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Morphometric Study of Orbital Index in Dry Fully Ossified Human Skulls

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Abstract: ***Background:*** The orbits are craniofacial structures and situated in the skull on either side of sagittal plane. The orbits enter the facial and cranial regions equally and each orbital cavity acts as a socket for the eyeball essentially. It also supports associated muscles, vessels, nerves, fascial strata, lacrimal apparatus, soft pad of fat and lodges the visual apparatus. Bony orbit is a very important area for anatomists, forensic experts, anthropologists as well as surgeons. ***Methods:*** This cross-sectional analytical study was carried out in the Department of Anatomy, Dhaka Medical College, Dhaka over a period of one year from January 2020 to December 2020. The study was conducted on 70 dry fully ossified human skulls and height, weight and index of orbit were measured and compared between right and left side. Data were analyzed by SPSS software, version-24 and p value < 0.05 was considered statistically significant for all tests. ***Results:*** The study revealed that in the right side, the mean orbital height, width and index were 33.64±0.88 mm, 39.63±1.66 mm and 85±3.45%, respectively. In the left side, the mean orbital height, width and index were 33.54±1.0 mm, 39.48±1.25 mm and 85.03±3.13%, respectively. There was no statistically significant difference of orbital height, width and index between right and left side (p = 301, p = 328 and p = 954, respectively). ***Conclusion:*** The present study was an attempt to produce a morphometric data on different variables (Orbital height, width and index) of fully ossified dry human orbital cavities.

Keywords: Orbital Height, Orbital Width and Orbital Index.

Original Researcher Article

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Article at a glance:

Study Purpose: *The purpose of the study was to determine the morphometric measurements of orbital index in dry fully ossified human skulls.*
Key findings: *The mean orbital height, width and index were 33.64±0.88 mm, 39.63±1.66 mm and 85±3.45%, respectively in right side and 33.54±1.0 mm, 39.48±1.25 mm and 85.03±3.13%, respectively in left side.*
Newer findings: *There was no statistically significant difference was found between right and left side in terms of orbital height, width and index.*
Abbreviations: *SPSS: Statistical package for social sciences, CT: Computed tomography and MRI: Magnetic resonance imaging.*

INTRODUCTION

The bony orbits are skeletal cavities situated on either side of the root of the nose and act as sockets for the eyes and associated tissues. The walls of each orbit protect the eye from external injury and provide attachment for six extraocular muscles. These muscles are responsible for correct positioning of the visual axis and determine the spatial relationship between both eyes. Spatial relationship is essential for both binocular vision and conjugate eye movements.[1]

The orbital shape is roughly pyramidal and the apex located posteriorly forming the optic canal and the orbital margin is formed by the base which is anteriorly located. This pyramid is not straight directly but medially tilted which is responsible for the human stereoscopic vision. The shape of orbital margin is quadrilateral with rounded corners. The superior orbital margin is continuous down into the posterior lacrimal crest, while the inferior is continuous with the anterior lacrimal crest.[2] The

orbital margin is formed by the frontal bone superiorly, the zygomatic bone and the maxilla inferiorly, the processes of the frontal and zygomatic bones laterally and the processes of the maxilla and the frontal bone medially.[3] Each orbit is formed by a base or orbital opening, apex, floor, roof, medial and lateral walls. Each of four bony walls of orbit has own unique features and is perforated by a number of fissures and foramina that carries important blood vessels and nerves.[4]

Frontal process of the maxilla, the lacrimal bone, the orbital plate of the ethmoid and the body of the sphenoid form the medial wall from before backward.3 Being very thin, this wall is important surgically and separates the contents of the orbit from the ethmoidal labyrinth. The anterior and posterior ethmoidal foramina are situated along the fronto-ethmoidal suture and more posteriorly the optic canal on this wall.[5] The lateral orbital wall is formed by zygomatic bone and the greater wing of sphenoid bone. This wall is important during intraorbial operations like exploration of orbital fractures, lateral orbitotomy and excision of the lacrimal gland.[6] Superior orbital wall is formed principally by orbital plate of frontal bone. This wall is important during several procedures like orbital decompression, frontal sinus obliteration, exploration for fractures and orbital exenteration.[7] Orbital plate of the maxilla forms the inferior wall of orbit and creates separation between the orbital cavity and the maxillary sinus.3 Important related procedures of inferior wall are orbital floor exploration and maxillectomy and is an important landmark during endonasal endoscopic surgery of the skull base.[7]

As the morphometry of the human skull can differentiate sex and ethnicity, the study of morphometry of it is a common practice among anatomists, forensic experts, anthropologists and surgeons.[8] According to Mungati, Mandela and Butt [9] and Ukoha *et al.*[10] the locations of various foramina in the orbit vary in different ancestral populations. The recent research by various authors showed that there is significant variation in morphometry of orbits among different races.[11]According to Yonguc *et al.*[12], Agrawal *et al.*[13] and Singh *et al.*[14] no significant differences were found between right and left orbital cavities of Chinese, Indian and Malaysian population. Again, Natsis *et al.*[15], Sreekanth and Hema[16] and Piagkou *et al.*[17] found some asymmetrical variables between right and left orbital cavities of European, Indian and Greek Caucasian population.

The study of orbital index is useful for surgical and clinical treatment in ophthalmology, maxillofacial and oral surgery, neurosurgery and plastic surgery and also in the design of eye protective equipment. The knowledge of orbital index is also important in various aspects such as anthropological investigation of unknown individuals for determining ethnicity, gender, skull classification in forensic medicine, interpretation of fossil records and in exploring the trends in ethnic and evolutionary differences.[18] Understanding the structural disposition of the human body is clearly aided by the advances in medical imaging techniques such as radiography, CT scan, MRI etc. But direct measurement on dry skulls is different and more natural perspective in assessing the orbital cavities.[10,19] Race, ethnicity, gender as well as age can effectively be determined through measurements of orbital structure. As pointed out by many previous parts of world, orbital morphometry varies not only with sex, race but also with regions. Not many studies had been done pertaining to morphometry of orbit in Bangladeshi population skulls. This study provided useful baseline orbital morphometric data of our population which are very important during plastic surgery, maxillofacial and neurosurgeries and also in the design of eye protective equipment.

METHODS

This cross-sectional analytical study was conducted in the Department of Anatomy, Dhaka Medical College, Dhaka over a period of one year from January 2020 to December 2020. Dry fully ossified human orbital cavities were the study population. However, damaged one or both orbital cavities were excluded from the study. A total of 70 dry fully ossified human orbital cavities that fulfilled the eligibility criteria were purposively taken as study sample. Consulting with the supervisor and reviewing the previous published literature, a semi-structured questionnaire was developed for the study. The morphometric parameters (orbital height, orbital width and orbital index) of orbit were measured and compared between right and left side by independent sample

t test. Measurements were taken by a Digital Sliding Vernier Caliper of 0.1 mm accuracy.

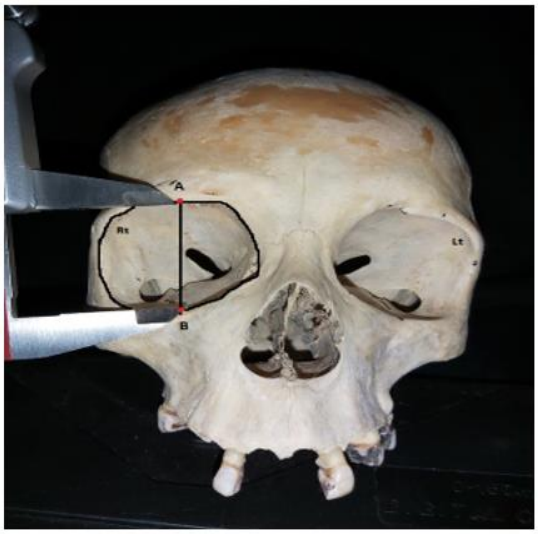

Figure 1: Height of right orbital cavity. AB = orbital height

Figure 2: Width of right orbital cavity. AB = orbital width, A = Dacryon, B = Ectochion

Maximum height of the orbit was measured which was perpendicular to the orbital width. To measure this distance, a point was identified in superior orbital margin and marked by red dot. Another point was taken in inferior orbital margin and marked with red dot. Sliding jaws of Vernier Caliper were fixed on two points and measured the distance in millimeter.[20] To measure orbital width a point on the medial border of the orbit at which the frontal, lacrimal and maxilla bone intersect (Dacryon) was identified and marked by red dot. Another point was the most lateral point in the lateral wall of the orbit (Ectochion) and marked by a red dot. Distance between two red dots was measured by Digital Vernier Caliper and recorded in millimeter.[20]

Orbital index was calculated by following formula

$$\text{Orbital Index (\%)} = \frac{orbital\ height}{orbital\ width} \times 100$$

Orbital index was calculated for each orbital cavity.

RESULTS

In right side, the mean orbital height was 33.64±0.88 mm and ranged from 31.49 mm to 35.37 mm. In left side, the mean orbital height was 33.54±1.0 mm and ranged from 31.37 mm to 35.70 mm. The mean orbital height was slightly higher in right side than left but it was not statistically significant (p=0.301) (Table 1).

Table 1: Comparison of orbital height between right and left orbital cavities (n=70 in each side)

Orbital height	Right side n=70	Left side n=70	p-value
Mean±SD (mm)	33.64±0.88	33.54±1.0	0.301 (non-significant)
Range (mm)	31.49 - 35.37	31.37 – 35.70	

The range of orbital width were 36.21 mm to 41.81 mm and 36.07 mm to 42.88 mm in right and left side, respectively. The mean orbital width in right and left side were 39.63±1.66 mm and 39.48±1.25 mm, respectively. No significant (p=0.328) difference was observed between right and left orbital width (Table 2).

Table 2: Comparison of orbital width between right and left orbital cavities (n=70 in each side)

Orbital width	Right side n=70	Left side n=70	p-value
Mean±SD (mm)	39.63±1.66	39.48±1.25	0.328 (non-significant)
Range (mm)	36.21 – 41.81	36.07 – 42.88	

The mean orbital index was 85±3.45% and 85.03±3.13% for right and left sides, respectively. The range for right orbital index was 76.23% to 96.08% and for left side it was 78.23% to 95.57%. No statistically significant (p=0.954) difference was found between right and left orbital index (Table 3).

Table 3: Comparison of orbital index between right and left orbital cavities (n=70 in each side)

Orbital index	Right side n=70	Left side n=70	p-value
Mean±SD (%)	85.00±3.45	85.03±3.13	0.954 (non-significant)
Range (%)	76.23 – 96.08	78.23 – 95.57	

DISCUSSION AND CONCLUSION

Several pathological conditions such as trauma, tumour, etc affect the bony orbit of human. Orbital decompression, exploration of the bony orbit or even exenteration of the eyeball may be required in such circumstances. Precise knowledge on orbital index is essential to prevent serious injuries to the neurovascular structures passing through the orbit. In the present study, the mean orbital height between right and left orbital cavities was not significant ($p < 0.05$). Same finding was considered for the population of Umma *et al.*[21] in Bangladesh, Pereira *et al.*[22] in Brazil, Sreekanth and Hema[16] in India, Yonguc *et al.*[12] in Turkey, Thuanthong and Sudwan [23] in Thailand, Ji *et al.*[25] in China, Badiu *et al.*[26] in Italy, Ukoha, *et al.*[10] in Nigeria.

A human race is defined as a group of people with certain common inherited features that distinguish them from other groups of people. Jodi Blumenfeld [24] recognized four human racial subspecies: *Homo sapiens europaues* (Caucasoid), *Homosapiens asiatics* (Mongoloid), *Homo sapiens afer* (Negroid) and *Homo sapiens americanus* (Australoid). Bangladesh has many ethnic groups which carry a diversity of genes and cultural traits. In the present study, no significant difference was observed the mean orbital width between right and left orbital cavities. Similarly, same finding was found with the studies done by Umma *et al.*[21] in Bangladesh, Pereira *et al.*[22] in Brazil, Sreekanth and Hema[16] in India, Yonguc *et al.*[12] in Turkey, Thuanthong and Sudwan[23] in Thailand, Ji *et al.*[25] in China, Badiu *et al.*[26] in Italy, Ukoha *et al.*[10] in Nigeria between right and left orbital cavities.

Measurements taken from orbital cavities have shown a slightly higher mean values for right side compared to left orbital cavities. The findings of present study were statistically analyzed and it revealed important information about morphometric measurements in right and left orbital cavities. Results of this study were compared with other studies of different countries like India, Brazil, Europe, Malaysia, Thailand, Turkey, Egypt, Kenya obtained from different publications. Different variables of the present study showed some similarities as well as dissimilarities with findings of other studies which were studied on different racial groups of different countries. Admixture of different races, different geographical distribution, different climates, different cultures, use of different measurement techniques and also different sample size and different age group of study samples cause variations among populations. In the present study, the mean orbital index was not statistically significant. Compared to the present study, Umma *et al.*[21], Sreekanth and Hema[16], Fetouh *et al.*[27] showed similarity for Bangladeshi, Indians and Egyptian populations. Badiu *et al.*[25] and Ukoha *et al.*[10] also found same similarity for Romanian and Nigerian population respectively.

There were some limitations of the study. The skeletons available in Bangladesh might come from neighboring countries. It cannot be ensured that these collected skeletons belonged to the orbital cavities of Bangladeshi people only. The samples were collected from Dhaka medical college in Dhaka city only which might not represent the actual picture of the entire population of Bangladesh. The study was based on physical measurement procedure which might have produced minor errors of measurements. As sample size was limited, racial and regional factors were not considered in current study. No statistically significant difference was found in orbital height, orbital width and orbital index between right and left side. Comparison was made between the study samples and the other countries. This may contribute to the understanding of the relative status of the study sample in the context of morphometric variations around the world.

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Authors contributions

ZF, SA, MAAM: Concept and design, data acquisition, interpretation, drafting and final approval. MAAM and TK: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

Declarations

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Conflict of interest: Authors declared no conflict of interest.

Ethical Approval: Ethical approval of the study was obtained from the Ethical Review Committee, Dhaka Medical College, Dhaka. As the study was done on dry adult human skulls (dead connective tissue), the ethical issues of the participants were not to be addressed. Verbal consent was obtained from them who voluntarily had been given consent to participate in the study by supplied their collected bones.

Consent for publication: Taken.

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