Metric Analysis of Sella Turcica for Sex Identification Using Multidetector Computed Tomography in a Sample of Adult Egyptians.

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KEYWORDS
Sella Turcica,
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Sex identification,
Discriminant analysis,
Forensic anthropology.

ABSTRACT

Sex identification is a preliminary step for personal identification. The current retrospective study aimed at investigating twenty-two variables in Sella Turcica and its boundaries of clinoid bones for sex determination among 148 adult Egyptians (74 males and 74 females) by using three-dimension reconstruction technique of Multidetector Computed Tomography images. Sella width, depth, anteroposterior diameter, height anterior, height median, height posterior and area were statistically significant larger in females. Anterior clinoid distance, posterior clinoid distance, anterior clinoid process length and posterior clinoid process transverse thickness were statistically significant larger in males. Sella length, interclinoid distance, Sella diameter, anterior clinoid process basal width and posterior clinoid process length showed non-significant sex difference. Only interclinoid distance and anterior clinoid process basal width showed significant difference between right and left side in females. The Sella height median achieved the highest sex predicting accuracy (66.9%) in the receiver operating characteristic (ROC) curve analysis followed by area, depth and height posterior with accuracies up to (65.5 %, 64.2% and 63.5%) respectively. In simple univariate discriminant analysis after cross validation; Sella area had the best accuracies (68.9%), (44.6%) and (56.8 %) for males, females and total respectively. There was fall in sex prediction accuracy on applying multivariate discriminant analysis. Equations were derived from univariate and multivariate discriminant analysis to be applied for sex determination in adult Egyptians. To conclude; sexual dimorphism of Sella Turcica and clinoid bones is evident in adult Egyptians and can be used as adjuvant tool for sex determination in Egyptian population.

Introduction

Sella Turcica is a saddle-shaped depression in the interior aspect of the skull base that lodges the pituitary gland. Sella floor is formed by the roof of the sphenoid sinus. The anterior clinoid processes and tuberculum sellae form the Sella anterior boundary; while as; the posterior clinoid processes and dorsum sellae bounded it posteriorly (Turamanlar et al., 2017). From the forensic point of view; the protected position of Sella Turcica in the base of the skull encourages its use in skull identification especially in cases of badly decomposed or dismembered bodies (Hasan et al., 2016a). There is a growing use of fast accurate radiological modalities as three-dimension Multidetector Computed Tomography (MDCT) for studying bone features in virtual forensic anthropology (El-Sehly et al., 2018).

Sex identification is the first step of identification especially in case of mass disasters (Attia et al., 2018). In intact corpse; skull represents the second most important

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sex predicting bone after pelvis with accuracy up to 92% (Abo El-Atta et al., 2020). Taking racial and ethnic variabilities into consideration; each population should formulate its own updated statistical anthropometric models to achieve the maximum accuracy form studying whole skull or part of it (Helmy et al., 2021).

Interestingly; metric measures of Sella Turcica show a wide range of variability among different populations in relation to sex. For example, Turamanlar et al. (2017) in Turkish population; Chou et al. (2021, 2022) in Taiwanese population and El-Sehly et al. (2018) in Egyptian population; revealed evident difference in Sella measurements between both sexes. On the other hand; Islam et al. (2017) in Bangladeshi population and Hasan et al. (2016b) in Iraqi population; reported non-significant difference between males and females as regard Sella measures. Moreover; few non-Egyptian studies concerned with sex related differences of anterior and posterior clinoid processes dimensions as well as distances between them (Sakran et al., 2015; Sabanciogullari et al., 2018; Chou et al., 2021, 2022).

Hence; the present study aimed at evaluating sexual dimorphism of Sella Turcica as well as its boundaries of clinoid processes in a sample of adult Egyptians by using metric analysis of three-dimensional reconstruction technique of MDCT images. Another aim of the current work was achieving cut offs with high specificity, sensitivity and accuracy of these Sella measurements to differentiate between both sexes as well as formulating Egyptian specific sex discrimination statistical models.

Material and Method

Sample size

The calculated sample size of the study was 74 subjects for both male and female groups at 5% level of significance and 80% power of the study, using (G power 3.1.9.2 software).

Study design and Subjects

The current retrospective cross sectional observational study was conducted on high resolution non contrast CT head imaging of 148 adult Egyptian patients. Images were randomly selected from images stored on picture archiving and communication system (PACS) system scans of Mansoura University Hospitals during the period between September 2021 and March 2022 after applying the exclusion criteria. Age of the enrolled subjects ranged between 18 and 70 years (Turamanlar et al., 2017; Silveira et al., 2020). All participants had skull CT for different diagnostic medical or surgical reasons and no unnecessary exposure to radiation was done for the research purpose. Subjects who had any of the following characters were excluded: any craniofacial congenital anomalies, abnormal skull shape, and history of trauma or surgery that involved the Sella or parasellar area and pituitary tumors (El-Sehly et al., 2018).

Ethical consideration:

The study was approved by the Institutional Review Board Faculty of Medicine Mansoura University (R.21.09.1456).

Method:

Head CT imaging was conducted using high resolution non contrast with 128-slice multidetector rows CT scanner (Philips Medical system). The Imaging parameters were: Slice thickness 1mm, 0.5 second rotation time, 0.5-1 pitch factor, 250mAs, 120KV, 512x512 matrix, Bony algorithm and 0.5mm reconstruction thickness. The CT scans were saved in archive system as Digital Imaging and Communications in Medicine (DICOM) files then transferred from the archive system to the Philips workstation for being reviewed. A bone preset was used to emphasize the bone details in the image. For all cases; re-evaluating the CT images was performed in Multiplanar Reconstruction (MPR) in three planes (mid-sagittal, axial and coronal) (Figure 1). The following Sella measurements from (1) to (6) were taken in the (MPR) mid-sagittal plane; while as; Sella measurements (13) and (14) were measured in MPR coronal and axial plane respectively. In addition; three-dimension reconstruction technique of the image was used in all cases to obtain measurements from (7) to (12) (Figure 2) as following:

1. **Sella length*:*** The distance between tuberculum sellae (midpoint on the anterior boundary of Sella Turcica in midsagittal plane) and dorsum sellae (midpoint on the posterior boundary of the Sella Turcica in the midsagittal plane) (El-Sehly et al., 2018).
2. **Sella width**: The distance between the most anterior point and the most posterior point of Sella Turcica (El-Sehly et al., 2018).
3. **Sella depth**: The distance between deepest point of the Sella Turcica floor and the line representing the Sella Turcica length (El-Sehly et al., 2018).
4. **Sella antero-posterior diameter (APD)**: The distance between the tuberculum sellae and the backmost point in the posterior wall of Sella Turcica (Turamanlar et al., 2017).
5. **Sella heights** (El-Sehly et al., 2018):
   a) *Height anterior (HA)*: The vertical distance from tuberculum sellae to Sella floor perpendicularly to Frankfort horizontal plan. (The plan from the most superior point on the upper rim of the external auditory meatus to the most inferior point on the lower rim of the orbit)
   b) *Height median (HM)*: The vertical distance from a point midway between tuberculum sellae and dorsum sellae to Sella floor perpendicularly to Frankfort horizontal plan.
   c) *Height posterior (HP)*: The vertical distance from dorsum sellae to Sella floor perpendicularly to Frankfort horizontal plan.
6. **Sella area**: The area included by the outline of the Sella and capped by a line representing the Sella length (El-Sehly et al., 2018).
7. **Interclinoid distance (ICD); (ICD-R)** for right side and **(ICD-L)** for left side: The distance between the apex of anterior clinoid process and apex of posterior clinoid process on the same side (Chou et al., 2021).

8. **Anterior clinoid distance (ACD):** The maximum transverse distance between the apexes of the two anterior clinoid processes (Chou et al., 2021).
9. **Posterior clinoid distance (PCD)*:*** The maximum transverse distance between the apexes of the two posterior clinoid processes (Chou et al., 2021).
10. **Sella diameter (SD); (SDR)** for right side and **(SDL)** for left side**:** The distance from the apex of the anterior clinoid process and the furthest point on Sella Turcica border on the same side (Chou et al., 2021).
11. **Anterior clinoid process length (ACPL)**; **(ACPL-R)** for right side and **(ACPL-L)** for left side: The height from the apex of anterior clinoid to the medial margin of the optic canal on the same side (Sabanciogullari et al., 2018).
12. **Anterior clinoid process basal width (ACPBW); (ACPBW-R)** for right side and **(ACPBW-L)** for left side**:** The distance from the medial margin of the optic canal to the lateral edge of the anterior clinoid process on the same side (Sabanciogullari et al., 2018).
13. **Posterior clinoid process length (PCPL); (PCPL-R)** for right side and **(PCPL-L)** for left side: The height from the apex of the posterior clinoid process to Sella floor (Sakran et al., 2015).
14. **Posterior clinoid process transverse thickness (PCPT); (PCPT-R)** for right side and **(PCPT-L)** for left side: was measured as distance between the apex and the back of the posterior clinoid process (Cheng et al., 2015).

All measurements were recorded by two radiologists with 10 years of practical experience; both were blinded to sex of subjects. Inter-observer variability was assessed and the mean value of the two measures was taken. All measurements were taken in millimeter (mm) except area was calculated in centimeter square (cm^2) and to arbitrary units.

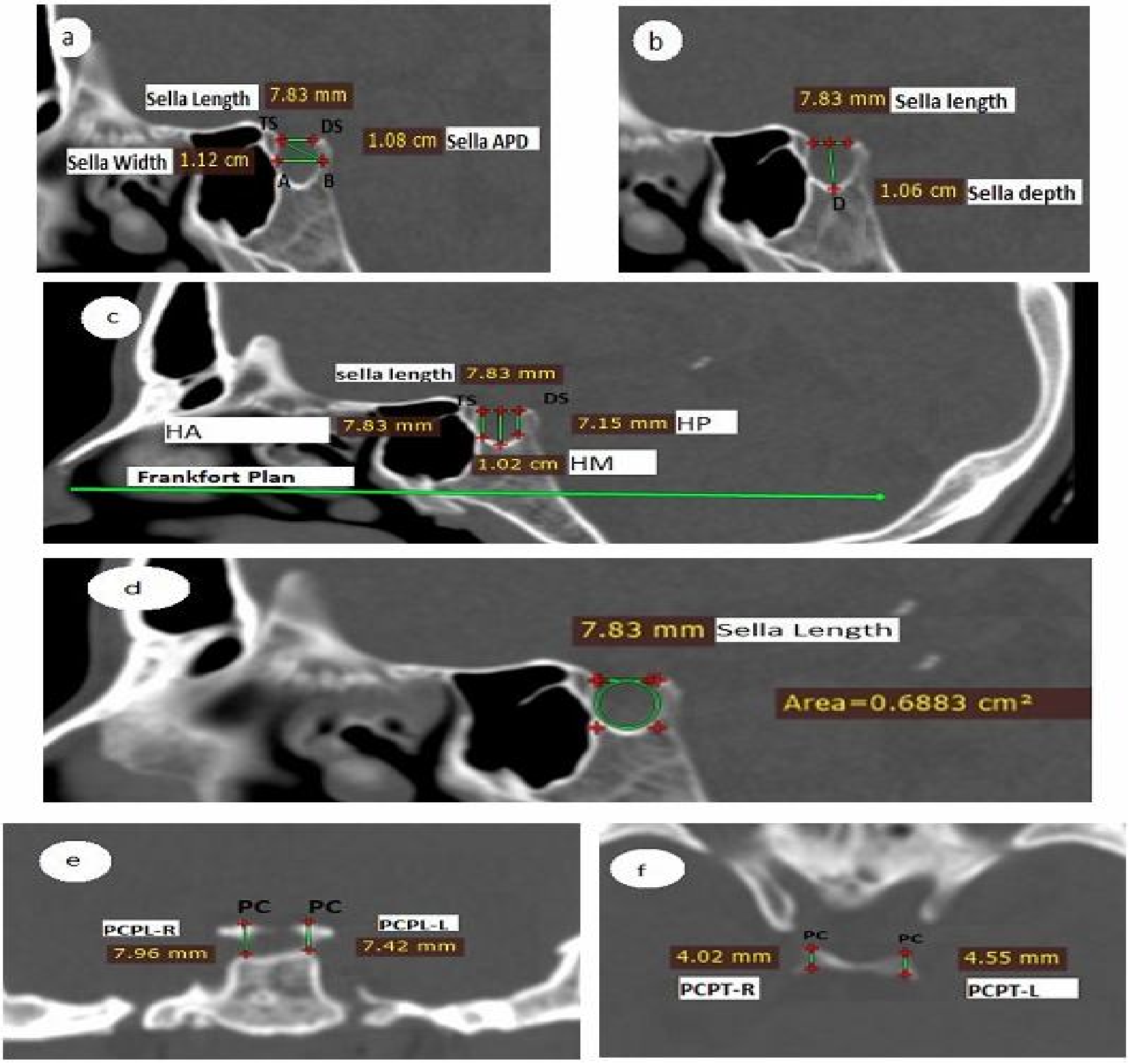

Fig. (1): Multiplanar Reconstruction (MPR) CT images of a male skull showing Sella Turcica measurements and boney land marks: **(a), (b), (c)** and **(d)** are in midsagittal plan, **(e)** is in coronal and **(f)** is in axial plan. **(a)** showing Sella length: the distance between (TS) tuberculum sellea and (DS) dorsum sellea; Sella width: the distance between (A) the most anterior part in the anterior wall and (B) the most posterior part in the posterior wall; APD: anteroposterior diameter : the distance between TS and B. **(b)** showing Sella depth : distance between (D) the depest point in Sella floor and the line presenting Sella length. **(c)** showing HA: height anterior: the distnace betweeen TS and the Sella floor; HM: height median the distance between the mid point of line representing the length and the Sella floor, HP: Height posterior the distance between DS and the Sella floor. HA, HM and HP all are perpendicular on the green arrow which represents the Frankfort horizontal plan. **(d)** Showing the area of Sella Turcica bounded by the line representing Sella length. **(e)** Coronal plan showing PCPL-R: posterior clinoid process length right side and PCPL-L: posterior clinoid process length left side measured as : the distance beween PC the apex of posterior clinoid process and the floor of Sella on both sides. **(f)** Axial plan showing PCPT-R :Posterior clinoid process transverse thickness right side and PCPT-L: Posterior clinoid process transverse thickness left side measured as: the distance between PC and the back of posterior clinoid process on both sides.

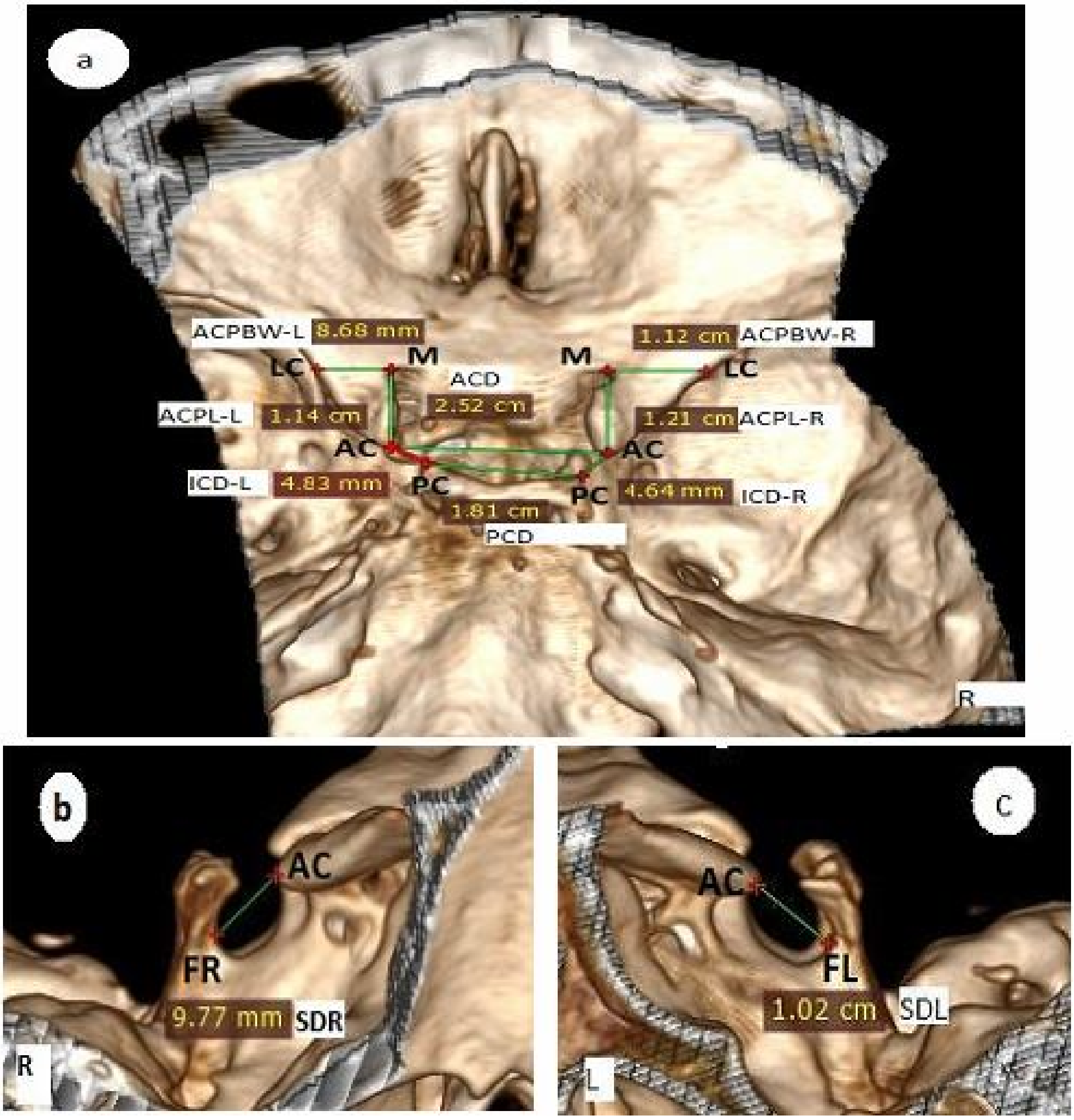

Fig. (2): Three-dimension reconstruction CT images of a female skull: (a) axial view of Sella Turcica from top of the head showing : ACD: anterior clinoid distance, the distance between the apexes of the anterior clinoid processes (AC) on both sides, PCD : posterior clinoid distance, the distance between the apexes of the posterior clinoid processes (PC) on both sides, ICD-R: interclinoid distance right side, the distance between AC and PC on right side, ICD-L: interclinoid distance left side, the distance between AC and PC on left side; ACPBW-R Anterior clinoid process basal width right side: the distance between the medial margin of the optic canal (M) and the lateral edge of anterior clinoid process (LC) on right side; ACPBW-L Anterior clinoid process basal width right side the distance between M and LC on the left side. ACPL-R: anterior clinoid process length right side, measured as the distance between AC and M on the right side; ACPL-L: anterior clinoid process length left side measured as the distance between AC and M on the left side. (b) The right-side view of the Sella Turcica showing SDR Sella diameter right, the distance between the furthest point on the right border (FR) of Sella Turcica and AC on the same side (c) the left side view of Sella Turcica showing SDL Sella diameter left the distance between furthest point on the left border of Sella Turcica (FL) and AC on the same side. R: right side, L: left side.

Statistical analysis:

Data were analyzed using the Statistical Package of Social Science (SPSS) program for Windows (Standard version 26). One-sample Kolmogorov-Smirnov test was used to test the normality of data. Continuous variables were presented as mean ± SD (standard deviation). Student T test was used to compare two groups; while as paired t-test was used to compare paired groups. Receiver operating characteristic (ROC) curve analysis was used to test sensitivity, specificity and accuracy of significant variables at different cut off points. Direct discriminant function analysis was done by stepwise, univariate and multivariate methods and sectioning point was calculated. A sectioning point was calculated by adding the two group centroids and dividing by two to discriminate between males and females. A leave –one- out classification was performed to measure the effectiveness and thus cross validated the accuracy of assignments to either male or female. The threshold of significance is fixed at 5% level (p-value). The results were considered significant when the probability of error is less than 5% ($p < 0.05$).

Results:

In the studied population; the mean age in males was (47± 9) years and in females, it was (45± 8) years. All data were normally distributed according to one-sample Kolmogorov-Smirnov test. Inter-observer variability was non-significant for all measured variables.

As shown in table (1), Sella width, depth, APD, HA, HM, HP and area were statistically significant larger in females than males. Sella length was larger in females than males, but this difference was statistically insignificant. On the other hand; ICD-R, ICD-L ACD, PCD, SDR, SDL, ACPL-R, ACPL-L, ACPBW-R, ACPBW-L, PCPL-R, PCPL-L, PCPT-R and PCPT-L were larger in males than females. Only ACD, PCD, ACPL-R, ACPL-L, PCPT-R and PCPT-L showed significant difference between males and females.

Table (1): Descriptive analysis and sex differences of Sella Turcica and clinoid processes measurements by using MDCT among the studied Egyptian population (n= 148).

Measured variables	Males (n=74)		Females (n=74)		Student T test	P value
	Mean ± SD	Min-Max	Mean ± SD	Min-Max		
Sella Length	9.74±1.71	5.70-13.90	9.80±1.74	5.16-14.70	t=0.208	0.836
Sella Width	10.69±1.41	7.23-13.70	11.66±1.81	8.46-17.00	t=3.656	≤0.001*
Sella Depth	8.83±1.30	5.57-12.60	9.84±1.93	1.02-15.50	t=3.735	≤0.001*
Sella APD	12.03±2.02	1.26-16.70	12.66±1.66	9.42-16.90	t=2.067	0.041*
Sella HA	5.88±1.86	2.10-11.90	7.14±2.19	2.56-14.10	t=3.751	≤0.001*
Sella HM	8.45±1.45	1.11-11.50	9.76±1.61	6.80-15.30	t=5.171	≤0.001*
Sella HP	7.29±1.34	4.55-11.80	8.24±1.63	4.46-12.60	t=3.834	≤0.001*
Sella Area	0.72±0.15	0.47-1.12	0.87±0.25	0.48-1.68	t=4.242	≤0.001*
ICD-R	5.45±2.41	1.29-9.59	5.31±2.27	1.87-11.00	t=0.372	0.710
ICD-L	5.84±2.36	2.36-9.50	5.38±2.15	2.73-11.90	t=1.251	0.213
ACD	25.56±2.70	19.3-31.8	24.43±2.42	20.1-30.2	t=2.692	0.008*
PCD	17.47±2.68	11.4-22.7	16.03±2.68	8.6-21.3	t=3.270	0.001*
SDR	9.83±2.24	4.17-18.00	9.27±1.89	5.34-13.60	t=1.617	0.108
SDL	9.71±2.13	3.83-17.10	9.23±2.07	4.55-12.70	t=1.403	0.163
ACPL-R	12.62±2.28	8.22-17.80	11.35±2.07	7.33-16.30	t=3.553	0.001*
ACPL-L	12.58±2.42	7.49-18.50	11.07±2.00	7.66-15.50	t=4.135	≤0.001*
ACPBW-R	11.92±2.24	7.60-17.80	11.51±2.33	4.12-15.90	t=1.069	0.287
ACPBW-L	11.65±2.43	6.44-17.10	11.04±2.10	3.73-15.50	t=1.630	0.105
PCPL-R	7.85±1.49	4.56-11.40	7.92±1.65	1.06-11.30	t=0.284	0.776
PCPL-L	7.73±1.42	4.02-11.10	7.71±1.64	1.10-1.10	t=0.056	0.956
PCPT-R	4.70±1.04	2.61-9.13	4.22±1.05	1.82-7.59	t=2.793	0.006*
PCPT-L	4.61±1.17	2.95-9.26	4.19±0.93	2.27-7.03	t=2.362	0.019*

APD: anteroposterior diameter, HA : height anterior, HM: height median, HP: height posterior, ICD-R: inter clinoid distance right side, ICD-L: inter clinoid distance left side, ACD: anterior clinoid distance, PCD: posterior clinoid distance, SDR: Sella diameter right side, SDL: Sella diameter left side, ACPL-R: anterior clinoid process length right side, ACPL-L: anterior clinoid process length left side ACPBW-R: anterior clinoid process basal width right side, ACPBW-L: anterior clinoid process basal width left side, PCPL-R: posterior clinoid process length right side, PCPL-L: posterior clinoid process length left side, PCPT-R: posterior clinoid process transverse thickness right side, PCPT-L: posterior clinoid process transverse thickness left side, n: number, SD: Standard deviation, Min: minimum, Max: maximum, p: probability, *significant p≤0.05. All measures were in millimeters except area was in centimeter square and to arbitrary units.

As regard bilateral Sella measures, there was no statistically significant difference between right and left sides in males. In females, only ICD, ACPBW showed significant difference between both sides (Table 2).

Table (2): Comparison between right and left sides of bilateral measurements of Sella Turcica and clinoid processes by using MDCT in studied Egyptian males and females.

Measured Variables	Males (n=74)				Females (n=74)			
	Right Mean ± SD	Left Mean ± SD	Paired t-test	P value	Right Mean ± SD	left Mean ± SD	Paired t - test	P value
ICD	5.45±2.41	5.38±2.36	t=0.048	0.962	5.31±2.27	5.84±2.15	t=3.45	0.001*
SD	9.87± 2.22	9.74± 2.14	t=0.876	0.384	9.30± 1.91	9.31± 2.02	t=0.091	0.928
ACPL	12.62±2.28	12.58±2.42	t=0.255	0.799	11.35±2.07	11.07±2.00	t=1.81	0.075
ACPBW	11.92±2.24	11.65±2.43	t=1.40	0.165	11.51±2.33	11.04±2.10	t=2.47	0.016*
PCPL	7.85±1.49	7.73±1.42	t=0.958	0.341	7.92±1.65	7.71±1.64	t=1.82	0.073
PCPT	4.70±1.04	4.61±1.17	t=0.811	0.420	4.22±1.05	4.19±0.93	t=0.238	0.812

ICD: inter clinoid distance, SD: Sella diameter, ACPL: anterior clinoid process length, ACPBW: anterior clinoid process basal width, PCPL: posterior clinoid process length, PCPT: posterior clinoid process transverse thickness, n: number, SD: Standard deviation, p: probability*significant p≤0.05. All measures were in millimeters.

As illustrated in table (3); Sella variables that showed statistically significant different between both sexes were enrolled in ROC curve analysis. The cut-off value of each Sella variable, which had the maximum sensitivity, specificity and accuracy to differentiate between males and females, was determined. The area under the curve (AUC) can be considered another criterion of comparison of accuracy in sex estimation. If the AUC is equal to 1.0, then the test will be perfect in discrimination of sex. If the AUC is close to 0.5, then a chance level is considered. The Sella HM had the largest AUC (0.734) and achieved the highest accuracy (66.9%) for sex prediction followed by area, depth and HP with accuracy up to (65.5 %, 64.2% and 63.5%) respectively, as shown in figure (3).

Table (3): Receiver operating characteristic (ROC) analysis of significant Sella Turcica and clinoid processes measured variables by using MDCT for sex discrimination in the studied Egyptian population (n=148)

Variables	AUC	95%CI		Cut off	Sensitivity	Specificity	PPV	NPV	Accuracy
		Lower limit	Upper limit						
Sella Width *	0.654	0.567	0.742	11.45	73%	51.4%	60%	65.5	62.2%
Sella Depth *	0.697	0.613	0.781	9.85	77%	51.4%	61.3%	69.1	64.2%
Sella APD*	0.576	0.484	0.668	12.45	55.4%	51.4%	53.2%	53.5	53.4%
Sella HA*	0.660	0.573	0.747	6.69	66.2%	52.7%	58.3%	60.9	59.5%
Sella HM*	0.734	0.653	0.815	9.57	82.4%	51.4%	62.9%	74.5	66.9%
Sella HP*	0.686	0.600	0.773	8.17	75.7%	51.4%	60.8%	67.9	63.5%
Sella Area*	0.685	0.599	0.770	0.8144	78.4%	52.7%	62.4%	70.9	65.5%
ACD**	0.635	0.545	0.725	24.55	68.9%	54.1%	60%	63.5	61.5%
PCD**	0.642	0.554	0.731	15.75	70.3%	48.6%	57.8%	62.1	59.5%
ACPL-R**	0.537	0.443	0.630	11.25	67.6%	52.7%	58.8%	61.9	60.1%
ACPL-L **	0.674	0.589	0.760	11.15	68.9%	48.6%	57.3%	61.0	58.8%
PCPT-R**	0.628	0.538	0.717	4.35	63.5%	48.6%	55.3%	57.1	56.1%
PCPT-L**	0.589	0.498	0.681	4.12	59.5%	47.3%	53%	53.8	53.4%

APD: anteroposterior diameter, HA: height anterior, HM: height median, HP: height posterior, ACD: anterior clinoid distance, PCD: posterior clinoid distance, ACPL-R: anterior clinoid process length right side, ACPL-L: anterior clinoid process length left side, PCPT-R: posterior clinoid process transverse thickness right side, PCPT-L: posterior clinoid process transverse thickness left side, AUC: area under the curve, CI: confidence interval, PPV: positive predictive value, NPV: negative predictive value, *Female if above the cutoff value, **Male if above the cut off value.

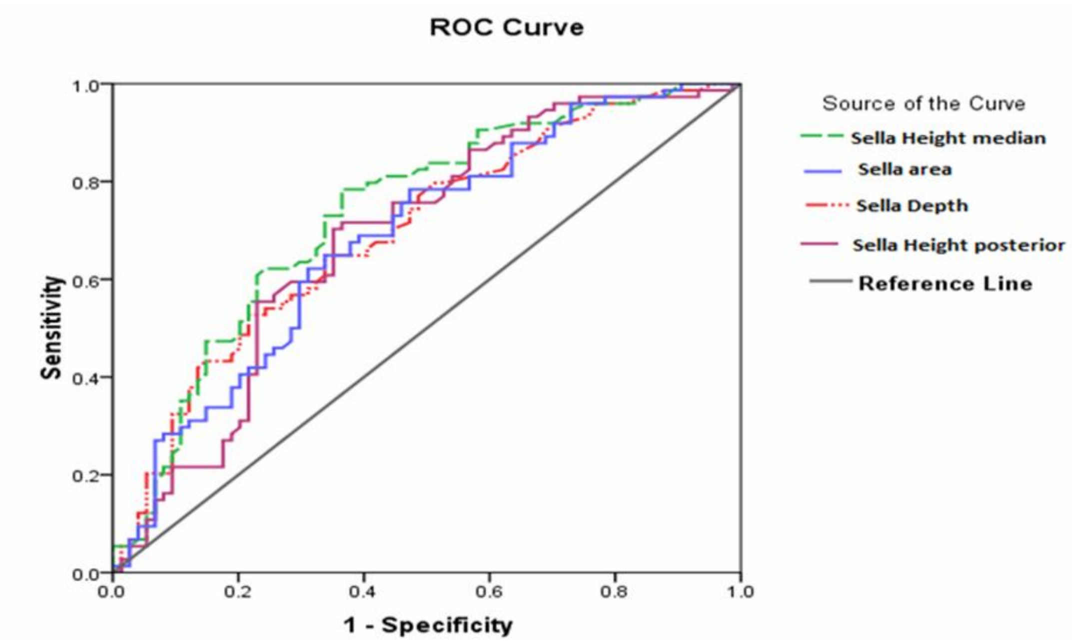

Fig. (3): Receiver operating characteristic (ROC) curve showing sensitivity, specificity and area under the curve for (Sella height median, area, depth and height posterior) in the studied Egyptian population (n=148).

In univariate discriminant analysis; the highest corrected prediction rate after cross validation (56.8%) was achieved on selection of Sella area with higher sensibility for male prediction (68.9%) than female prediction (44.6%) followed by HM (54.8%) (Table 4). In multivariate discriminant analysis; corrected prediction of all significant tested Sella variables after cross validation was (52.7%) with higher sensibility to males (67.6%) than females 37.8% (Table 5). Furthermore; equations were derived from discriminant analysis to calculate the discriminant score either from single variable in univariate analysis (Table 4) and from all significant tested variables in multivariate discriminant analysis (Table 5). Section point was calculated to be zero, and then sex determination is determined by comparing the discriminant score with the sectioning point.

Table (4): Univariate discriminant function analysis for sex prediction through assessment of the Sella Turcica and clinoid processes significant variables measured by using MDCT in 148 Egyptians

Variables	Constant	Co-efficient	Wilks' Lambda	p-value	Group centroid		Original Corrected prediction rates (%)		Corrected prediction rates after cross – validation (%)		
					Male	Female	Male	Female	Male	Female	Total
Sella Width *	-6.872	0.615	0.916	≤.001	-0.301	0.301	63.5	39.2	63.5	39.2	51.4
Sella Depth *	-5.649	0.605	0.913	≤.001	-0.307	0.307	64.9	40.5	64.9	40.5	52.7
Sella APD *	-6.646	0.538	0.972	0.041	-0.170	0.170	52.7	48.6	52.7	48.6	50.7
Sella HA *	-3.193	0.490	0.912	≤.001	-0.308	0.308	60.8	45.9	60.8	45.9	53.4
Sella HM *	-5.925	0.651	0.845	≤.001	-0.425	0.425	73.0	36.5	73.0	36.5	54.8
Sella HP *	-5.185	0.667	0.909	≤.001	-0.315	0.315	60.8	35.1	60.8	35.1	48.0
Sella Area *	-3.819	4.784	0.890	≤.001	-0.349	0.349	70.3	44.6	68.9	44.6	56.8
ACD **	-9.733	0.389	0.953	0.008	0.221	-0.221	62.2	36.5	60.8	36.5	48.7
PCD **	-6.241	0.373	0.932	0.001	0.269	-0.269	64.9	41.9	64.9	41.9	53.4
ACPL-R **	-5.498	0.459	0.920	0.001	0.292	-0.292	55.4	36.5	55.4	36.5	46.0
ACPL-L **	-5.324	0.450	0.895	≤.001	0.340	-0.340	56.8	32.4	56.8	32.4	44.6
PCPT-R **	-4.243	0.950	0.949	0.006	0.230	-0.230	58.1	43.2	58.1	43.2	50.7
PCPT-L **	-4.146	0.941	0.963	0.019	0.194	-0.194	52.7	37.8	52.7	37.8	45.3

Sectioning point = zero
Discriminant score= constant+ (coefficient* measure)
*Female if the discriminant score more than sectioning point and male if the discriminant score less than the sectioning point
** Male If the discriminant score more than sectioning point and female if the discriminant score less than sectioning point

APD: anteroposterior diameter, HA: height anterior, HM: height median, HP: height posterior, ACD: anterior clinoid distance, PCD: posterior clinoid distance, ACPL-R: anterior clinoid process length right side, ACPL-L: anterior clinoid process length left side, PCPT-R: posterior clinoid process transverse thickness right side, PCPT-L: posterior clinoid process transverse thickness left side.

Table (5): Multivariate discriminant function analysis for sex prediction through assessment of the Sella Turcica and clinoid processes significant variables measured by using MDCT in 148 Egyptians

	Co-efficient	Wilks' Lambda	p-value	Group centroid		Original Corrected prediction rates (%)		Corrected prediction rates after cross – validation (%)		
				Male	Female	Male	Female	Male	Female	Total
Sella Width	-0.238	0.916	≤.001							
Sella Depth	-0.074	0.913	≤.001							
Sella APD	0.016	0.972	.041							
Sella HA	-0.047	0.912	≤.001							
Sella HM	-0.271	0.845	≤.001							
Sella HP	-0.056	0.909	≤.001							
Sella Area	0.687	0.890	≤.001							
ACD	0.145	0.953	0.008	0.659	-0.659	77.0%	27.0%	67.6%	37.8%	52.7%
PCD	0.021	0.932	0.001							
ACPL-R	0.130	0.920	0.001							
ACPL-L	0.117	0.895	≤.001							
PCPT-R	0.126	0.949	0.006							
PCPT-L	0.142	0.963	0.019							
Constant		-2.293								

Section point= zero

Discriminant score = -2.293 + (-0.238 × Sella width) + (-0.074× Sella Depth) +(0.016× Sella APD) + (-0.047× Sella HA) + (-0.271× Sella HM) + (-0.056× Sella HP) + (0.687× Sella Area) + (0.145×ACD) + (0.021×PCD) +(0.130×ACPL-R) + (0.117×ACPL-L) +(0.126×PCPT-R) +(0.142×PCPT-L)

Male if discriminant score is more than section point (>0) and female if discriminant score is less than section point (<0).

APD: anteroposterior diameter, HA: height anterior, HM: height median, HP: height posterior, ACD: anterior clinoid distance, PCD: posterior clinoid distance, ACPL-R: anterior clinoid process length right side, ACPL-L: anterior clinoid process length left side, PCPT-R: posterior clinoid process transverse thickness right side, PCPT-L: posterior clinoid process transverse thickness left side.

Discussion:

Sexual dimorphism of Sella Turcica measurements is still a point of controverse among different populations (Olubunmi et al., 2016; Islam at al., 2017; Turamanlar et al., 2017; Chou et al., 2021). The aim of the present study was to evaluate the sex related differences in the metric measures of Sella Turcica and its boundaries of clinoid processes among a sample of adult Egyptian population; in line with establishing sex determination statistical models specific for Egyptian population. To achieve the designed aim of the current study, three-dimension MDCT was used. Boney land marks are more consistently seen in MDCT compared to MRI (Hasan et al., 2016a). The three-dimension MDCT provides more accurate images, without magnification, distortion or superposition between right and left side, compared to the two-dimension lateral cephalometric X-ray (Islam et al., 2017; Chou et al., 2022). Taking into consideration that; Sella Turcica dimensions continue its increase parallel to pituitary gland growth until the age of 16-18 years old (Luong et al., 2016). Hence; the lower limit of the age enrolled in the current study was chosen to be 18 years old; as previously used by (Silveira et al., 2020). The upper limit of the age enrolled in the current study was chosen not to exceed 70 years old to avoid extensive bone resorption; as previously reported by (Turamanlar et al., 2017). Choi et al. (2001) and El-Sehly et al. (2018) reported that no significant age changes occur in Sella Turcica dimensions above the age of 25 year. Thus; the age categorization in the current study was not done and was not considered in development of statistical models.

Our results revealed significant sexual dimorphism in most of the measured Sella Turcica variables. In the current work; Sella width, depth, APD, HA, HM, HP and area had significant higher mean values in Egyptian females compared to Egyptian males. These findings came in harmony with other previous studies which reported sexual dimorphism of Sella Turcica. For example; similar to our results, El-Sehly et al. (2018) reported that Egyptian females had significant larger Sella width, HA and HM compared to males. In the current work and in El-Sehly et al. (2018) study; females had insignificant larger Sella length compared to males. Unlike our results and mainly due to difference in sample size, El-Sehly et al. (2018) reported larger but insignificant Sella HP and area in females compared to males. Like the current work; Brazilian females had significant larger Sella APD compared to males (Silveira et al., 2020). In partial agreement; Malaysian females had larger values of Sella length, depth, HA, HM and area compared with males showing significant difference for HA only (Hasan et al., 2016a).

The present findings came different from other studies which reported sexual dimorphism of Sella Turcica measurements but with majority of values larger in males compared to females. For example, Sella length, depth, APD and area were larger in American males compared to females with significant difference for length only (Luong et al., 2016). Turkish males had larger Sella length, width, APD, HM, HP and area than females with significant difference for length and width only (Turamanlar et al., 2017). Indian males had larger Sella length, depth, APD compared to female with significant difference for depth only (Gargi et al., 2019). Nigerian males had significantly larger Sella length and APD compared to females (Usman et al., 2020). Sella length was significantly larger in Italian males compared to females (De Donno et al., 2021).

On the other hand, in contrast to our findings and to the above-mentioned studies that reported sexual dimorphism of Sella Turcica; in Iraqi population (Hasan et al., 2016b), in Nigerian population (Olubunmi et al., 2016; Ejike et al., 2017), in Bangladeshi population (Islam at al., 2017), in Indian populations (Shaha et al., 2017), and in Turkish population (Taner et al., 2019); reported absence of sex related difference in Sella measurements.

Few previous non-Egyptian studies concerned with the effect of gender on the dimensions of the clinoid processes and the distances between them as well as SDR and SDL. Our findings came in accordance with cone beam CT (CBCT) studies of (Chou et al., 2021, 2022) on adult Taiwanese population which revealed that ACD, PCD were significantly longer in males compared to females; while ICD-R and ICD-L were insignificantly longer in males than females. In the current study and in Taiwanese population studies (Chou et al., 2021, 2022).; both SDR and SDL were longer in males compared to females, but these differences were significant in Taiwanese population and were insignificant in our results.

As regard bilateral asymmetry of SD in relation to sex, both the present work and (Chou et al., 2022) in Taiwanese population reported that SD showed no side difference in both sexes. On the other hand; ICD showed significant side difference in females only in the current work, while both Taiwanese males and females had significantly shorter ICD-R compared to ICD-L (Chou et al., 2022). The ICD is depending on the degree of interclinoid ligament ossification, as the greater the degree of ossification, the shorter the ICD. The degree of interclinoid ligament ossification varies among different populations (Chou et al., 2022).

Similar to our results and with comparable values; Turkish males had significantly longer ACD compared to females in Sabanciogullari et al. (2018) CT study and in Akay et al. (2020) CBCT study. Contradictory to our findings; Yasa, et al. (2017) reported absence of sex difference as regard ACD in CBCT study on Turkish population. Unlike our results, Sakran et al. (2015) reported that Saudi Arabians females had significant longer ICD-R and ICD-L compared to males. Meanwhile both the current study and Sakran et al. (2015) reported longer PCPL in males compared to females but this difference was insignificant. Moreover; PCPT was significantly larger in Egyptian males than females in the current work and on reviewing literature; no studies were concerned with PCPT sex related difference.

In the current work and in Turkish population (Sabanciogullari et al., 2018); the anterior clinoid bones were significantly longer in males than females and ACPBW-R showed to be insignificantly larger in males than females. Unlike our results; Turkish males had significantly larger ACPBW-L than females (Sabanciogullari et al., 2018); while as in our study; males had larger but insignificant ACPBW-L compared to females. The present results reported that; ACPBW was the only anterior clinoid process dimension that showed bilateral asymmetry in Egyptian females. In partial agreement; in Indian population; Souza et al. (2016) reported that ACPBW showed statistically significant side difference; although sex difference was not assessed. Unlike our results; Sibuor, et al. (2018) in Kenyan population; reported that no statistically significant side differences in the anterior clinoid process dimensions.

For further analysis of the current results; ROC curve was applied and the most reliable sex predicating variable was Sella HM (66.9%) followed by Sella area (65.5%). On reviewing literature; no previous studies applied ROC curve analysis for sex prediction from Sella Turcica measures. Univariate discriminant analysis could be useful in cases of fragmented bone residue as it depends on single variable (Abo El-Atta et al., 2020). On applying univariate discriminant analysis; the current results revealed that; Sella area had the highest sex prediction accuracy (56.8 %) followed by Sella HM (54.8%). Notably; the current findings showed about 10% decrease in sex prediction accuracy on applying univariate discriminant analysis compared to ROC curve. Saini et al. (2012) reported that the percentage of sex prediction accuracy changed according to the change in statistical method used for analysis. Few non-Egyptian studies applied discriminant analysis for sex prediction from Sella measures. Unlike our results; in Indian population, Sella depth attains the highest overall accuracy (56.9%) in univariate discriminant analysis followed by APD (53.9%) (Subasree and Dharman, 2019). In another Indian study; multivariate discriminant analysis, using only (Sella APD and depth) as independent variables, revealed that the overall accuracy was (58.1%) with higher sensibility in Indian females (58.5%) than Indian males (57.7%) (Kiran et al., 2017). In the current study multivariate discriminant analysis achieved over all accuracy of (52.7%) with higher sensibility in Egyptian males (67.6%) compared to

Egyptian females (37.8 %). In the current study; multivariate discriminant analysis achieved lower percentage of sex prediction accuracy compared to univariate discriminant analysis in spite of increased number of enrolled variables. Similarly; lower percentage of sex prediction had been reported on using multivariate discriminant analysis for sex prediction from mastoid process as another skull region (Kramer et al., 2018; Helmy et al., 2021). Moreover; Subasree and Dharman (2019) reported increase in sex prediction over all accuracy up to (65.7%) on adding other parameters related to maxillary sinus to the multivariate statistical models. Hence, Sella Turcica can be used as relatively good adjuvant tool in sex prediction. Taking into consideration that; equations derived from both univariate and multivariate discriminant analysis are population specific (Abo El-Atta et al., 2020). Hence; equations specific for Egyptian population were derived from discriminant models.

Finally, the differences in metric measures and accuracy of sex prediction between the current results and the other studies could be assumed to ethnic, racial variability among different populations as well as differences in the used radiological techniques and sample size (Sakran et al., 2015; Subasree and Dharman, 2019; Chou et al., 2021)

In conclusion; the present work revealed sex related differences in the metric measures of Sella Turcica and its boundaries of clinoid bone among a sample of adult Egyptians. Sella height median achieved the highest sex predicting accuracy in ROC curve analysis followed by Sella area. Sella area was the most accurate sex predicting variable in univariate discriminant analysis after cross validation with higher sensibility to males. However, the accuracy after cross validation in multivariate discriminant analysis was decreased. Data derived from the present work can still be used as relatively good adjuvant tool in sex prediction among adult Egyptians. The limitation of the present study was relatively small sample size for evaluating the morphological variants of the Sella Turcica shape and their sex related difference. Further research with larger sample size is recommended for applying the formulated equation in line with investigating the morphological variants of Sella Turcica as well as establishing statistical models using Sella Turcica as adjuvant tool in sex prediction

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Conflicts of interest:

The authors stated that the current work has no conflict of interest and did not receive any organization or financial support.

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التحليل المتري للسرج التركى لتحديد الجنس باستخدام التصوير المقطعي متعدد الكاشفات في عينة من المصريين البالغين.

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تحديد الجنس هو خطوة أولية لتحديد الهوية الشخصية. هدفت الدراسة الحالية بأثر رجعي إلى التحقق من اثنين وعشرين متغيرًا في السرج التركى وحدوده من عظام الكلينويد لتحديد الجنس بين 148 مصريًا بالغًا (٧٤ ذكرًا و ٧٤ إناثًا) باستخدام تقنية إعادة البناء ثلاثية الأبعاد للصور المقطعية متعددة الكاشفات. اظهر كل من عرض السرج التركى ، عمقه، قطره الأمامي الخلفي ، ارتفاعه الأمامي ، ارتفاعه الاوسط، وارتفاعه الخلفي ومساحته زياده ذات اهميه احصائية فى الاناث. بينما كانت المسافة الامامية والخلفية بين عظام الكلينويد وطول عظام الكلينويد الامامية وكذا السمك المستعرض لعظام الكلينويد الخلفية ذوى دلالة احصائية هامة فى الذكور .و قد اظهر كل من طول السرج التركى والمسافة بين عظام الكلينويد وقطر السرج والعرض القاعدى لعظام الكلينويد الامامية فروق احصائية غير هامة بين الجنسين .و اظهرت فقط المسافة بين عظام الكلينويد والعرض القاعدى لعظام الكلينويد الامامية فروق احصائية هامة بين الجانبين الايمن واليسر فى الاناث .هذا و قد حقق الارتفاع الاوسط للسرج التركى أعلى دقة في التنبؤ بالجنس (٦٦,٩٪) في تحليل منحنى خاصية تشغيل المستقبل (ROC) متبوعًا بالمساحة والعمق والارتفاع الخلفي وبدقة تصل إلى (٦٥,٥٪ ، ٦٤,٢٪ ، ٦٣,٥٪) على التوالي. في التحليل للتمييز أحادي المتغير بعد التحقق من الصحة كانت مساحة السرج التركى الأفضل دقة (٦٨,٩٪) و (٤٤,٦٪) و (٥٦,٨٪) للذكور والإناث والإجمالي على التوالي. و كان هناك انخفاض في دقة التنبؤ بالجنس في تطبيق تحليل التمييز متعدد المتغيرات. تم اشتقاق المعادلات من تحليل تمييزي أحادي المتغير ومتعدد المتغيرات ليتم تطبيقه على تحديد الجنس عند البالغين المصريين. و يستنتج من ذلك إزدواج الشكل الجنسي لعظام السرج التركى وعظام كلينويد في المصريين البالغين و من ثم يمكن استخدامها كأداة مساعدة لتحديد الجنس في المصريين .