ORIGINAL ARTICLE

Eur. J. Anat. 18 (4): 303-315 (2014)

Morphometric analysis of the orbit in adult Egyptian skulls and its surgical relevance

Fathy A. Fetouh and Dalia Mandour

Department of Anatomy, Faculty of Medicine, Zagazig University, Egypt

SUMMARY

The present study aimed to measure the bony orbit in adult Egyptian skulls and to assess side and sex differences. 52 dry skulls (30 males and 22 females) were used. The measurements included orbital height, orbital breadth, orbital index, orbital rim perimeter, orbital opening area, orbital bony volume and the distances between the defined landmarks and the fissures and foramina in the 4 orbital walls. Also, different shapes and locations of the inferior orbital fissure were assessed. The mean orbital height was 35.57 mm in males and 35.12 mm in females. The mean orbital breadth was 43.25 mm in males and 42.37 mm in females. The mean orbital index was 82.27 in males and 82.5 in females. The mean orbital rim perimeter was 12.60 cm in males and 12.28 cm in females. The mean orbital opening area was 12.08 cm² in males and 11.71 cm² in females and the mean orbital volume was 28.75 ml in males and 25.68 ml in females. In the superior wall, the mean distances from the supraorbital foramen to the superior orbital fissure and to the optic canal were 46.23 mm and 49.64 mm respectively in males and 45.26 mm and 48.16 mm in females. In the medial wall, the mean distances from the anterior lacrimal crest to the anterior ethmoidal foramen, to the posterior ethmoidal foramen, and to the optic canal were 26.76 mm, 35.39 mm, 47.25 mm respectively in males and 26.17 mm, 35.26 mm, 46.21 mm in females. In the inferior wall, the mean distances from the inferior orbital rim above the inferior orbital foramen to the inferior orbital fissure, to the posterior margin of the inferior orbital canal, and to the optic canal were 24.62 mm, 29.16 mm, 51.76 mm respectively in males and 23.60 mm, 27.98 mm, 50.53 mm in females. In the lateral wall, the mean distances from the frontozygomatic suture to the superior orbital fissure, to the inferior orbital fissure and to the optic canal were 39.94 mm, 29.08 mm, 44.25 mm respectively in males and 39.12 mm, 27.32 mm, 43.58 mm in females. The inferior orbital fissure was located in the inferolateral quadrant of the orbit, and 5 different types were observed in which the wide type was most frequent. Statistically significant side and sex differences were found.

Key words: Morphometry – Orbit – Surgical anatomy

INTRODUCTION

The orbital cavity contains the visual apparatus (Williams et al., 1999), including the eye ball and associated muscles, vessels, nerves, lacrimal apparatus, and fascial strata. The orbit is a craniofacial structure that can be affected by a large number of congenital, traumatic, neoplastic, vascular and endocrine disorders. In these cases, the measurements of bony orbital volume (BOV) and a description of the orbital shape may have crucial clinical applications for estimating craniofacial asymmetry, the severity of the injury, and possible complications in preoperative planning and in postoperative evaluation (Ji et al., 2010). The orbit may be exposed to many surgeries, such as orbital decompression, enucleation, exenteration, optic nerve decompression and vascular ligation. To

Corresponding author: Fathy Ahmed Fetouh. Department of Anatomy, Faculty of Medicine, Zagazig University, 23 July Street, Diarb nigm city, Sharkia governorate, Egypt. Tel: 00218925677687. E-mail: fghait@yahoo.com

Submitted: 7 February, 2014. *Accepted:* 12 May, 2014.

avoid injuries to the important structures in the orbit, mainly neurovascular bundles passing through various foramina and fissures, precise knowledge of the anatomy of these openings is very important. The existing data suggest that the locations of various foramina in the orbit vary in different ancestral populations (Rontal et al., 1979; McQueen et al., 1995; Hwang and Baik, 1999; Karakas et al., 2002; Huanmanop et al., 2007). As no published data are currently available for Egyptian populations, it is necessary to study the morphometry of the orbit in these populations.

The orbital approaches in orbital surgeries may be extra-orbital surgical approaches for orbital tumors or trans-orbital surgical approaches (Matei and Stanila, 2012). Regarding the extra-orbital approaches, the cranio-orbitozygomatic approach gives an opportunity to access a wide range of pathologies involving the skull base and the hidden areas under the brain. An important anatomical landmark in these surgeries is the inferior orbital fissure into which some of the skull base osteotomies extend. The inferior orbital fissure needs to be identified (Shimizu et al., 2005). Maxillectomy is potentially complicated by injuries to the orbital contents, lacrimal apparatus, optic nerve, and ethmoidal arteries. A sound understanding of 3-dimensional anatomy of the surrounding structures is therefore essential (Fagan, 2014). Transcranial approach can be used for removal of the cranio-orbital tumors completely (Liu et al., 2012). The trans-orbital surgical approaches include: the lateral approach, which can expose the lateral compartment of the orbit; the superior approach, which provides a good access to the superior part of the orbit, and is the only route which can explore all parts of the optic nerve even the optic canal. The superolateral approach has advantages over the two preceding routes, as it gives access to the superior and lateral parts of the orbit (Hayek et al., 2006). The present study aimed to measure the bony orbit in detail in Egyptian dry adult skulls and also to study side and sex differences.

Fig. 1. Female skull.

Fig. 2. Male skull.

MATERIALS AND METHODS

Fifty-two adult dry skulls (104 orbits), 30 males and 22 females of Egyptian origin were used in this study. The skulls were obtained from the skeletal collection stored at the Department of Anatomy, Faculty of Medicine, Zagazig University, Egypt. The ages at death of the individuals were estimated using dental eruption, tooth wear (Vodanovic et al., 2011; D'incaua et al., 2012), and cranial suture closure (Meindle and Lovejoy, 1985). Table 1 shows the age distribution of the sample.

Sex was determined using standard criteria in forensic medicine, including robusticity of the supraorbital, occipital and mastoid regions (Buikstra and Ubelaker, 1994; Pickering and Bachman, 1997), and characteristics of the mid sagittal curve of the neurocranium (Bigoni et al., 2012; Figs. 1 & 2). The skulls with damage, malformations or any other pathologies were excluded.

The linear parameters were measured using a divider with two fine tip ends and then carried to a ruler. Also, a flexible wire and ruler were used for the orbital rim perimeter. The morphometric analysis of the orbit was designed for 3 categories:

A) Parameters regarding the general morphology and the shape of the orbit. Following Ji et al. (2010), 4 fixed points on the orbital opening were used:

1. Maxillofrontale point (MF): the junction between

Table 1. Age distribution of examined skulls

Age category (year)	Number of skulls	
	Males	**Females**
30-39	3	2
40-49	4	2
50-59	13	7
Above 60	10	11
Total number	30	22

Fig. 3. Measuring orbital height.

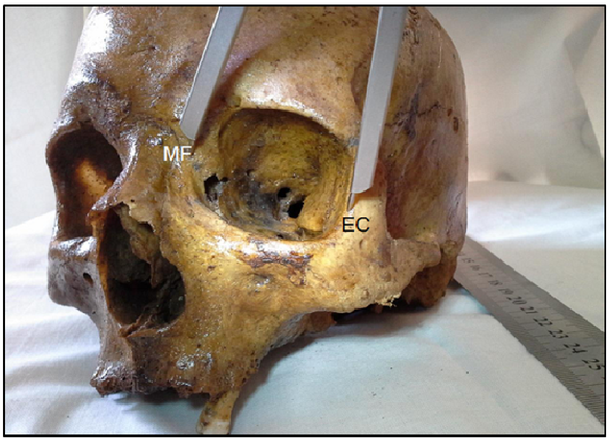

Fig. 4. Measuring orbital breadth.

the frontomaxillary suture and the medial orbital rim.

2. Ectoconchion point (EC): the junction between the lateral orbital rim and the horizontal line that divides the orbital opening into two equal parts.
3. Supraorbital point (SO): the superior junction between the superior orbital rim and the perpendicular bisector line of line MF- EC.
4. Infraorbital point (IO): the inferior junction between the inferior orbital rim and the perpendicular bisector line of line MF- EC.

The parameters studied were:

a. Orbital height: between MF-EC (Fig. 3).
b. Orbital breadth: between SO-IO (Fig. 4).
c. Orbital index (OI) = height of orbit / orbital breadth × 100.
d. Orbital rim perimeter (Fig. 5).
e. Orbital opening area = 22/7 × AB where A and B are the halves of orbital height and breadth respectively (Sarma, 2006).

f.Bony orbital volume (BOV): the water-filling method was used to assess the bony orbital volume. Briefly, three-dimensional models were made for the bony orbits. Each model was immersed in graduated cylinder filled witth distilled water. The displaced water was measured and represented the volume in ml (Acer et al., 2009), (Fig. 6).

Fig. 5. Measuring orbital rim perimeter.

B) Parameters regarding the distances between easily palpable points (landmarks) on the 4 orbital margins and the different foramina and fissures in the orbital walls. These points according to Huan-

Fig. 6. Measuring bony orbital volume by the water filling method (Acer et al., 2009).

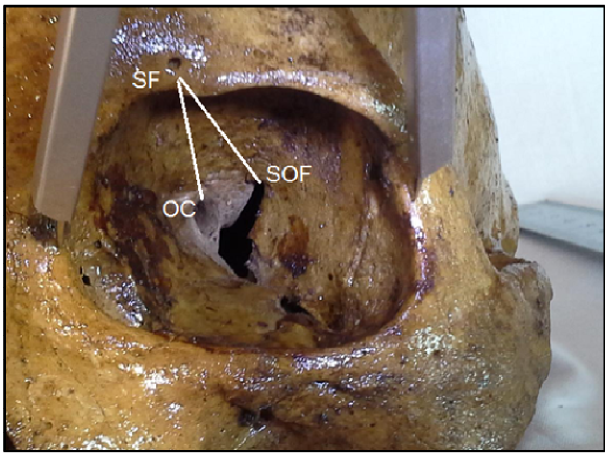

Fig. 7. Distances in the superior orbital wall.

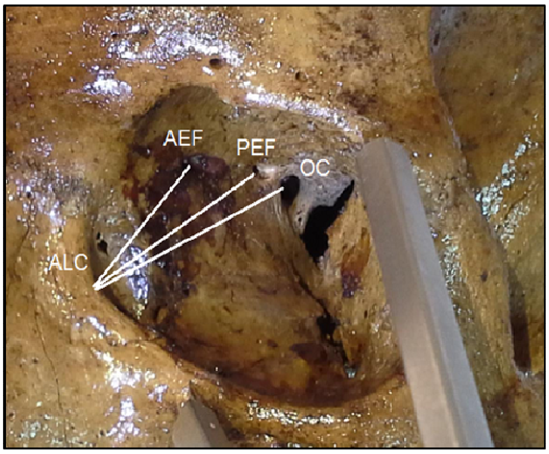

Fig. 8. Distances in the medial orbital wall.

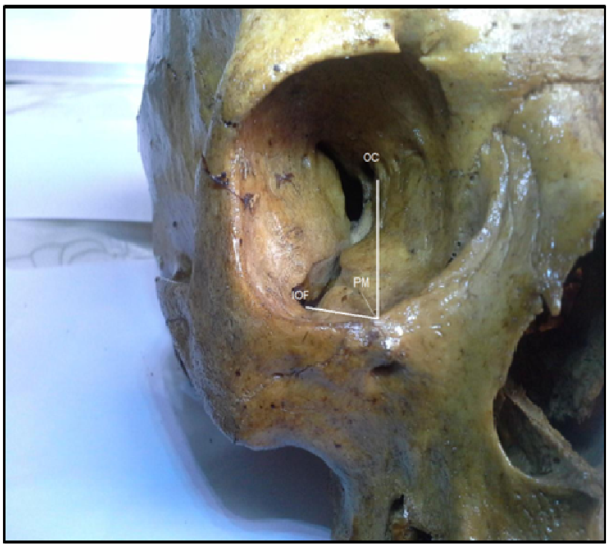

Fig. 9. Distances in the inferior orbital wall

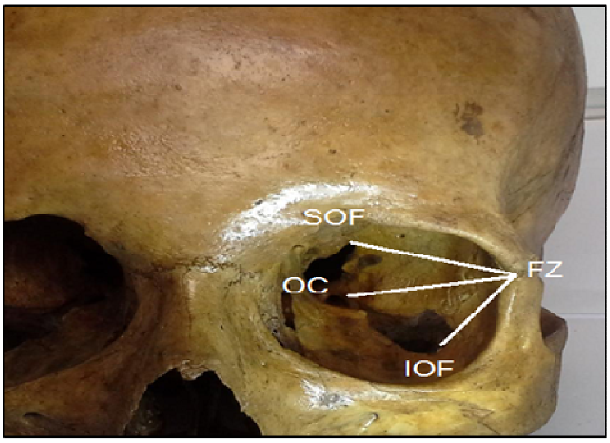

Fig. 10. Distances in the lateral orbital wall.

manop et al. (2007) are: supraorbital notch or foramen (SF), the middle of the anterior lacrimal crest (ALC), the orbital rim above the inferior orbital foramen (IF), and the fronto-zygomatic suture (FZ).

1. The measured distances in the superior wall: the distances from supraorbital foramen (SF) to the closest margin of the superior orbital fissure (SOF) and to the superior border of the optic canal (OC) were determined (Fig. 7).
2. The measured distances in the medial wall: the distances from the middle of the anterior lacrimal crest (ALC) to the anterior ethmoidal foramen (AEF), the posterior ethmoidal foramen (PEF), and to the medial border of the optic canal (OC) were determined (Fig. 8).
3. The measured distances in the inferior wall: the distances from the orbital rim above the inferior orbital foramen (IF) to the closest margin of the inferior orbital fissure (IOF), to the inferior border of the optic canal (OC) and to the posterior margin of the infraorbital canal (PM) were determined (Fig. 9).
4. The measured distances in the lateral wall: the distances from the fronto-zygomatic suture (FZ) to the closest margin of the superior orbital fissure (SOF), to the closest margin of the inferior orbital fissure (SOF) and to the lateral border of the optic canal (OC) were determined (Fig. 10).

C) Location and the shape of the inferior orbital fissure (IOF). The orbits were divided into 4 quadrants by 2 perpendicular bisecting lines into superomedial, superolateral, inferomedial, and inferolateral quadrants (Fig. 11). The precise location of the inferior orbital fissure was determined. Also the different shapes of IOF were assessed. All measurements were taken by the two researchers separately, then a comparison was made and the mean of data was obtained. All measurements were taken bilaterally and the data were compared between the male and female skulls and the right and left sides. Statistical analysis was carried out using the SPSS statistical analysis software to detect the mean, standard deviation, ranges (in right and left and total in both right and left) and the paired samples *t*-test between the right and left in both males and females. Also, sex differ-

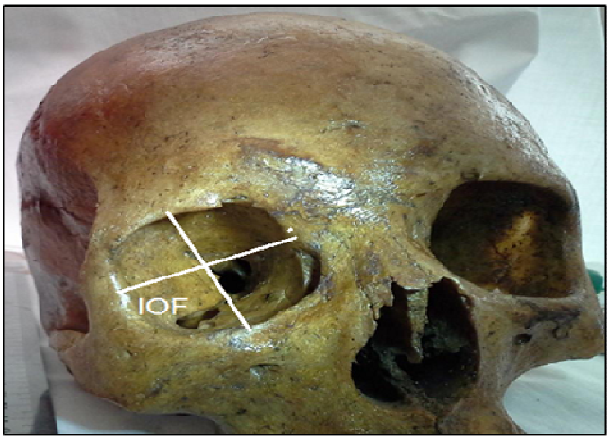

Fig. 11. The four quadrants of the orbit.

ences in the total means (in each individual and for each variable, the mean between right and left side was calculated) between the males and females for all the parameters. Differences were considered statistically significant when $p<0.05$.

RESULTS

The data measured regarding general parameters for the right and left orbits in male skulls are shown in Table 2. The mean orbital height was 35.83 mm in right and 35.27 mm in left with a total range from 32-38.5 mm in both sides. The mean orbital breadth was 43.62 mm in right and 42.60 mm in left with a total range from 40.5-45 mm. The mean orbital index was 82.20 in right and 82.81 in left with a total range from 74.41-87.65. The mean orbital rim perimeter was 12.67 cm in right and 12.54 cm in left with a total range from 12.2-13 cm. The mean orbital opening area was 12.28 cm² in right and 11.8 cm² in left with a total range 10.81-13.46 cm². The mean bony orbital volume was 29.07 ml in right and 28.15 ml in left with a total range from 26-33 ml. All the parameters were greater in the right than in the left side with statistically significant differences ($p<0.05$) except in the orbital index, where the difference was insignificant ($p>0.05$)

The data measured regarding general parameters for the right and left orbits in female skulls are shown in Table 3. The mean orbital height was 35.53 mm in right and 34.71 mm in left with a total range from 34-38 mm in both sides. The mean orbital breadth was 42.75 mm in right and 42.0 mm in left with a total range from 39-44.5 mm. The mean orbital index was 84.13 in right and 82.88 in left with a total range from 78.82-90. The mean orbital rim perimeter was 12.36 cm in right and 12.21 cm in left with a total range from 11.45-12.95 cm. The mean orbital opening area was 11.95 cm² in right and 11.47 cm² in left with a total range from 10.55-13.11 cm². The mean bony orbital volume was 26.16 ml in right and 25.21 ml in left with a total range from 24-28 ml. All the parameters were greater in the right than in the left with statistically significant difference ($p<0.05$) except in the orbital index, where the difference was insignificant ($p>0.05$).

Table 4 compares the total means (right and left) of the general parameters between males and females. The parameters of breadth, perimeter, opening area, and the volume were greater in males than females with statistically significant difference ($p<0.05$) while in height and the orbital index, the differences were insignificant ($p>0.05$).

The data regarding the measured distances between the defined landmarks and fissures and

Table 2. Mean, standard deviation and range of the parameters of general morphology in right and left male orbits and *t*-test significance between the right and left.

Parameters of the general morphology	Male (right orbits)		Male (left orbits)		Total range	*t*-test	
	Mean ±SD	Range	Mean ±SD	Range		T	P
Orbital height (mm)	35.83±1.23	33.5 -38.5	35.27±1.35	32 - 38	32 - 38.5	4.35	0.000
Orbital breadth (mm)	43.62±1.13	40.5 - 45	42.6±0.94	40.5 - 44	40.5 - 45	5.49	0.000
Orbital index	82.20±2.97	76.13-87.65	82.81±3.02	74.41-87.35	74.41-87.65	-1.4	0.173
Orbital rim perimeter (cm)	12.67±0.16	12.3 - 3	12.54±0.18	12.2 - 12.9	12.2 - 3	7.25	0.000
Orbital opening area (cm²)	12.28±0.60	11.29-13.46	11.80±0.60	10.31-12.89	10.81-13.46	4.60	0.000
Bony orbital volume (ml)	29.07±1.64	26 - 33	28.15±1.32	26 - 31	26 - 33	2.81	0.011

SD=Standard deviation

Table 3. Mean, standard deviation and range of the parameters of general morphology in right and left female orbits and t-test significance between the right and left.

Parameters of the general morphology	Female (right orbits)		Female (left orbits)		Total range	*t*-test	
	Mean ±SD	Range	Mean ±SD	Range		T	P
Orbital height (mm)	35.53±0.95	34 - 37.5	34.71±1.12	33.5 - 38	33.5 - 38	4.10	0.001
Orbital breadth (mm)	42.75±1.35	4o - 44.5	42.0±1.37	39 - 43.5	39- 44.5	4.36	0.001
Orbital index	84.13±3.76	79.31- 90	82.88±3.31	78.82-89.74	78.82- 90	1.45	0.170
Orbital rim perimeter (cm)	12.36±0.34	11.65- 12.9	12.21±0.34	11.45-12.95	11.45-12.95	5.50	0.000
Orbital opening area (cm²)	11.95±0.49	11.31-13.11	11.47±0.59	10.55-12.98	10.55-13.11	5.25	0.000
Bony orbital volume (ml)	26.16±1.23	24.5 - 28	25.21±1.03	24 - 27	24 - 28	7.72	0.000

SD=Standard deviation

Table 4. Sex differences between the total means of parameters of the general morphology of orbit and *t*- test significance between males and females.

Parameters of the general morphology	Male orbits		Female orbits		*t*-test	
	Total mean	**SD**	**Total mean**	**SD**	**T**	**P**
Orbital height (mm)	35.57	1.37	35.12	1.10	1.23	0.229
Orbital breadth (mm)	43.25	1.25	42.37	1.39	2.84	0.008
Orbital index (mm)	82.27	3.18	83.50	3.53	-1.39	0.175
Orbital rim perimeter (cm)	12.60	0.202	12.28	0.35	4.33	0.000
Orbital opening area (cm^2)	12.08	0.681	11.71	0.58	2.18	0.037
Bony orbital volume (ml)	28.75	1.57	25.68	1.21	8.06	0.000

SD=Standard deviation

Table 5. Mean, standard deviation and range of the measured distances between the landmarks and nearby foramina and fissures in right and left male orbits and *t*-test significance between right and left.

Walls of the orbit	Measured distances (mm)	Male (right orbits)		Male (left orbits)		Total range	*t*-test	
		Mean ±SD	**Range**	**Mean ±SD**	**Range**		**T**	**P**
Superior wall	SF - SOF	46.12±1.99	42 - 50	47.20±1.95	45 - 51	42 - 51	-2.70	0.014
	SF- OC	49.92±2.18	46.5 -53.5	50.55±2.53	47-53.5	46.5-53.5	-1.44	0.164
Medial wall	ALC - AEF	27.37±1.92	24 - 31	27.57±2.44	23 - 32	23 - 32	-0.59	0.560
	ALC- PEF	36.07±1.85	32 - 40	36.27±2.84	31-39.5	31 - 40	-0.42	0.676
	ALC- OC	47.82±1.80	44.5 -50.5	48.12±2.64	43 - 52	43 - 52	-0.94	0.359
Inferior wall	IF - IOF	25.05±1.72	21.5 - 28	25.52±2.35	22 - 29	21.5 - 29	-0.49	0.625
	IF - OC	51.90±1.83	48 - 55	52.35±1.68	49 - 55	48 - 55	-1.28	0.214
	IF - PM	29.47±1.68	26.5 -32.5	28.97±1.61	26 - 32	26 - 32.5	1.05	0.304
Lateral wall	FZ - SOF	40.27±2.16	37- 44	39.42±2.09	36.5-44	36.5 - 44	1.88	0.075
	FZ - IOF	29.45±1.40	27-32	28.97±2.11	25 - 33	25 - 33	1.07	0.296
	FZ - OC	45.05±1.88	42- 48	45.17±3.17	39.5-50	39.5 - 50	-0.29	0.771

SF=Supraorbital foramen, **SOF**=Supraorbital fissure, **OC**=Optic canal, **ALC**=Anterior lacrimal crest, **AEF**=Anterior ethmoidal foramen, **PEF**=Posterior ethmoidal foramen, **IF**=Orbital rim above the infraorbital foramen, **PM**=Posterior margin of roof of infraorbital canal, IOF=Inferior orbital fissure, **FZ**=Frontozygomatic suture

Table 6. Mean, standard deviation and range of the measured distances between the landmarks and nearby foramina and fissures in right and left female orbits and *t*-test significance between right and left.

Walls of the orbit	Measured distances (mm)	Female (right orbits)		Female (left orbits)		Total range	*t*-test	
		Mean ±SD	**Range**	**Mean ±SD**	**Range**		**T**	**P**
Superior wall	SF- SOF	45.10±1.63	42.5 - 48	45.42±1.92	43 - 48.5	42.5-28.5	-0.91	0.375
	SF- OC	48.10±2.61	44.5 - 52.5	48.21±2.67	45 - 52,5	44.5-52.5	-0.41	0.684
Medial wall	ALC- AEF	26.39±1.66	23 - 29.5	25.96±2.04	23 - 29	23 - 29.5	1.74	0.104
	ALC- PEF	35.71±2.20	31 - 40.5	34.82±2.56	31.5 - 39	31 - 40.5	2.09	0.056
	ALC - OC	46.17±2.63	42.5 - 51	46.25±3.22	42.5 - 51	42.5 - 51	-0.15	0.882
Inferior wall	IF - IOF	23.53±1.49	21 - 26	23.67±1.35	21.5 - 26.5	21 -26.5	-0.56	0.583
	IF - OC	50.46±1.71	48 - 53	50.60±1.84	48 - 54	48 - 54	-0.44	0.667
	IF - PM	28.14±1.26	26 - 31	27.82±1.60	25 - 31	25 - 31	1.35	0.200
Lateral wall	FZ - SOF	39.64±1.78	37 - 43	38.60±1.53	36 - 41.5	36 - 43	6.10	0.000
	FZ - IOF	27.35±1.63	25 - 30	27.28±1.87	24 - 30	24 - 30	0.32	0.752
	FZ - OC	43.46±2.76	39.5 - 48	43.71±3.53	39.5 - 49	39.5- 49	-0.90	0.382

SF=Supraorbital foramen, **SOF**=Supraorbital fissure, **OC**=Optic canal, **ALC**=Anterior lacrimal crest, **AEF**=Anterior ethmoidal foramen, **PEF**=Posterior ethmoidal foramen, **IF**=Orbital rim above the infraorbital foramen, **PM**=Posterior margin of roof of infraorbital canal, IOF=Inferior orbital fissure, **FZ**=Frontozygomatic suture

foramina of the orbit for the right and left sides in males are shown in Table 5. In the superior wall, the mean distance between SF and SOF was 46.12 mm in right and 47.20 mm in left with a total range from 42-51 mm. The mean distance between SF and OC was 49.92 mm in right and 50.55 mm in left with a total range from 46.5-53.5 mm.

In the medial wall, the mean distance between ALC and AEF was 27.37 mm in right and 27.57 mm in left with a total range from 23-32 mm. The mean distance between ALC and PEF was 36.07 mm in right and 36.27 mm in left with a range from 31-40 mm. The mean distance between ALC and OC was 47.82 mm in right and 48.12 mm in left with a total range from 43-52mm.

In the inferior wall, the mean distance between IF and IOF was 25.05 mm in right and 25.52 mm in left with a total range from 21.5-29 mm. The mean distance between IF and PM was 29.47 mm in right and 28.97 mm in left with a total range from 26-32.5 mm. The mean distance between IF and OC was 51.9 mm in right and 52.35 mm in left with a total range from 48-55 mm.

Table 7. Sex differences between the total means of the distances between the landmarks and nearby foramina and fissures and *t*-test significance between males and females.

Walls of the orbit	Measured distances (mm)	Male orbits		Female orbits		*t*-test	
		Total mean	SD	Total mean	SD	T	P
Superior wall	SF- SOF	46.23	2.04	45.26	1.75	2.31	0.029
	SF - OC	49.64	2.16	48.16	2.59	2.70	0.012
Medial wall	ALC- AEF	26.76	2.06	26.17	1.84	1.182	0.248
	ALC- PEF	35.39	2.03	35.26	2.39	0.226	0.823
	ALC- OC	47.25	2.11	46.21	2.88	1.56	0.130
Inferior wall	IF- IOF	24.62	1.71	23.60	1.40	2.80	0.009
	IF - OC	51.76	1.82	50.53	1.74	2.89	0.007
	IF - PM	29.16	1.65	27.98	1.42	3.007	0.006
Lateral wall	FZ - SOF	39.94	2.11	39.12	1.71	1.714	0.098
	FZ- IOF	29.08	1.49	27.32	1.72	4.28	0.000
	FZ - OC	44.25	2.31	43.58	3.12	0.892	0.380

SF= Supraorbital foramen, **SOF**=Supraorbital fissure, **OC**=Optic canal, **ALC**=Anterior lacrimal crest, **AEF**=Anterior ethmoidal foramen, **PEF**=Posterior ethmoidal foramen, **IF**=Orbital rim above the infraorbital foramen, **PM**=Posterior margin of roof of infraorbital canal, **IOF**=Inferior orbital fissure, **FZ**= Frontozygomatic suture

Table 8. Frequency of the different shapes of inferior orbital fissure in males and females.

Type of inferior orbital fissure	Males			Females		
	Right N (%)	Left N (%)	Total N (%)	Right N (%)	Left N (%)	Total N (%)
Type 1	23 (76.6%)	21(70%)	44 (73.3%)	18 (81.8 %)	17(77.2%)	35 (79.5%)
Type 2	2 (6.6%)	3 (10%)	5 (8.4%)	1 (4.5%)	1 (4.5%)	2 (4.5%)
Type 3	2 (6.6%)	3 (10%)	5 (8.4%)	1 (4.5%)	2 (9%)	3 (6.8%)
Type 4	2 (6.6%)	2 (6.6%)	4 (6.6%)	1 (4.5%)	1 (4.5%)	2 (4.5%)
Type 5	1 (3.3)	1 (3.3)	2 (3.3%)	1 (4.5%)	1 (4.5%)	2 (4.5%)

In the lateral wall, the mean distance between FZ and SOF was 40.27 mm in the right and 39.42 mm in left with a total range from 36.4-44 mm. The mean distance between FZ and IOF was 29.45 mm in the right and 28.97 mm in the left with a total range from 25-33 mm. The mean distance between FZ and OC was 45.05 mm in right and 45.17 mm in left with a total range from 39.5-50 mm. There were no significant differences in measured parameters between the right and left (p>0.05) except the SF-SOF distance where the difference was statistically significant (p<0.05).

The data regarding the measured distances between the defined landmarks and fissures and foramina of the orbit for the right and left sides in females are shown in Table 6. In the superior wall, the mean distance between SF and SOF was 45.10 mm in right and 45.42 mm in left with a total range from 42.5-48.5 mm. The mean distance between SF and OC was 48.10 mm in right and 48.21 mm in left with a total range from 44.5-52.5 mm.

In the medial wall, the mean distance between ALC and AEF was 26.39 mm in right and 25.96 mm in left with a total range of 23-29.5 mm. The mean distance between ALC and PEF was 35.71 mm in right and 34.82 mm in left with a range from 31-40.5 mm. The mean distance between ALC and OC was 46.17 mm in right and 46.25 mm in left with a total range from 42.5-51 mm.

In the inferior wall, the mean distance between IF and IOF was 23.53 mm in right and 23.67 mm in left with a total range from 21-26.5 mm. The mean distance between IF and PM was 28.14 mm in right and 27.82 mm in left with a total range from 25-31 mm. The mean distance between IF and OC was 50.46 mm in right and 50.60 mm in left with a total range from 48-54 mm.

In the lateral wall, the mean distance between FZ and SOF was 39.64 mm in the right and 38.60 mm in left with a total range from 36-43 mm. The mean distance between FZ and IOF was 27.35 mm in right and 27.28 mm in left with a total range from 25-30 mm. The mean distance between FZ and OC was 43.46 mm in right and 43.71 mm in left with a total range from 39.5-49 mm. There were no significant differences between the right and left measured parameters (p>0.05) except the FZ-SOF distance, where the difference was statistically significant (p<0.05).

Table 7 compares the total means of the measured distances between males and females. The total means of the measured distances were greater in males than that of female but the differences were statistically significant (p<0.05) only in the measured distances of the superior wall, the inferior wall and FZ-IOF distance in the lateral wall.

Regarding the shape of the inferior orbital fissure, 5 different types were observed in both males and females. These types can be described as follows: type 1 appeared the widest with a concave lateral border, type 2 appeared as narrow slit, type 3 appeared as rectangular, type 4 appeared as triangular, type 5 appeared as V

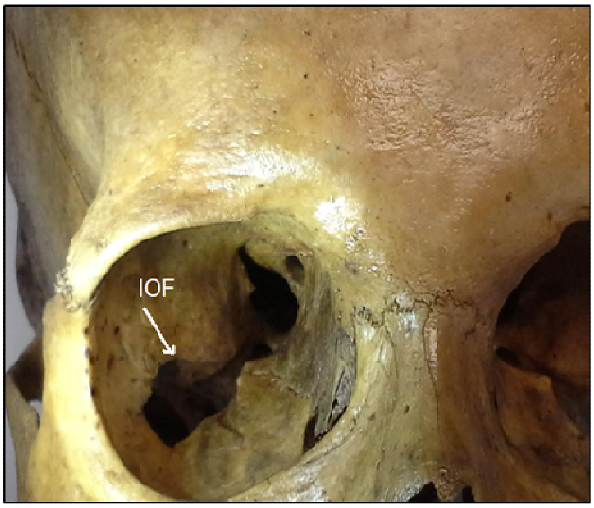

Fig. 12. Type 1 inferior orbital fissure.

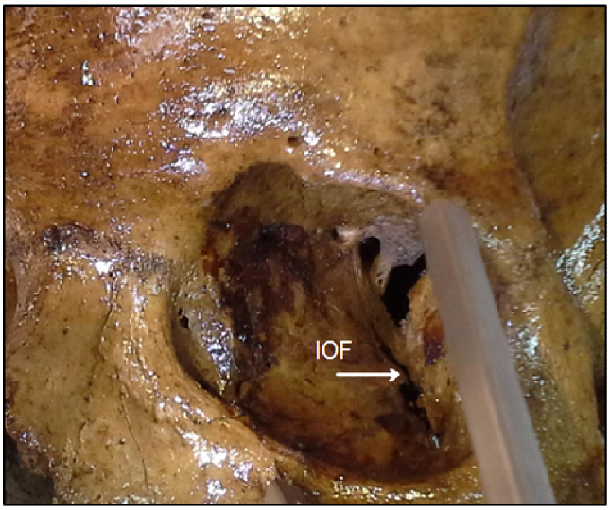

Fig. 13. Type 2 inferior orbital fissure.

Fig. 14. Type 3 inferior orbital fissure.

Fig. 15. Type 4 inferior orbital fissure.

Fig. 16. Type 5 inferior orbital fissure.

shaped (Figs. 12-16). Type 1 is the most frequent in males and females as shown in Table 8. The location of the inferior orbital fissure was in the inferolateral compartment in all male and female skulls examined.

DISCUSSION

Table 9 compares the measured distances in the 4 orbital walls with that of other populations. The total mean of measured height of the orbit was 35.57 mm in males and 35.12 mm in females. These values are greater than that measured by Ukoha et al. (2011) in Nigerian (31.9 mm in males and 31.45 mm in females), and by Ji et al. (2010) in Chinese (33.35 mm in males and 33.22 mm in females). The total mean of the orbital breadth in the present study was 43.25 mm in males and 42.37 mm in females. These values were also greater than that measured by Ukoha et al. (2011) in Nigerian (36.03 mm in males and 34.98 mm in females), and that measured by Ji et al. (2010) in Chinese (40.02 mm in males and 38 mm in females). The orbital index gives an idea about the shape of the orbit. In the present study, the mean orbital index was 82.27 in males and 83.5 in females. These values were less than that measured by Igbigbi and Ebite (2010) in Malawian skulls (94.35 in males and 96.03 in females), and by

Table 9. Comparison of the orbital distances between different nations.

Measured distances	Rontal et al. (1979)	McQueen et al. (1995)	Hwang et al. (1999)	Karakas et al. (2002)	Abed et al. (2011)	Abed et al. (2012)	Huan-manop et al. (2007)	Manguti et al. (2012)		Present study	
								Kenyan		Egyptian	
	Indian	USA	Kore-an	Male Turkish	Cauca-sian	British Cauca-sian	Thai	Male	Female	Male	Female
SF - SOF	40	44.34	40				40			46.23	45.26
SF - OC	45	48.65	44.9	45.3			44.7	53.25	51.93	49.64	48.16
ALC- AEF	24	21.96	21	23.9		25.61	23.5			26.76	26.17
ALC- PEF	36	33.36	31.7	35.6		36.09	36			35.39	35.26
ALC- OC	42	43.29	40.5	41.7		43.77	42.2			47.25	46.21
IF - IOF	24	37.43	21.6		25.4		21.7	23.56	22.28	24.62	23.6
IF - OC	48	49.73	45.5		43.23		46.2	55.18	53.63	51.76	50.53
IF - PM	14	17.08					12.3			29.16	27.98
FZ - SOF	35	36.59	34.3				34.5			39.94	39.12
FZ - IOF	25	40.92	24.8				24			29.08	27.32
FZ - OC	43	47.10	47.4	44.9			46.9			44.25	43.58

Ukoha et al. (2011) in Nigerian (89.21). The orbital index in the present study was near to that measured by Jeremiah et al. (2013) in Kenyan (82.57 in males and 83.48 in females). Using the orbital index according to Tripathi and Webb (2007), three classes of orbits are recognized: megaseme (OI > 89), mesoseme (OI between 89 and 83) and microseme (OI ≤ 83). In the present study, the orbits were mostly found in the microseme category. Microseme orbits were recorded in Kenyan population (Jeremiah et al., 2013), megaseme type in Nigerian and Malawian (Ukoha et al., 2011; Igbigbi and Ebite, 2010), and mesoseme orbits in Caucasians (Tripathi and Webb, 2007). The orbital rim, as the margin of the orbital opening is a superficial structure that determines the orbitofacial appearance (Ji et al., 2010). In the present study, the orbital rim perimeter was 12.6 cm in males and 12.28 cm in females and these values are approximate to that measured by Ji et al. (2010) in Chinese (12.08 cm in males and 12.20 cm in females). The total mean of the orbital area in the present study was 12.08 cm² in males and 11.71 cm² in females. These values are approximate to that found in Chinese (11.8 cm² in males and 11.10 cm² in females; Ji et al., 2010). The bony orbital volume (BOV) is a common parameter used to estimate the orbital changes or abnormalities (Ji et al., 2010). In the present study, the total mean of BOV was 28.75 ml in males and 25.68 ml in females. These values are approximate to that measured by Deveci et al. (2000) and Regensburg et al. (2008) in Caucasian (28.41 ml and 25.17 ml respectively), but greater than that measured in Hongkong Chinese (22.2 ml in males and 19.81 ml in females) (Chau et al., 2004), in Chinese (26.02 ml in males and 23.32 ml in females) (Ji et al., 2010), in Korean (23.94 ml) (Ye et al., 2006), in Japanese (23.6 ml in males and 20.9 ml in females) (Furuta, 2001), and in Turkish (17.8ml) (Acer et al., 2009). All these variations in the BOV reflect ethnic factors and different measurement methods. Orbital volume measurement may help the surgeon to predict the volume to be restored and to avoid probable complications (Deveci et al., 2000). These parameters of the present study were greater in the right side than in the left in both males and females with significant differences, except the orbital index, which was insignificant. This is in accordance with Seiji et al. (2009), who observed skull asymmetry in dry skulls in the 4 parameters (height, breadth, perimeter and orbital opening area) and assumed that this asymmetry is a normal anatomical pattern. On the other hand, Forbes et al. (1985) reported minimal difference in orbital volume between the right and left. The difference between the right and left may be attributed to the differential growth of the two sides of the brain and in this case the right side has shown dominance (Teul et al., 2002). Other important factors include customs prevalent in a given population which may significantly change the morphology of the skeleton. For the skull, the practice of using a pillow or any other object to support the head while sleeping is also important (Teul et al., 2002; Rossi et al., 2003). In the present study the values of the measured parameters were greater in males than in females, which were statistically significant in breadth, perimeter, area and volume, while insignificant in height and index. This is in agreement with Ji et al. (2010), who found that the average measured values in Chinese male are greater than those of female for all parameters, especially the volume, perimeter, breadth and there is no significant difference in height.

In the superior orbital wall, the superior orbital approach is involved in several procedures, including orbital decompression, exploration for fracture, and excision of cranio-orbital tumours (Hayek et al., 2006; Goldberg et al., 2000). The mean measured distances from SF to SOF and to OC were 46.23 mm and 49.64 mm respectively in males and 45.26 mm and 48.64 mm respectively in females. These are approximate to those found by McQueen et al. (1995) in U.S. (44.34 mm and 48.65) and greater than those found in Indian (40 mm and 45 mm; Rontal et al., 1979), in Korean (40 mm and 44.9 mm; Hwang and Baik, 1999), in Turkish (45.3 mm for SF– OC distance; Karakas el al., 2002), and in Thai (40 mm and 44.7 mm; Huanmanop et al., 2007), but less than measured in Kenyan for SF–OC distance (53.25 mm in males and 51.93 mm in females; Munguti et al., 2012). The SF–OC distance represents the superior orbital depth, and in the present study posterior dissection may be extended up to 49 mm. Also, the wide total range from 46.5-53.5 mm in male and 44.5-52.5 mm in females for SF-OC distance should be considered in the transcranial approach which targets the intraorbital lesions through the roof of the orbit and ideally suited for apical lesions and superior orbital fissure lesions. The amount of bone removal depends on the location of the lesion (Bejjani et al., 2001). Also, Cockerham et al. (2001) described the sub-brow approach in superior orbitomy for superior orbital lesions and mentioned that a horizontal extension should be generous (at least 3 cm). So, the amount of bone removal or the extension needed can be guided by the measured distances in the present study (SF-SOF and SF-OC distances). No significant side differences were detected except in SF-SOF distance in males. On the other hand, statistically significant differences were detected between males and females which may be due to the larger glabello-maximal length of the male cranium relative to that of females (Oladipo et al., 2009). This is in agreement with Hwang et al. (1999) who reported significant sex differences. During superior orbital approaches, it should be noted that female structures are closer than males.

Regarding the medial wall of the orbit, the medial orbital approach is involved in several procedures, including ethmoidal vessel ligation, orbital decompression and exploration for fractures (Takahashi et al., 2013; Asamura et al., 2009). The mean measured distances between ALC to AEF, ALC to PEF, and ALC to OC were 26.76 mm, 35.39 mm, and 47.25 mm respectively in males and 26.17 mm, 35.26 mm, and 46.21 mm, respectively, in females. As shown in Table 9, the distances from ALC to AEF are approximately equal to those measured in British Caucasian individuals (25.61 mm), and greater than those measured in Indian (24 mm), U.S. (21.96 mm), Korean (21 mm), Turkish (23.9 mm) and Thai (23.5 mm). The distances from ALC to PEF are approximate to those measured in British Caucasian (36.09 mm), Thai (36 mm), Turkish (35.6 mm) and Indian individuals (36 mm), but greater than those measured in U.S. (33.36 mm) and Korean (31.7 mm). The distances from ALC to OC are greater than that of other population group (Table 9) which may permit for more wide dissection with attention to its wide range (43-52 mm in males and 42.5-51 mm in females). This helps in more generous extension in the medial orbitomy which is effective in the management of medial orbital tumors, such as cavernous hemangiomas, schwannomas, and isolated neurofibromas (Cockerham et al., 2001). Also, in transnasal endoscopic orbital decompression, the entire medial orbital wall and the medial portion of the orbital floor is removed (Metson and Pletcher, 2006)). There were no significant differences found between the right and left or between males and females.

In the inferior orbital wall, the inferior orbital approach is involved in several procedures, including exploration for fracture, decompression, and maxillectomy (Kwon et al., 2008; Takahashi et al., 2013; Fagan, 2014). The mean measured distances of IF to IOF, IF to PM, and IF to OC were 24.62 mm, 29.16 mm and 51.67 mm, respectively, in males, and 23.6 mm, 27.98 mm, and 50.53 mm, respectively, in females. The values of IF-IOF distance are comparable to those found in Caucasian (25.4 mm), Kenyan (23.65 mm in males and 22.28 mm in females) and Indian individuals (24 mm) but greater than those found in Korean (21.6 mm) and Thai (21.7 mm). On the other hand McQueen et al. (1995) in U.S. individuals observed much higher value (37.43 mm). These variations should be noted in dealing with the neurovascular bundle of IOF in subciliary and subtarsal approaches in inferior orbitomy to reach the orbital floor and orbital rim (Bahr et al., 1992) and in the endoscopic transnasal repair of orbital floor fractures (Ducic and Verret, 2009). The distance from IF to PM measures the length of the roof plate covering the anterior part of the infra-orbital groove to form the infra-orbital canal, which contains the infra-orbital nerve and vessels. The values of the present study were greater than those measured in Indian (14 mm), in U.S. (17.08 mm), Thai (12.3 mm) and Polish individuals (14.23 mm in right and 13.71 mm in left; Przygocka et al., 2013). The distance from IF to OC was approximate to that measured in U.S. individuals (49.73 mm), but greater than that measured in Indian (48 mm), Korean (45.5 mm), British Caucasian (43.23mm) and Thai (46.2 mm), and less than that measured in Kenyan (55.18 mm in males and 53.63 mm in females). Thus, the Egyptian individuals can be considered to have deeper inferior orbital walls compared to Thai, Caucasian, Korean, and Indian populations, but shallower inferior orbital walls compared to Kenyans. This could be attributed to the lower cranial index recorded among Africans due to their larger glabello-maximal length relative to the cranial vault height (Oladipo et al., 2009). These variations in the depth of inferior orbital wall should be considered in endoscopic sinus surgery to reach the orbital apex transnasally for tissue biopsy or decompression of the orbit or optic nerve (Al-Mujaini et al., 2009). Statistically significant differences were observed between males and females.

In the lateral orbital wall, the lateral surgical approach involves several procedures, including exploration for fractures, decompression, excision of the lacrimal gland, and orbitozygomtic craniotomy (Shimizu et al., 2005; Takahashi et al., 2013; Lee et al., 2013; Fagan, 2014). The mean measured distances from FZ to SOF, FZ to IOF, and FZ to OC were 39.94 mm, 29.08 mm, 44.25 mm, respectively, in males, and 39.12 mm, 27.32 mm, 43.58 mm, respectively, in females. The values of FZ–SOF distance as shown in Table 9 are greater than those measured in Indian (35 mm), in U.S. (36.59 mm), Korean (34.3 mm), and Thai individuals (34.3 mm). Also, the distance from FZ-IOF is greater than that measured in Indian (25 mm), Korean (24.8 mm) and Thai individuals (24 mm) but less than that of U.S. (40.92 mm). Surgeons should be aware of these population variations when conducting lateral surgical approach. The lateral surgical approach provides enough exposure to remove lesions completely without major complications. The extent of bone removal considers the distances to superior orbital fissure superiorly and inferior orbital fissure inferiorly (Kaptanoğlu et al., 2002). The distance from FZ-OC is comparable in the Egyptian individuals to that of Indian (43 mm) and Turkish (44.9 mm), but less than that measured in U.S. (47.1 mm), Korean (47.4 mm) and Thai (46.9 mm). Knowing these variations in FZ-OC distance helps in lateral orbitomy in retrobulbar lesions and more posterior lesions. The exposure can be extended posteriorly all the way to the orbital apex (Arai et al., 1996). Statistically significant differences were observed between the right and left sides in FZ-SOF distance in females. Also, statistically significant sex differences were observed in FZ-IOF distance. This is in agreement with Huanmanop et al. (2007) who found significant sex difference in FZ-IOF distance in Thai individuals.

Regarding the shape and location of the IOF, it was located inferolaterally in all specimens examined in both males and females. This is in agreement with Ozer et al. (2009), who found that the IOF is most frequently situated in the inferior quadrant and surgical access is easier when IOF is in the inferolateral quadrant. When the lateral aspect of the IOF is found, dissection can then proceed either superomedially or inferomedially to allow a detailed inspection of the orbital contents. In the present study, the IOF showed 5 different types. Type 1 (widest, with a concave lateral border) was the most frequent in both male and females. Types 2 through 5 were seen less frequently. This is in agreement with Ozer et al. (2009), who recorded 6 types of IOF, from which the widest type is the most frequent. These authors found that removal of the lateral wall of the orbit should be started inferiorly just lateral to the IOF and then extended superolaterally as the anterolateral end of the IOF was usually wider.

Conclusion: It can be concluded that the general morphometric parameters and the distances measured in the orbit of the Egyptian skulls examined showed values which differed when compared with other population groups. Also, side and sex differences have been confirmed. These findings can be considered as a guide for the orbital surgeon in Egypt, to aid in planning operations and minimizing complications.

REFERENCES

ABED SF, SHEN S, ADDS P, UDDIN JM (2011) Morphometric and geometric anatomy of the Caucasian orbital floor. *Orbit*, 30: 214-220. doi: 10.3109/01676830.2010.539768.

ABED SF, SHAMS P, SHEN S, ADDS PJ, UDDIN JM (2012) A cadaveric study of ethmoidal foramina variation and its surgical significance in Caucasians. *Brit J Ophthalmol*, 96: 118-121.

ACER N, SAHIN B, ERGUR H, BASALOQLU H, CERI NG (2009) Stereological estimation of the orbital volume: a criterion standard study. *J Craniofac Surg*, 20: 921-925. doi: 10.1097/SCS.0b013e3181a1686d.

AL-MUJAINI A, WALI U, ALKHABORI M (2009) Functional endoscopic sinus surgery: indications and complications in the ophthalmic field. *OMJ*, 24: 70-80. doi:10.5001/omj.2009.18.

ARAI H, SATO K, KATSUTA T, RHOTON AL Jr (1996) Lateral approach to intraorbital lesions: anatomic and surgical considerations. *Neurosurgery*, 39: 1157-1162.

ASAMURA S, MATSUNAGA K, MOCHIZUKI Y, WADA Y (2009) Surgical approach to medial wall fracture of the orbit by osteotomy. *Acta Med Kinki Univ*, 34: 35-39.

BAHR W, BAGAMBISA FB, SCHLEGEL G, SCHILLI W (1992) Comparison of transcutaneous incisions used for exposure of the infraorbital rim and orbital floor. A reconstructive study. *Plast Reconstr Surg*, 90: 585-591.

BEJJANI GK, COCKERHAM KP, KENNERDELL JS, MAROON JC (2001) A reappraisal of surgery for orbital tumors. part 1: extraorbital approaches. *Neurosurg Focus*, 10: E2.

BIGONI L, VELEMINSKA J, BRUZEK J (2012) Three-dimensional geometric morphometric analysis of craniofacial sexual dimorphism in a central European sample of known sex. *Homo-Journal of Compar Hum Biol*, 61: 16-32.

BUIKSTRA JE, UBELAKER DH (eds) (1994) Standards for data collection from human skeletal remains, proceeding of a seminar at the field museum of natural history, Fayetteville AR: Arkansas Archaeological Survey Research Series no. 44.

CHAU A, FUNG K, YIP L, YAP M (2004) Orbital development in Hong Kong Chinese subjects. *Ophthalmic Physiol Opt*, 24: 436-439.

COCKERHAM KP, BEJJANI GK, KENNERDELL JS, MAROON JC (2001) Surgery for orbital tumors. Part II: transorbital approaches. *Neurosurg Focus*, 10: 1-6.

DEVECI M, OZTURK S, SENGEZER M, PABUSCU Y (2000) Comparison of pre- and postoperative orbital volume using three dimensional CT imaging in zygomatic fracture patients. *Eur Plast Surg*, 23: 432-437.

D'INCAUA E, COUTURE C, MAUREILLE B (2012) Human tooth wear in the past and the present: Tribological mechanisms, scoring systems, dental and skeletal compensations. *Arch Oral Biol*, 57: 214-229.

DUCIC Y, VERRET DJ (2009) Endoscopic transantral repair of orbital floor fractures. *Otolaryngol Head Neck Surg*, 140: 849-854. doi: 10.1016/j.otohns.2009.03.004.

FAGAN J (2014) The open access Atlas of Otolaryngology, Head and Neck Operative Surgery. Chapter of medial maxillectomy by Johan Fagan (Editor).

FORBES G, GEHRING DG, GORMAN CA, BRENNAN MD, JACKSON IT (1985) Volume measurements of normal orbital structure by computed tomographic analysis. *Am J Roentgenol*, 145: 149-154.

FURUTA M (2001) Measurements of orbital volume by computed tomography: especially on the growth of the orbit. *Jpn J Ophthalmol*, 45: 600-606.

GOLDBERG RA, PERRY JD, HORTALEZA V, TONG JT (2000) Strabismus after balanced medical decompression for dysthyroid orbitopathy. *Ophthal Plast Reconstr Surg*, 16: 271-277.

HAYEK G, MERCIER PH, FOURNIER HD (2006) Anatomy of the orbit and its surgical approach. In: Advances and Technical Standards in Neurosurgery. Springer, Vienna publisher, pp 35-71.

HUANMANOP T, AGTHONG S, CHENTANEZ V (2007) Surgical anatomy of fissures and foramina in the orbits of Thai adults. *J Med Assoc Thai*, 90: 2383-2391.

HWANG K, BAIK SH (1999) Surgical anatomy of the orbit of Korean adults. *J Craniofac Surg*, 10: 129-134.

IGBIGBI PS, EBITE LE (2010) Orbital index of adult Malawians. *Anil Aggrawal's Internet J Forensic Med Toxicol*, 11(1).

JEREMIAH M, PAMELA M, FAWZIA B (2013) Sex differences in the cranial and orbital indices for a black Kenyan population. *Int J Med Med Sci*, 5: 81-84.

JI Y, QIAN Z, DONG Y, ZHOU H, FAN X (2010) Quantitative morphometry of the orbit in Chinese adult based on a three- dimensional reconstruction method. *J Anat*, 217: 501-506.

KAPTANOĞLU E, SOLAROĞLU I, OKUTAN Ö, BESKONAKLI E (2002) Lateral orbital approach to intraorbital lesions. *J Ankara Med School*, 24: 177-182.

KARAKAS P, BOZKIR MG, OGUZ O (2002) Morphometric measurements from various reference points in the orbit of male Caucasians. *Surg Radiol Anat*, 24: 358-362.

KWON JH, KIM JG, MOON JH, HWAN J (2008) Clinical analysis of surgical approaches for orbital floor fractures. *Arch Facial Plast Surg*, 10: 21-24.

LEE J, TAHIRI Y, RAY AA, LESSARD L (2013) Delayed repair of lateral orbital wall and orbital floor fracture. *J Craniofacial Surg*, 24: 34-37.

LIU Y, MA JR, XU XL (2012) Transcranial through pterional approach for removal of cranio-orbital tumours by an interdisciplinary team of neurosurgeons and ophthalmologists. *Int J Ophthalmol*, 5: 212 -216.

MATEI C, STANILA A (2012) The surgical treatment of orbital tumours. *Acta Medica Transilvanica*, 2: 169-170.

MCQUEEN CT, DIRUGGIERO DC, CAMPBELL JP, SHOCKLEY WW (1995) Orbital osteology: a study of the surgical landmarks. *Laryngoscope*, 105: 783-788.

MEINDL RS, LOVEJOY CO (1985) Ectocranial suture closure: a revised method for the determination of skeletal age at death based on the lateral-anterior sutures. *AJPA*, 68: 57-66.

METSON R, PLETCHER SD (2006) Endoscopic orbital and optic nerve decompression. *Otolaryngol Clin N Am*, 39: 551-561.

MUNGUTI J, MANDELA P, BUTT F (2012) Referencing orbital measures for surgical and cosmetic procedures. *Anat J Africa*, 1: 40-45.

OLADIPO GS, OLOTU JE, SULEIMAN Y (2009) Anthropometric studies of cephalic indices of the Ogonis Nigeria. *Asian J Med Sci*, 1: 15-17.

OZER MA, CELIK, GOVSA F (2009) A morphometric study of the inferior orbital fissure using three-dimensional anatomical landmarks: Application to orbital surgery. *Clin Anat*, 22: 649-654.

PICKERING RB, BACHMAN DC (1997) The use of forensic anthropology. Boca Raton, FL: CRC Press, pp 84-86.

PRZYGOCKA A, SZYMANSKI J, JAKUBCZYK E, JEDRZEJEWSKI K, TOPOL M, POLGUJ M (2013) Variation in the topography of the infraorbital canal/groove complex: a proposal for classification and its potential usefulness in orbital floor surgeries. *Folia Morphol*, 72: 311-317.

REGENSBURG NI, KOK PH, ZONNEVELD FW, BALDESCHI L, SAEED P, WIERSINGA WM, MOURITS MP (2008) A new and validated CT- based method for the calculation of orbital soft tissue volume. *Invest Ophthalmol Vis Sci*, 49: 1758-1762.

RONTAL E, RONTAL M, GUILFORD FT (1979) Surgical anatomy of the orbit. *Ann Oto Rhinol Laryngol*, 88: 382 -386.

ROSSI M, RIBEIRO E, SMITH R (2003) Craniofacial asymmetry in development: an anatomical study. *Angle Orthod*, 73: 381-385.

SARMA K (2006) Morphological and craniometrical studies on the skull of Kagoni goat (*Capra hircus*) of Jammu region. *Int J Morphol*, 24: 449-455.

SEIJI F, MOREIRA RS, DEANGELIS MA, SMITH CHAIRMAN RL (2009) Orbital asymmetry in development: an anatomical study. *Orbit*, 28: 342-346.

SHIMIZU S, TANRIOVER N, RHOTON AL, YOSHIOKA N, FUIJI K (2005) The MacCarty key hole and inferior orbital fissure in orbitozygomatic craniotomy. *Neurosurg*, 57(1 suppl): 152-159.

TAKAHASHI Y, MIYAZAKI H, ICHINOSE A, NAKANO T, ASAMOTO K, KAKIZAKI H (2013) Anatomy of deep lateral and medial orbital walls: implications in orbital decompression surgery. *Orbit*, 32: 409-412.

TEUL I, CZERWINSKI F, GAWLIKOWSKA A, KONSTANTY-KURKIEWICZ V, STAWINSKI G (2002) Asymmetry of the ovale and spinosum foramina in mediaeval and contemporary skulls in radiological examination. *Folia Morphol*, 61: 147-152.

TRIPATHI EB, WEBB AAC (2007) Post-traumatic orbital reconstruction: Anatomical landmarks and the concept of the deep orbit. *Br J oral Maxillofac Surg*, 45: 183-189.

UKOHA U, EGWU OA, OKAFOR IJ, OGUGUA PG, ONWUDINJO O, UDEMEZUE O (2011) Orbital dimensions of adult male Nigerian: a direct measurement study using dry skulls. *Int J Bio Med Res*, 2: 688-690.

VODANOVIĆ M, DUMANČIĆ J, GALIĆ I, SAVIĆ PAVIČIN I, PETROVEČKI M, CAMERIERE R, BRKIĆ H (2011) Age estimation in archaeological skeletal remains: evaluation of four non-destructive age calculation methods. *J Forensic Odontostomatol*, 29: 14-21.

WILLIAMS PL, BANNISTER LH, BERRY MM, COLLINS P, DYSON M, DUSSEK JE, FERGUSON MWJ (1999) Skeletal system. In: Soames RW (ed). *Gray's Anatomy*. Churchill Livingstone, Edinburgh, London, pp 555-560.

YE J, KOOK KH, LEE SY (2006) Evaluation of computer-based volume measurements and porous polyethylene channel implants in reconstruction of large orbital wall fractures. *Invest Ophthalmol Vis Sci*, 47: 509-513.