The measurements will include: (1) the length of the ST (i.e., the distance between the tuberculum sellae and the dorsum sellae); (2) the depth of the ST (*i.e.*, the line drawn vertically from the deepest point of the sella turcica to the ST length); (3) the anteroposterior (AP) diameter (i.e., the distance between the tuberculum sellae and the furthest point on the posterior-inner wall of the ST). Fig. 11; A & B]. Before images collected, de-identified analysis was demographic data, including the number, age, and gender of the patients.



Figure 1: Sagittal head CT image, morphometric measurements of ST. (A &B), length of ST (L), the depth of ST (D), the anteroposterior diameter of ST (APD); (C&D) morphometric measurements of ST in male & female

Statistical analysis: The collected data were processed, computed, and analyzed by using SPSS software version 26 (IBM, Armonk, NY, USA). The gender and age comparisons were evaluated, and the results were considered significant when the P-value was less than 0.05.

Ethical considerations: All procedures in this study involving human participants complied with the ethical standards of the research ethics committee in Benghazi-Libya. Since this study is retrospective, formal consent was not needed.

Study period: The study was conducted in 15 months, from September 2023 to December 2024.

RESULTS

This descriptive analysis aimed to capture the key characteristics and patterns observed in a sample of the Libyan population in measurements of the ST of human skulls. A sample of 181 persons was recruited, male sex represented 63% (114/181) and female 37% (67/181) (Table 1). Age distribution of the whole sample ranged between 18 years and 93 years, with a mean age of 50.2 \pm 17.7 years (the median age is 50). The mean age of males is 51.3 years, with a maximum age of 93, and an SD of 18.7 years, and the mean age of females is 48.5 years, with a maximum age of 78 and an SD of 15.9 years (Table 2, Figure 2). The mean depth of the sella for

the entire sample in mm is 8.7 (\pm 1.9), with a median of 8.6 and a range from 4.6 to 19.6. The depth of sella in mm for males was reported for 113 of them; its mean is 8.62 mm (SD =1.93), with a minimum of 5.78 and a maximum of 19.6. For females, the mean depth was 8.73 (SD = 1.78) and the range was 4.55 to 13.2 (Table 3). An independent sample t-test revealed an insignificant difference in the mean depth of sella across genders (t= -0.406, P- P-value = 0.685). The mean sella length (SL) of the sample in mm is $10.7 (\pm 2.1)$, with a median of 10.5and a range from 1.1 to 18.4. The mean SL for male participants reported for 113 individuals is 10.8 mm (SD = 2.03), with a minimum of 6.17 mm and a maximum of 18.4 mm. For female participants, the mean SL is 10.5 mm (SD = 2.17), with a range from 1.08 mm to 15.2 mm (Table 4). The independent sample t-test revealed no significant difference in the mean length of the sella across genders (t=1.03, P=0.302). The mean AP diameter of the sella for the entire sample is $12.9 (\pm 1.9)$ mm, with a median of 12.7 and a range from 7.7 to 18.6. The AP diameter of the sella in mm for both sexes was reported without any missing measurements. For males, the mean AP diameter is 13.0 mm (SD = 1.88), with a minimum of 8.98 mm and a maximum of 18.6 mm. For females, the mean AP diameter is 12.7 mm (SD = 1.85), with a range from 7.72 mm to 17.1 mm (Table 5). The independent sample t-test revealed no significant difference in the mean AP diameter of the sella across genders (t=0.939, P=0.34

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_	Table 1: Frequencies of Sex									
	Sex	Counts	% of Total	Cumulative %						
	Male	114	63.0 %	63.0 %						
	Female	67	37.0 %	100.0 %						

Table 2: Age statistics of the sample

	Sex	Ν	Missing	Mean	Median	SD	Minimum	Maximum
Age	Male	114	0	51.3	51.5	18.7	18	93
	Female	67	0	48.5	48	15.9	18	78



Figure 2: Age Distribution of the Sample

Table 3: Sella Turcica Depth (In Mm) Statistics

	Sex		Ν	Mi	ssing	Mear	n M	edian	SD	Minimum	Maxin	num
SD	SD Male		113	1		8.62	8.4	0	1.93	5.78	19.6	
	Fema	le	67	0		8.73	8.6	54	1.78	4.55	13.2	
	Independent Samples T-Test											
	Statistic df p											
	SD Student's t				-0.40)6	178	0.68	35			
	Note.	H_{a}	μ_{male} 7	≠µ _{fe}	male]

Table 4: Sella Turcica Length (In Mm) Statistics

								/		
	Sex	Ν	Mis	ssing	Mean	Mediar	n SD	Min	imum	Maximum
SL	Male	113	1		10.8	10.6	2.0	3 6.17		18.4
	Female	66	1		10.5	10.4	2.1	7 1.08		15.2
	Independent Samples T-Test									
						Statistic	df	р		
	SL Student's t 1.03 177 0.302									
	Note. $H_a \mu_{male} \neq \mu_{female}$									

Table 5: Anteroposterior Diameter (in Mm) of Sella Turcica

	Sex		Ν		Missing	Mean	Median	SD	Minimum	Maximum
AP diameter Male		114		0	13.0	12.8	1.88	8.98	18.6	
Female		67		0	12.7	12.5	1.85	7.72	17.1	
			Inde	ependent	Samples	T-Test				
						Statistic	df	р		
AP diameter			Stu	dent's t	0.939	179	0.349			
Note. $H_a \mu_{male} \neq \mu_f$			μ _{fema}	ale						

Age groups for 181 observations and 4 levels. >50: n = 88, 48.62%. 41-50: n = 32, 17.68%. 18-30: n =

31, 17.13%. 31-40: n = 30, 16.57%. There are 0 missing values (Table 6).

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Tuble 0. Trequencies of fige groups									
Age groups	Counts	% of Total	Cumulative %						
18-30	31	17.1 %	17.1 %						
31-40	30	16.6 %	33.7 %						
41-50	32	17.7 %	51.4 %						
>50	88	48.6 %	100.0 %						

Table 6: Frequencies of Age groups

Ta	ble 7:	Dimensior	s of Sella	a Among	g Differen	t Age Grouj	ps

Age gro	oup	SL	SD	AP diameter
18-30	Ν	31	31	31
	Missing	0	0	0
	Mean	9.7	8.2	12.1
	Median	9.6	8.25	11.9
	Std. Deviation	1.4	1.8	1.7
31-40	Ν	30	30	30
	Missing	0	0	0
	Mean	10.9	8.5	12.7
	Median	10.6	8.6	12.5
	Std. Deviation	1.7	1.5	1.5
41-50	Ν	32	32	32
	Missing	0	0	0
	Mean	10.9	8.85	13.0
	Median	10.4	8.76	13.05
	Std. Deviation	1.76	2.05	2.2
>50	Ν	88	88	88
	Missing	0	0	0
	Mean	10.9	8.8	13.1
	Median	10.9	8.6	12.9
	Std. Deviation	2.4	1.91	1.8

SL (Sella length), SD (Sella depth), AP (Antero-posterior)

Comparison of Sella Mean Length Among Different Age Groups

The mean length of sella for the age group 18-30 is 9.7 (\pm 1.4), and for 31-40 it is 10.9 (\pm 1.7), for the age group 41-50, 10.9 (\pm 1.7); and for the age group >50, it is 10.9 (\pm 2.4). (Table 7) Analysis of variance ANOVA test results reveal a significant variation in the mean sella length among the four age groups (F=3.0, P=0.032). This notable difference is primarily due to the mean sella length of the 18-30 age group (9.7), which is considerably lower compared to the mean lengths of the other age groups (10.9) (Table 8).

Table 8: Comparison of Sella Mean Length Among Different Age Groups (ANOVA)

	Sum of Squares	df	Mean Square	F	р
Age groups	37.6	3	12.55	3.00	0.032
Residuals	740.2	177	4.18		

Comparison of Sella Mean Depth Among Different Age Groups

The mean depth of the sella for the age group 18-30 is 8.2 (\pm 1.8). For the age groups 31-40, 41-50, and

>50, the mean depths are 8.5 (\pm 1.5), 8.85 (\pm 2.05), and 8.8 (\pm 1.9), respectively. (Table 7) The results of the ANOVA test indicated no significant difference in depth among the four age groups (F=1.02, P=0.38) (Table 9).

Table 9: C	Comparison	of Sella Mean	n Depth A	mong Different	Age Groups	(ANOVA)
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	Sum of Squares	df	Mean Square	F	p
Age groups	10.7	3	3.56	1.02	0.383
Residuals	614.5	177	3.47		

Comparison of Sella Mean AP-Diameter Among Different Age Groups

The mean AP diameter of the sella for the age group 18-30 is 12.1 (\pm 1.7). For the age groups 31-40, 41-50, and >50, the mean AP diameters are 12.7 (\pm 1.5), 13 (\pm 2.2), and 13.1 (\pm 1.8), respectively (table 7). The

ANOVA test results indicate a significant difference in AP diameter across the four age groups (F=2.81, P=0.041). This difference is primarily due to the mean AP diameter of the 18-30 age group (12.1), which is smaller compared to the mean AP diameters of the other three age groups (12.7, 13.0, and 13.1) (Table 10).

	Sum of Squares	df	Mean Square	F	р
Age groups	28.6	3	9.55	2.81	0.041
Residuals	601.7	177	3.40		

Table 10: Comparison of Sella Mean AP-Diameter Among Different Age Groups (ANOVA)

DISCUSSION

The present research used CT scans of patients who had CT head exams to study the normal dimensions of the ST and their relationship with age and gender in Libyan subjects living in Benghazi. The morphometry of the ST is an important topic of research in craniofacial anatomy, endocrinology, and diagnostic radiology. The study often uses CT for an accurate and detailed assessment. The mean length, depth, and AP diameter in this study group were 10.7mm, 8.7mm, and 12.9mm, respectively. In males, the mean values were 10.8mm, 8.62mm, and 13.00mm, while in females the values were 10.5mm, 8.73mm, and 12.7mm.

Mohammed FA et al. [12] reported that the average length, depth, and AP diameter of the ST in males in the Benghazi population were 10.5 mm, 7.89 mm, and 13.02 mm, respectively. In females, the ST's mean length, depth, and AP diameter were 10.2 mm, 8.47 mm, and 12.76 mm, respectively. Male and female mean differences were not statistically significant (p = 0.529), which is consistent with our study's findings that male dimensions are 10.8 mm, 8.62 mm, and 13.00 mm, respectively. Additionally, they measured 10.5 mm, 8.73 mm, and 12.7 mm in females, respectively. Likewise, Hani et al. [13] found no statistically significant difference between males and females concerning all sella measurements in their recent morphometric study of the ST using CT in the Benghazi population, Libya, and that the mean length, depth, and AP diameter were 9.92 mm, 8.57 mm, and 12.5 mm, respectively. These results fell within the range of our study. The present study demonstrated that the mean depth of ST in females was slightly higher than in males, which is similar to the study conducted in Libya [12]. Ethiopia. [14] and northern India [15]. The mean length and AP diameter of the sella in the study group were slightly higher in males than in females, with a nonsignificant difference between genders. We compared the linear dimension values from our investigation with those from earlier research. The findings of the study agreed with those of previous studies on Indians [16, 17]. Saudi Arabian, [9] Malaysian, [18] Bangladeshi, [19] Nepali, [20] Turkish, [21] Iraqi, [22] Pakistani, [23] and Nigerian populations [24]. Additionally, our results agree with those of F.K. Muhammad et al. [25]. Where the size and morphology of the ST were assessed in relation to gender, age, and race. For Chinese and Nepalese, the ST length, depth, and diameter were 9.0, 7.0, and 10.6 mm and 8.6, 6.8, and 9.96 mm, respectively. The results showed that among the people under study, there were no significant gender differences in ST dimensions among the populations studied. In 2023, S. Al-dwairy [26] carried out a study in Jordan to measure the shape and dimensions of the ST in individuals of various ages and

genders. The ST's average dimensions were 9.98 mm in length, 12.45 mm in diameter, and 8.38 mm in depth. The study revealed no significant correlation between the sella dimensions and age or gender. In the present study, there was no significant distinction between males and females in any of the three dimensions (p > 0.05). Compared to most research, the values in this study were greater for each of the examined parameters as compared to most studies [16, 18, 20]. Given that ST dimensions were geographically and genetically impacted and varied substantially, the difference may have been caused by race and environmental factors [5, 7]. Additionally, variations in research group composition, such as age group and sample size, may also account for variations among studies. It is obvious that the current study's values are lower than those of Zagga [27]. and Alkofide et al. [9] who reported values of 11.4 mm in length, 9.3 mm in depth, and 14.0 mm in A-P diameter; and Alkofide et al. [9]. Who reported values of 11.0 mm in length, 9.1 mm in depth, and 13.9 mm in AP diameter. Asad and Hamid [28]. Also reported a similar pattern, stating that the mean length of ST is 14.9 mm, and Usman et al. [29] who reported values of 12.4 mm, depth of 9.6 mm, and A-P diameter of 14.1 mm, values that are generally greater than the values reported by Zagga. This could be explained by the various populations, varying ethnicities, genetic compositions, and environmental influences, as well as by the measurement techniques used. The findings show that there is no correlation between gender and the linear dimensions of the ST in the vast majority of the population. In order to help physicians with diagnosis and treatment planning, this research expands our understanding of gender, which is not a clinical diagnostic trait. While many studies report no significant gender differences in ST dimensions, some research indicates otherwise. According to the findings of the Ethiopian study by G. Abebe et al. [14] females had a greater mean ST depth, which was statistically significant (p = 0.002). However, in both sexes, length and AP diameter were not statistically significant. Sathyanarayana [4]. and Srinivas [30]. Discovered a statistically significant variation in the length of ST between males and females in the South Indian population. The length of the ST was greater in men and reached a significant difference at various age groups, according to Axelsson et al. [30] who also noted that no differences between males and females were found for the depth and A-P diameter of the ST. Chou et al. [32] used cone beam CT to measure sella turcica diameters and check if gender affects sella size. They discovered that there were notable, significant differences in sella size between the sexes, with males typically having bigger dimensions. Similarly, Suryvanshi et al. [33] found that there were significant gender differences in ST dimensions, with males typically having higher

measurements. Magat *et al.* [7] and Chavan SR *et al.* [34] compared the size of ST between the sexes and found that the volume of the ST is statistically significantly greater in females. Similarly, another study conducted in Saudi Arabia by Issrani *et al.* [35] discovered that the females had considerably larger linear dimensions than the males (P < 0.001).

Although it was not statistically significant, the current study did find that the parameter depth increased with age. AP diameter (P < 0.041) and parameter length (P < 0.032) both showed statistically significant increases with age. The results of our investigation showed a strong correlation between age and ST size. Our study's mean depth and AP diameter results were similar to those of Muhammed *et al.* [25] A studies by Kumar *et al.* [26] Nagaraj T *et al.* [17] and Axelsson *et al.* [31] found a statistically significant increase in the depth and AP diameter of ST as age advanced. In Ethiopia, G. Abebe *et al.* [14] used CT scanning to determine the ST's volume. They discovered that when

age increased, ST's length, depth, and AP diameter all increased (p < 0.05). According to research by Sathyanarayana HP et al. [4], Alkofide et al. [9], and Andredaki M et al. [36], the linear dimensions of ST tend to increase with age progression. Due to somatic growth patterns, particularly during puberty, and the pituitary gland's increasing size with age, the ST's dimensions may rise with age. During the early years of life, up to the age of six or seven, the ST grows quickly according to a neural growth pattern. Following puberty, this growth may be the result of bone remodeling [37]. According to the findings of Shrestha et al. [20]. Onal V. [21], and Mohammed et al. [12], there was no statistically significant difference (p > 0.05) between the ST dimensions by age. The variation in results may be attributed to differences in the age range of the study population. In this study, the age range was 18-93 years, compared to 9-27 years in Sathyanarayana HP et al. [4], 6-17 years in Andredaki M et al. [36], and 10-26 years in Alkofide et al. [9].

Studies	Length (mm)	Depth (mm)	AP diameter (mm)	Method
Present study	10.7	8.7	12.9	CT scans
Saudi. [9]	11.0	9.1	13.9	Lateral cephalogram
Saudi. [35]	11.57	9.54	11.54	CT scans
Jordan. [5]	7.55	6.32	-	CT scans
Ethiopia. [14]	10.3	7.12	11.89	CT scans
India. [30]	9.51	7.39	10.13	CT scans
Nepal. [20]	8.13	6.40	9.60	CT scans
Malaysia. [18]	8.46	7.44	10.79	CT scans
Nigeria. [29]	12.4	9.6	14.1	CT scans
Turkey [21]	7.02	7 56	10.54	Lateral cephalogram

 Table 11: Comparison of Different Studies for Sella Turcica Linear Dimension

CONCLUSION

Overall, the ST measured 10.7 mm in length, 8.7 mm in depth, and 12.9 mm in AP diameter. There was no significant difference between the dimensions of ST based on gender (p > 0.05). Additionally, there was a notable rise in the ST dimension across age groups. This study provides baseline data on the morphometric variance and linear dimensions of the ST for Libyans, which aids in the diagnosis of sellar diseases for researchers and clinicians.

Recommendations:

Further studies should be conducted to investigate the relationship between the dimensions of the sella turcica and pathological conditions using advanced imaging techniques.

Limitations:

Compared to the number of male study participants, the number of females was extremely small. Another weakness is that there is an uneven age distribution among the studies selected, and the study primarily focused on age groups between 18 and 93 years, potentially missing crucial developmental changes that might occur in younger individuals.

Abbreviation: ST: Sella turcica; CT: Computed tomography; BMC: Benghazi Medical Center; SPSS: Statistical Package for Social Sciences. SD: Standard deviation. L: Length of sella turcica; AP: Anteroposterior diameter; D: Depth of sella turcica.

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