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Original Research Article

MORPHOMETRIC ANALYSIS OF ORBIT IN INDIAN SKULLS AND COMPARISON WITH INTERNATIONAL STUDIES

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ABSTRACT

Introdction: Morphometric analysis of skull is of great significance to anatomists, radiologists and medicolegal experts. Skull resists decomposition and is the preferred bone for identification of sex of an individual. Among several parameters, orbital measurements also show sexual dimorphism. Assessment of orbital dimensions is also important for surgical management of pathologies around orbit. Previous studies present large variations in orbital morphometry due to genetic and environmental factors, racial and ethnic differences, different measurement methods and sample size. Thus to obtain population specific standards, to assess the bilateral asymmetry and gender differences in orbital parameters, the present study was conducted.

Materials and Methods: The study was performed on 98 adult Indian skulls (196 orbits) consisting of 60 male and 38 female skulls ofknown age and sex. Parameters measured were Orbital height (OH), Orbital breadth (OB) and Orbital Index (OI) which were expressed in descriptive statistics i.e. mean, range and standard deviation.

Results: In the present study, in males, the mean OH for the right and left sides were 32.64±2.07 and 32.39±2.18mm respectively while their OB were 37.52±1.35 and 37.08±1.96mm respectively and the mean OI was 87.47. In Females, the mean OH for the right and left sides were 32.55±1.91 and 32.31±1.55mm respectively while their OB were 37.25±1.64 and 36.67±1.56mm respectively and the mean OI was 87.88.

Conclusion: The mean OI in the present study was 87.47 placing the Indian population in Mesoseme group. Difference in orbital breadth on two sides was statistically significant emphasizing bilateral asymmetry. However the gender differences in OH, OB and OI were statistically insignificant.

KEY WORDS: Orbital Height, Orbital Breadth, Orbital index; Morphometry; Sexual dimorphism; Skull.

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INTRODUCTION

Knowledge of morphometry of the skull is indispensible to anatomists, forensic experts, anthropologists and surgeons. Skull remains the most preferred bone for identification and sexual dimorphism because it is least perishable and resists fire, explosions and mutilations.Sex ofan individual can be identified accurately in 90% of casesusing skull alone and in 98% cases using pelvis and skull together [1]**.** Among other parts, orbits also show sexual dimorphism,male orbits are square,relatively smaller while orbit

of female skulls are usually rounder and relatively larger [2-4].

Orbit is the pyramid shaped bony cavity situated on either side of the root of the nose. Bones contributingto the framework of each orbit are the maxilla, zygomatic, frontal, ethmoid, lacrimal, sphenoid, and palatine bones. Each orbit contains eyeball and related muscles, vessels, nerves and lacrimal apparatus [5].

The orbit have important clinical implications as they can be involved in a number of congenital, traumatic, neoplastic, vascular and endocrine disorders [6]. Morphological knowledge of the orbit is also essential in several surgical procedures (ophthalmological, maxillary surgeries and reconstructive cosmetic surgeries of face) and in assessing syndrome such as Down syndrome [7-9].

The orbital characters including OI vary with age, sex, race, regions and ethnic groups and periods in evolution [7, 10-12]. It is necessary to determine their reference value in order to help anthropologists, forensic expertsand anatomists identify morphological variants of this structure and surgeons and physicians for surgical and cosmetic procedures. Hence the present study was conducted to find out the baseline measurements of both orbits in Indian subjects. The morphometric differences between two sexes were observed for and orbital symmetry for each individual was assessed.

MATERIALS AND METHODS

The study was conducted on 98 adult skulls (196 orbits) of known sex available in the Anatomy department of Govt. medical college, Aurangabad, of which 60 were male and 38 were female. Measurements were taken after putting the skull in Frankfurt's horizontal plane. The measurements of right and left side were recorded separately for male and female skulls. Instruments used for the measurement were Vernier caliper, scale and marker. Measurements were taken twice at different sittings and their average was taken.

Only dry, ossified, intact adult skullsfree of any deformity or artifacts were included in the study.

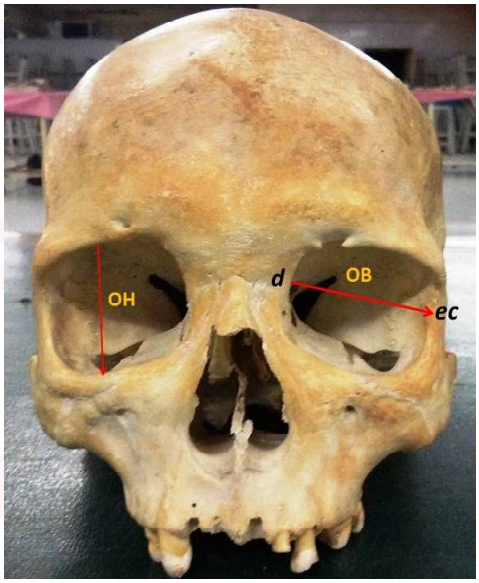
Following orbital parameters were measured in all the skulls on both the sides (**Fig.1**):

1. Orbital Breadth (OB): from the **dacryon (d)** to the **ectoconchionec (ec). [dacryon d**- The point of frontal, lacrimal, and maxillary intersection on the medial border of the orbit; **ectoconchionec**- Intersection of the lateral border of the orbit with a line bisecting the orbit along its long axis] [13].

2. Orbital Height (OH): the maximum vertical distance between the superior and inferior orbital margins

3. Orbital Index (OI): OI was calculated by dividing the orbital height with the orbital breadth and multiplying the result by 100 [10].

Fig. 1: Photograph showing the measurement of orbital breadth (OB) and orbital height (OH) (***d***-dacryon; ***ec***-ectoconchionec**)**



All the measurements were recorded in millimeters and were tabulated. Descriptive statistics i.e. mean, SD and Range were calculated. The results were analyzed using Statistical Package for Social Sciences (SPSS) version 18. The means of right and left sides and between the male and female samples were compared for significance using the Student t-test. Confidence intervalof 95% was assumed and the differences were considered significant at ≤ 0.05.

RESULTS

In male skulls, the mean OH for the right and left sides were32.64±2.07 and 32.39±2.18mm respectively while their OB was 37.52±1.95 and 37.08±1.96mm and OI was 87.28±7.94 and 87.66±8.61 respectively (Table 1).

Table 1: Orbital measurements (in mm) in adult Male skulls.

Parameters	Mean	SD	P value
ROH	32.64	2.07	0.0773
LOH	32.39	2.18	
Mean OH	**32.52**	**2.08**	--
ROB	37.52	1.95	**0.0021**
LOB	37.08	1.96	**(<0.05, Statistically Significant)**
Mean OB	**37.3**	**1.9**	--
ROI	87.28	7.94	0.4782
LOI	87.66	8.61	
Mean OI	**87.47**	**8.09**	--

R- Right, L-Left, OH-Orbital Height, OB-Orbital Breadth, OI-Orbital Index, SD- Standard Deviation

In female skulls, the meanOHfor the right and left sides were 32.55±1.91 and 32.31±1.55mm respectively while their OB was 37.25±1.64 and 36.67±1.56mm and OI was 87.52±6.15 and 88.24±5.22 respectively (Table 2).

Table 2: Orbital measurements (in mm) in adult Female skulls.

Parameters	Mean	SD	P value
ROH	32.55	1.91	0.1457
LOH	32.31	1.55	
Mean OH	**32.43**	**1.69**	--
ROB	37.25	1.64	**0.0001**
LOB	36.67	1.56	**(<0.05, Statistically Significant)**
Mean OB	**36.96**	**1.56**	--
ROI	87.52	6.15	0.1557
LOI	88.24	5.22	
Mean OI	**87.88**	**5.55**	--

R- Right, L-Left, OH-Orbital Height, OB-Orbital Breadth, OI-Orbital Index, SD- Standard Deviation

While comparing the parameters of right and left side for symmetry, it was observed thatalthough ROH>LOH, ROB>LOB and LOI>ROI in both sexes, the difference was statistically significant only between ROB and LOB (P<0.05), thus emphasizing bilateral asymmetry in orbital breadth.

It was observed while comparing the parameters between male and female skulls that the OH and OB was more and OI was less in males as compared to females but the difference were statistically insignificant (Table 3). The mean OI in male skulls was 87.47 and female skull was 87.88 placing the study population in Mesoseme category.

Table 3: Comparison of Orbital measurements in Male and Female skulls.

Parameters	Male		Female		P value
	Mean	SD	Mean	SD	
ROH	32.64	2.07	32.55	1.91	0.8442
LOH	32.39	2.18	32.31	1.55	0.8639
Mean OH	**32.52**	**2.08**	**32.43**	**1.69**	**0.85**
ROB	37.52	1.95	37.25	1.64	0.5436
LOB	37.08	1.96	36.67	1.56	0.3465
Mean OB	**37.3**	**1.9**	**36.96**	**1.56**	**0.4273**
ROI	87.28	7.94	87.52	6.15	0.8899
LOI	87.66	8.61	88.24	5.22	0.7446
Mean OI	**87.47**	**8.09**	**87.88**	**5.55**	**0.8111**

R- Right, L-Left, OH-Orbital Height, OB-Orbital Breadth, OI-Orbital Index, SD- Standard Deviation

DISCUSSION

Orbital Measurements: Metric parameters of skull including orbital height, breadth and index are useful for identification and sex determination. Morphometric parameters of orbit are also important in ophthalmology, oral maxillofacial surgery and neurosurgery. The measurements of orbit and the orbital index are known to vary with age, sex, race and regions in the same race [7, 10-12]. The knowledge of these measurements is must for their successful application.

In the present study, the mean OH in male skulls on the right and left sides were 32.64±2.07 and 32.39±2.18mm respectively (mean OH=32.52 mm±2.08), while their OB was 37.52±1.95 and 37.08±1.96mm (mean OB=37.3±1.90mm), and OI was 87.28±7.94 and 87.66±8.61 respectively (mean OI=87.47±8.09) (Table 1).

In female skulls, the mean OH for the right and left sides were 32.55±1.91 and 32.31±1.55mm respectively (mean OH=32.43mm±1.69), while their OB was 37.25±1.64 and 36.67±1.56mm (mean OB=36.6±1.56mm), and OI was 87.52±6.15 and 88.24±5.22 respectively (mean OI=87.88±5.55) (Table 2). These parameters are similar to those observed by Biswas et al. on Indian (Bengali) skulls, Weaver et al. on Caucasians and Ji et al on Chinese (Table 4, 5) [4, 12, 14]. Higher OH, OB and lower OI was observed by Mekala et al.on south Indian skulls could be due to environmental and genetic factors [15].

Variations in the observed parameters between different studies (Table 4, 5) may be due to racial differences, variations in the sample size, environmental and genetic factors or different measurement methods.

Orbital Asymmetry (**Table. 4**): While comparing the parameters of right and left side for symmetry, it was observed in this study that although ROH>LOH and ROB>LOB in both males and females, the difference was statistically significant only between ROB and LOB (P<0.05), thus emphasizing bilateral asymmetry in orbital breadth (Table.4).This is partly in agreement with the study by Fetouh and Mandour who observed both OH and OB were greater in the right side than in the left in both males and females with significant differences [6]. 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 [16]. A few studies, however, observed that the bilateral difference in height and width of the orbits was not significant statistically [3,15,17].

The slight difference observed between the right and left side, specifically OB in this study, could be attributed to the differential growth of the brain on two sides.This difference has to be kept in mind while surgical correction of the bony orbits.

Table 4: Comparison of means of Right and Left Orbital parameters (in mm) (Male & Female together).

Name and year of the study	No. of crania studied	Study population	Right Orbit			Left Orbit			MEAN OI	Type	Significant Side Differences in
			ROH	ROB	ROI	LOH	LOB	LOI			
Biswas et al (2015) [4]	n=53	Indian (Bengali)	32.1	36.6	86.59	32.95	36.55	90.05	**88.93**	**Mesoseme**	--
Kaur et al (2012) [11]	n=30	Indian (North)	31.9	39.7	80.35	32.2	38.8	82.99	**81.65**	Microseme	--
Kumar and Nagar (2014) [3]	n=68	Indian (North)	33.47	42.06	79.65	33.65	41.87	80.49	**79.97**	Microseme	--
Mekala et al (2015) [15]	n=200	Indian (South)	35.5	41.7	85.22	35.3	41.8	84.82	**85.8**	**Mesoseme**	--
Present Study (2016)	**n=98**	**Indian**	**32.64**	**37.52**	**87.28**	**32.39**	**37.08**	**87.66**	**87.47**	**Mesoseme**	**OB**
Jeremiah et al (2013) [10]	n=150	Kenyans	--	--	--	--	--	--	**83.03**	Microseme	--
Marinescu et al. (2014) [18]	n=200	Romanian	--	--	--	--	--	--	**84.23**	Mesoseme	--
Fetouh&Mandour (2014) [6]	n=52	Egyptian	35.68	43.19	82.62	34.99	42.3	82.72	**82.67**	Microseme	OH OB
Ukoha et al. (2011) [17]	n=70	Nigerian	31.9	36.03	88.54	31.45	34.98	89.91	**89.21**	Megasme	--
Pires et al (2016) [7]	n=77	Brazillian	32.89	37.15	88.53	--	--	--	**88.72**	**Mesoseme**	--
Elzaki et al. (2015) [20]	110 CT Scans	Sudanese	37.9	34.1	111.14	37.86	34.06	111.16	**111.15**	Megasme	--
Ji et al. (2015) [14]	64 CT	Chinese	33.45	39.1	85.55	33.28	38.94	85.46	**85.32**	**Mesoseme**	--
Igbigbi&Ebite (2010) [22]	136 X-rays	Malawian	--	--	--	--	--	--	**95.19**	Megasme	--
Sangvichien et al (2007) [19]	n=101	Thailand	--	--	--	--	--	--	**84.83**	**Mesoseme**	--
Weaver et al (2010) [12]	39 CT	Caucasian	--	--	--	32	36.9	86.72	**86.72**	**Mesoseme**	--

R- Right, L-Left, OH-Orbital Height, OB-Orbital Breadth, OI-Orbital Index, SD- Standard Deviation

Orbital Index and racial differences: Patnaik et al stated that in each orbital cavity, the width is usually greater than the height, the relation between the two is given by the orbital index, which varies in different races (Orbital Index= Orbital Height/Orbital Breadth). Using the OI, Orbits are classified into three types: **Megaseme** (OI >89) for the Orientals (except the Eskimos) where the orbital opening is round, **Mesoseme** (89 > OI > 83) for the Caucasians and **Microseme** (OI $\leq$ 83) for the Africans where the orbital opening is rectangular [8, 21].

Orbital index is essential for fossil records interpretation, classification of skull and understanding the trends in evolutionary and ethnic differences.Knowledge of orbital indices is essential in the evaluation and diagnosis of craniofacial syndromes and post traumatic deformities [15].

The orbital index gives an idea about the shape of the orbit.In the present study, the mean OI was 87.47 placing the study population in **Mesoseme** category [Table 4]. This is in accordance with study of Mekala et al on south Indian skulls with mean OI of 85.80 placing them under Mesoseme category [15]. The results partly corroborates with Biswas et al who observed the orbital indices for the male skulls fall in the Mesoseme category (86.89) while that for the female skulls fall in the Megaseme category

(90.31) in Bengali Indian skulls [4]. The orbital index in the present study is similar to Caucasians in which the orbits are of Mesoseme type [21].

The result is contrary to previous study by Kumar and Nagar which observed OI of 79.97 and by Kaur et al. which observed OI of 81.65 classifying north Indian skulls as microseme [3, 11]. The OI of the present study differfrom Egyptian (mean OI of 82.27 in males and 83.5 in females) and Kenyan (mean OI of 82.57 in males and 83.48 in females) skulls which grouped them in Microseme category [6, 10].

Studies in Nigerians (mean OIof 89.21) and Malawians (mean OI of 94.35 in males and of 96.03 in females) grouped them in Megaseme category [17, 22].

Asymmetry in OI (Table 4): In the present study, the mean LOI was more than ROI emphasizing asymmetry between right and left orbits but the difference was not significant. Similar observations [Table.4] were made on Indian, Egyptian, Nigerian and Sudanese orbits [4, 3, 6, 11, 17, 20]. Ji et al in Chinese and Mekala et al. in south Indian skulls however, observed ROI to be more than LOI [15, 14].

Gender Differences in OI (Table 5): In the present study, the mean OI in female skull was 87.88 which was more than that in male skulls (87.47). The difference, however, is statistically not significant to warrant the use of the OI in sexual dimorphism of skulls in Indian population. The higher OI found among orbits of female subjects was similar to what has been reported in previous studies [Table.5] conducted among different populations [6, 10, 15, 22]. However, Biswas et al and Sangvicichien et al observed significantly higher OI in female than male skulls [4, 19].

Comparison withdifferent studies shows that there is a large variation in orbital morphometry due to genetic and environmental factors, racial and ethnic differences, different measurement method and sample size (Table 4, 5).

Table 5: Comparison of means of Orbital parameters between Males and Females (in mm) (Right & Left together).

Name and year of the study	No. of crania studied	Study population	Males			Females			Significant Gender Difference in
			Mean OH	Mean OB	Mean OI	Mean OH	Mean OB	Mean OI	
Biswas et al (2015) [4]	n=53	Indian (Bengali)	32.15	37.15	86.9	32.75	36.35	90.31	Left OI
Mekala et al (2015) [15]	n=200	Indian (South)	36.2	42.9	84.62	34.5	40.5	85.46	OB OH
Present Study (2016)	**n=98**	**Indian**	**32.52**	**37.3**	**87.47**	**32.43**	**36.96**	**87.88**	---
Jeremiah et al (2013) [10]	n=150	Kenyans	--	--	82.57	--	--	83.48	---
Marinescu et al. (2014) [18]	n=200	Romanian	33.1	39.9	82.96	32.6	38.1	85.56	OB
Fetouh&Mandour (2014) [6]	n=52	Egyptian	35.57	43.25	82.27	35.12	42.37	83.5	OB
Ukoha et al. (2011) [17]	n=70	Nigerian	33.35	36.03	92.56	33.22	34.98	94.97	---
Elzaki et al. (2015) [20]	110 CT	Sudanese	38.73	34.92	110.9	37.51	33.71	111.2	OB OH
Ji et al. (2015) [14]	64 CT	Chinese	33.35	40.02	83.33	33.22	38	87.42	OB
Igbigbi&Ebite (2010) [22]	136 X-rays	Malawian	42.07	44.57	94.35	40.26	42.15	96.03	---
Sangvichien et al (2007) [19]	n=101	Thailand	33.44	40.1	83.5	32.89	38.09	86.61	OB OI
Weaver et al (2010) [12]	39 CT	Caucasian	32.44	37.42	86.69	31.75	36.6	86.75	---

R- Right, L-Left, OH-Orbital Height, OB-Orbital Breadth, OI-Orbital Index, SD- Standard Deviation

CONCLUSION

In the present study the mean OI was 87.47 placing the Indian study population in Mesoseme group. OH and OB was more and OI was less on right side than the left side. However, only the difference in Orbital breadth was statistically significant emphasizing bilateral asymmetry in orbital breadth. OH and OB was more and OI was less in male skulls than the female skulls. However the differences were statistically insignificant excluding their role in the sexual dimorphism of the skull.

The present study provides baseline measurements of both the orbits in Indian population thus adding population specific standards in craniometric database. A comparison with different studies and population in discussed in detail. This complete data will serve as a guide

to anatomists, ophthalmologists, oral and maxillofacial surgeons and forensic experts. The measurements can also be used for determining race, ethnicity, gender etc.

Conflicts of Interests: None

REFERENCES

[1]. Krogman WM, Iscan YM. The Human Skeleton in Forensic Medicine (2nd Edition) 1986. Springfield, Illinois, U.S.A. Charles C. Thomas Pub Ltd.

[2]. Kanchan T, Krishan K, Gupta A, Acharya J. A Study of Cranial Variations Based on Craniometric Indices in aSouth Indian Population. J Craniofac Surg. 2014;25:1645-9.

[3]. Kumar A, Nagar M. Morphometry of the Orbital Region: "Beauty is bought by judgement of the eyes". Int J Anat Res. 2014;2(3):566-70.

[4]. Biswas S, Chowdhuri S, Das A, Mukhopadhyay PP. Observations on Symmetry and Sexual Dimorphism from Morphometrics of Foramen Magnum and Orbits In Adult Bengali Population. J Indian Acad Forensic Med.2015;37(4):346-51

[5]. Standring S, et al. Gray's Anatomy: The Anatomical Basis of ClinicalPractice. Churchill Livingstone and Elsevier; 2008; 40: 419-20.

[6]. Fetouh FA, Mandour D. Morphometric analysis of the orbit in adult Egyptian skulls and its surgical relevance. Eur J Anat. 2014;18(4):303-15.

[7]. Pires LAS, Teixeira AR, Leite TFO, Babinski MA,Chagas CAA. Morphometric aspects of the foramen magnum and the orbit in Brazilian dry skulls. International Journal of Medical Research &Health Sciences, 2016, 5, 4:34-42

[8]. Patnaik, V.V.G., BalaSanju, SinglaRajan, K.: Anatomy of the bony orbits-Some applied aspects. Journal of The Anatomical Society of India. 2001;50(1):59-67.

[9]. Ghosh A, Manjiri C, Mahaptra S. The craniofacial anthropometric measurements in a population of normal newborns of Kolkata.Nepal journal of medical sciences. 2013; 2(2): 12-9.

[10]. Jeremiah M, Pamela M and Fawzia B. Sex differences in the cranial and orbital indices for a black Kenyan population. International Journal of Medicine and Medical Sciences 2013; 5(2):81-84

[11]. Kaur J, Yadav S, Sing Z. Orbital dimentions – A direct measurement study using dry skulls. J. Acad. Indus. Res. 2012; 1(6):293-5.

[12]. Weaver AA, Loftis KI, Tan JC, DumaSM, Stitzel JD. CT scan based three-dimensional measurement of orbit and eye anthropometry. IOVS. 2010; 51(10): 4892-7.

[13]. Buikstra JE, Ubelaker DH: Standards for data collection from human skeletal remains. Arkansas Arch Survey 1994, 44.

[14]. Ji Y, Qian Z, Dong Y, Zhou H, Fan X. Quantitative morphometry of the orbit in Chinese adults based on a three-dimensional reconstruction method. J Anat. 2010; 217(5):501-6.

[15]. Mekala D, Shubha R, Rohini Devi M. Orbital dimensions and Orbital index: a measurement study on south indian dry skulls. Int J Anat Res 2015;3(3):1387-1391.

[16]. Teul I, Czerwinski F, Gawlikowska A, Konstanty-Kurkiewicz V, Stawinski G Asymmetry of the ovale and spinosum foramina inmediaeval and contemporary skulls in radiologicalexamination. Folia Morphol, 2002; 61: 147-152.

[17]. P. Ukoha U, Egwu O, Okafor I, Ogugua P, Onwudinjo O, Udemezue O. Orbital dimensions of adult male nigerians: a direct measurement study using dry skulls. Int JBiol Med Res. 2011;2(3):688-90.

[18]. Marinescu M,Panaitescu V, Rosu M, Maru N, Punga A. Sexual dimorphism of crania in a Romanian population: Discriminant function analysis approach for sex estimation. Romanian Journal of Legal Medicine 2014; 22:21-26.

[19]. Sangvichien S, Boonkaew K, Chuncharunee A, Komoltri C, Piyawinitwong S, Wongsawut A, Namwongsa S. Sex determination in Thai skulls by using craniometry: Multiple logistic regression analysis. Siriraj Med J 2007;59:216-221.

[20]. Elzaki MM, Ayad CE, Hassan HA, Abdalla EA. Cranio-OrbitoZygomatic Normative Measurements In Adult Sudanese: CT Based Study. GloAdv Res J Med Med Sci. 2015;4(11):477-84.

[21]. Evans BT, Webb AAC. Post-traumatic orbital reconstruction: Anatomical landmarks and the concept of the deep orbit. Br. J. Oral. Maxillofac Surg 2007;45:183-189.

[22]. Igbigbi PS, Ebite LE. Orbital Index of Adult Malawians. Anil Aggrawal's Internet Journal of Forensic Medicine and Toxicology. 2010;11(1):P21.

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