MORPHOMETRIC EVALUATION OF SELLA TURCICA FOR SEX DISCRIMINATION USING MULTIDETECTOR COMPUTED TOMOGRAPHY IN A SAMPLE OF EGYPTIAN POPULATION

Amira Mamdouh Khattab[1], Mona Sayed Elgohary[2], Haitham Mosbah Foda[3], Ghada Attia Sagah[2]

[1]*Department of Forensic Medicine and Clinical Toxicology, Faculty of Medicine, Kafr El-Sheikh University, Egypt.*

[2]*Department of Forensic Medicine and Clinical Toxicology, Faculty of Medicine, Tanta University, Egypt.*

[3]*Department of Diagnostic and Interventional Radiology, Faculty of Medicine, Kafr El-Sheikh University, Egypt.*

ABSTRACT

Background: Sex identification of the adult skeleton is an important initial step as the estimation of age and stature of individual is sex dependent. Sella turcica is located in the middle cranial fossa which is less likely to be damaged and may still carry useful information for personal identification even in fractured skulls. Multidetector computed tomography (MDCT) scanning has become extensively used in forensic medicine for sex identification. **Aim of the work:** To evaluate morphological and metric measurements of sella turcica for sex discrimination using MDCT in a sample of Egyptian population. **Subjects and Methods:** This study was a prospective cross-sectional study, conducted on randomly selected 334 adult Egyptians (167 males and 167 females) who underwent MDCT scans on the head. The ages of participants ranged between 18 and 68 years. **Results:** The length and depth of the sella showed statistically significant differences between males and females. The notching shape of the posterior part of dorsum sellae showed the highest accuracy for predicting male sex. Conversely, the bridging shape of the sella turcica could significantly predict female sex with 57% accuracy. The multivariable regression analysis model indicated that the sellar length, depth, and notching shape of the posterior part of dorsum sellae were significant predictors of male sex with 63.2% accuracy. **Conclusion:** The sella turcica can serve as a relatively good adjuvant tool for sex identification among adult Egyptians. Additionally, the equations derived from both univariate and multivariate regression analysis models can be used by forensic specialists for sex discrimination among the adult Egyptian population.

Keywords: *Morphometric, Sella Turcica, Sex Discrimination, Multidetector Computed Tomography*.

Corresponding author: *Dr. Amira Mamdouh Khattab*

Email: amira.khattab@med.kfs.edu.eg

ORCID: 0009-0006-4857-5569

INTRODUCTION

Human skeletal remains identification is essential in the forensic field ***(Jayakrishnan et al., 2021)***. Sex discrimination of the adult skeleton is a crucial initial step as the identification of the age and stature of the individual is sex dependent ***(Battan et al., 2023)***. The skull represents the most reliable part of the skeleton after the pelvis, with an accuracy of 92% in sex identification ***(Kotěrová et al., 2022)***.

Personal identification is challenging when the remains are incomplete, which may occur in various episodes such as mass disasters, fires, explosions, and crashes ***(Byard, 2023)***.

For this reason, many studies have been done to find out new-sex-related bones' features ***(Kamiński et al., 2024)***. Sella turcica represents one of the focuses due to its location in the middle cranial fossa. Even in fractured skulls, this cavity may be less probably damaged and it may still carry useful information for personal identification ***(De Donno et al., 2021)***.

Sella turcica is located in the middle cranial fossa on the intracranial surface of the body of sphenoidal bone ***(Kurbanova et al., 2024)***. It is bounded by tuberculum sellae anteriorly, dorsum sellae posteriorly and the floor is hypophyseal fossa, which carries the pituitary gland ***(Chmielewski, 2023)***.

Imaging techniques are highly efficient, easy to use, and incredibly accurate. Computed Tomography (CT) scanning is a form of tomography (imaging using sections) that is a combination of multidirectional X-ray images, computer-processed to produce cross-sectional images of a desired object ***(Abhisheka et al., 2024)***. It has been proven that Multidetector Computed Tomography (MDCT) scan is better than the other modalities in studying bones for identification as they capture multiple sectional images of the body part in the same session and can archive raw images for further studies in both two-dimensional (2D) and three-dimensional (3D) formats ***(Hussain et al., 2022)***. Accordingly, MDCT is being increasingly utilized in virtual forensic anthropology for age and sex identification ***(Conlogue et al., 2020)***.

Reference wise and according to the best of our recent knowledge, there is limited data on sella turcica dimensions within African populations, particularly in Egypt. Three studies only have been conducted in Egypt to establish a database on the metric measurements of the sella turcica for the purpose of sex discrimination **(*Ramdan et al., 2000; El-Sehly et al., 2018; Abd El Rahman et al., 2023*)**. However, no studies have examined the shape of the sella turcica using MDCT for sex identification.

THE AIM OF THE WORK

The current study aimed to evaluate the morphometrics of sella turcica using MDCT for sex identification in a sample of the Egyptian population.

SUBJECTS AND METHODS

- **Sample size calculation**

  The sample size was determined using G*power (version 3.1.9.2 for Windows), assuming an alpha error level of 0.05, and a power of 0.80. The conclusion was to include 334 subjects (167 males and 167 females). The calculation of the effect size was based on the measurements cited in the study by ***Sathyanarayana et al. (2013)*** who found that the mean (SD) measurements of length were 8.9 (1.611) and 9.4 (1.634) in female and male subjects respectively.

- **Study design and population**

This study was a prospective cross-sectional one that involved 334 randomly selected Egyptian subjects (167 males and 167 females). They were subjected to MDCT scans on the head at the Radiodiagnosis and Medical Imaging department at Kafr El-Sheikh University Hospitals. The ages of participants ranged (18-68) years. The duration of the study was six months, from the 1st of February 2023 to the 31st of July 2023.

They underwent MDCT examinations of the head as recommended by their treating physicians for different diagnostic medical or surgical reasons. Whereas, the patients with the following criteria (a history of traumatic or surgical involvement of sella turcica or para-sellar area, in addition to pituitary tumors, craniofacial syndromes, clefts, or other malformations, as well as any radiological findings affecting the shape of sella turcica) were excluded from the current study.

The participants were divided into five groups based on their age as follows: Group I consisted of 136 participants from the age of 18 years up to the age of 28 years. Group II included 50 participants aged above 28 years up to 38 years. Group III consisted of 68 participants with ages above 38 years up to 48 years. Group IV was composed of 48 participants with an age range above 48 years up to 58 years. Lastly, Group V participants were above 58 years up to 68 years old and consisted of 32 participants.

- **Methods**

For every participant, MDCT was performed on the head by using TOSHIBA AQUILION CT Scanner 320 slices with full head area coverage. There is no particular preparation required prior to undergoing a head CT scan, except for taking off any jewelry and metallic items that could cause metallic artifacts affecting the quality of the images. All MDCT scans were performed with the patient lying supine and utilizing a cranio-caudal scanning approach. To achieve high-quality CT images, all subjects should remain completely stationary during the examination as little movement can blur the images.

TOSHIBA AQUILION CT Scanner 320 slices machine uses the following acquisition parameters: collimation (320 x 0.5 mm), increment (0.5 mm), rotation time (1 second), tube voltage (120 Kilovolt), tube current (200 – 250 Milliampere) and field of view (FOV) was 20 – 24 cm. The scan extension should include the middle cranial fossa, extending from the skull base to the skull vault. The following measurements were obtained in the mid-sagittal section:

(A) <u>Sella length and depth:</u> According to ***Silverman (1957)* and *Kisling (1966)*** methods, the length is the distance from the tuberculum sellae to the dorsum sellae, while the depth is the distance measured perpendicularly from the line representing the sellar length to the deepest point on the base of the pituitary fossa (**Figure 1**).

(B) <u>Sella width and anteroposterior diameter</u>: Sella width was estimated according to ***Andredaki et al. (2007)***, it is the line extending from the most anterior point to the most posterior point of sella turcica and parallel to the Frankfort horizontal plane.

According to ***Silverman (1957)* and *Kisling (1966)*** methods, the anteroposterior diameter is the distance between the tuberculum sellae and the backmost point in the interior surface of the sella turcica posterior wall as shown in **figure (2)**.

According to ***Axelsson et al. (2004)***, the sella turcica shapes were classified into five variations in addition to the normal shape. As demonstrated in **figure (3),** the following shapes of sella turcica were found in the mid-sagittal section: the normal shape of sella turcica, pyramidal shape of the dorsum sellae, irregularities (notching) in the posterior part of dorsum sellae, sella turcica bridge, oblique anterior wall of sella turcica and double contour of the floor of sella turcica.

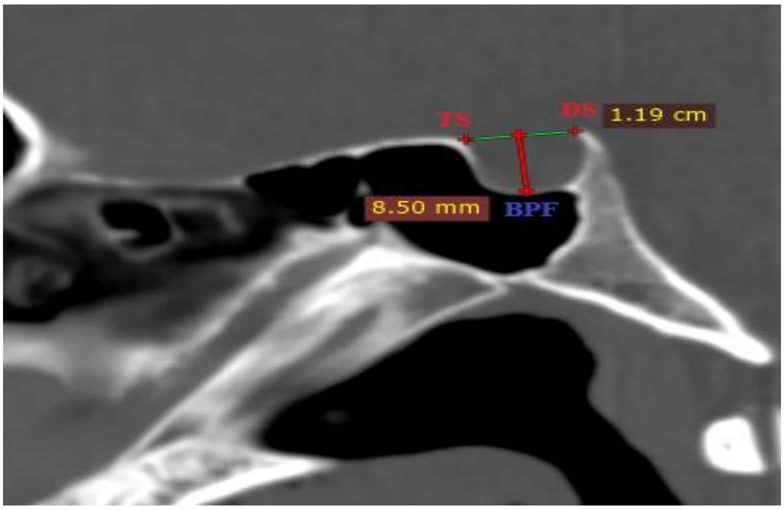

Figure (1): Mid-sagittal image of multidetector computed tomography (MDCT) shows the sella turcica's length (the green line) and depth (the red line). {TS: Tuberculum sellae, DS: Dorsum sellae, BPF: The base of the pituitary fossa}

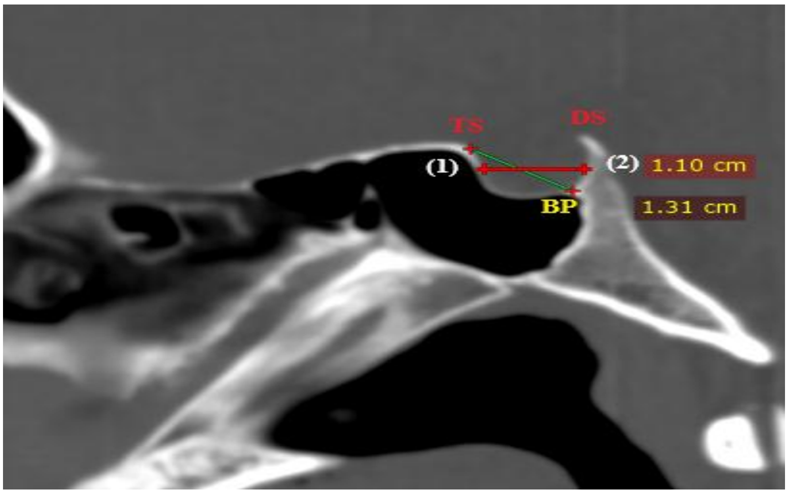

Figure (2): Mid-sagittal image of multidetector computed tomography (MDCT) shows the width (the red line) and the anteroposterior diameter of sella turcica (the green line). {TS: Tuberculum sellae, DS: Dorsum sellae, (1): The most anterior point of sella turcica, (2): The most posterior point of sella turcica, BP: the backmost point in the interior surface of sella turcica's posterior wall}

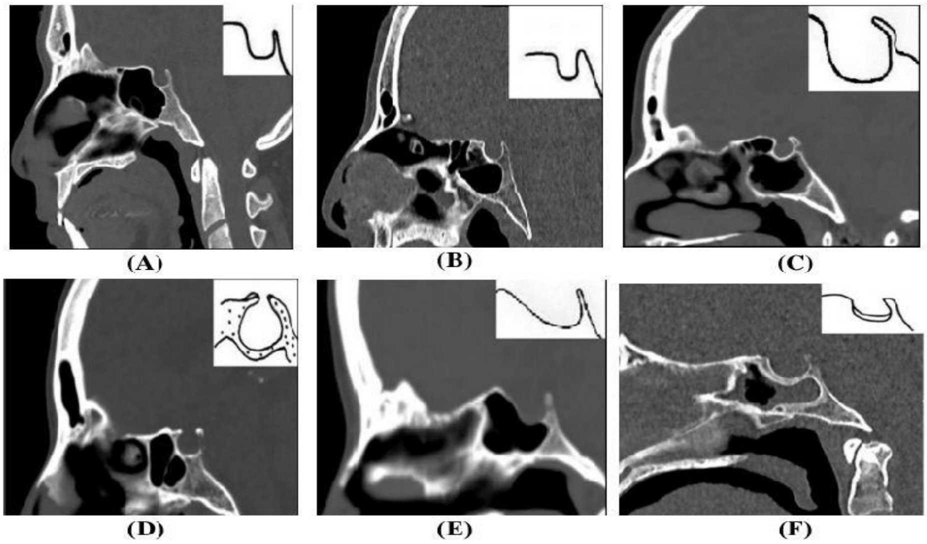

Figure (3): Mid-sagittal image of multidetector computed tomography (MDCT) shows different shapes of sella turcica. {(A) Normal shape of sella turcica, (B) Pyramidal shape of dorsum sellae, (C) Irregular posterior wall of sella turcica (notching), (D) Bridging of sella turcica, (E) Oblique anterior wall of sella turcica and (F) Double contour of the floor of sella turcica}

● Ethical considerations

This study was done after the approval of the Research Ethics Committee in the Faculty of Medicine, Tanta University with *approval code number: 36264MS21/1/2.*

Data confidentiality was maintained by making a code number for each participant.

Following the explanation of detailed information regarding the study, written informed consent was obtained from each participant or his/ her guardians if the participant was unable to give the consent.

Statistical Analysis:

All data were tabulated and analyzed by the statistical package designed for the social sciences software program, IBM SPSS Statistics for Windows, version 27 (IBM Corp., Armonk, N.Y., USA). Descriptive statistics included categorical data presented as numbers, and percentages and numerical data first tested for normality by the Shapiro-Wilk test. Normally distributed data were expressed as the mean ± standard deviation while not normally distributed data were presented as the median and interquartile range. We also compared age distribution among male and female groups by running the Mann-Whitney U test. Inter-observer and Intra-observer reliability testing was investigated by intraclass correlation coefficients (ICC) for continuous data and Cohen's weighted Kappa (κ) for nominal data Inferential statistics included comparisons of the studied measurements between male and female groups by applying the Independent Samples T-test. Furthermore, the association between the shape of sella turcica and the sex of the studied subjects was performed by Pearson's Chi-Square test. To develop prediction models for the male sex from the length, depth, and shape of sella turcica (data that showed significant relationships with sex), univariate and multivariable binary logistic regression analyses were applied to all the studied subjects and in a specific age group. Equations for determining the male sex were retrieved. P <0.05 was considered statistically significant.

RESULTS

This study included a total of 334 participants (167 males and 167 females). The participants' ages ranged from 18 to 68 years. The median age for females was 33 years, and for males was 35 years. Regarding the distribution of the participants among age groups, the highest percentage was among group I (40.7%) of the total participants. While groups II, III, IV, and V represent 15%, 20.4%, 14.4%, and 9.6% of total participants respectively. However, females and males were equally distributed among all age groups with no significant difference between them **(Figure 4)**.

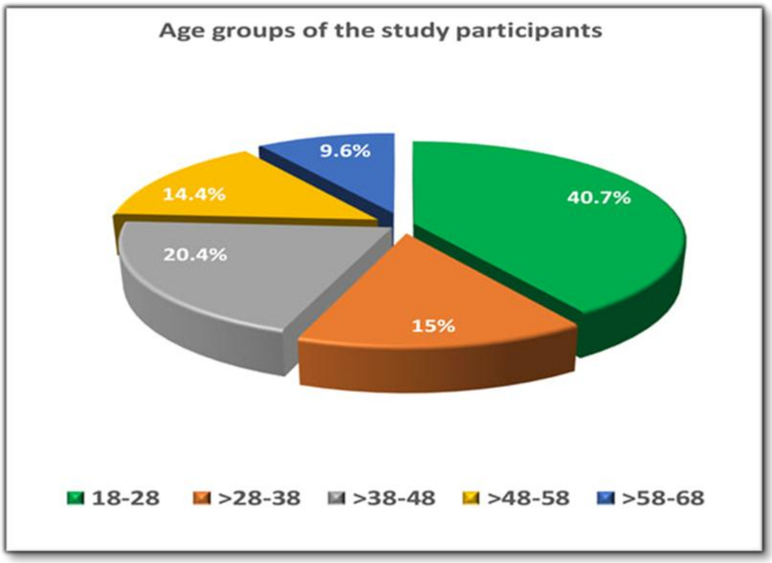

Figure (4): Age distribution of the studied participants.

The ICC for the four measurements of sella turcica was assessed in this study and showed excellent inter-observer and intra-observer reliability (All ICCs > 0.9). In addition, sella turcica shapes had perfect inter-observer and intra-observer agreement, with κ values of 0.835 and 0.856, respectively. A comparison was made between female and male participants regarding the four studied measurements of sella turcica as shown in **table (1)**. The mean value of sella turcica length was significantly higher among males than females (10.19±1.58 in males *vs* 9.64±1.56 in females). On the other hand, the sella turcica depth was significantly higher among female than male participants (8.73±1.38 in females *vs* 8.26±1.19 in males). Regarding the anteroposterior diameter and width of sella turcica, the mean values were higher in females than in males. However, this difference was statistically insignificant (P value > 0.05).

Table (2) shows the sexual dimorphism of the four measurements of sella turcica in different age groups. As regards the length of sella turcica, the mean values were higher in males than in females among all age groups. Moreover, the length of sella turcica demonstrated a statistically significant difference between male and female participants in age group I (P=0.002).

The mean values of sella turcica depth for females across different age groups were higher than those for males. However, this difference was statistically significant in age group I (P=0.003). Regarding the width and the anteroposterior diameter of sella turcica, there was a non-significant difference between female and male participants in different age groups.As for sex discrimination based on different shapes of sella turcica, there was a significant difference between female and male participants regarding the shape of sella turcica. The irregular (notching) shape of the posterior part of the dorsum sellae was significantly higher in males than females (P<0.001). In contrast, bridging of the sella turcica was significantly higher in females compared to males (P<0.001). The irregular (notching) shape of the posterior part of dorsum sellae recorded the highest accuracy for predicting male sex achieving 57.5% with 93% specificity and 22% sensitivity. Conversely, the bridging shape of sella turcica could significantly predict the female sex with a specificity of 97%, an accuracy of 57%, and a sensitivity of 17% **(Table 3)**.

The results of the univariate binary logistic regression analysis model among all participants indicated that both sellar length and depth were significant predictors of male sex with accuracies of 57.2% and 56.6% respectively. For every unit increase in sellar length, the probability of the male sex increased by 1.272. On the contrary, for every unit decrease in sellar depth, the probability of the male sex increased by 0.751.

By applying a multivariable binary logistic regression analysis model for male sex prediction using both sella turcica length and depth among all subjects. It was observed that the sellar length and depth significantly contributed to the model and the overall model correctly classified 62.9% of subjects. For every unit increase sellar length, the probability of male sex increased by 1.326. Conversely, for every unit decrease in sella turcica depth, the probability of the male sex increased by 0.713. Additionally, the length, depth, and notching shape of the posterior part of dorsum sellae contributed significantly to the multivariate regression analysis to predict the male sex giving rise to a statistically significant model. The overall model could classify sex with an accuracy of 63.2% as shown in **table (4)**.

The equations obtained from univariate and multivariate regression analysis models to predict the male sex based on sella turcica measurements (length and depth) and shape covariates within all participants were demonstrated in **table (5)**.

Concerning age group I (18-28 years), a univariate binary logistic regression analysis model indicated that both sellar length and depth could significantly predict the male sex with accuracies of 61.8% and 61%, respectively. Moreover, the sellar length and depth contributed significantly to the multivariate binomial logistic regression analysis to predict the male sex giving rise to a statistically significant model.

The overall model accurately classified 72.1% of subjects. Additionally, the length, depth and notching shape of the posterior part of the dorsum sellae significantly contributed to the model and the overall model correctly classified 72.8% of subjects **(Table 6)**.

The equations derived from the models to predict male sex based on sella turcica measurements (length and depth) and shape covariates among age group I (18-28 years) were displayed in **table (7)**.

Table (1): Comparison between females and males as regards the four studied parameters of sella turcica (length, depth, width, and anteroposterior diameter).

	Sex		Total N=334	Independent samples T-test	
	Female N=167	**Male** N=167			
	Mean±SD	**Mean±SD**	**Mean±SD**	**t**	**P**
Length(mm)	9.64±1.56	10.19±1.58	9.91±1.59	3.211	**0.001***
Depth(mm)	8.73±1.38	8.26±1.19	8.49±1.31	-3.319	**0.001***
Width(mm)	10.87±1.21	10.69±1.37	10.78±1.29	-1.313	0.190
AP diameter (mm)	12.60±1.55	12.40±1.61	12.5±1.58	-1.149	0.252

*AP diameter: Anteroposterior diameter, mm: millimeter, N: number, SD: standard deviation, t: independent T-test, *Significant at p <0.05.*

Table (2): Sexual dimorphism of sella turcica length, depth, width and anteroposterior diameter in different age groups.

			Length (mm)	t	P
Age groups (years)	**Group I**	**Female**	9.30± 1.50	3.128	**0.002***
		Male	10.09±1.43		
	Group II	**Female**	9.62±1.67	1.823	0.074
		Male	10.41±1.37		
	Group III	**Female**	9.96±1.80	0.183	0.855
		Male	10.04±1.94		
	Group IV	**Female**	9.87±1.39	1.451	0.154
		Male	10.49±1.59		
	Group V	**Female**	10.07±1.12	0.125	0.902
		Male	10.14±1.71		
			Depth (mm)		
Age groups (years)	**Group I**	**Female**	8.81±1.18	-3.041	**0.003***
		Male	8.16±1.34		
	Group II	**Female**	8.58±1.18	-0.640	0.525
		Male	8.39±0.91		
	Group III	**Female**	8.35±1.68	-0.177	0.860
		Male	8.29±1.15		
	Group IV	**Female**	8.86±1.29	-1.524	0.060
		Male	8.76±0.94		
	Group V	**Female**	9.18±1.81	-0.755	0.456
		Male	8.77±1.25		

Width (mm)					
Age groups (years)	**Group I**	**Female**	10.68±1.18	-0.528	0.599
		Male	10.56±1.49		
	Group II	**Female**	10.92±1.06	-0.141	0.889
		Male	10.87±1.20		
	Group III	**Female**	11.00±1.45	-0.560	0.577
		Male	10.82±1.20		
	Group IV	**Female**	10.91±1.09	-0.096	0.924
		Male	10.88±1.22		
	Group V	**Female**	11.28±1.20	-1.807	0.081
		Male	10.36±1.64		
AP diameter (mm)					
Age groups (years)	**Group I**	**Female**	12.44±1.38	-1.207	0.230
		Male	12.12±1.73		
	Group II	**Female**	12.41±1.37	0.469	0.641
		Male	12.61±1.60		
	Group III	**Female**	12.76±1.87	-0.812	0.420
		Male	12.43±1.45		
	Group IV	**Female**	12.84±1.49	-0.182	0.856
		Male	12.76±1.53		
	Group V	**Female**	12.86±1.84	-0.305	0.763
		Male	12.68±1.49		

*Data are presented as mean ± SD. *Significant P value <0.05. t: independent T-test. AP: anteroposterior. mm: millimeters.*

Table (3): Sex discrimination based on different shapes of sella turcica.

Shape of Sella Turcica		**Sex**				**Power of Sex Discrimination**			**Chi-Square test**	
		Female N=167		**Male N=167**						
		N	%	N	%	**Sens. %**	**Spec. %**	**Accu. %**	**X^2**	**P-Value**
Normal	**No**	63	37.7%	75	44.9%	62.0	45.0	53.6	1.778	0.182
	Yes	104	62.3%	92	55.1%					
Notching	**No**	155	92.8%	131	78.4%	22.0	93.0	57.5	14.014	**<0.001***
	Yes	12	7.2%	36	21.6%					
Pyramidal	**No**	150	89.8%	142	85.0%	15.0	90	52.4	1.743	0.187
	Yes	17	10.2%	25	15.0%					
Bridging	**No**	139	83.2%	162	97.0%	17.0	97.0	57.0	17.788	**<0.001***
	Yes	28	16.8%	5	3.0%					
Oblique anterior wall	**No**	164	98.2%	159	95.2%	5.0	98.0	51.5	2.350	0.125
	Yes	3	1.8%	8	4.8%					

*N: number, Sens.: sensitivity, Spec.: specificity, Accu.: accuracy, X^2: Chi-Square test, *Significant at p <0.05.*

Table (4): Univariate and multivariate binary logistic regression analysis models for predicting male sex from the sella turcica measurements (length, depth) and shape covariates among all participants (Number =334).

		Beta coefficient	**Odds ratio**	**95% CI for odds ratio**		**Accu.**	**HL test**	**P**
				Upper	**Lower**	57.2%	0.062	**<0.001***
Total	**Length (mm)**	0.241	1.272	1.468	1.103			
	Constant	-2.381	0.092	--				
	Depth (mm)	-0.286	0.751	0.894	0.631	56.6%	0.343	**<0.001***
	Constant	2.430	11.358	--				

		Beta coefficient	**P**	**AOR**	**95% CI for AOR**		**Accu.**	**HL test**	**P**
					Upper	**Lower**			
Total	**Length (mm)**	0.282	**<0.001***	1.326	1.537	1.144	%62.9	0.563	**<0.001***
	Depth (mm)	- 0.339	**<0.001***	0.713	0.854	0.595			
	Constant	0.084	0.931	0.785	--				
	Length (mm)	0.301	**<0.001***	1.351	1.572	1.161	63.2%	0.886	**<0.001***
	Depth (mm)	-0.366	**<0.001***	0.693	0.835	0.576			
	Notching	1.413	**<0.001***	4.109	8.483	1.990			
	Constant	-0.058	0.954	0.944	--				

**Significant P value<0.05. CI: confidence interval, HL test: Hosmer and Lemeshow test, Accu.: accuracy, AOR: adjusted odds ratio. mm: millimeter.*

Table (5): The equations derived from univariate and multivariate binary logistic regression analysis models for predicting male sex from the sella turcica measurements (length and depth) and shape covariates among all participants.

- The equation for male sex prediction using sella turcica length:

  Logit (p)= -2.381+ (0.241x sellar length in mm).
- The equation for male sex prediction using sella turcica depth:

  Logit(p) = 2.430 + (-0.286 x sellar depth in mm).
- The equation for male sex prediction using both sella turcica length and depth:

  Logit (p)= 0.084+ (0.282 x sellar length in mm) + (- 0.339 x sellar depth in mm).
- The equation for male sex prediction using sella turcica length, depth and shape covariates:

  Logit (p)= -0.058+ (0.301x sellar length in mm) + (-0.366 x sellar depth in mm) + (1.413x notching).

N.B: If notching is present put 1, otherwise put 0.

Logit (p) can be transformed to the probability of being male by the following formula:

$P= 1/ 1+e^{-\text{logit (p)}}$

Table (6): Univariate and multivariate binary logistic regression analysis models for predicting male sex from the sella turcica measurements (length, depth) and shape covariates in group I (Number=136).

		Beta coefficient	Odds ratio	95% CI for odds ratio Upper	95% CI for odds ratio Lower	Accu.	HL test	P
Group I	Length (mm)	0.388	1.475	1.898	1.145	61.8%	0.398	**0.001***
	Constant	-3.751	0.023	--				
	Depth (mm)	-0.416	0.660	0.875	0.498	61.0%	0.399	**0.003***
	Constant	3.523	33.885	--				

		Beta coefficient	P	AOR	95% CI for AOR Upper	95% CI for AOR Lower	Accu.	HL test	P
Group I	Length (mm)	0.513	**<0.001***	1.669	2.194	1.271	72.1%	0.393	**<0.001***
	Depth (mm)	- 0.578	**<0.001***	0.561	0.770	0.409			
	Constant	- 0.050	0.975	0.951	--				
	Length (mm)	0.543	**<0.001***	1.721	1.721	1.297	72.8%	0.429	**<0.001***
	Depth (mm)	-0.645	**<0.001***	0.525	0.525	0.377			
	Notching	1.837	**0.012***	6.275	6.275	1.497			
	Constant	0.045	0.978	1.046	--				

**Significant P value<0.05. CI: confidence interval, HL test: Hosmer and Lemeshow test, Accu.: accuracy, AOR: adjusted odds ratio. mm: millimeter.*

Table (7): The equations obtained from univariate and multivariate binary logistic regression analysis models for male sex prediction based on sella turcica measurements (length and depth) and shape covariates among age group I (18-28 Years).

- The equation for male sex prediction based on sella turcica length:

  Logit (p)= -3.751+ (0.388 x sellar length in mm).
- The equation for male sex prediction based on sella turcica depth:

  Logit (p)= 3.523+(-0.416 x sellar depth in mm).
- The equation for male sex prediction from both sella turcica length and depth:

  Logit (p) = - 0.050 + (0.513 x sellar length in mm) + (- 0.578 x sellar depth in mm).
- The equation for male sex prediction from sella turcica length, depth and shape covariates:

  Logit (p)= 0.045+ (0.543x sellar length in mm) + (-0.645 x sellar depth in mm) + (1.837x notching).

  N.B: If notching is present put 1, otherwise put 0.

Logit (p) can be transformed to the probability of being male by the following formula:

$P= 1/ 1+e^{-\text{logit (p)}}$

DISCUSSION

Identification is the process of determining a person's unique identity. This process is divided into two steps: constructing a biological profile (sex, age, stature, and race) and comparing individualizing markers to achieve a positive identification ***(Klales, 2021)***. Accurate sex determination of unidentified human skeletal remains is essential for developing a comprehensive biological profile. However, identifying age and stature depends on proper sex identification ***(Allam et al., 2021)***.

The current study was a cross-sectional one held to evaluate the morphological and metric measurements of sella turcica for sex discrimination using MDCT in a sample of the Egyptian population (334 participants). We have selected the sella turcica for sex determination due to its location in the middle cranial fossa. Even in fractured skulls, this cavity is less likely to be damaged and may still carry useful information for personal identification ***(De Donno et al., 2021)***.

As regards the age of the studied participants in the current study, the lower limit of age was 18 years as the spheno-occipital synchondrosis (SOS) between the basisphenoid and basioccipital bones completely ossifies. In addition, the dimensions of the sella turcica increase in parallel with the growth of the pituitary gland until around 16-18 years of age, while the upper limit of age was less than 70 to avoid extensive bone resorption (***Turamanlar et al., 2017; Abd El Rahman et al., 2023***).

Regarding the sexual dimorphism of the four studied measurements of sella turcica, Egyptian females had higher mean values in all the studied measurements of sella turcica compared to males except for sellar length, which was greater in males than in females. These results came in harmony with the findings of ***Keşkek and Aytuğar (2021)*** in their study on Turkish participants. These results may be attributed to the fact that the pubertal growth spurt in females starts two years earlier than in males ***(Abebe et al., 2021)***.

Additionally, the development of the sella turcica is closely linked to the growth of the pituitary gland and this development is significantly affected by hormonal levels. For instance, increased Luteinizing hormone (LH) production during puberty in females leads to a significantly higher pituitary height compared to males, with a peak observed at 20-29 years ***(Yadav et al., 2017)***.

In the current study, it was found that the sellar length and depth had the most significant sexual dimorphism. This came in agreement with the Turkish study conducted by ***Keşkek and Aytuğar (2021)*** who reported that there was a statistically significant difference in sellar length and depth according to both genders. However, studies held by ***Otuyemi et al. (2017)*** in Nigeria and ***Mohammed et al. (2021)*** in Libya, reported a difference between males and females regarding sellar length and depth, however, this difference was non-significant (P>0.05).

Other studies among different populations have shown varied results concerning sexual dimorphism using sella turcica measurements. ***Luong et al. (2016)*** in America and ***De Donno et al. (2021)*** in Italy demonstrated that sellar length was the only statistically significant parameter between males and females.

However, ***Gargi et al. (2019)*** in India and ***Abebe et al. (2021)*** in Ethiopia concluded that sellar depth only indicated a significant difference between sexes. In addition, a study conducted by ***Usman et al. (2020)*** in Nigeria reported that there was a significant difference between males and females regarding the sella turcica length and anteroposterior diameter. Moreover, ***Kiran et al. (2017)*** in India found that sellar depth and anteroposterior diameter were significant variables for sex discrimination. Sexual dimorphism studies vary greatly as they are very specific to the population studied. Hence, the different populations may explain the differences observed between the findings of various studies and those of the present study. Additionally, the differences in sample sizes and radiological techniques used may contribute to these variations.

As regards the sexual dimorphism of the four studied measurements of sella turcica in different age groups, the length and depth of sella turcica presented a statistically significant difference between female and male participants only in the age group I (18-28 years). This result aligns partially with the results observed by ***Axelsson et al. (2004)*** who reported a significant difference between the Norwegian females and males regarding the sella length in a group aged eighteen years with no significant differences regarding the sellar depth.

These findings could be supported by the fact that the pituitary fossa tends to be larger in males than females from around 1 to 13 years of age. Due to the pubertal growth spurt, which begins 2 years earlier in females than in males, the dimensions of the pituitary fossa undergo significant changes in females between the ages of 11 and 15. Subsequently, males experience a growth spurt a couple of years later, leading to both genders having almost the same size of the sella later in life (***Shrestha et al., 2018; Issrani et al., 2023***).

In the present study, there was a significant difference between female and male participants regarding the shape of sella turcica. This agrees with the study of ***Mortezai et al. (2023)*** in Iran who registered a significant relationship between the sella turcica shapes and sex. In contrast, ***Yassir et al. (2010)*** in Iraq, ***Kiran et al. (2017)*** in India, and ***Otuyemi et al. (2017)*** in Nigeria revealed that there was no significant difference in sella turcica shape between male and female subjects. In the current study, the irregular (notching) shape in the posterior part of dorsum sellae was significantly higher in males than females. In contrast, bridging of the sella turcica was significantly higher in females compared to males (P<0.001).

These findings aligned with the results obtained by ***Mortezai et al. (2023)*** in Iran. However, the differences between our study and other studies might be explained by racial variations. The differences between races could be attributed to genetic causes, environmental conditions, or dietary habits ***(Bulatao and Anderson, 2004)***.

In the present study, a univariate binary logistic regression analysis model was done to predict the male sex based on two measurements: the sella turcica length and depth. The results indicated that both sellar length and depth were significant predictors of male sex with accuracies of 57.2% and 56.6% respectively. This result was consistent with ***Subasree and Dharman (2019)*** in India who applied univariate discriminant function analysis to predict male sex based on sellar length achieving an accuracy of up to 46.1%. However, ***Abd El Rahman et al. (2023)*** in Egypt used univariate discriminant function analysis to predict male sex based on sellar depth achieving an accuracy of 52.7%. Similarly, ***Subasree and Dharman (2019)*** in India correctly predicted male sex using sellar depth with an accuracy of 56.9%. The differences in sex prediction accuracy percentages between this study and others may be attributed to ethnic and racial variations among populations, as well as the different radiological techniques, and statistical methods used for analysis ***(Helmy et al., 2021; Abd El Rahman et al., 2023)***.

Multivariable binary logistic regression analysis was performed in the current study to predict the male sex from both the length and depth of sella turcica. Regarding the length of sella turcica, for every unit increase in sellar length, the probability of male sex increased by 1.326. Conversely, for every unit decrease in sellar depth, the probability of the male sex increased by 0.713. The model accurately classified 62.9% of the studied subjects and it was a good fit model for sex prediction. These results are nearly consistent with those obtained by ***De Donno et al. (2021)*** in Italy who found that the probability of predicting male sex increased by 1.471759 for each unit increase in sella length. Additionally, for every unit increase in sella width, the probability of male sex prediction increased by 1.167947.

To the best of the authors' knowledge, the current research was the first one that used the multivariable binary logistic regression analysis model for predicting male sex from length, depth, and shape covariates. It was observed that the length, depth, and notching shape significantly contributed to the model (P<0.001).

For every unit increase in sellar length, the probability of male sex increased by 1.351. In addition, for every unit decrease in depth, the probability of male sex increased by 0.693. Furthermore, the presence of the notching shape of the dorsum sellae was a significant predictor of the male sex and was associated with an increased probability of male sex by 4.109. The overall model could classify the sex with an accuracy of 63.2%.

For age group I, a univariate binary logistic regression analysis model was performed to predict the male sex based on two measurements: the sella turcica length and depth. The analysis revealed that both the length and depth of the sella turcica could significantly predict the male sex in this age group with accuracies of 61.8% and 61% respectively. By applying the multivariable binary logistic regression analysis model for predicting male sex from length and depth of sella turcica among age group I, we recorded that both the length and depth of sella significantly contributed to the model and the overall model correctly classified 72.1% of subjects. However, the accuracy improved to 72.8% when using a multivariate binary logistic regression model that included the notching shape of the posterior part of the dorsum sellae, in addition to the sellar length and depth. The high sex prediction accuracy percentages among age group I could be attributed to the large number of participants in this group (40.7%) compared to other age groups. Additionally, the differences between males and females in the studied sella measurements were more consistent at this young age group allowing the model to predict sex more accurately.

Based on the findings of the current study, there were notable sex-related differences in the morphological and metric measurements of the sella turcica in a sample of adult Egyptians. Regarding the morphology of the sella turcica, the irregular (notching) shape of the dorsum sellae showed the highest accuracy for predicting the male sex.

Conversely, the bridging shape of the sella turcica could significantly predict the female sex with 57% accuracy. Concerning the metric measurements, sella length was the most accurate variable for sex prediction in univariate binary logistic regression. However, the accuracy improved to 62.9% when using a multivariate binary logistic regression model that incorporated both the length and depth of the sella turcica. Moreover, the multivariable binary logistic regression analysis model for predicting the male sex using the metric and morphological characteristics of the sella turcica found that length, depth, and notching shape significantly contributed to the model, correctly classifying 63.2% of subjects.

CONCLUSION

In conclusion, sella turcica can serve as a relatively good adjuvant tool for sex identification among adult Egyptians. Its metric measurements and morphology contributed significantly to the multivariate regression models that could predict male sex with an overall accuracy of 63.2%. However, the accuracy of the model improved to 72.8% when applied to Egyptian individuals aged between 18 and 28 years. Furthermore, the equations derived from both univariate and multivariate binary logistic regression analysis models can be used by forensic specialists for sex discrimination among the adult Egyptian population.

Limitations of the study:

The applicability of the developed models to other populations may be limited, as they were derived from a specific group with distinct genetic, racial, and environmental characteristics. Therefore, further studies across major global populations are recommended to validate these models universally. Additionally, further studies should be performed on a larger sample size across different regions of Egypt due to the considerable population variety among Egyptians. Another limitation of this study is that the ages of participants ranged between 18 and 68 years. Hence, future studies on younger age groups under 18 years are recommended.

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التقييم المورفومتري للسرج التركي للتمييز بين الجنسين باستخدام التصوير المقطعي المحوسب متعدد الكواشف في عينة من المصريين

أميرة ممدوح إبراهيم خطاب[1]، منى سيد أحمد الجوهري[2]، هيثم مصباح فوده[3]، غادة عطية عبد الحميد صاجة[2]
[1]قسم الطب الشرعي والسموم الإكلينيكية ، كلية الطب البشرى، جامعة كفر الشيخ، مصر
[2]قسم الطب الشرعي والسموم الإكلينيكية ، كلية الطب البشرى، جامعة طنطا، مصر
[3]قسم الاشعة التشخيصية والتداخلية ، كلية الطب البشرى، جامعة كفر الشيخ، مصر

الملخص العربى

المقدمة: يعد تحديد جنس الهيكل العظمي البالغ خطوة أولية مهمة حيث يعتمد تقدير عمر الفرد وقامته على الجنس. يقع السرج التركي في الحفرة القحفية الوسطى والتي من غير المرجح أن يصيبها ضرر كما انها لا تزال تحمل معلومات مفيدة لعملية الاستعراف الشخصي حتى في الجماجم المكسورة. هذا وقد أصبح التصوير المقطعي المحوسب متعدد الكواشف (MDCT) مستخدمًا على نطاق واسع في الطب الشرعي لتحديد الجنس.

الهدف من الدراسة: تهدف هذه الدراسة الى تقييم القياسات المورفولوجية والمترية للسرج التركي للتمييز بين الجنسين باستخدام التصوير المقطعي المحوسب متعدد الكواشف في عينة من السكان المصريين.

طريقة البحث: كانت هذه الدراسة دراسة مقطعية مستقبلية أجريت على ٣٣٤ مصريًا بالغا تم اختيارهم عشوائيًا (١٦٧ ذكرًا و١٦٧ أنثى) خضعوا لمسح التصوير المقطعي المحوسب متعدد الكواشف على الرأس. وتراوحت أعمار المشاركين ما بين ١٨ الى ٦٨ عاما.

النتائج: بينت النتائج أن كلا من طول وعمق السرج قد أظهروا اختلافات ذات دلالة إحصائية بين الذكور والإناث. كما أظهر الشكل غير المنتظم (وجود شق) بالجزء الخلفي من ظهر السرج أعلى دقة للتنبؤ بجنس الذكر. وعلى العكس من ذلك، يمكن لشكل الوصل القنطري للسرج التركي أن يتنبأ بشكل كبير بجنس الأنثى بدقة تصل الى ٥٧٪. كما أشار نموذج تحليل الانحدار اللوجستي متعدد المتغيرات الى أن طول السرج وعمقه وشكل "الشق" بالجزء الخلفي من ظهر السرج ساهموا بشكل كبير في تصنيف النموذج الى للتنبؤ بجنس الذكور بشكل صحيح لـ ٦٣.٢٪ من الأشخاص.

الاستنتاج: من ثم يمكن استنتاج أن السرج التركي يعد بمثابة أداة مساعدة جيدة نسبيًا لتحديد الجنس بين المصريين البالغين. بالإضافة إلى ذلك، يمكن للمتخصصين في الطب الشرعي استخدام المعادلات المستمدة من تحليلات الانحدار اللوجستي الثنائي أحادي المتغير ومتعدد المتغيرات للتمييز بين الجنسين بين السكان المصريين البالغين.