SUBMITTED 9 NOV 21
REVISIONS REQ. 18 JAN 22; REVISIONS RECD. 27 JAN 22
ACCEPTED 27 FEB 22
ONLINE-FIRST: MARCH 2022
DOI: https://doi.org/10.18295/squmj.3.2022.023

Radiologic Assessment of Orbital Dimensions among Omani Subjects

Computed tomography Imaging-based study at a single tertiary center

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Abstract

Objectives: A sound knowledge of the normal orbital dimensions is clinically essential for successful surgical outcomes. Racial, ethnic, and regional variations in the orbital dimensions have been reported. This study aimed to determine the orbital dimensions of Omani subjects who had been referred for computed tomography (CT) images at a tertiary care hospital. ***Methods:*** A total of 273 Omani patients referred for a CT scan of the brain were evaluated retrospectively, using electronic medical records database. The orbital dimensions were recorded using both axial and sagittal planes of CT images. ***Results:*** The mean orbital index (OI) was found to be 83.25±4.83, and the prevalent orbital type was categorized as mesoseme. The mean orbital index was 83.34±5.05 and 83.16±4.57 in males and females, respectively, with their difference being statistically not significant (p=0.76). A statistically significant association was observed between the right and left orbits regarding horizontal distance ($p<0.05$) and vertical distance ($p<0.01$) of orbit and OI ($p<0.05$). No significant difference between the OI and age groups was observed in males and females. The mean interorbital distance and interzygomatic distance were found to be 19.45±1.52 mm and 95.59±4.08 mm, respectively. These parameters were significantly higher in males ($p<0.05$). ***Conclusions:*** Results of the present study provide reference values of orbital dimensions in

Omani subjects. The prevalent orbital type of Omani subjects is mesoseme, which is a hallmark of the white race.

Keywords: Computed Tomography**,** Ethnicity, Orbit**,** Oman**,** Variation, Hypertelorism.

Advances in Knowledge

- This is the first study to evaluate the orbital dimensions of the Omani population.
- Results of the present study provide reference values of orbital dimensions in Omani
- subjects.
- The prevalent orbital type of Omani subjects is mesoseme, a hallmark of the white race.

Application to Patient Care

1. The reference values of orbital dimensions including orbital index, interorbital distance and interzygomatic distance reported in this study are essential for diagnosing and treating various orbital pathologies.
2. These values are also crucial for surgical corrections of craniofacial anomalies such as orbital hypertelorism, hypotelorism, and orbital clefts.

Introduction

The bony orbit or orbital cavity is a complex anatomical region of the facial skeleton. The orbit and its contents are affected by various diseases[1] and craniofacial anomalies such as orbital hypertelorism, hypotelorism, and orbital clefts.[2,3] The majority of orbital diseases and craniofacial anomalies require a thorough knowledge of the normal orbital dimensions to diagnose and treat them effectively. Previously, many studies have enumerated the reference values of orbital dimensions among different populations.[1,4,5] These studies reported a significant variation in orbital dimensions depending on the race and ethnicity of the population. Generally, the orbit shape differs according to ancestry: rectangular orbits are present in Africans, angular orbits in northern and southern Europeans, and round orbits in Central Asians and Central Europeans.[6] In most circumstances, the breadth of the orbital cavity is greater than the height, and the orbital index (OI) reflects this relationship. Paul Broca has developed OI to quantitatively enumerate the orbit size and symmetry for the first time.[5] OI refers to the proportion of orbital height to the orbital width multiplied by 100%. The shape of the face determines the OI of an individual.[4] Based on different values obtained from previous research, OI is classified into three categories. The first category is megaseme, which refers to a large index and is seen in yellow races. The second category is mesoseme, which indicates intermediate value and is associated with the white races. And the small one, microseme, is a characteristic of the black races.[7]

Craniofacial indices are a reliable source to provide successful results for ethnicity identification compared to appendicular skeletal remains indices.[8] Radiological investigations are frequently used for craniofacial indices where the dry bone collection is impossible.[9] Factors such as gender, age and laterality influences on OI have been reported in the majority of the studied populations.[10-12] The interorbital distance (IOD) is typically used as diagnostic criteria in evaluating craniofacial anomalies such as hypertelorism, hypotelorism, and orbital clefts.[2,3,13] This parameter is also used to determine the severity of these anomalies and while planning the surgical correction.[14,15] In addition to the clinical importance, orbital dimensions are frequently used in anthropology and forensic medicine.[11] Till date, there are no studies to evaluate the orbital dimensions of the Omani population. Hence, in the present study, we sought to provide the baseline data of OI and IOD of Omani subjects referred for CT scans at a tertiary care hospital and classify them under one of the three predetermined categories.

Materials and methods

In the present study, the adult Omani patients (aged ≥18 years) who had visited tertiary care referral center in the Department of Radiology and Molecular Imaging in Oman were studied retrospectively using an electronic medical records database (TrakCare Unified Health Information System). The study was conducted after receiving ethical approval from the Medical Research Ethics Committee. Thank you for the comments. In the present study, we included all the consecutive patients of either sex aged ≥18 years who had been referred for a CT scan of the brain during the period from 1st January 2019 to 31st March 2019. After applying the inclusion and exclusion criteria there were 273 Omani patients. This statement has been added in the methods section. The patients with orbital fractures and ocular or facial surgery or deformity were excluded. In addition, scans with motion artifacts or incomplete coverage of the orbits and those performed for non-Omani patients were excluded as well from the study sample.

All the CT scans were performed as per the routine standard protocol for non-enhanced CT of the brain using 64 slice multidetector CT (Siemens Sensation 64) with kilovoltage peak of 120 kV and tube current modulation. The images and measurements were assessed using the

Picture Achieving and Communication System (PACS) (Synapse PACS, FUJIFILM Worldwide, version 5.7.102).

The measurements were performed using the reconstructed thin slices of 1.2 mm in the bone window. A window width/window level of 2000/500 was used while screening the images. The following measurements were performed for every subject: the inter-orbital distance, inter-zygomatic distance, horizontal orbital diameter and vertical orbital diameter. First, the orientation of the axial images was adjusted to Frankfort horizontal plane which is defined as the line from the highest point of the opening of the external auditory canal to the lower margin of the orbital rim.[16] After adjusting the axial plane, the IOD was measured as the minimal distance between the medial orbital walls (Figure 1). The interzygomatic distance (IZD) was determined as the maximum distance between the anterior aspects of the zygomatic arches (Figure 1). The horizontal distance of orbit (HDO) for each orbit was measured as the maximum distance from the anterior lacrimal crest to the lateral orbital wall (Figure 2a). The vertical distance of orbit (VDO) was performed in the sagittal plane after adjusting the angulation of the sagittal image along the long axis of the orbit and measured as the maximum distance between the frontal and the maxillary bones (Figure 2b). Finally, OI was calculated using the following formula: OI = VDO/HDO*100.

Statistical Package for the Social Sciences (SPSS, version 23.0, IBM Corporation, NY, USA) for Windows was used to analyze the data. The data were presented as mean and standard deviation. Independent sample *t*-test was used to determine the associations between the orbital dimensions and gender, while paired *t*-test was used to determine the laterality difference. The association between the orbital dimensions and age groups were determined using One-way ANOVA. The differences were considered significant at *p*-value <0.05.

Results

In the present study, we evaluated 546 orbits from 273 patients. Among these patients, males were 136 (49.82%), and females were 137 (50.18%). The mean age of the study subjects was 58.81 years ± 19.41, with a range of 18 to 94 years. Only one observer was involved in screening all the 273 subjects' CT scans to measure the orbital dimensions. The mean HDO of the right and left orbits was 39.76±1.75 mm and 39.42±1.66 mm, respectively. The mean VDO of the right and left orbits was 32.83±1.90 mm and 33.01±1.89 mm, respectively.

As described in the methods, the OI was calculated using the VDO and HDO. The mean OI of the right side and left side orbits were found to be 82.67±5.36 mm and 83.83±4.93 mm, respectively. A statistically significant association was observed between the right and left orbits with regard to HDO ($p<0.05$) and VDO ($p<0.01$) and OI ($p<0.05$) (Table 1). The associations of orbital dimensions with respect to gender are presented in Table 2. There was no significant association between gender and OI of both sides of the orbit. The OI in different age groups of female and male patients is presented in Table 3 & 4, respectively. There was no significant association between age groups and IO among the study subjects. The mean IOD and the mean IZD distance were found to be 19.45±1.52 mm and 95.59±4.08 mm, respectively. The mean IOD ($p<0.05$) and the mean IZD ($p<0.05$) were significantly higher in males when compared to females.

Discussion

In the past, several radiological and anatomical studies have been conducted to explore the bony dimensions of the orbit. Evidence from these studies reported a significant variation among different races, ethnicities, and within the region. The reporting of reference values of orbit dimensions is clinically important for a better diagnosis, surgical approach and outcome, and follow-up of various orbital pathologies. The knowledge of orbit dimensions pertaining to each race and ethnic group is also crucial in anthropology and forensic medicine, particularly for identifying and classifying the skull. Despite having tremendous importance, the normative bony dimensions of the orbit were not studied in all populations world-wide. To date, the OI has been documented only in three populations from the Middle Eastern region, including Egypt,[17] Turkish[18] and Iranian[19] populations. To the best of our knowledge, for the first time, we report the baseline data of orbit dimensions, including OI, IOD, and IZD in the Omani population.

The orbital cavity possesses greater height than width and is typically classified into three categories: microseme, mesoseme, and megaseme. Previously, studies from different Asian countries, including Japan, China, India, Sri Lanka, Turkey and Iran, have documented the OI of their respective populations and classified them under one of the categories.[1,4,5] In the present study, the mean OI of Omani subjects was found to be 83.25±4.83, and the prevalent orbital type was categorized as mesoseme. Similar to the present study, the mesoseme orbital class was found in the Iranian population. In Egyptian female subjects, it was mesoseme while it was microseme in male subjects. In the Turkish population from the middle-eastern region, the megaseme orbital category was observed.[18]

In the literature, there are conflicting reports on the sexual dimorphism of OI. In Omani subjects, the observed OI of males was 83.34±5.05, while it was 83.16±4.57 in females. Both genders belonged to the mesoseme category. No significant gender difference in OI was observed in the Omani subjects. Similar findings were reported in Brazillian[5] and South Indian subjects[20], and in Kalabaris and Ikwerres of the Rivers ethnic group of Nigeria.[21] In contrast, a significant gender difference in OI was found in the Igbo and Urhobos ethnic groups of Nigeria and Ghanaian subjects.[4] In agreement with these studies, gender differences in bony volume and dimensions were observed even in the Iranian population.[19]

Furthermore, in Omani subjects, the laterality differences with HDO, VDO and OI were statistically significant. These findings are similar to the study results from the Iranian population.[19] However, contradictory findings of laterality differences were observed in Indian,[20] Nigerian[22] and Ghanaian[4] populations. In the present study, there were no significant differences in OI among different age groups in both males and females. Similar findings were observed in Ghanaian subjects.[4] However, in the Malawian[7] and Igbo ethnic groups of Nigerian subjects,[22] the OI was significantly different in different age groups. These discrepancies observed between the studies with regard to orbital dimensions and their associated factors are possibly due to genetic factors.

The IOD is clinically used to diagnose both orbital hypotelorism and hypertelorism. Orbital hypertelorism is distinguished by a longer IOD, most often associated with a variety of craniofacial conditions, including Crouzon syndrome, craniofacial dysplasias and clefts.[23] On the other hand, hypotelorism is also linked to several diseases, including holoprosencephaly and craniosynostosis.[24] Reference values are also important while correcting the surgeries involving the above-mentioned craniofacial anomalies. Previously, authors have provided the reference values of IOD for different populations. An IOD of 26.7 and 25.6 mm was observed in American males and females, respectively.[13] In the Indian population, the reported overall mean IOD was 26.89 mm, while in males and females, the mean distance was 27.46 mm and 25.93 mm, respectively.[1] In the present study, the observed IOD values (males: 19.79±1.46; females: 19.12±1.52) were lower than those reported in Indian and American subjects. However, the mean IOD of Omani subjects was close to that of the

Iranian population (males: 23 mm; females: 21.7 mm).[25] In previous studies, the observed normal IZD was within the range of 90 mm and 109 mm.[1,26,27] In line with these studies, the interzygomatic distance in Omani subjects is found to be within this range.

The variations in orbital dimensions among different populations world-wide could be attributed to the evolutionary processes wherein inheritable mutations can generally occur by natural selection. As a result, population-based differences reflect contemporary environmental pressures, genetic drift, historical and present hybridization between geographically disparate populations, and current selective adaptation of human varieties to their surroundings.[28] In forensic anthropology, human skeletal remains are considered strong evidence for population origin identification and identification of other factors, including sex, age, and stature. Therefore, the reference values of orbital dimensions reported in the present study are important in anthropological characterization. These values are also crucial for the diagnosis as well as while planning the surgical treatments for various orbital pathologies. The present study has the following limitation. As the present study is a single-centered study, the study sample may not be a true representative of the Omani population. A multi-centered study considering the ethic differences of Omani subjects would be more interesting to explore.

Conclusion

Results of the present study provide reference values of orbital dimensions in Omani subjects. The prevalent orbital type of Omani subjects is mesoseme, which is a hallmark of the white race. Further, these findings may be helpful in the field of forensic medicine and anthropology and also for ophthalmologists and neurosurgeons and maxillofacial surgeons.

Conflicts of interest

The authors declare that they have no conflict of interest.

Funding

The present study is an unfunded project.

Authors contributions

Study conception and design: EA, HD, SRS; Material preparation and investigation: EA, MS, MM, SRS; Formal analysis: MM, SRS, Validation of the data collection and results analysis: EA, SRS, HD; Visualization and/or presentation of data: EA, MS, SRS, HD; Original manuscript preparation: EA, MS, MM, SRS. All authors have read and approved the final version of the manuscript.

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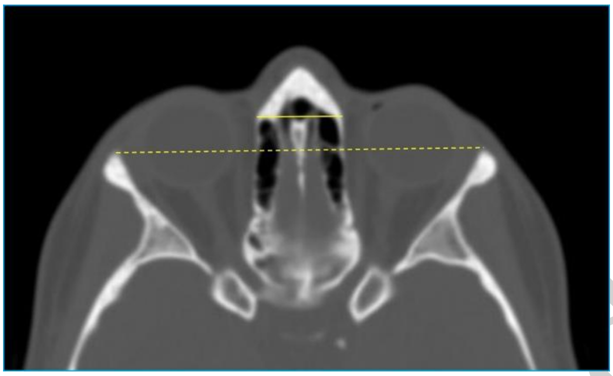

Figure 1. Axial CT image of the orbits in the bone window showing the interorbital distance (short solid line) and inter-zygomatic distance (long dashed line).

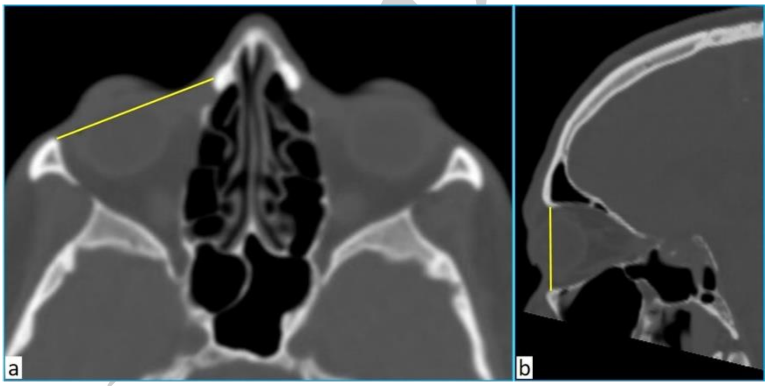

Figure 2. Axial CT image at the level of the orbits shows (a) the horizontal orbital distance of the right orbit and (b) a sagittal image shows the vertical orbital distance

Table 1: Comparison between left and right orbital dimensions.

Parameters	Mean± SD	P value
OI%		
Left orbit	83.83±4.93	
Right orbit	82.67±5.36	0.05

VDO (mm) Left orbit Right orbit	 33.01±1.89 32.83±1.90	 0.003
HDO (mm) Left orbit Right orbit	 39.42±1.66 39.76±1.75	 0.05

OI: orbital index; VDO: vertical distance of orbit, HDO: horizontal distance of orbit

Table 2: Associations of orbital dimensions with respect to gender on right and left sides of orbit.

Parameters	Mean± SD	P value
ROI (%) Female Male	 82.49±4.93 82.85±5.77	 0.59
LOI (%) Female Male	 83.82±4.71 83.83±5.16	 0.99
RVDO (mm) Female Male	32.44±1.79 33.22± 1.95	 0.001
LVDO (mm) Female Male	 32.71± 1.76 33.31±1.98	 0.01
RHDO (mm) Female Male	 39.37±1.56 40.16±1.84	 0.001
LHDO (mm) Female Male	 39.07±1.57 39.77±1.68	0.001

ROI: right orbital index, RVDO: right vertical distance of orbit, RHDO: right horizontal distance of orbit, LOI: left orbital index, LVDO: left vertical distance of orbit, LHDO: left horizontal distance of orbit.

Table 3: Comparison between orbital indices of different age groups among females.

Side	Age	Frequency	Mean (%)	Standard deviation	P value
Right	18-25	5	82.78	5.49	
	26-35	7	82.66	3.6	
	36-45	19	82.49	3.9	
	46-55	20	81.63	5.17	0.93
	56-65	24	81.76	4.36	
	66-75	38	82.85	5.77	
	≥76	24	83.25	5.11	
Left	18-25	5	84.06	5.04	
	26-35	7	83.54	3.05	
	36-45	19	83.44	4.43	0.89
	46-55	20	83.9	4.88	
	56-65	24	82.71	3.26	

	66-75	38	84.44	5.13	
	≥76	24	84.17	5.82	

Table 4: Comparison between orbital indices of different age groups among males.

Side	Age	Frequency	Mean (%)	Standard deviation	P value
Right	18-25	18	81.61	5.04	0.35
	26-35	14	83.49	6.21	
	36-45	11	80.12	5.20	
	46-55	10	83.52	4.76	
	56-65	16	82.16	4.41	
	66-75	35	84.46	7.26	
	≥76	32	82.55	4.99	
Left	18-25	18	83.40	4.79	0.34
	26-35	14	84.07	5.12	
	36-45	11	80.96	5.07	
	46-55	10	79.44	5.33	
	56-65	16	83.64	3.02	
	66-75	35	85.34	5.61	
	≥76	32	83.53	5.57	