Sex Discrimination from Orbital Aperture by Using Computed Tomography: Sample of Egyptian population

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KEYWORDS
Sex discrimination,
Orbital apertures,
Dimensions,
Computed tomography.

ABSTRACT

The present study was designed to measure and compare various measurements of orbital apertures between male and female subjects using digital computed tomography. Also to assess the usefulness of orbital aperture measures as an aid in sex determination in sample of Egyptian population. The study included 92 subjects (44 males and 48 females) with age ranged from 18 to 65 years. The results showed that males exhibited greater mean values for all the measurements except for left orbital width that was slightly increased in females. There were significant differences (p<0.05) between males and females regarding right orbital height, right and left area and inter zygomatic distance. The accuracy of correct sex classification was achieved up to 74.7%. Discriminant analysis revealed that inter zygomatic distances showed significant discrimination (p= 0.028) between both sexes. Receiver Operating Characteristic (ROC) curve analysis for sex discrimination demonstrated that inter zygomatic distance at a cutoff of 96.7 had sensitivity 76.7%, specificity 65% and accuracy 71% (p<0.001). In conclusion, inter zygomatic distance was found to be the best reliable parameter and achieved the highest accuracy 71%. So, it was seen that inter zygomatic distance could be used for the sex determination from computed tomography.

Introduction

The identification of human skeletal remains in forensic investigations is crucial for further analysis (Saini et al., 2011). Sex determination of the adult skeleton is an important initial step as estimation of age and stature of individual is sex dependent (Scheuer, 2002). Previous study revealed that skull was the most dimorphic and easily sexed portion of skeleton after pelvis, with accuracy up to 92% (Saini et al., 2011). Human skulls have been used to study the morphological variations of orbital aperture and also orbital bone may be used in forensic medicine as a parameter for sexual and ethnic determination in human identification (Weaver et al., 2010).

Radiographs have been used to identify unknown human remains since the early 1900s (Besana and Rogers, 2010). Metric analyses on the radiographs are often found to be of superior value due to their objectivity, accuracy and reproducibility. Computerized tomography (CT) was developed as a medical diagnostic tool; however its use within the field of forensic anthropology has since become comprehensive and significant. 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. Specimens can, therefore, be viewed as 2D, or as a stack of 3D, rendered images (Kalender, 2011).

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Several radiographic techniques are used to determine the dimensions of the craniofacial structures (Swan and Stephan, 2005). Studies involving orbital aperture morphometry have been conducted on dry skulls for sex determination (Nitek et al., 2009; Rajangam et al., 2012; Kumar and Gnanagurudasan 2015) but in Egyptian population, literatures hardly revealed any study with regard to orbital aperture measurements in Egyptian population.

The present study was designed to measure and compare various measurements of orbital apertures between male and female subjects using digital computed tomography. Also to assess the usefulness of orbital aperture measures as an aid in sex determination in samples of Egyptian population.

Subjects and Methods

Sample size and power of the study:

The highest suggested accuracy for the equation is 65%, the lowest is 50%. The decided power of the study is 80 with type I error 0.05. The estimated sample is 62. The research team decides to increase the sample by 30 percent. The sample is 92. The level of confidence is 95%, with alpha error 0.05.

Ethical Approval:

The research protocol was approved by the Ethical Committee of Faculty of Medicine, Mansoura University (proposal code: R/ 18.02.52).

Subjects:

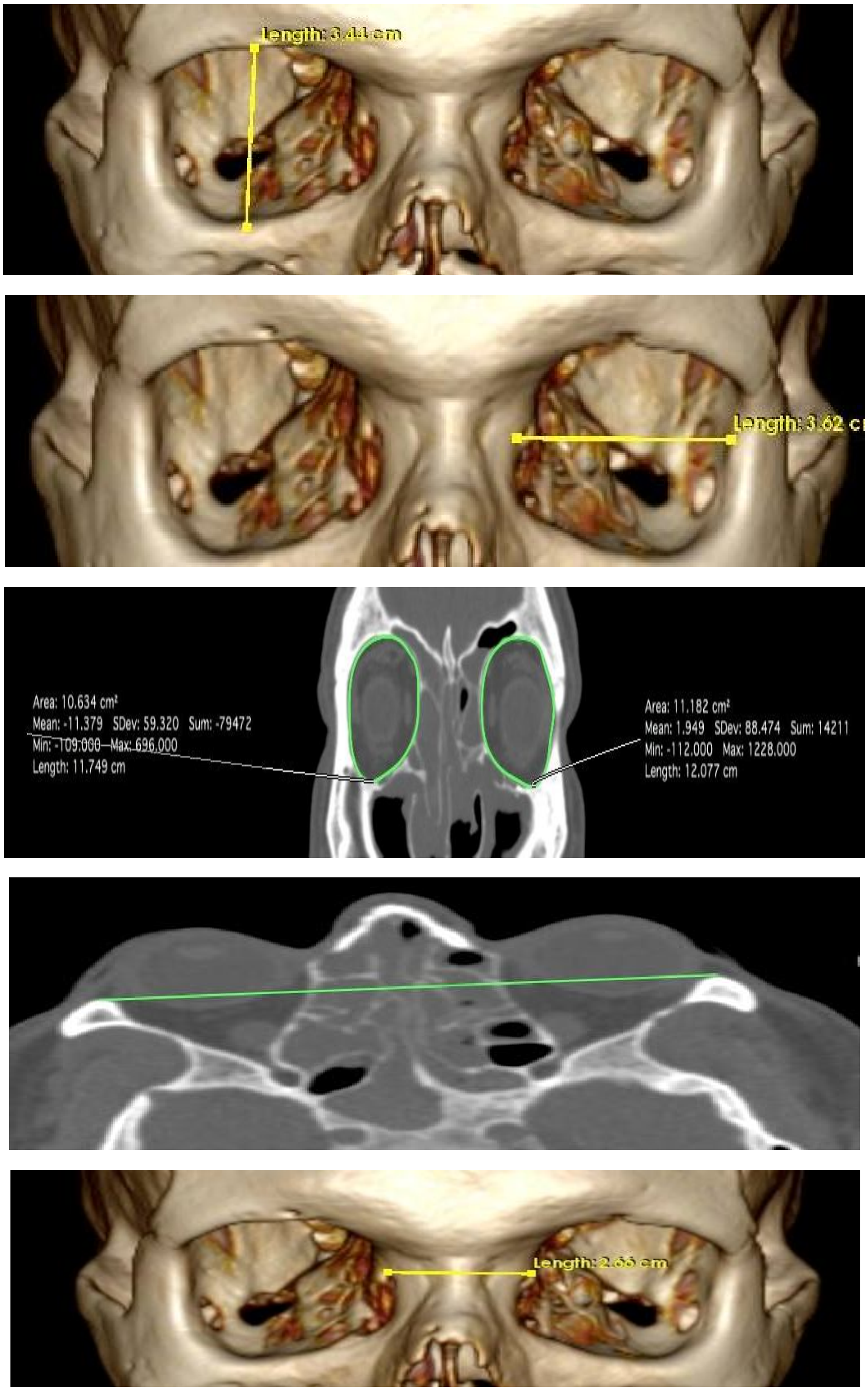
Comparative Cross Sectional study was conducted in the period from March 2016 to February 2018. The subjects were recruited from those attend to radio diagnosis out-patient clinic, Mansoura University Hospital, for the purpose of computerized tomography (CT) scanning on brain for diagnosis of the cause of headache.

The study included 92 adults subjects (44 males and 48 females) with age ranged from 18 to 65 years. The anatomic integrity of the orbits was the main inclusion criteria. Patients with head injury or orbital injuries were excluded from the study. Prior to imaging, the patient was informed about the investigation and instructed not to move or swallow during scanning.

Methods

All patients were examined using a 128 detectors scanner (Inginia, Philips, Netherland). The scanning parameters were tube voltage (120 kV), tube current (208 to 276 mAs), rotation time (1s) and slice acquisition (3 mm).

From the volumetric data, contiguous axial, coronal and volume rendering images are reconstructed at 5 mm intervals and were analyzed by using Philips extended work space release 2.6 workstation. The measured parameters were maximum height (right and left) of the orbital aperture (Figure 1 A), maximum width (right and left) of the orbital aperture (Figure 1 B), the orbit area (right and left) (Figure 1 C), inter zygomatic distance (maximum distance between the most prominent points on the right and left zygomatic arches) (Figure 1 D), inter-orbital distance (minimum distance between the medial walls of the orbits) (Figure 1 E) and orbital index (right and left) (the proportion of the orbit height to its width multiplied by 100%). All measurements were obtained from the volume rendering images except for orbit area and inter-zygomatic distance obtained from the coronal and axial images respectively. All were measured using mouse-driven method (by moving the mouse and drawing lines using chosen points on the image). All measurements were expressed in millimeters.



A

B

C

D

E

Fig. (1): The studied orbital measurements: orbital height (A), orbital width (B), orbital area (C), inter zygomatic distance (D) and inter-orbital distance (E)

Statistical Analysis

All data were subjected to descriptive and discriminate analyses using the SPSS package (version 16; SPSS Inc., Chicago, IL). All continuous data were tested for its normality and expressed as mean ± standard deviation (SD). The significant differences in all measurement between males and females, between right and left orbital sides and between the different age groups were tested by using Student t test. Then the significant parameters in sex discrimination were identified by using multivariate logistic regression test. *P*-value was considered significant at ≤ 0.05 and highly significant at ≤ 0.001. Receiver operator characteristics curve (ROC) was applied for significant parameter to get the cutoff value of the highest sensitivity and specificity in sex discrimination.

Results

The study included 92 subjects, 44 males represented (47.8%) with mean age 38.248±13.16y while 48 females represented (52.2%) with mean age 37.865±12.75y. The males presented mostly in age group 3 (between 35-44 year; 13 subjects) and the females were mostly in age group 2 (between 25-34 year; 14 subjects) (Table 1)

Table (1): Frequency of the studied male and female subjects in relation to age groups.

Sex	Age groups (years)					Total
	1 (18 -24)	2 (25-34)	3 (35-44)	4 (45-54)	5 (55-65)	
Males	9 56.2%	7 33.3%	13 56.5%	11 47.8%	4 44.4%	44 47.8%
Females	7 43.8%	14 6.7%	10 43.5%	12 52.2%	5 55.6%	48 52.2%

It is observed from table (2) that males exhibited greater mean values for most of the measurements except for the left orbital width which was slightly increased in females. There were significant differences (p<0.05) between males and females regarding right orbital height, right and left area and inter zygomatic distances.

Table (2): The descriptive data and statistical significance of all orbital measurements studied for sex discrimination

	Sex	Number n = 92 (100%)	Mean± S.D (mm)	t test	p value
Right orbital height	Males	44	37.3 ±3.2	2.141	0.035*
	Females	48	35.9± 2.8		
Left orbital height	Males	44	36.9 ±2.9	1.637	0.105
	Females	48	35.9 ±2.8		
Right orbital width	Males	44	37.2 ±4.7	0.111	0.912
	Females	48	37.1 ±3.7		
Left orbital width	Males	44	36.7 ±4.1	0.333	0.740
	Females	48	37 ±3.6		
Right orbital area	Males	44	103.8 ±14.5	2.314	0.023*
	Females	48	97.8 ±10.2		
Left orbital area	Males	44	104.7 ±11.1	3.070	0.003*
	Females	48	97.7 ±10.8		
Inter zygomatic Distance	Males	43	98.6± 4.1	2.945	0.004*
	Females	48	95.8± 4.9		
Inter orbital distance	Males	44	27.4 ±11.3	1.597	0.114
	Females	48	24.5± 4.7		
Right sided index	Males	44	101.7 ±15.1	1.512	0.134
	Females	48	97.6 ±10.9		
Left sided index	Males	44	101.4± 11.4	1.524	0.131
	Females	48	97.9 ±10.6		

n.: number, SD: standard deviation, *significance, mm: millimeter.

There is no side difference between males and females for all studied measurements (Table 3).

Table (3): Comparison between right and left sides of each measurement in males and females.

Variables (mm)	Male			Female		
	Right side	Left side	p value	Right side	Left side	p value
Orbital height	37.3 ±3.2	36.9 ±2.9	0.376	35.9± 2.8	35.9 ±2.8	0.978
Orbital width	37.2 ±4.7	36.7 ±4.1	0.166	37.1 ±3.7	37 ±3.6	0.652
Orbital area	103.8 ±14.5	104.7 ±11.1	0.592	97.8 ±10.2	97.7 ±10.8	0.919
Orbital index	101.7 ±15.1	101.4± 11.4	0.839	97.6 ±10.9	97.9 ±10.6	0.797

mm: millimeter

Comparison between males and females in the different age groups is represented in table (4). There are significant differences between males and females in age group 3 (35-44 years) as regard left width and right and left indices. Also, there is significant difference between males and females in age group 4 (45-54 years) regarding inter zygomatic distance.

Table (4): Comparison between males and females in the different age groups.

Variables		Age groups (years) 1 (18-24) Mean ± SD	2 (25-34) Mean ± SD	3 (35-44) Mean ± SD	4 (45-54) Mean ± SD	5 (55-65) Mean ± SD	p value
Rt ht	Males	35.8±2.8	37.029±2.8	38.06±3.6	37.482±3.7	37.80±1.8	p1: 0.28 p2: 0.40 p3: 0.10 p4: 0.91 p5: 0.09
	Females	34.04±3.4	36.229±1.5	35.52±3.2	37.317±3.0	35.08±2.2	
Lt ht	Males	36.46±2.5	36.64±3.5	37.03±3.6	37.28±2.2	36.45±2.1	p1: 0.12 p2: 0.27 p3: 0.44 p4: 0.83 p5: 0.82
	Females	34.21±3.1	35.28±2.1	35.96±2.6	37.51±2.9	36.08±2.5	
Rt width	Males	38.52±6.3	36.69±4.2	36.82±5.1	36.76±3.5	37.30±4.8	p1: 0.39 p2: 0.81 p3: 0.25 p4: 0.99 p5: 0.86
	Females	36.14±3.9	36.28±3.5	38.83±2.1	36.78±4.6	37.84±4.6	
Lt width	Males	37.91±5.6	35.41±2.7	35.97±4.1	36.96±2.9	37.58±5.2	p1:0. 99 p2: 0.57 **p3: 0.05*** p4: 0.37 p5: 0.85
	Females	37.94±4.8	36.20±2.9	38.85±2.1	35.61±4.1	36.98±4.1	
Rt area	Males	103.66±11.4	100.40±10.5	107.10±11.2	107.12±8.2	90.45±36.8	p1: 0.08 p2: 0.07 p3: 0.21 p4: 0.09 p5: 0.59
	Females	92.66±11.8	92.99±7.4	101.78±7.8	101.81±6.2	100.92±19.2	
Lt area	Males	103.38±10.7	98.24±9.9	105.36±12.1	108.10±11.3	108.00±9.7	p1:0.19 p2: 0.15 p3: 0.40 p4: 0.09 p5: 0.51
	Females	94.89±14.1	92.17±8.0	101.51±8.9	101.47±6.5	100.80±18.6	
IZD	Males	97.98±5.3	97.30±2.6	98.27±4.9	100.01±2.0	99.60±5.2	p1:0.26 p2: 0.11 p3: 0.82 **p4: 0.00*** p5: 0.34
	Females	92.96±11.7	95.64±1.7	97.87±3.1	95.51±2.2	96.90±2.6	
IOD	Males	24.02±4.1	24.83±4.6	26.05±6.3	26.82±2.7	45.12±33.0	p1:0. 35 p2: 0.81 p3: 0.11 p4: 0.36 p5: 0.28
	Females	22.17±3.5	25.34±4.3	22.36±3.2	25.57±3.6	27.34±8.8	
Rt index	Males	94.85±15.3	101.16±9.4	105.23±17.3	103.25±16.7	102.41±11.9	p1:0.98 p2: 0.84 **p3: 0.03*** p4: 0.92 p5: 0.21
	Females	94.69±9.4	100.69±10.1	91.59±8.4	102.68±13.1	93.38±7.5	
Lt index	Males	97.84±13.9	103.61±7.9	104.03±14.0	101.28±8.0	98.04±11.1	p1:0.33 p2:0.16 **p3:0.03*** p4: 0.22 p5: 0.98
	Females	91.14±11.7	97.95±8.4	92.82±8.5	106.20±10.5	98.14±7.8	

Rt: right. Lt: left. ht: height. IZD: inter zygomatic distance. IOD: iner orbital distance.SD: standard deviation
t1: t test between males and females in age group 1 (18-24 years). t2: t test between males and females in age group 2 (25-34 years).
t3: t test between males and females in age group 3 (35-44 years). t4: t test between males and females in age group 4 (45-54 years).
t5: t test between males and females in age group 5 (55-65 years).

In table (5), the present results reveals that the 10 orbital measurements give accuracy of correct sex up to 74.7%.

Table (5): Correct percentage for sex by using multivariate functions.

Observed		Predicted		
		Sex		Accuracy Correct %
		Male	Female	
Sex	*Males*	28	15	65.1
	Females	8	40	83.3
Overall Percentage				74.7

The multivariate discriminant analysis reveals that among the measurements that showed significant difference between males and females, inter zygomatic distance shows the significant discriminant (p= 0.028) between sexes (Table 6).

Table (6): Significant measurement in sex determination using discriminant analysis.

Variables	B	S.E.	Wald	Sig.	Exp(B)	95% confidence interval
Right orbital height	-0.124-	0.095	1.722	0.189	0.883	0.56-1.78
Right orbital area	-0.008-	0.028	0.071	0.790	0.993	0.88-4.78
Left orbital area	-0.015-	0.035	0.181	0.671	0.985	0.87-5.45
Inter zygomatic distance	-0.167-	0.076	4.831	0.028*	0.846	0.43-0.95
Constant	23.150	7.796	8.817	0.003	11.32	

SE: standared error, SIG.: significant, EXP.: expectant

Receiver Operating Characteristic (ROC) curve for sex discrimination demonstrated that the inter zygomatic distance is the best discriminant as it has sensitivity 76.7%, specificity 65% and accuracy 71% at a cutoff of 96.7 (p<0.001) (Figure 2 [A,B,C, &D]).

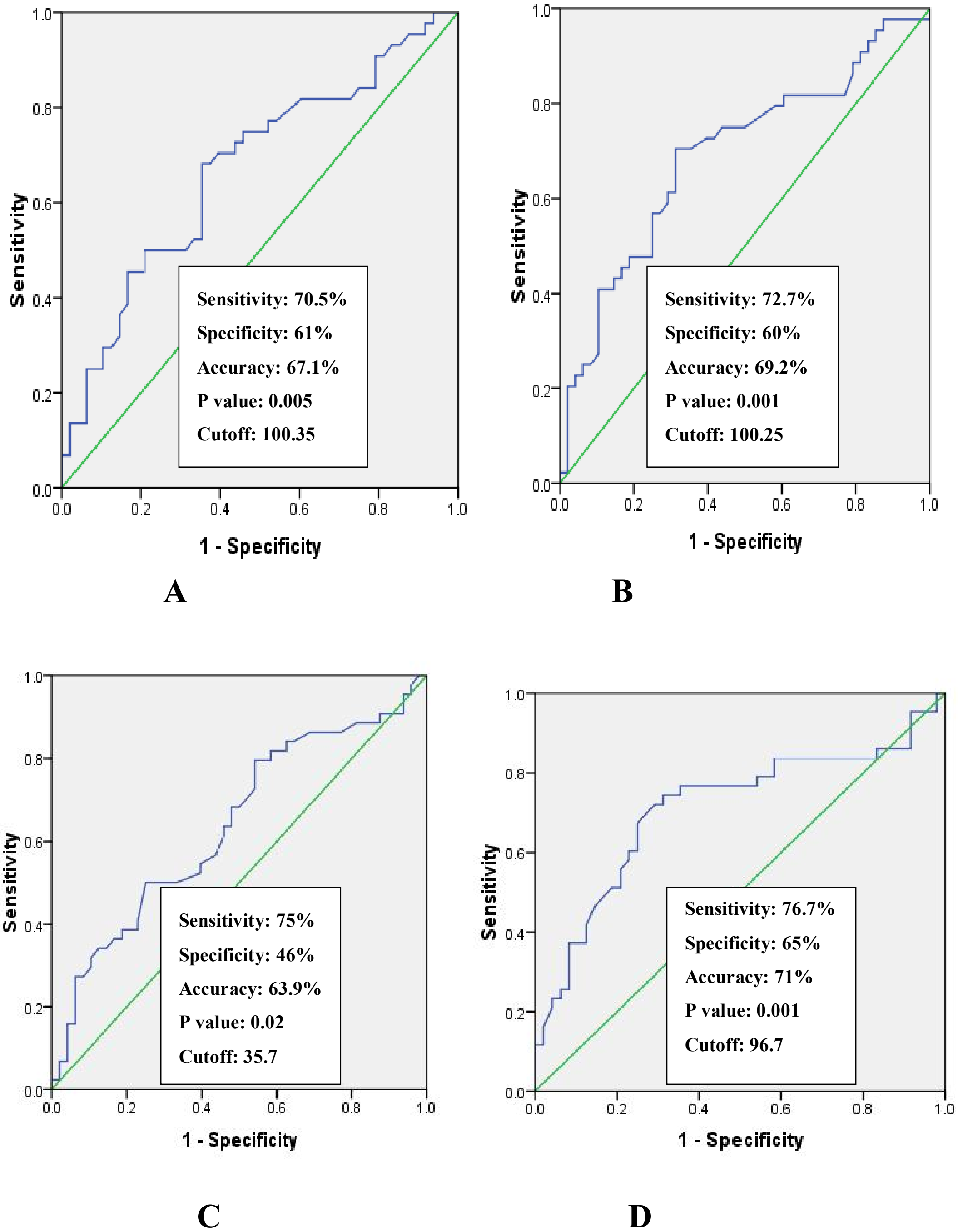


Fig. (2): ROC curve of left orbital area (A); right orbital area (B); right orbital height (C) and inter zygomatic distance (D).

Discussion

The present study was designed to measure and compare various measurements of orbital apertures between male and female subjects using digital computed tomography. Also to assess the usefulness of orbital aperture measures as an aid in sex determination in a sample of Egyptian population.

In the present study, it is observed that males exhibit greater mean values for all the measurements except for left orbital width which was slightly increased in females. There were significant differences between males and females regarding right orbital height, right and left area and inter zygomatic distances.

In accordance, Rossi et al. (2012) observed in Brazilian individuals, that orbital area in males was significantly larger than in females and the inter-orbital distance showed significant differences between sexes. But, the orbital height showed non-significant differences between sexes and between sides.

In addition, Nitek et al. (2009) evaluated that the orbital width and height were larger in males than in females in a study that included 100 Polish dry human skulls.

Moreover, Cheng et al. (2008) concluded that males had significantly larger distances than females and explained that by the large male skull sizes in the Chinese population. On the other hand, they observed non-significant differences between sexes regarding orbital height.

In accordance, Jehan et al. (2014) found that the orbit dimensions were statistically greater in males. They stated that the mean of inter zygomatic distance in male was 95.5mm and in female was 92.6mm with significance statistical difference. They stated that this is a very strong parameter which can be used for sex determination in India.

Also, Ghorai et al. (2017) demonstrated that the orbital width and the inter-orbital distance were larger in males than in females in Indian individuals with significant difference between sexes. However, the orbital height showed non-significant differences between sexes.

Moreover, in the current work, there was no statistical difference between right and left sides in either males and females for all studied measurements. Accordingly, Botwe et al. (2017) showed that there was non- significant difference between the orbital height and orbital width of both sides, indicating that the orbit has similar dimensions of both sides. This is in line with the findings of Mekala et al. (2015) and Ezeuko and Om'Iniabohs (2015). However, the findings of this study contradict that of Gopalakrishna and Kashinatha (2015).

In the present work, comparison between males and females in the different age groups showed a significant difference in age group 3 (35-44 years) as regard left width and right and left indices and there was a significant difference between males and females in age group 4 (45-54 years) regarding inter zygomatic distance.

Meanwhile, Botwe et al. (2017) suggested a variation between the orbital indices of the same age group when the two gender groups are compared. This is in line with the findings of Igbigbi and Ebite (2010) which indicated that within the same age group, female orbital indices were higher than males.

Furthermore, in the current work, identification of significant parameters in sex determination using discriminant analysis revealed that inter zygomatic distances showed the significant discrimination between both sexes with overall accuracy 74.7% and the ROC curve analysis also demonstrated the inter zygomatic distance at a cutoff of 96.7, had sensitivity 76.7% and specificity 65% in sex discrimination.

In disagreement with our results, Jain et al. (2015) who found that from univariate analysis, inter-orbital breadth was found to be the best reliable parameter and achieved the highest accuracy of 76.0%.

Meanwhile, Saini et al. (2011) also studied orbital breadth and orbital height for sex determination of crania and found that the accuracies from using both in sex discrimination were 62.5% and 48.20%, respectively.

On the other hand, Kaya et al. (2014) analyzed data regarding the computerized scans of orbital aperture measurements in Turkish population for sex discrimination. Sexual dimorphism in terms of orbital breadth and orbital height was analyzed using discriminant function analysis. From univariate analysis, highest accuracy (67.9%) was achieved from orbital breadth of left side.

In addition, Dayal et al. (2008) studied fourteen measurements on 120 skulls for the assessment of sex of the Black South Africans. Orbital breadth and orbital height were measured. Accuracy achieved were 65.80% and 53.30% respectively.

As an explanation, Weaver et al. (2010) stated that the orbit widens with age and they suggested that variation in orbital anthropometry can be partially attributed to differences in subjects’ height, age, sex, and race.

Conclusion

The present results revealed that out of 10 orbital measurements, accuracy of correct sex classification was achieved up to 74.7%. Inter zygomatic distance was found to be the best reliable parameter and achieved the highest sensitivity (76.7%), specificity (65%) and accuracy (71%).

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التمييز بين الجنسين من أبعاد فتحة حجاج العين بإستخدام الأشعة المقطعية: دراسة في عينة من المصريين

عفاف محمود عطية۱ و ماهيتاب غنيم۲ و سحر الخماري۲

من أقسام الطب الشرعي والسموم الإكلينيكية[١] والأشعة التشخيصية[٢] - كلية الطب - جامعة المنصورة

صُممت الدراسة الحالية لقياس وتقييم ومقارنة القياسات المختلفة لفتحة حجاج العين بين الذكور والإناث بإستخدام الأشعة المقطعية ، وأيضاً لتقييم مدى فائدة قياسات فتحة حجاج العين في تحديد النوع في عينة من المصريين. وشملت الدراسة ٩٢ شخصا (٤٤ ذكرا و ٤٨ أنثى) ممن تتراوح أعمارهم بين ١٨ و ٦٥ سنة. وكشفت النتائج الحالية أن الذكور أظهرت زيادة في القيم المتوسطة لجميع القياسات باستثناء عرض فتحة حجاج العين اليسري الذي أظهرت زيادة طفيفة في الإناث عن الذكور. وأظهرت المقارنة بين الذكور والإناث لكل قياس وجود فرق ذو دلالة احصائية (p < ٠,٠٥) فيما يتعلق بإرتفاع فتحة حجاج العين اليمني ومحيط الفتحة الأيمن والأيسر والمسافة بين الوجنتين. وتم تحقيق دقة تصنيف الجنس الصحيح حتى ٧٤,٧٪ من قياسات فتحة حجاج العين. وكشف التحليل التمييزي أن المسافة بين الوجنتين أظهرت وجود تمييز كبير (p= ٠,٠٢٨) بين الجنسين. وأظهر تحليل منحنى ROC للتمييز بين الجنسين أن المسافة بين الوجنتين اعطت حساسية ٧٦,٧ ٪ ، وخصوصية ٦٥ ٪ ودقة ٧١ ٪ في التمييز بين الجنسين ، وكانت المسافة بين الوجنتين أفضل قياس موثوق بها وحققت أعلى دقة ٧١ ٪ لذلك ، خلصت النتائج الي أن المسافة بين الوجنتين يمكن استخدامها لتحديد الجنس بإستخدام الأشعة المقطعية .