

Original communication

ORBITAL MORPHOLOGY WITH REFERENCE TO BONY LANDMARKS

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RESUMEN

Las órbitas óseas son cavidades del esqueleto situadas a cada lado de la nariz. Se conocen las diferencias raciales en las medidas orbitales. El objetivo del presente estudio era determinar las distancias de varias fisuras y foramen en la órbita en relación a ciertos puntos de referencia óseos / quirúrgicos sobre los márgenes orbitales en la población india, lo que puede ser útil durante la cirugía orbital. La distancia de canal óptico (OC), fisura orbitaria superior (SOF), fisura orbital inferior (IOF) y forámenes lagrimales (LF) se mide a partir de puntos de referencia como cresta lacrimal anterior (ALC) para la pared medial, muesca/foramen supra orbital (SN) para la pared superior, sutura cigomática frontal (FZ) de la pared lateral y un punto en el margen inferior (OIM) justo encima del agujero infraorbitario. Se midió la distancia del foramen etmoidal anterior y posterior (AEF y PEF) de ALC. Se observó la presencia de foramen etmoidal media (MEF) y forámenes lagrimales (LF). La distancia media de OC fue $39,71 \pm 2,67$ mm (de ALC), $45,11 \pm 3,4$ mm (de SN), $48,32 \pm 2,8$ mm (de FZ) y $45,97 \pm 3,9$ mm (de OIM). La distancia segura para el nervio óptico para cada pared orbital se calcula restando 5 mm de la distancia más corta medida.

Palabras clave: Morfología orbitaria, canal óptico, pared orbitaria.

ABSTRACT

The bony orbits are skeletal cavities located on either side of the nose. Racial differences in orbital

measurements are known. The aim of the present study was to determine the distances of various fissures and foramen in the orbit with reference to certain bony / surgical landmarks on the orbital margins in Indian population which can be useful during various surgical procedures. The distance of optic canal (OC), superior orbital fissure (SOF), inferior orbital fissure (IOF), lacrimal foramen (LF) were measured from landmarks like anterior lacrimal crest (ALC) for medial wall, supraorbital foramen/ notch (SON) for superior wall, fronto-zygomatic suture (FZ) for lateral wall and a point on inferior margin (IOM) just above the infraorbital foramen. Distance of anterior and posterior ethmoidal foramen (AEF and PEF) from ALC was measured. The incidence of middle ethmoidal foramen (MEF) and lacrimal foramen (LF) was noted. The mean distance of OC was 39.71 ± 2.67 mm (from ALC), 45.11 ± 3.4 mm (from SN), 45.97 ± 3.9 mm (from FZ) and 48.32 ± 2.8 mm (from IOM). The safe distance for optic nerve for each orbital wall was derived by subtracting 5 mm from the shortest measured distance.

Key words: Orbital morphology, optic canal, orbital wall

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INTRODUCTION

The bony orbits are skeletal cavities located on either side of the nose. The walls of the orbit protect the eye from injury also provides points of attachments for six extraocular muscles which allow the accurate positioning of the visual axis and determine the relationship between the eyes, which is essential both for binocular vision and conjugate eye movements. The roof of the orbit is formed by frontal bone and the lesser wing of the sphenoid. The optic canal (OC) lies between the roots of the lesser wing and is bounded medially by the body of the sphenoid, transmitting the optic nerve with its meningeal sheath and the ophthalmic artery. Medial orbital wall is formed by lamina papyracea (a paper thin orbital plate) of the ethmoid bone, the body of the sphenoid and the lacrimal bone. The floor of the orbit is mostly formed by the orbital plate of the maxilla, which articulates with the zygomatic bone antero-laterally and the orbital process of the palatine bone, postero-medially. The lateral wall is formed by the orbital surface of the greater wing of the sphenoid, posteriorly and the frontal process of the zygomatic bone, anteriorly. Superior orbital fissure (SOF) is the gap between the greater and the lesser wings of the sphenoid bone. The SOF connects the cranial cavity with the orbit and transmits the oculomotor, trochlear and abducent nerves, branches of the ophthalmic nerve and the ophthalmic vein (Standring, 2008). The orbital margin consists of four curved sides. The supraorbital margin is notched or canalized near the medial end for the passage of the supraorbital nerve and artery. The lateral margin is formed by the conjoined processes of frontal and zygomatic bones. The infraorbital margin is formed half and half by the zygomatic bone and the maxilla meeting at a suture. The medial margin of the orbit consists of two ridges which overlap. From the inferior margin, the anterior lacrimal crest (ALC) rises upward and from the superior margin the posterior lacrimal crest runs down behind this (McMinn, 1990).

To avoid injuries to the important structures in the orbit, mainly neurovascular bundles passing through various foramen and fissures, precise knowledge of the anatomy of these openings is indispensable. Anatomical variations of the important apertures in the orbit have been reported (Huanmanop et al, 2007).

Racial differences in orbital measurements were observed by several authors.(Huanmanop et al, 2007; Karakas et al, Rontal et al, 2003; McQueen et al, 1995; Rontal et al, 1979). Huanmanop et al (2007) have reported the racial differences of various fissures and foramina from standardized (fixed) bony landmarks.

The aim of the present study was to determine the distances of various fissures and foramen in the orbit with special reference to certain osseous/ surgical landmarks on the orbital margins in Indians, which can be useful for surgery.

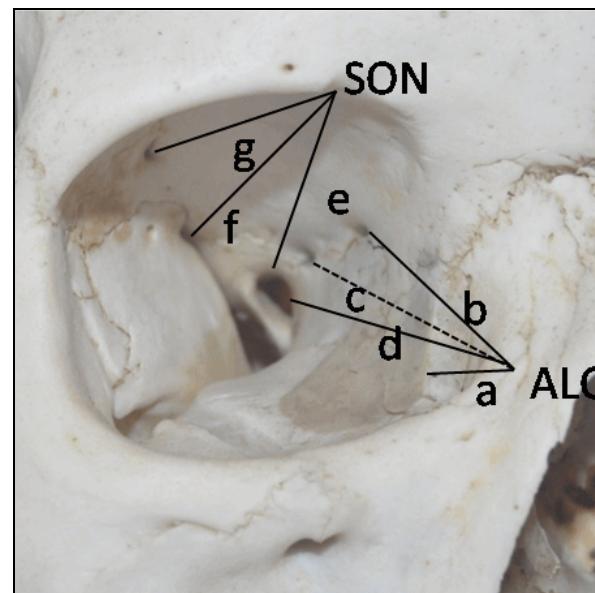


Figure 1 - Figure showing landmarks used for various parameters on medial and superior wall of the orbit. ALC – anterior lacrimal crest, SON – Supraorbital notch, a – ALC to Posterior lacrimal crest, b – ALC to anterior ethmoidal foramen, c – ALC to Posterior ethmoidal foramen, d – ALC to medial margin of optic canal, e – SON to superior border of optic canal, f – SON to superior orbital fissure, g – SON to lacrimal foramen

MATERIALS AND METHODS

We studied 68 intact dry Indian skulls (136 orbits) of unknown sex in the Department of Anatomy. The project was approved by Bioethical commity. (Ref. no. PDVVPF'SMCH/IEC/Pharmac01/16/08/2013). The digital Vernier caliper accurate up to 0.01 mm was used to measure various distances. All the measurements were taken twice by the same observer to avoid errors. We followed the method described by Huanmanop et al (2007). The following parameters were studied.

Superior wall (Fig.1) The supraorbital notch (SON) was used as a reference point. The distance between it and the closest margin of the superior orbital fissure (SOF), the superior border of OC and the lacrimal foramen (LF), when present were measured. The incidence of supraorbital foramen or notch was also noted.

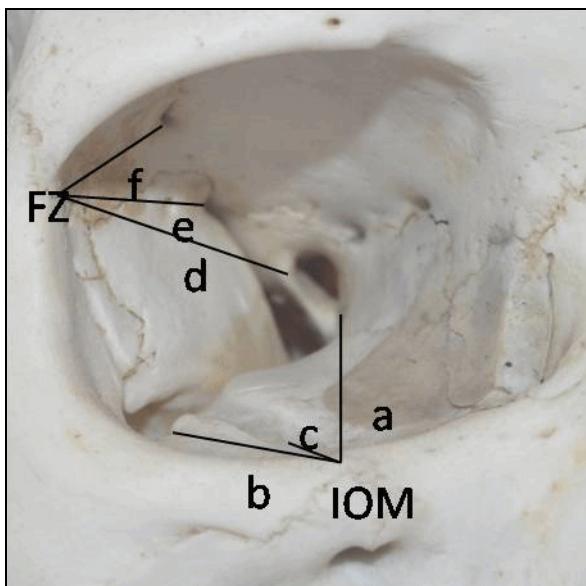


Figure 2 – Figure showing landmarks used for various parameters on inferior and lateral wall of the orbit. IOM – point just above infraorbital foramen on Inferior orbital margin, FZ –fronto-zygomatic suture, a – IOM to inferior border of optic canal, b – IOM to inferiro orbital fissure, c – IOM to anterior margin of infraorbital canal, d – FZ to lateral margin of optic canal, e – IOM to superior orbital fissure, f – FZ to lacrimal foramen

Medial wall (Fig. 1) The distance from the anterior lacrimal crest (ALC) to posterior lacrimal crest (PLC), anterior ethmoidal foramen (AEF), posterior ethmoidal foramen (PEF) and medial border of OC were measured. The distances between AEF, PEF and OC were determined. Presence of middle ethmoidal foramen (MEF) and its distance from ALC was measured. The position of the foramen in relation to fronto-ethmoidal suture was also noted.

Inferior wall (Fig.2) The point on the inferior orbital margin (IOM) just above the infraorbital foramen was used as a landmark. The distances between IOM and inferior margin of OC, inferior orbital fissure (IOF) and posterior margin of the infraorbital canal (IOC) were noted.

Lateral wall (Fig.2) Distance of lateral margin of OC, SOF, IOF and LF (if present) were measured from the fronto-zygomatic (FZ) suture. The safe distance to optic nerve from each orbital margin was determined by subtracting 5 mm from the shortest measurement as suggested McQueen et al (1995). The mean, standard deviation, range were calculated using SPSS 17 software. T-value was used to evaluate bilateral asymmetry. $P < 0.05$ was considered as significant.

RESULTS

The results are shown in table 1.

Supraorbital notch was present in majority (Rt.- 69.1%, Lt –73.5%) orbits but the foramen was found in 29.4% of right and 22% of left orbits. Both foramen and notch were present in two left orbits, while both foramen and notch were absent in one right and one left orbit. In 51% right and 38% left orbits the ethmoidal foramens were present on the fronto-ethmoidal suture. The middle ethmoidal foramen (MEF) was present in 25% of right and 17.6% of left orbits. The incidence of lacrimal foramen was 20% on both right as well as left side.

The safe distance for the optic nerve in Indian population was determined by subtracting 5 mm from the shortest distance on each wall of the orbit. Hence for the superior wall the safe distance was 28.7 mm, for the medial wall 28.3, for the inferior wall 36.7 and for the lateral wall 21.8 mm.

When all the parameters were compared bilaterally using t-test the difference was not significant statistically. (Table 1).

DISCUSSION

Orbital morphometry is an important aspect during surgical procedures, such as reconstruction of the face and cranium. These are done to restore lost functional capacity or to improve cosmetic appearance. Periorbital and intraorbital neurovascular structures risk relative damage during these maneuvers. A thorough understanding of orbital morphology is therefore essential to avoid surgical complications. The ethmoidal canal, the periorbit, the muscular cone, the optic nerve and the superior orbital fissure are the important structures in the topographic arrangement of the orbit (Martins et al 2011). The AEF and PEF, through which anterior and posterior ethmoidal vessels pass, are present in the medial wall. The anatomy of these foramen is important when performing several procedures, for example, ethmoidal vessels ligation for epistaxis, exploration of medial wall fracture and orbital decompression (Huanmanop et al, 2007). In the present study 55% of the ethmoidal foramens were laying out of the fronto-ethmoidal suture. The incidence of MEF was 21.3% in the present study. Downie et al (1995) encountered a MEF in 28% of the skulls examined.

No.	Parameter	Right (Mean +SD)	Left (Mean +SD)	Range (mm)	T value	P value
1	Superior wall					
	SON -OC	45.15 ± 4.04	41.07 ± 2.88	23.7 – 53.7	0.13	>0.05
	SON -SOF	40.06 ± 3.16	40.68 ± 3.35	29.2 – 48.3	1.02	>0.05
	SON -LF	33.07±5.04 (n=14)	32.14±5.58 (n=14)	22.3 – 41.5	0.41	>0.05
2	Medial wall					
	ALC-PLC	7.07 ± 4.46	10.16 ± 17.58	3.5 – 14.2	0.65	>0.05
	ALC-AEF	21.24 ± 3.69	20.16 ± 2.25	5.2 – 31.4	1.74	>0.05
	ALC-PEF	33.24 ± 3.42	32.98 ± 2.3	22.7 – 39.6	0.47	>0.05
	ALC-OC	39.69 ± 2.71	39.77 ± 2.63	33.1 – 46	0.16	>0.05
	AEF – PEF	12.15 ± 3.78	13.3 ± 3.59	17.5 – 25.2	1.51	>0.05
	PEF – OC	6.68 ± 3.06	6.93 ± 1.83	5.3 – 10.4	0.52	>0.05
	AEF – MEF	28.41 ± 3.0 (n= 17)	26.80±3.75 (n=12)	23.6 – 34.3	0.57	>0.05
3	Inferior wall					
	IOM – OC	48.32 ± 2.99	48.33 ± 2.73	41.2 – 55.4	0.02	>0.05
	IOM – IOF	21.11 ± 2.73	21.91 ± 2.34	15.5 – 31.2	1.76	>0.05
	IOM – IOC	13.37 ± 4.48	12.72 ± 4.49	5.4 – 26.9	0.79	>0.05
4	Lateral wall					
	FZ – OC	46.33 ± 3.71	45.61 ± 4.17	26.7 – 52.7	0.97	>0.05
	FZ – SOF	33.12 ± 3.15	33.14 ± 3.11	24.5 – 46.8	0.03	>0.05
	FZ – IOF	26.76 ± 4.56	24.13 ± 4.14	17.1 – 47.3	3.09	>0.05
	FZ - LF	24.79±2.59 (n=14)	24.00±3.01 (n=14)	18.5 – 30.3	0.74	>0.05

Table 1 - Observations of the parameters of various walls of the orbit SON – Supraorbital notch, OC – Optic canal, SOF –Superior orbital fissure, LF – Lacrimal foramen, ALC –Anterior lacrimal crest, PLC –Posterior lacrimal crest, AEF –Anterior ethmoidal foramen, PEF –Posterior ethmoidal foramen, MEF – Middle ethmoidal foramen, IOM – Inferior orbital margin, IOF – Inferior orbital fissure, IOC – Infraorbital canal, FZ – Frontozygomatic suture

Analysis of racial and seasonal variations in the position and incidence of ethmoidal canal in 58% crania from several populations showed AEF to lie outside the fronto-ethmoidal suture in 10-20% of several modern races and 62% out of 53 Peruvian crania (Saoemes, 1999).

The cranial openings of ethmoidal canals are related with the anterior and posterior limits of the ethmoidal cribriform plate. Anterior to the anterior ethmoidal canal is the frontal portion of the anterior cranial fossa and posterior to posterior ethmoidal canal is the area of planum sphenoidale. This anatomical fact has been used as a topographical landmark during endonasal approach to the anterior cranial fossa. Similarly, the position of the orbital openings of the ethmoidal canals can be useful to separate different orbital regions: anterior to anterior ethmoidal canal is the bulbar part of the orbit. Between both canals is the retrobulbar part and posterior to posterior ethmoidal canals the orbital apex (Martins et al, 2011) Hence anterior and posterior ethmoidal foramen can be used as important surgical landmarks.

In the present study, the distance between AEF and PEF was 12.75 mm. Huanmanop et al (2007) found the same distance in 13.2 mm. The distance between PEF and OC was 6.8 mm in the present study, a similar finding was observed by (6.8 mm) by Karakas et al (2003) but it was less (6.3 mm) than the observation by Huanmanop et al (2007). The mean distance of the optic canal from ALC in the present study was 39.7 mm. Huanmanop et al (2007) observed it as 42.2 mm in Thais, while Karakas et al (2003) as 41.7 mm in Caucasians. Hwang and Baik (1999) in Korean adults observed it as 40.5 mm. The supraorbital foramen/ notch were used as a landmark for measuring its distance from optic canal, superior orbital fissure and inferior orbital fissure. The authors observed the mean distances as 45.11 mm, 40.37 mm and 32.6 mm respectively. While studying African population, Munguti et al (2012) observed the distance between optic canal and supraorbital notch in 53.25 mm, which is more than the present study (45.11 mm) and other studies (Karakas et al,

2003 – 45.3 mm, Huanmanop et al, 2007 – 44.7 mm). (Table 2)

Huanmanop et al (2007) observed presence of lacrimal foramen in 37%, MacQueen et al (1995) in 44%, Jadhav et al (2012) in 44.33%, while in the present study it was observed in 20.5% orbits. The distance between the supraorbital notch and LF was similar to those reported earlier. (Table 2)

The distance of optic canal was measured from a point on the inferior orbital margin just above the infraorbital foramen. In the present study it was 48.32 mm more than the observations by Huanmanop et al (2007) (46.2 mm), but less than that by Munguti et al (2012) (55.18 mm) and by Hwang and Baik (1999) (54.5 mm).

Variable length of the roof plate covering the anterior part of the infraorbital groove to form the

infraorbital canal which contains the infraorbital nerves and vessels has been reported (Huanmanop et al, 2007). The authors observed the distance between the anterior margin of inferior orbital canal (IOC) and the point on the inferior orbital margin (IOM) as 13.04 mm while Huanmanop et al (2007) observed it as 12.3 mm. In the lateral orbital approaches, the orbital lesions can be reached by displacing the temporal bone and performing pure zygomatic osteotomy, without the need of a combined crano-orbital approach (Martins et al, 2011). The fronto-zygomatic suture was used as a constant landmark for the measurements of the lateral wall. The distance of optic canal from FZ suture was 45.97 mm in the present study; Huanmanop et al (2007) observed it as 46.9 mm and Karakas et al (2003) as 44.9 mm.

No	Parameter	Mungutie t al (220)†	Huanmanop et al*(100)	Karakas et al(62)	Hwang et al (82)	Present study* (136)
1	Superior wall					
	SON – OC	52.59	44.7 ± 2.3	45.3± 3.2	44.9 ± 2.0	45.11± 3.4
	SON – SOF		40.0 ± 2.4		40.0 ± 2.5	40.37 ± 3.2
	SON – LF		33.6 ± 3.5			32.6 ± 5.3
2	Medial wall					
	ALC – OC		42.2 ± 2.3	41.7± 3.1	40.5 ± 3.0	39.71 ± 2.67
	ALC – PLC		6.6 ± 1.1			8.66 ± 4.46
	ALC - AEF		23.5 ± 2.6	23.9± 3.3	21.0 ± 3.3	20.7 ± 2.97
	ALC – PEF		36.0 ± 2.5	35.6± 2.3	31.7 ± 3.0	33.1 ± 2.86
	AEF - PEF		13.2 ± 2.0			12.75 ± 3.68
	PEF – OC		6.3 ± 1.7			6.8 ± 2.44
3	Inferior wall					
	IOM – OC	54.40	46.2 ± 2.8		45.5± 2.5	48.32 ± 2.8
	IOM – IOF		21.7 ± 2.0		21.6 ± 1.8	21.51 ± 2.5
	IOM – IOC		12.3 ± 3.7			13.04 ± 4.4
4	Lateral wall					
	FZ – OC		46.9 ± 2.4	44.9± 2.5	47.4 ± 3.0	45.97 ±3.9
	FZ – SOF		34.5 ± 2.6		34.3 ± 2.7	33.13 ± 3.1
	FZ – IOF		24.0 ± 2.3		24.8 ± 2.3	25.45 ± 4.3
	FZ - LF		27.2 ± 3.7			24.39 ± 2.8

Table 2 - Comparison with some of the previous studies. * Data derived from both sides in combination. † - figures in the bracket indicate number of orbits studied. SON – Supraorbital notch, OC – Optic canal, SOF – Superior orbital fissure, LF – Lacrimal foramen, ALC –Anterior lacrimal crest, PLC – Posterior lacrimal crest, AEF –Anterior ethmoidal foramen, PEF –Posterior ethmoidal foramen, IOM – Inferior orbital margin, IOF – Inferior orbital fissure, IOC – Infraorbital canal, FZ – Fronto-zygomatic suture

Distance of SOF and IOF from FZ suture was 33.1 mm and 25.4 mm respectively, which were comparable with the previous studies (Huanmanop et al, 2007; Karakas et al, 2003).

The average distance of lacrimal foramen from FZ suture was (24.39 mm) lesser than the observations by Huanmanop et al (2007).

In the present study suprorbital notch, anterior lacrimal crest, point on the inferior orbital margin just above the infraorbital foramen and fronto-zygomatic suture were used as the landmark for measuring its distance from optic canal for the respective walls. The safe distance for the optic nerve was derived by subtracting 5 mm from the

shortest measured distances. It was 28.7 mm for superior wall, 28.3 mm for medial wall, 36.7 mm for inferior wall and 21.8 mm for lateral wall. Surgeons can avoid injuries to the optic nerve by keeping these distances in mind for Indian population.

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