MORPHOMETRIC MEASUREMENTS OF THE BONY ORBIT IN ADULT EGYPTIANS

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ABSTRACT

Precise localization of the orbital bony anatomy is very important for successful operative results in orbital and maxillofacial surgeries. This study was constructed to decrease the risks in operation in this region.

Orbits of both sides of seventy-six skulls of both sexes were subjected to different measurements using Vernier calipers. On the lateral wall, the mean distances between the frontozygomatic suture and the midpoint of lacrimal groove, lateral margin of optic foramen, inferior orbital fissure, midpoint of fossa for lacrimal gland and frontomaxillary suture were 41.1 mm, 50.4 mm, 34.6 mm, 16.1 mm and 39.5 mm respectively. On the medial wall, the mean distances between the midpoint of anterior lacrimal crest and the anterior ethmoidal foramen, posterior ethmoidal foramen, midpoint of optic foramen and posterior lacrimal crest were 25.5 mm, 37.4 mm, 47 mm and 8.5 mm respectively. On the same wall, the distance between plane of anterior-posterior ethmoidal foramina to the ethmoido-maxillary suture was 14.2 mm. The mean distances between each of the posterior and anterior ethmoidal foramina and posterior end of optic canal were 16.4 mm and 29.2 mm respectively. In 25.6% of orbits, a third foramen was found between the anterior and posterior ethmoidal foramina On the superior wall, the distances between the supraorbital notch/foramen and the midpoint of superior orbital fissure, midpoint of lacrimal groove, superior margin of optic foramen, midpoint between superior orbital fissure and posterior ethmoidal foramen, midpoint of fossa for lacrimal gland, midline and nasion

were 49 mm, 29.8 mm, 47.5 mm, 43.4 mm, 24.5 mm, 24 mm, and 23.8 mm respectively. On the inferior orbital wall, the distances between the infraorbital foramen and inferior end of lacrimal groove, inferior orbital rim, midpoint of superior orbital fissure, anterior nasal spine, midline, lateral end of fossa for lacrimal gland, frontozygomatic suture, inferior margin of optic foramen and inferior orbital fissure (at the end of infraorbital groove) were 14.4 mm, 7.2 mm, 43.5 mm, 36.3 mm, 27.4 mm, 39.3 mm, 31.9 mm, 52.4 mm and 29.6 mm respectively. The length of the infraorbital groove was 11.4 mm. The distance between the lateral margin of optic canal and junction of middle and lateral one-third of infraorbital rim was 52.6 mm.

The distribution of supraorbital notch/foramen and frontal notch/foramen were determined. The shape of infraorbital foramen, presence of accessory foramina and the relation to the supraorbital notch/foramen and maxillary teeth were discussed.

INTRODUCTION

The bony orbits, which contain the eyeballs with their muscles, vessels and nerves, are situated between the cranial and facial regions of the skull (Williams et al 1995). The bony orbit is frequently involved in fractures of the upper facial skeleton as Le Fort type II and III fractures that variously cross the maxilla, nasal, Lacrimal, ethmoid bones and medial wall of the orbit (Dixon 1986). Fractures of the internal orbit are frequently approached with a great deal trepidation. The reason is usually a concern that the surgery will iatrogenically cause blindness because of injury to the optic nerve (Converse et al 1967, Lederman 1981). When operating in or around the orbit, the key to successful result is precise anatomical localization of vital orbital structures from reliable periorbital bony anatomy (Hwang & Baik 1999). The rim of each orbit is subcutaneous (Dixon 1986). Anatomic measurements from fixed points on the orbital rim were described in some populations: in Indian skulls (Rontal et al 1979), in Korean skulls (Hwang & Baik 1999) and in Caucasian skulls (Karakas et al 2002).

The infraorbital foramen is an important anatomic landmark for the oral and maxillofacial surgeons for both surgical and local anesthetic perspective (Aziz et al 2000). The injection of

infraorbital nerve in the infraorbital canal gives full anesthesia to the anterior superior dental nerve for major operations of the anterior part of the upper jaw (Triandafilidi et al 1990). Previous works described the anatomic characteristics of the infraorbital foramen in various populations (Hindy & Abdel-Raouf 1993, Aziz et al 2000 and Kazkayasi et al 2001). The locational relationship of the supraorbital notch/foramen and infraorbital foramen was described in Koreans and Americans (Chung et al 1995, Aziz et al 2000).

The aim of this work is to determine the morphometric variations in the bony orbit of Egyptian skulls to decrease risks in orbital and maxillofacial surgeries.

MATERIALA AND METHODS

A. Materials :

Seventy-six human dry skulls from the Anatomy department, Faculty of Medicine, Mansoura University were used in this study. With the exception of two skulls younger than 25 years, the other 74 skulls showed completely ossified sphenooccipital suture. The skulls were classified into two groups according to sex (36 males and 40 females). The sex was determined depending on the superciliary arch, eminence of glabella, concavity of nasal bones and size of mastoid process (9,10,17).

B. Methods :

According to Rontal et al (1979) and Karakas et al (2002), four easily identified and readily accessible constant structures on the rim were used as reference points. From these reference points, the distances to different intraorbital bony landmarks were measured in mm using Vernier caliper. The measurements were considered to belong to one of the four walls of the orbit according to the reference point. The right and left orbits of each skull were subjected to the following measurements:

On the lateral wall of the orbit (Fig. 1) :

The reference point was the frontozygomatic suture at the orbital rim, from which the distances were measured to:

A) Lacrimal groove mid point.
B) Lateral margin of optic foramen.
C) Inferior orbital fissure opposite the end of the infraorbital groove.
D) Fossa for lacrimal gland mid point.
E) Frontomaxillary suture at the orbital rim.

On the medial wall of the orbit (Fig. 2) :

The reference point was the midpoint of anterior lacrimal crest, from which distances were measured to:

A) Anterior ethmoidal foramen.
B) Posterior ethmoidal foramen.
C) Optic foramen midpoint.
D) Posterior lacrimal crest.

On the same wall, the following distances were also measured:

E) The distance between plane of anterior to posterior ethmoidal foramina and ethmoido-maxillary suture.
F) The distance between posterior ethmoidal foramen and posterior end of optic canal.
G) The distance between anterior ethmoidal foramen and posterior end of optic canal (Fig.1).

The distance between anterior and posterior ethmoidal foramina and the distance between posterior ethmoidal foramen and midpoint of opening of optic canal were calculated.

Some skulls had three ethmoidal foramina, so we also measured the distance of the middle one to the anterior lacrimal crest and to the posterior end of optic canal.

On the superior wall of the orbit (Fig. 3) :

The reference point was the supraorbital notch/foramen, from which the distances were measured to:

A) Superior orbital fissure mid point.
B) Lacrimal groove (midpoint).
C) Superior margin of optic foramen.
D) Mid point between superior orbital fissure and posterior ethmoidal foramen.
E) Fossa for lacrimal gland (mid point).
F) Midline (The perpendicular distance to a vertical line passing through the nasion and anterior nasal spine).
G) Nasion.

When a frontal notch/foramen was present, the distance between it and the nasion was measured.

The presence of supraorbital and frontal notches and/or foramina on both sides was determined (Fig.6-11 and tables 5,6).

On the inferior wall of the orbit (Fig. 4) :

The reference point was the infraorbital foramen, from which the distances were measured to :

A) Lacrimal groove inferior end.

B) Inferior orbital rim (vertical distance).
C) Supra-orbital foramen.
D) Anterior nasal spine.
E) Midline (The perpendicular distance to a vertical line passing through the nasion and anterior nasal spine).
F) Lateral end of fossa for lacrimal gland.
G) frontozygomatic suture.
H) Inferior margin of optic foramen.
I) Inferior orbital fissure at the infraorbital groove (infraorbital canal + groove).

Other measurements :

The length of infraorbital groove was measured and the length of the infraorbital canal was calculated.

The distance between the lateral margin of optic foramen and junction of the middle and lateral one third of inferior orbital rim was also measured.

The infraorbital foramen :

The foramen was examined for its shape, presence of accessory foramina and its relation to the maxillary teeth.

C. Statistical analysis:

For all the measurements, the mean, standard deviation (SD) and range were calculated using Microsoft Excel. The student-t test for paired variable was applied to detect any statistically significant difference between males and females and right and left orbits.

RESULTS

Measurements obtained from the orbits of 76 skulls are shown in Tables 1-8. The student t-test revealed that, in most cases, there was no statistically significant difference between male and female orbits. However, a statistically significant difference between males and females was noticed in the distance between supraorbital notch/foramen and superior orbital fissure ($P = .000$ on the right, $P = .046$ on the left). Also, the distance of the inferior orbital foramen to the midline and to the anterior nasal spine showed statistically significant difference between males and females ($P = .004$ and $.001$ on the right, $P = .004$ and $.002$ on the left respectively). There was no statistically significant difference between right and left side.

The measurements of the lateral wall are listed in Table 1. The average distance from the frontozygomatic suture to the lateral aspect of optic

foramen was 50.4 mm with a range of 40.2 - 58.3 mm. The distances between both the Frontomaxillary suture, the midpoint of lacrimal groove and frontozygomatic suture were very close.

The measurements of the medial wall are presented in tables 2 and 3. A middle ethmoidal foramen was present in 28% of male skulls (23.5% on the right side and 32.4% on the left side) and 22.7% of female skulls (18.6% on the right side and 26.8% on the left side). The average position of the posterior ethmoidal foramen in relation to the anterior lacrimal crest and optic canal was the same whether the skull had two or three foramina. The posterior ethmoidal foramen was absent on one side of two skulls (1.3%). The mean distance between anterior and posterior ethmoidal foramina was 12 mm ±2.9 (3.8-20.3 mm) on the right side and 11.4 mm ±3.1 (5.5-18.8 mm) on the left side. The distance between posterior ethmoidal foramen and midpoint of optic canal was 9.8 mm ±2.1 (5.8-15.9) on the right side and 10.1 mm ±2.7 (3.3-16.3 mm) on the left side. The optic canal was about 6.2 mm long (right side) and 6.6 mm long (left side).

The superior wall measurements are shown in table 4. The mean distances between supraorbital notch/foramen and the superior aspect of the optic foramen (47.5 mm), and midpoint of superior orbital fissure (49.1 mm) were very close to each other. On the same wall, the mean distances between the supraorbital notch/foramen and the midline (23.9 mm), nasion (23.7 mm) and mid point of fossa for lacrimal gland (24.5 mm) were also very approximate.

The inferior wall measurements are seen in table 7. The inferior aspect of the optic foramen was 52.4 mm (range 44-58.5 mm). The distances between the four main reference points (anterior lacrimal crest, frontozygomatic suture, supraorbital notch/foramen and infraorbital foramen) and the optic canal were very close. The infraorbital groove was seen in all orbits, but was as short as 4 mm in 4 skulls. A complete roof of the infraorbital canal was always present although deficient in the middle sometimes. The proportional length of the canal and groove varied widely among orbits. The infraorbital foramen was on average 7.2 mm caudal to the inferior orbital rim, and 27.4 mm

lateral to the midline. The mean distance between the lateral margin of optic canal and the junction of the middle and lateral one-third of inferior orbital rim was 52.6 mm.

Supraorbital notch/foramen and frontal notch/foramen :

Frontal notch/foramen could not be identified in some skulls (72 sides) and only one supraorbital notch (Fig.1) or foramen (Fig.10) could be seen. The supraorbital notch was very shallow in some instances. In 17.1% (right side) and 18.4% (left side) of all skulls, the transverse diameter of the supraorbital notches was more than 5mm and we described them as wide notches (Fig.6). In about 16.7%-17.5% the supraorbital and frontal notches were so close and appeared as two fused notches separated by bony projection or faint ridge (Fig.7). The incidence of supraorbital foramen ranged from 22.2%-25% according to the side and gender. The incidence of frontal notch was 51.3% of all orbits. While that of the frontal foramen did not exceed 2.8% (in males) with an average of 2% of all orbits. The distribution of symmetrical notches and/or foramina in orbits of both sides of skull is shown in Table 6.

Infraorbital foramen (IOF) :

Examination of the 152 sides of the 76 skulls revealed that the IOF was single in 139 sides and double (Fig.17) in eight sides (5.3%) but the accessory foramen was usually small. Two skulls (3%) had double foramina on both sides. One skull had three foramina (Fig.18) on the right side (0.7%) with two of them were small. In some skulls, one or more small foramina were found on the frontal process of maxilla. The shape of the foramen was oval in 95 sides (62.5%) (7 horizontally oval, 15 vertically oval and the rest were oblique) (Fig.12-14). It was round in 50 (32.9%) (Fig.15), and in 7 sides (4.6%) a small bony projection from its superolateral margin was noticed (Fig.16) or it appeared pear-shaped as if a smaller foramen has fused with the principal one. It had a sharp superolateral margin and a sloping inferomedial margin in most cases. In some cases the sharp margin was superiorly or laterally only.

Relation of the infraorbital foramen to the maxillary teeth :

The foramen was on the same vertical plane of the second premolar tooth in 74, between the first and second premolar in 15, opposite the first

premolar in 8 and just behind the second premolar in 9 sides. Thirty per cent of the skulls were edentulous with smooth alveolar margin and the relation to the premolar teeth could not be determined.

Relation of the infraorbital foramen and supraorbital notch/ foramen :

The centers of the supraorbital notch/foramen and infraorbital foramen were located in the same vertical plane in 16.5% (19.7% right side and 13.2% left side) of all skulls. The infraorbital foramen was lateral to the supraorbital notch/foramen in 73.6% (69.7% right side and 77.6% left side). In 27.6% of cases the vertical plane through the infraorbital foramen was less than 4 mm lateral to the supraorbital notch/foramen. In 46% of cases it was more than 4 mm laterally. The lateral displacement reached 19.2 mm in one skull. In 9.9% (10.6% on the right and 9.2% on the left) the infraorbital foramen was medial to the supraorbital notch/foramen. The largest medial displacement was 7.2 mm.

Table 1. Measurements of the lateral wall of the orbit

		Right			Left		
		♂	♀	♂+♀	♂	♀	♂+♀
A	Mean ± SD	41.5±1.6	40.7±2.1	41.1±1.9	41.6±2.2	40.5±3.2	41.1±2.8
	Range	38 -45.2	36.2- 45.5	36.2- 45.5	37.4- 48.5	35.7- 50.6	35.7- 50.6
B	Mean ± SD	50.5±2.6	50.1±3	50.3±2.8	50.6±2.4	50.3±3.4	50.5±2.9
	Range	46-56.5	44.3- 57.5	44.3- 57.5	45.3- 55	40.2- 58.3	40.2- 58.3
C	Mean ± SD	35.6±2.7	34.9±3.0	35.2±2.9	34.7±4.1	33.5±4.2	34±4.2
	Range	29.5 - 42	29.8- 45.2	29.5- 45.5	27.6- 50	24.4- 45.4	24.4- 50
D	Mean ± SD	16.9±1.8	16.0±2.1	16.4±2	16.5±2.6	15.3±1.9	15.8±2.4
	Range	12.3 - 20	10.1- 19.8	10.1- 20	10.2- 23.5	12- 19.5	10.2- 23.5
E	Mean ± SD	40.3±2.6	39.1±2.1	39.6±2.4	39.9±2.3	39±2.5	39.4±2.4
	Range	34.2- 45.3	33.9- 43.8	33.9- 45.3	34.2- 45	33.9- 48	33.9- 48

Measurements in mm of the distances between frontozygomatic suture and:
A. Lacrimal groove mid point.
B. Lateral margin of optic foramen.
C. Inferior orbital fissure (opposite the end of the infraorbital groove).
D. Fossa for lacrimal gland mid point.
E. Frontomaxillary suture.

Table 2. Measurements of the medial wall of the orbit

		Right			Left		
		♂	♀	♂+♀	♂	♀	♂+♀
A	Mean ± SD	25.5±3.6	25.2±3	25.4±2.9	26.1±2.2	25.1±3	25.6±2.7
	Range	20.7- 33.6	19.2- 32.9	19.2- 33.6	21.4- 30.6	14.7- 31.5	14.7- 31.5
B	Mean ± SD	38.8±3.1	36.4±3	37.3±3.4	37.9±2.2	35.7±2.8	36.7±2.8
	Range	32.1-48	30.8-42	30.8-48	31.2-42	29.2-41	29.2-42
C	Mean ± SD	47.8±1.2	46.6±2.3	47.1±2.5	47.4±2.6	46.5±3	46.9±2.8
	Range	42.5- 53	42- 50.7	42- 53	41.3- 53.8	37.2- 51.4	37.2- 53.8
D	Mean ± SD	8.6±2.3	8.0±1.2	8.5±1.2	9±1.2	8.1±1.2	8.5±1.3
	Range	7.4- 12.1	5.3- 11	5.3- 12.1	7- 12	5- 10.6	5- 12
E	Mean ± SD	14.5±3.7	13.9±2.1	14.1±2.2	15.7±2.4	14.3±2.5	14.9±2.5
	Range	11.2- 20.1	10- 18.2	10- 20.1	11.5-21	4- 20.4	4- 21
F	Mean ± SD	15.6±3.2	16.2±2.6	16±2.8	15.8±3.4	17.4±3	16.7±3.3
	Range	10.5-22.4	11.2-22	10.5-22	11-22.2	12.6-23.9	11-23.9
G	Mean ± SD	29.9±3.6	28.5±3.4	29.1±3.5	29.8±4.0	28.9±2.6	29.3±3.4
	Range	24.4- 38.7	20.3- 33.8	20.3- 38.7	21.6- 42.2	24.6- 34	21.6- 42.2

Measurements in mm of the distances between:

A. Anterior lacrimal crest and anterior ethmoidal foramen.
B. Anterior lacrimal crest and posterior ethmoidal foramen.
C. Anterior lacrimal crest and optic foramen midpoint.
D. Anterior lacrimal crest and posterior lacrimal crest.
E. Plane of anterior to posterior ethmoidal foramina and ethmoido-maxillary suture.
F. Posterior ethmoidal foramen and posterior end of optic canal.
G. Anterior ethmoidal foramen and posterior end of optic canal.

Table 3. Measurements of the medial wall of orbits with three ethmoidal foramina

		Right			Left		
		♂	♀	♂+♀	♂	♀	♂+♀
A	Mean ± SD	34.0±2.2	33.4±2.4	33.7±2.1	34.1±3.8	33±3.7	33.6±3.7
	Range	31.4-37.8	31-38	31-38	27.6-39.8	23-37	23-39.8
B	Mean ± SD	39.2±2.7	37.6±2.0	38.3±2.3	39.5±2.8	37.6±1.6	38.6±2.5
	Range	38.3±2.3	34.6-40.6	34.6-45	35.3-44.8	35.2-40	35.2-44.8
C	Mean ± SD	20.9±1.7	19.0±3.3	19.4±2.6	21.7±2.9	19.6±2.2	20.7±2.8
	Range	17.5-23	14.8-24	14.8-24	16.1-26	16.5-24.1	16.1-26
D	Mean ± SD	15±1.9	15.6±3.4	15.1±2.8	16±2.5	15.1±2.8	15.5±2.6
	Range	12.2-16.7	10.8-22	10.8-22	10.8-19.2	10.4-20	10.4-20

Measurements in mm of the distances between:

A. Anterior lacrimal crest and the middle ethmoidal foramen.
B. Anterior lacrimal crest and the posterior ethmoidal foramen.
C. Middle ethmoidal foramen and posterior end of optic canal.
D. Posterior ethmoidal foramen and posterior end of optic canal.

Table 4. Measurements of the superior wall of the orbit

		Right			Left		
		♂	♀	♂+♀	♂	♀	♂+♀
A	Mean ± SD	50.7±2.5	48.3±3	49.4±3.0	49.4±3.3	48.0±2.6	48.7±3.0
	Range	44.9- 56.1	41.6- 56.2	41.6- 56.2	41.8- 56.7	41.5- 52.8	41.5- 56.7
B	Mean ± SD	30.5±2.8	29.1±2.9	29.8±2.9	30.4±3.	29.3±2.9	29.8±3.0
	Range	24.6- 36.4	21.9- 35	21.9- 36.4	22.6- 37	23.2- 37	22.6- 37
C	Mean ± SD	48.5±3.5	46.7±3.8	47.6±3.7	48.0±2.9	46.9±3.0	47.4±3.0
	Range	42- 58	38- 55.6	38- 58	41.5- 54.8	41.4- 52.5	41.4- 54.8
D	Mean ± SD	45.1±3.0	43.6±3.8	44.3±3.5	43.8±2.9	41.3±2.8	42.5±3.1
	Range	39.6- 50.6	34.8- 52.7	34.8- 52.7	38- 49.8	34- 46.6	34- 49.8
E	Mean ± SD	24.6±2.9	24.3±3.4	24.5±3.2	24.4±2.2	24.3±2.7	24.4±2.5
	Range	17.6- 30.8	14.9- 33	14.9- 33	20.7- 28.3	15.9- 30.3	15.9- 30.3
F	Mean ± SD	24.7±3.7	23.7±2.8	24.2±3.3	23.9± 4.6	23.2±3.1	23.5±3.1
	Range	18.2- 33.8	18.6- 31.4	18.2- 33.8	18.9- 31.7	18.3- 29.3	18.3- 31.7
G	Mean ± SD	24.5±3.8	23.4±3.3	23.9±3.6	24.6±4.6	22.7±2.9	23.6±3.9
	Range	20.8-35.7	17.5-31.6	17.5-35.7	18.8-38.4	17.7-32	17.7-38.4
H	Mean ± SD	17.5±3.3	17±2.5	17.2±2.8	18.1±3.8	16.7±2.6	17.4±3.3
	Range	12.7-24	11.3-21.2	11.3-24	12.8-27.3	12.1-21.8	12.1-27.3

Measurements in mm of the distances between supraorbital notch/foramen and:
A. Superior orbital fissure mid point.
B. Lacrimal groove (midpoint).
C. Superior margin of optic foramen.
D. Mid point between superior orbital fissure and posterior ethmoidal foramen.
E. Fossa for Lacrimal gland (mid point).
F. Midline.
G. Nasion.
Note: H. Distance between frontal notch/foramen and nasion.

Table 5. Distribution of supraorbital and frontal notches (N) or foramina (F) in 76 human skulls and their percentages

	Right			Left		
	♂	♀	♂+♀	♂	♀	♂+♀
	Skull (%)	Skull (%)	Skull (%)	Skull (%)	Skull (%)	Skull (%)
A	8 (22.2%)	11 (27.5%)	19 (25%)	5 (13.9%)	13 (32.5%)	18 (23.7%)
B	8 (22.2%)	5 (12.5%)	13 (17.1%)	8 (22.2%)	6 (15%)	14 (18.4%)
C	6 (16.7%)	7 (17.5%)	13 (17.1%)	6 (16.7%)	7 (17.5%)	13 (17.1%)
D	6 (16.7%)	7 (17.5%)	13 (17.1%)	8 (22.2%)	5 (12.5%)	13 (17.1%)
E	3 (8.3%)	1 (2.5%)	4 (5.3%)	3 (8.3%)	1 (2.5%)	4 (5.3%)
F	1 (2.8%)	1 (2.5%)	2 (2.6%)	1 (2.8%)	- (0%)	1 (1.3%)
G	4 (11.1%)	8 (20%)	12 (15.9%)	5 (13.9%)	8 (20%)	13 (17.1%)

A. Single supraorbital notch.
B. Single wide supraorbital notch.
C. Two fused supraorbital and frontal notches.
D. Single supraorbital and single frontal notch.
E. Single supraorbital foramen.
F. Single supraorbital and single frontal foramina.
G. Single supraorbital foramen and single frontal notch.

Table 6. Distribution of symmetrical supraorbital and frontal notches or foramina on both sides

	♂	♀	♂+♀
	Skull (%)	Skull (%)	Skull (%)
A	3 (8.3%)	6 (15%)	9 (11.8%)
B	8 (22.2%)	3 (7.5%)	11 (14.5%)
C	1 (2.7%)	4 (10%)	5 (6.6%)
D	2 (5.6%)	2 (5%)	4 (5.3%)
E	1 (2.7%)	- (0%)	1 (1.3%)
F	1 (2.7%)	- (0%)	1 (1.3%)
G	2 (5.6%)	5 (12.5%)	7 (9.2%)

A. Single supraorbital notch.
B. Single wide supraorbital notch.
C. Two fused supraorbital and frontal notches.
D. Single supraorbital and single frontal notch.
E. Single supraorbital foramen.
F. Single supraorbital and single frontal foramina.
G. Single supraorbital foramen and single frontal notch.

Table 7. Measurements of the inferior wall of the orbit

		Right			Left		
		♂	♀	♂+♀	♂	♀	♂+♀
A	Mean ± SD	14.9±3.0	14.2±2.6	14.5±2.8	14.6±2.5	13.9±2.6	14.2±2.6
	Range	8.7- 23.4	8.7- 18.8	8.7- 23.4	9- 19.6	7.2- 19.3	7.2- 19.6
B	Mean ± SD	7.5±2.2	7.1±1.5	7.3±1.8	7.3±1.8	6.9±1.6	7.1±1.7
	Range	3.8- 13.7	4- 9.4	3.8- 13.7	4- 10.5	3.3- 11.3	10.5- 11.3
C	Mean ± SD	44.3±3.6	42.6±2.9	43.4±3.3	44.2±4	43.5±3.8	43.5±3.8
	Range	38.2- 53.7	38- 52.1	38- 53.7	37.3- 57.4	38.6- 54.4	38.6- 54.4
D	Mean ± SD	37.0±2.6	35.2±2.2	36.1±2.5	37.7±3.5	35.5±2.7	36.5±3.3
	Range	31.8- 42	28.7- 40	28.7- 42	31.6- 49.6	30.2- 41.3	30.2- 49.6
E	Mean ± SD	27.9±2.4	26.4±2.2	27.1±2.4	28.6±3.2	26.7±2.5	27.6±3
	Range	24- 33.9	22.6- 31	22.6- 33.9	24.4- 38.6	21.5- 32.6	21.5- 38.6
F	Mean ± SD	39.9±3.1	38.9±2.2	39.4±2.7	39.4±2.7	39.1±2.6	39.2±2.7
	Range	34- 48	34- 45.3	34- 48	34.3- 45	35.4- 48.1	34.3- 48.1
G	Mean ± SD	38±2.5	36.9±1.6	37.5±2.2	37.9±2.0	37.1±1.7	37.5±1.9
	Range	30.6-42.3	34-40.4	30.6-42.3	33.2-41.3	33.1-40.6	33.1-41.3
H	Mean ± SD	52.9±2.1	51.4±2.6	52.3±2.4	53±2.4	51.5±2.6	52.5±2.5
	Range	48.5-57	45.8-56.5	53±2.4	48-58.3	44-56.1	44-58.3
I	Mean ± SD	30.2±3.6	29.2±2.7.	29.7±3.2	29.7±3.5	29.3±2.6	29.5±3.0
	Range	24.6- 37.1	24- 39	24- 39	22.8- 38	25.2- 33.6	22.8- 38
J	Mean ± SD	10.9±3.7	10.9±4.7	10.9±4.2	12.2±4	11.8±4.6	11.8±4.6
	Range	4.7-17.8	5.2-23	4.7-23	4.5-13.2	4-24	4-24
K	Mean ± SD	53.5±3.2	51.8±2.5	52.6±3	53.1±3.0	52.1±2.8	52.6±2.9
	Range	45.7- 60.3	46.8-58	45.7- 60.3	47.6- 62.6	47- 57.8	47- 62.6

Measurements in mm of the distances between infraorbital foramen and:
A. Lacrimal groove inferior end.
B. Inferior orbital rim.
C. Supra-orbital notch/foramen.
D. Anterior nasal spine.
E. Midline.
F. Lateral end of fossa for lacrimal gland.
G. Frontozygomatic suture.
H. Inferior margin of optic foramen.
I. Inferior orbital fissure (infraorbital canal + groove).
Note: J. Length of infraorbital groove.
K. Distance between lateral aspect of optic foramen and junction of the middle and lateral one third of inferior orbital rim.

Table 8. Comparison of vertical planes between infraorbital and supraorbital foramina

	Right			Left		
	♂	♀	♂+♀	♂	♀	♂+♀
	Skull (%)	Skull (%)	Skull (%)	Skull (%)	Skull (%)	Skull (%)
A	8 (22.2%)	7 (17.5%)	15 (19.7%)	1 (2.8%)	9 (22.5%)	10 (13.2%)
B	9 (25%)	12 (30%)	21 (27.6%)	14 (38.9%)	7 (17.5%)	21 (27.6%)
C	16 (44.4%)	16 (40%)	32 (42.1%)	18 (50%)	20 (50%)	38 (50%)
D	0 (0%)	4 (10%)	4 (5.3%)	3 (8.3%)	1 (2.5%)	4 (5.3%)
E	3 (8.3%)	1 (2.5%)	4 (5.3%)	0 (0%)	3 (7.5%)	3 (3.9%)

A. The centers of the infraorbital foramen and supraorbital notch/foramen were in the same vertical plane.
B. The infraorbital foramen was < 4 mm lateral to the vertical plane through the center of supraorbital notch/foramen.
C. The infraorbital foramen was > 4 mm lateral to the vertical plane through the center of supraorbital notch/foramen.
D. The infraorbital foramen was < 4 mm medial to the vertical plane through the center of supraorbital notch/foramen.
E. The infraorbital foramen was > 4 mm medial to the vertical plane through the center of supraorbital notch/foramen.

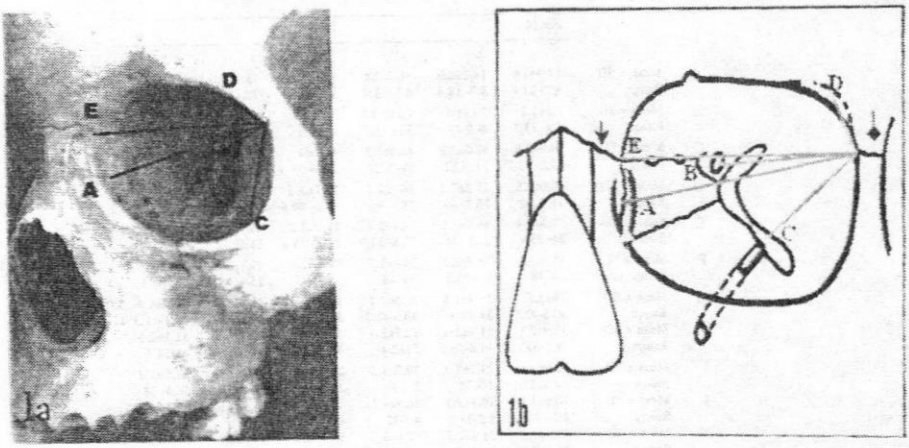

Fig (1) : A photomicrograph (a) and a diagram (b) of the orbit showing the distances (represented by lines) measured on the lateral wall between frontozygomatic suture (diamond arrow) and :

A) Lacrimal groove mid point.
B) Lateral margin of optic foramen.
C) Inferior orbital fissure opposite the infraorbital groove.
D) Fossa for lacrimal gland mid point.
E) Fronto-maxillary suture (arrow).

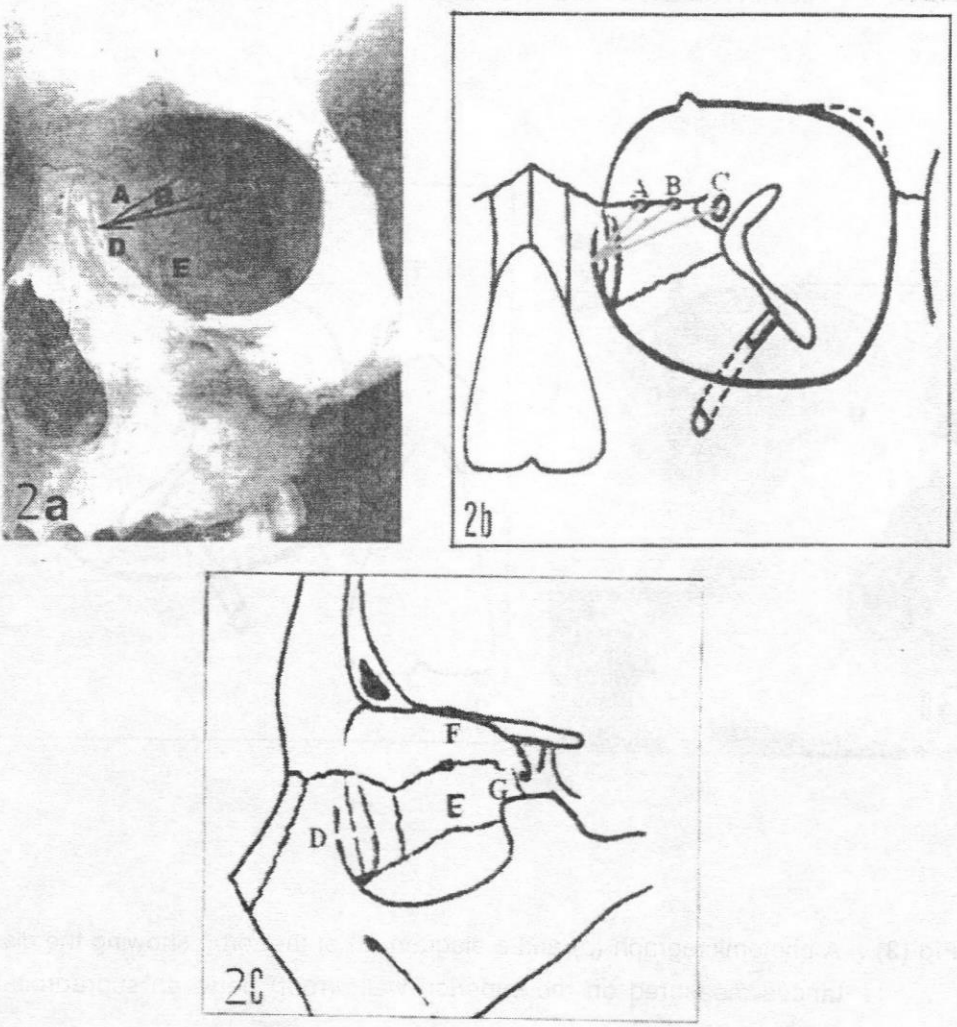

Fig (2) : A photomicrograph (a) and a diagram (b,c) of the orbit showing the distances measured on the medial wall between :

A) Anterior lacrimal crest and anterior ethmoidal forament.
B) Anterior lacrimal crest and posterior ethmoidal foramen.
C) Anterior lacrimal crest and optic foramen midpoint.
D) Anterior lacrimal crest and posterior lacrimal crest.
E) Plane of anterior to posterior ethmoidal foramina and Ethmoido-maxillary suture.
F) Posterior ethmoidal foramen and posterior end of optic canal.
G) Anterior ethmoidal foramen and posterior end of optic canal.

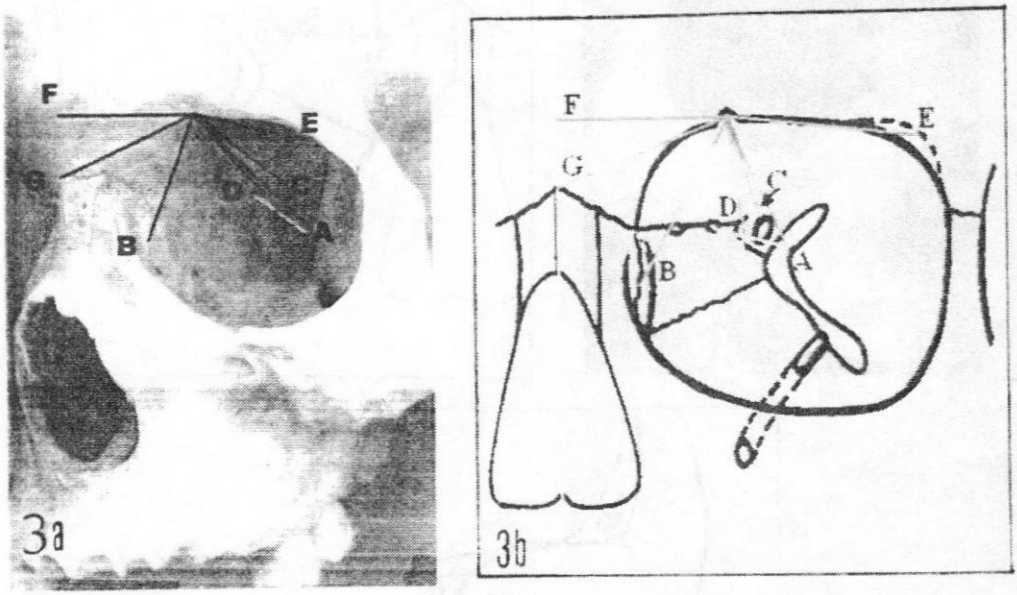

Fig (3) : A photomicrograph (a) and a diagram (b) of the orbit showing the distances measured on the superiorl wall (roof) between supraorbital notch and :

A) Superior orbital fissure mid point.

B) Lacrimal groove (midpoint).

C) Superior margin of optic foramen.

D) Midpoint between superior orbital fissure and posterior ethmoidal foramen (arrow) .

E) Fossa for lacrimal gland (mid point).

F) Midline.

G) Nasion.

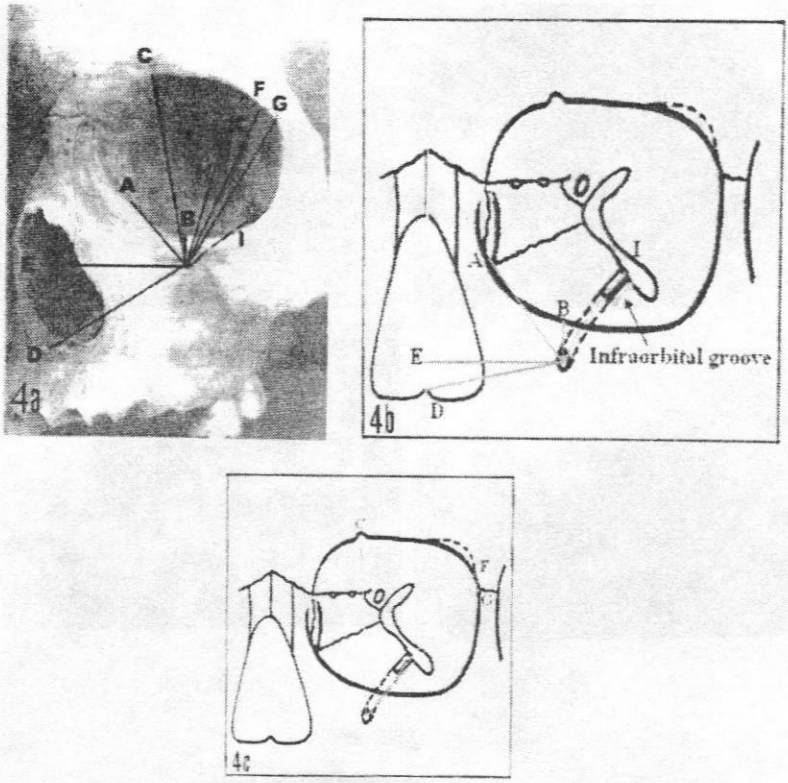

Fig (4) : A photomicrograph (a) and a diagram (b,c) of the orbit showing the distances measured on the inferior wall (floor) between infraorbital foramen and :

A) Lacrimal groove inferior end.

B) Inferior orbital rim.

C) Supra-orbital notch.

D) Anterior nasal spine .

E) Midline.

F) Lateral end of fossa for lacrimal gland.

G) Frontozygomatic suture.

H) Inferior aspect of optis foramen.

I) Note : Inferior orbital fissure at the infraorbital groove.

J) Distance between lateral margin of optic canal and junction of the middle and lateral one third of inferior orbital rim.

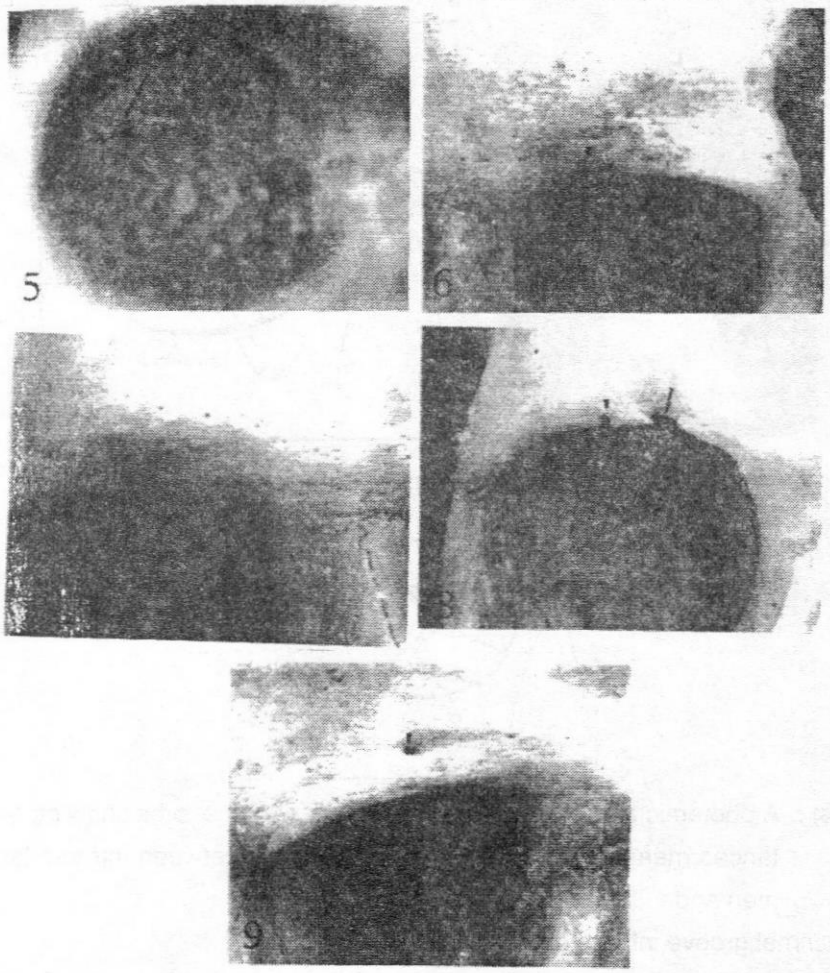

Fig (5) : A photomicrograph of a magnified medial orbital wall showing three ethmoidal foramiina. Note arrow pointing to middle ethmoidal foramen .

Fig (6) : A photomicrograph of the superior orbital margin showing a single wide supraorbital notch (arrowhead).

Fig (7) : A photomicrograph of the superior orbital margin showing fused supraorbital & frontal notches (arrowheads).

Fig (8) : A photomicrograph of the superior orbital margin showing supraorbital (arrowhead) and frontal notches (arrow).

Fig (9) : A photomicrograph of the superior orbital margin showing single supraorbital foramen (arrowheads).

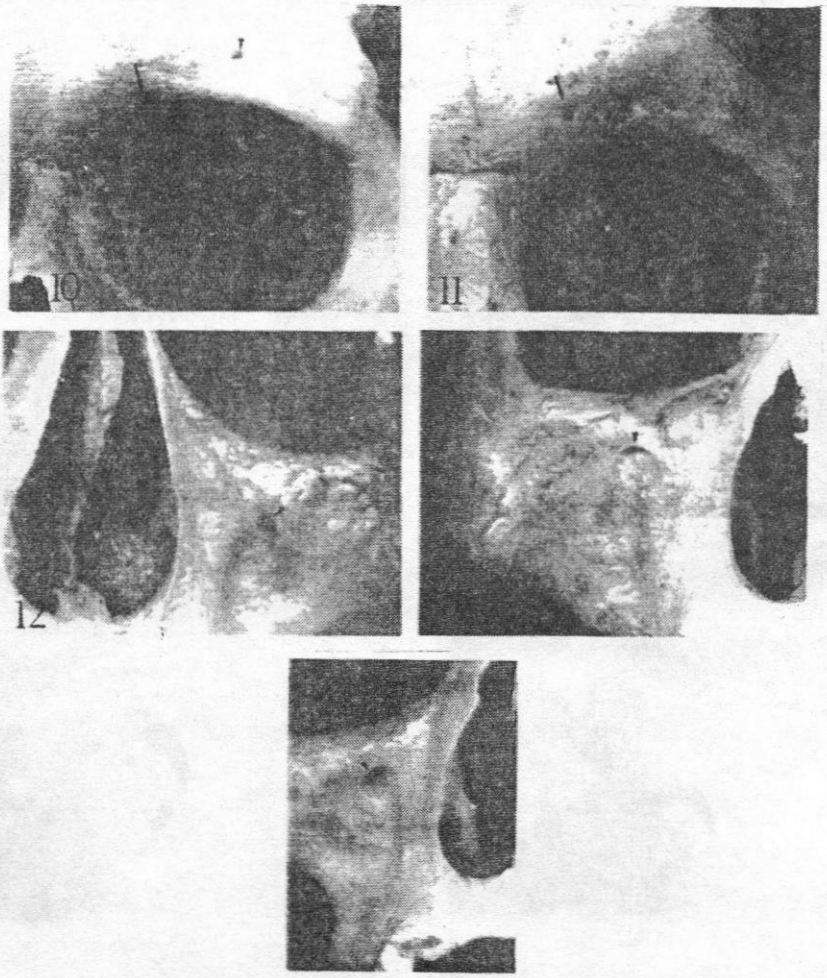

Fig (10) : A photomicrograph of the superior orbital margin showing a supraorbital foramen (arrowhead) and a frontal notch (arrow) .

Fig (11) : A photomicrograph of the superior orbital margin showing supraorbital (arrowhead) and frontal (arrow) foramina.

Fig (12) : A photomicrograph of the inferior orbital margin showing an oval infraorbital foramen with a vertical long axis (arrowhead) .

Fig (13) : A photomicrograph of the inferior orbital margin showing an oval infraorbital foramen with a horizontal long axis (arrowhead).

Fig (14) : A photomicrograph of the inferior orbital margin showing an oval infraorbital foramen with an oblique long axis (arrowhead).

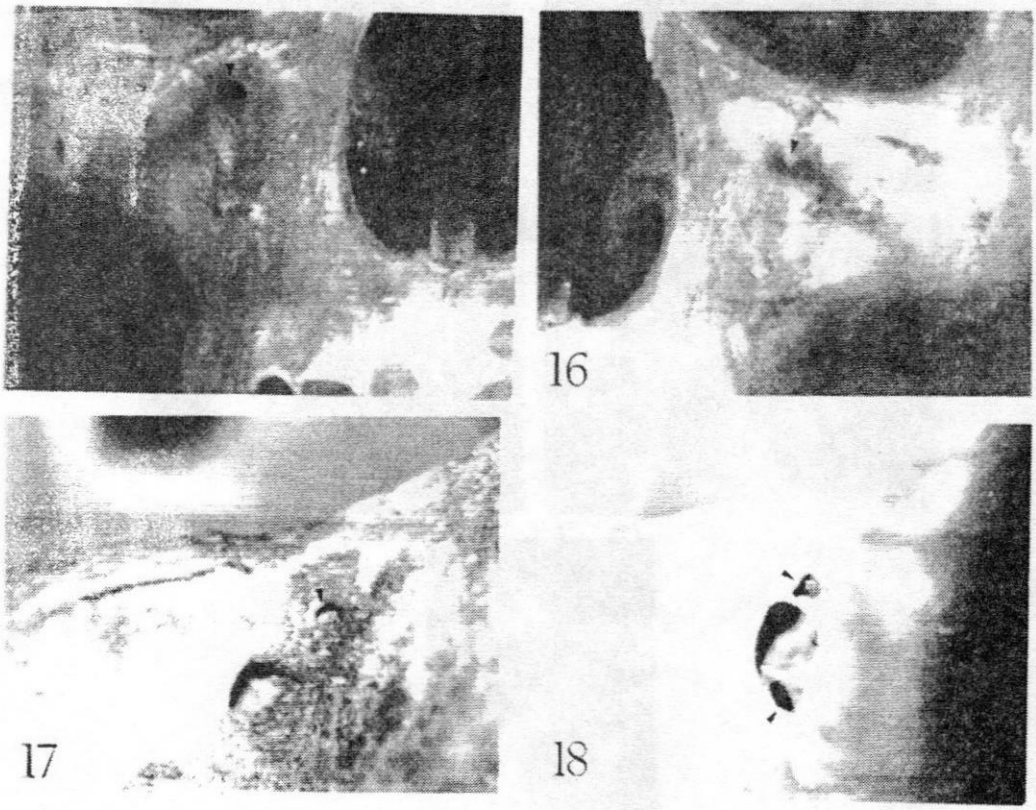

Fig (15) : A photomicrograph of the inferior orbital margin showing a round infra-orbital foramen (arrowhead) .

Fig (16) : A photomicrograph of the inferior margin showing an infraorbital foramen with a bony projection on the upper margins (arrowhead) .

Fig (17) : A photomicrograph of the inferior orbital margin showing an one small accessory infraorbital foramen (arrowhead) .

Fig (18) : A photomicrograph of the inferior orbital margin showing two small accessory infraorbital foramina (arrowheads) close to the large round main foramen (arrowhead).

DISCUSSION

The skull is probably the second best region of the skeleton to determine the sex (Bass 1971). Krogman and Íscan (1986) stated that determination of sex, age and race, with levels of reliability of 92% was possible when using the skull alone. Some indicators such as superciliary arch, size of mastoid process, shape of supraorbital margin and nuchal cresting were used to define sex (Konigsberg & Hens 1998). Funayama et al (1986) stated that in males the eminence of the glabella and nasal concavity develop much more markedly than in females, presenting a clear skeletal difference between both sexes. De Paiva and Segre (2003) showed that the triangle area measurement demarcated through the xerographic projection of craniometrical points related to the mastoid process is useful in the sexing of skulls with the total surface area of male more than that of largest female .For sex determination, the present study used the superciliary arch, the eminence of glabella, nasal concavity and mastoid process to classify the skulls into male and female ones.

Internal orbital surgery requires precise knowledge of anatomical localization of orbital structures. It has been reported that direct intraoperative iatrogenic optic nerve damage is possible (Stankiewicz 1989). To traumatize the optic nerve during dissection, the clinician must first encounter and disrupt the contents of the inferior or superior orbital fissures, the origin of levator palpebrae superioris or superior oblique muscles, and the tendinosus annulosus of Zinn (Danko & Haug 1998). Numerous studies have attempted to identify safe distances from anatomic landmarks to serve as clinical guidelines (Rontal et al 1979, Mcqueen 1995, Danko & Haug 1998).

The anatomy of the medial wall is important for successful results of some orbital procedures such as ethmoidal vessel ligation, medial wall fractures, orbital decompression, ethmoid sinus exenteration, transethmoidal sphenoidotomy and transethmoidal sphenoidal hypophysectomy (Rontal et al 1979). The mean distances in 152 orbits between the midpoint of anterior lacrimal crest and anterior ethmoidal foramen, posterior ethmoidal foramen, optic canal midpoint and posterior lacrimal crest in the present results were 25.5 mm, 37 mm, 47 mm and 8.5 mm. Karakas et al (2002) performed a similar study on

62 orbits (31 male Caucasian skulls) and found these distances as follows: 23.9 mm, 35.6 mm, 41.7 mm and 6.9mm. Rontal et al (1979) studied 48 orbits in 24 Indian skulls and arrived at these mean values: 24mm, 36mm, 41mm and 7mm. Our results resembles both studies except for the distance between anterior lacrimal crest and midpoint of optic canal which is slightly longer in the present study. Also the mean value of the distance between anterior and posterior ethmoidal foramina was 12.5 mm while that of Karakas et al (2002) was 9.8 mm. Hwang and Baik (1999) measured the distance between anterior lacrimal crest and posterior ethmoidal foramen in 82 orbits obtained from 41 Korean skulls. It was 31.7 mm, which is slightly smaller than the present results and both Rontal et al (1979) and Karakas et al (2002). Like Rontal et al (1979) we found that the distance between posterior ethmoidal foramen and optic nerve was not less than 3 mm. Thus surgical approach to this artery must be done with great caution.

In 25.6% of all orbits, a third foramen was found between the anterior and posterior ethmoidal foramina, but the incidence on the left side (average 29.6%) was greater than the right side (average 21.5%) in both male and female skulls. This foramen was called middle ethmoidal foramen (Williams et al 1995) and was reported to occur in 28% of skulls (Downie 1995). The posterior ethmoidal foramen was absent in two orbits, which accounts for nearly 1.3% of all orbits. The incidence of its absence differed among various population samples with the highest incidence in the Mexican sample (7.7% ♂ , 16.7% ♀) (Berry 1975).

The lateral wall of the orbit is the site of lateral orbitotomy, which is used for the removal of orbital tumors and for orbital decompression. The optic canal was located at about 50 mm from the frontozygomatic suture. This is somewhat larger (5-8 mm) than that reported by Rontal et al (1979) and Karakas et al (2002). The distance between the suture and inferior orbital fissure was similar to that of Karakas et al (2002) but larger than that reported by Rontal et al (1979).

On the superior orbital wall, the measurements from the supraorbital notch/foramen to the superior orbital fissure, superior aspect of optic canal and midpoint of fossa for lacrimal

gland were: 50.5 mm, 48.3 mm and 24.5 mm in males and 48.2 mm, 46.8 mm and 24.3 mm in females. Rontal et al (1979) reported these measurements to be 40 mm, 45mm and 32 mm in Indians, while Karakas et al (2002) found them equal to 45.7 mm, 45.3 mm and 26.0 mm in Caucasians. Using Korean adult skulls, Hwang and Baik (1999) determined the distance between supraorbital notch and superior orbital fissure to be 40 mm. This difference may be related to racial factors.

On the orbital floor, the distance between infraorbital foramen and inferior orbital fissure (length of the infraorbital groove and canal) was 29.6 mm, which is similar to that reported in previous studies (Hindy & Abdel-Raouf 1993, Kaskayasi et al 2001, Karakas 2002), but slightly different from the results of Hwang and Baik (1999) and Rontal et al (1979) who found it equal to 26.4 mm and 24 mm respectively. Like Kaskayasi et al (2001), the present study found variability in length of the canal to groove. The optic canal was 52.4 mm from the infraorbital foramen, which is slightly beyond what found in Indian skulls (Rontal et al 1979).

In retrobulbar anesthesia, the needle is directed towards the lateral margin of optic canal from a point at the junction of the middle and lateral one-third of inferior orbital rim. We found this distance to be 52.6 mm on average with a range of 45.7-62.6 mm. It is slightly longer than that of Karampatakis et al (1998), which was 49.6 mm with a range of 44-57 mm. Shallow or deep orbits exist in both males and females but individuals with shallow orbits are obviously more susceptible to optic nerve injury by retrobulbar needle (Karampatakis et al 1998).

The supraorbital notch or foramen lies at the junction of the rounded medial one-third and the sharper lateral two-thirds of the superior orbital rim (Williams et al 1995). An additional, more medial, notch or foramen has been described in varying percentages of skulls. It has been given the name frontal notch or foramen (Williams et al 1995). Webster et al (1986) labeled the neural and vascular structures that emerge near the roof of the nose as supratrochlear arteries and nerves and the notches or foramina (when present) through which these pass as the supratrochlear notches or foramina. Previous studies on the supraorbital notch/

foramen showed that the incidence of a notch ranged from 61.6%-78%, while that of a foramen was 22%-38.4% (Webster et al 1986, Chung et al 1995, Aziz et al 2000, Saylam et al 2003). The present study showed very close results. The presence of frontal foramen was limited to 2% of orbits which is similar to that reported by Webster et al (1986) and Saylam et al (2003). Berry (1975) listed the incidence of frontal foramen in different world regions and gave very different results ranging from 15.5%-78%.

In exposing facial fractures for reduction and fixation with coronal, subciliary, subtarsal, and upper buccal sulcus approaches, the supraorbital and infraorbital nerves are susceptible to injury. The location of the supraorbital and infraorbital nerves can be predicted by palpating for the supraorbital notch. Significant edema as seen with facial fractures can make these prominent bony landmarks difficult to palpate (Wilhemi et al 2003). So prediction of the position of supra-orbital notch/foramen and infraorbital foramen is of great importance. In this study, the supraorbital notch or foramen was 23.9 mm from the midline, and almost the same from the nasion. This is in agree with Cutright et al (2003), Chung et al (1995) and Saylam et al (2003) who found the distance to be: 25 mm, 22.7 mm and 25.2 mm respectively, but slightly smaller than those of Beer et al (1998) (31 mm) and Webster et al (1986) (32 mm). The mean distance of the frontal notch/foramen from the nasion (17.3 mm) was less than that reported by Beer et al (1998) which was 25 mm. It was more close to the average distance between the frontal notch/foramen and midline found by Saylam et al (2003) that was 20.2 mm. The supratrochlear notch/foramen described by Webster et al (1986) was 22.5 mm from the midline.

This study found that the average distance between the infraorbital foramen and midline was 27.4 mm. There was small but significant difference in the foramen location between males and females. This is similar to what reported in other studies (Chung et al 1995, Aziz et al 2000, Cutright et al 2003) although Chung et al (1995) did not find variation according to sex. The average distance between infraorbital foramen and supraorbital notch/foramen was 43.4 mm. Aziz et al (2000) gave very close measurements (42.6 mm) while that of Chung et al (1995) gave slightly larger (45.6

mm). The infraorbital foramen was located lateral to the center of the supraorbital notch/ foramen in 73.6% of cases, although the lateral deviation was less than 4 mm in 27.6%. Chung et al (1995) reported also predominance of lateral position of infraorbital foramen (63.6%) but did not find any case in which the infraorbital foramen was medial to the supraorbital notch/ foramen. They attributed that to the lateral extension of the zygomatic arch in Korean people. Aziz et al (2000) stated that the location of infraorbital foramen on the same vertical plane as the supraorbital notch/ foramen accounted for 50% of the cadavers they studied.

The present study like that Hindy and Abdel-raouf (1993); found that in the majority of the skulls, the infraorbital foramen was in the same vertical plane as the second premolar tooth. Aziz et al (2000) said that the tooth most commonly found in the same vertical plane as the infraorbital foramen was the first premolar.

A wide range of values for the location of infraorbital foramen in relation to the inferior orbital rim (2.5-15 mm) with an average of 6.1-9 mm has been listed in literatures (Hindy & Abdel-raouf 1993, Chung et al 1995, Aziz et al 2000, Kaskayasi et al 2001, Cutright et al 2003). This is also evident in our study.

The closest estimation of the location of the infraorbital foramen should be used when designing access incisions to the orbital floor and rim and planning regional nerve blockade (Aziz et al 2000). Several techniques have been suggested to define this location: a) by a line passing through the supraorbital notch, the pupil of the eye, the infraorbital foramen and second bicuspid tooth (Molliex et al 1996), b) by dropping a vertical line from the palpable supraorbital notch to about 10-15 mm below the inferior orbital rim (Kleier et al 1983, Scott 1989), c) by a point medial to the upper nasolabial groove, a few millimeters lateral to the alar groove and 4-7 mm below the inferior orbital rim (Zide & Swift 1998), d) by a point in the same vertical plane as the first premolar tooth, 24-29 mm lateral to the facial midline and about 8 mm below the infraorbital rim (Aziz et al 2000). According to our results, it will be more effective if the first premolar is replaced by the second premolar in the majority of cases in which the infraorbital

foramen is lateral to the supraorbital notch/foramen.

On estimating the location of infraorbital foramen, accessory foramina have to be taken in consideration. Multiple ipsilateral infraorbital foramina were found in 6%, which is consistent with Kaskayasi et al (2001). Hindy and Abdel-Raof (1993) found double foramina in 10% of the Egyptian skulls. Berry (1975) noted incidence of multiple foramina in 2-18% of various world populations. It may be astute for surgeons to recall that multiple supernumerary foramina may exist in a minority of patients, and injury to any branch can result in a sensory deficit (Aziz et al 2000).

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قياسات عظام تجويف العين فى الانسان المصرى البالغ

د. منى الشحات ، د. ألفت السعيد ، د. أمانى شمس الدين

قسم التشريح - كلية الطب - جامعة المنصورة

ان التحديد الدقيق للمواقع التشريحية لعظام تجويف العين مهم جداً لضمان نجاح العمليات الجراحية لعظام التجويف والمنطقة الوجهية المجاورة لها. لذلك أجريت هذه الدراسة للعمل على التقليل من مخاطر العمليات الجراحية فى هذه المنطقة.

فى هذا البحث تم أخذ القياسات من أربع نقاط رئيسية على الحد الخارجى على ١٥٢ تجويف عين فى ست وسبعين جمجمة من كل من الجنسين وذلك باستخدام القدمة ذات الورنية ومن هذه النقاط تم أخذ قياسات مختلفة على الجدران الأربعة للتجويف (العلوى والسفلى والجانبى الانسى والجانبى الوحشى).

وقد تم حساب المتوسط والمدى ومعدل الانحراف لكل قياس وتم تطبيق إختيارتى لتبين وجود أى إختلاف ذو أهمية إحصائية بين الجنسين أو بين الجهة اليمنى واليسرى لتجويف العين .

وقد تم أيضاً دراسة الفتحات تحت التجويف وفوقه من حيث الشكل والعدد والعلاقة بينهم من حيث الموقع .