CRANIOFACIAL SURGERY

Three Dimensional Computed Tomography Morphometric Analysis of the Orbit in Iraqi Population

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ABSTRACT

Objectives: **This study aims to introduce reference data and to provide guidance for maxillofacial, reconstructive and plastic surgeons managing Iraqi subjects. The three-dimensional Computed Tomography (3DCT) reconstruction technique serves as a practical tool in pre-operative diagnosis, surgical treatment planning, and outcome prediction.**

Methods: **3DCT reconstruction technique was used for description eight anatomical linear parameters and orbital foramen area of the orbital morphologic features of the Iraqi populations. Seventy-one Iraqi subjects (49 males and 22 females) with an age range of 1 - 70 years were taken and selected randomly from patients who had undergone craniofacial CT scans in Hila hospital to diagnose conditions other than craniofacial or orbital deformations. The CT images were stored in Digital Imaging and Communications in Medicine (DICOM) format. The images were processed using Mimics V17.0 software. All measurements were based on craniometric anatomical landmarks pre-defined by the authors and were identified by radiologist. A single calibrated did all the measurements.**

Results: **Comparisons between the two orbits and between the two genders were considered. The method of measurement showed high reproducibility of results. No difference between the two orbits was found. There were significant differences between men and women in all anatomic parameters.**

Conclusions: **The morphometry of the orbital parameters could be gained from a 3D reconstruction method. All anatomical parameters concluded that the two orbits were symmetrical. Orbital size was significantly smaller in women than in men. The findings of the present study allow for quantification of the orbital features of Iraqi subjects and provide parameters for preoperative planning and prediction of postoperative outcome.**

KEY WORDS

orbital parameters, quantitative morphometry, 3DCT, Iraqi population

INTRODUCTION

The orbital region play a main role in the evaluation and recognition of the human craniofacial complex, and relevant morphometric data are often used for multiple diagnostic and forensic procedures. In clinics, reference morphometric data are necessary to assess traumas, to define the phenotype of chromosomal and single gene alterations, to help in the diagnosis of teratogenic-induced conditions such as the foetal alcohol syndrome, as well as to provide guidelines for treatment planning (Douglas & Mutsvangwa, 2010; Fang *et al*, 2011; Ji *et al*, 2010).

For instance, reference data are necessary to maxillofacial, plastic, aesthetic and reconstructive surgeons treating craniofacial deformities: diagnosis, treatment planning and post-operative care should obtain harmonious craniofacial characteristics concurring to a sound functionality. Moreover, reference values that should be collected for each age, sex and ethnic group are required in the forensic field, facial reconstruction, artificial ageing techniques and age estimations (Wilkinson, 2010; Cattaneo *et al*, 2009).

Among the others, personal identification is greatly determined by craniofacial characteristics. The definition of age, sex and ethnic specific morphometric reference data may help to detect those craniofacial features that best discriminate among persons (De Angelis *et al*, 2009; Mallett *et al*, 2010).

The craniofacial-structure of the orbit is affected by several orbital diseases, e.g. congenital orbital dysplasia, orbital fracture, and intraorbital tumor. In children obvious physical signs such as enophthalmos and exophthalmos results in orbital deformation, and may also lead to serious disequilibration of bilateral craniofacial development. The main objectives of plastic surgery for congenital orbital hypoplasia and orbital fracture are to repair the craniofacial- structure of the orbit and to regenerate the symmetric relationship between the two orbits. Practical evaluation of orbital deformations is no longer suitable for the level of accuracy that can now be achieved in craniofacial reconstruction surgery, and a quantitative morphometric method is needed. 3D reconstruction based on high-resolution spiral CT scans has been used for more than 15 years to reveal the anatomic location and morphologic features of orbital abnormalities and plays an important role in diagnosis, surgical planning, and outcome prediction (Katsumata *et al*, 2005; Lopes *et al*, 2008). In plastic and reconstructive surgery application of the 3D technique overcomes the limitations of two dimensional scans, making it possible to observe craniofacial bones from various angles and to calculate the lengths and volumes of some parameters with certain software (Park *et al*, 2006). This technique has confirmed to have practicability and high accuracy (Bin Yahya *et al*,2013; Acer *et al*, 2009), but relevant studies have focused only on measurements of the orbital volume and a complete and systematic set of anatomic parameters which describe the orbital features more precisely and quantitatively is lacking. In addition, the data acquired in previous studies are mainly from Caucasian subjects and cannot be applied to an Iraqi population. Few

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Table1. Definition of anatomical landmarks of the orbit and relevant length parameters.

Orbital landmarks / Orbital length parameters	Definition
Maxillofrontal (Mf)	Junction between frontomaxillary suture and medial orbital rim
Ectoconchion (Ec)	Junction between the lateral orbital rim and the horizontal line that divides the orbital foramen into two equal parts
Supraorbital point (Os)	Superior junction between the superior orbital rim and the perpendicular bisector line of line Mf-Ec
Infraorbital point (Oi)	Inferior junction between the inferior orbital rim and the perpendicular bisector line of line Mf-Ec
Point on the optic foramen (Of)	Optic foramen
Orbital breadth	Mf-Ec
Orbital height	Os-Oi
Medial orbital wall length	Mf-Of
Lateral orbital wall length	Ec-Of
Orbital roof length	Os-Of
Orbital floor length	Oi-Of
Intraorbital distance (IOD)	Mf-Mf
Extraorbital distance (EOD)	Ec-Ec
Orbital foramen area	

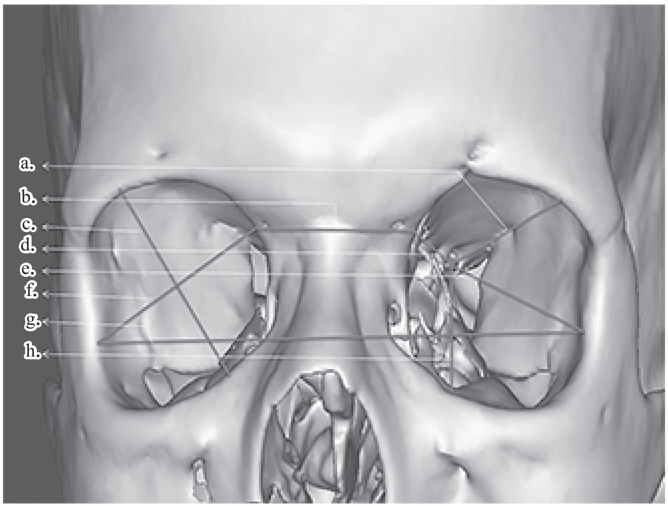

Figure 1. Frontal view shows linear orbital parameters: a, Orbital roof length (Os-Of); b, Intraorbital distance (Mf-Mf); c, Orbital height (Os-Oi) d, Medial orbital wall length (Mf-Of); e, Lateral orbital wall length (Ec-Of); f, Orbital breadth(Mf-Ec); g, Extraorbital distance (Ec-Ec); h, Orbital floor length (Oi-Of).

reported studies have been performed in Iraqi subjects. Therefore, the purpose of our study was to calculate the orbital linear parameters of normal Iraqi subjects using a 3D reconstruction method to determine criteria for a morphologic description of the human orbit in Iraqi populations.

Table 2. Comparison of measure values between the two orbits (n = 71)

Variables	Right (Mean ± SD)	Left (Mean ± SD)	t	P
Mf-Ec	33.66 ± 2.15	33.44 ± 2.17	0.59	0.55
Os-Oi	39.28 ± 2.94	39.11 ± 3.21	0.33	0.73
Mf-Of	39.51 ± 4.49	39.33 ± 4.59	0.23	0.81
Ec-Of	42.58 ± 3.80	42.34 ± 3.86	0.37	0.71
Os-Of	45.41 ± 4.06	44.83 ± 4.02	0.86	0.39
Oi-Of	42.75 ± 4.81	42.55 ± 4.67	0.25	0.80
Area	715.04 ± 117.92	717.58 ± 115.43	-0.13	0.89

Table 3. Comparisons of orbital measurements between male and female subjects.

Variables	Mean (SD) distance (mm)		95% Confidence Interval		P value
	Male	Female	Lower Bound	Upper Bound	
Mf-Ec	39.49(3.05)	36.46(3.08)	1.51	4.55	0.00
Os-Oi	33.33(2.45)	26.30(5.25)	4.80	9.26	0.00
Mf-Of	39.80(4.74)	36.54(4.45)	1.01	5.51	0.00
Ec-Of	42.65(4.38)	40.38(3.05)	0.50	4.04	0.01
Os-Of	45.55(4.57)	42.83(3.93)	0.65	4.77	0.01
Oi-Of	42.87(5.31)	40.01(4.35)	0.53	5.19	0.01
Area	723.2(127.19)	600.25(88.08)	71.78	174.18	0.00
Mf-Mf	24.18(3.60)	21.11(2.22)	1.68	4.45	0.00
Ec-Ec	88.46(16.09)	80.76(5.78)	2.38	13.01	0.00

SUBJECTS AND METHODS

Subjects

This was a retrospective study of Iraqi patients who had their CT scan at the Radiology Department, Hila Hospital to diagnose conditions other than craniofacial or orbital deformation. CT scans of 71 individuals randomly selected (49 males and 22 females) with an age range of 1 - 70 years were taken.

Subjects who had diseases that might affect the eye or orbit, such as thyroid disease, orbital fracture, intraorbital or intraocular tumor, congenital microphthalmia or anophthalmia, and orbitofacial cleft, were excluded from the study. All subjects were in a good health status, and did not report any major systemic disease.

CT imaging

CT images were collected from CT database of Hila Hospital. These scans were of high resolution, helical scans obtained with General Electric (GE) Light Speed plus CT Scanner System (GE Company, Medical system group, Wisconsin, USA). The CT resolution was at 1.25 mm thickness and 1.25mm spacing. These scans were saved in a CT database at the Radiology Department of Hila Hospital.

3D Reconstruction

CT scans were saved in DICOM3 format, transferred to a personal computer, and reconstructed with a 3D image-segmentation program Mimics V17.0 software (Materialise, Leuven, Belgium). This software uses the existing axial view to create cross-sections in the sagittal and frontal views. The Hounsfield Unit (HU), which expresses the gray scale, was adjusted for each tissue in the CT system.

Measurements

Five points were selected carefully and nine orbital parameters were repeatedly measured between identified point landmarks on each of the 3D image-segmentation using Mimics software program. Table 1 lists the landmarks used in this study and the linear measurements defined using the above mentioned point landmarks. The nine linear measurements were done on each 3D image. A single radiologist did all the measurements. All linear measurements were repeated 3 times. The second measurements were conducted after 2 weeks, which the results were blinded to minimize the examiner's bias. For the third time, the same blinding was done which is 2 weeks after the second measurements. The averages of three readings of each measurement were considered for the statistical analysis in order to minimize the intra-examiner variation.

Statistical analysis

All data were analyzed using SPSS software 22.0 (IBM, Armonk, NY, USA). The normality of the data was evaluated with the skewness and kurtosis measurements. General descriptive statistics were calculated for each parameter and the differences between mean values for two orbits and for two sexes were compared using independent t-tests. Statistical significance was set at $p < 0.05$.

RESULTS

Table 2 summarises the measured values of the two orbits. Comparison of the all parameters at P value > 0.05 showed that there were no any statistically significant differences. The landmarks representing the linear parameters were shown in Figure 1. For sexual dimorphism, the data showed that the mean value of all orbital parameters in males were greater than those in females in all linear measurements Table 3. In males and females, respectively, mean orbital height 33.33 and 26.30 mm, mean orbital width 39.49 and 36.46 mm, mean medial orbital wall length 39.80 and 36.54 mm, mean lateral orbital wall length 42.65 and 40.38 mm, mean orbital roof length 45.55 and 42.83 mm, mean orbital floor length 42.87 and 40.01 mm, mean orbital foramen area 723.2 and 600.25 cm, mean intraorbital distance 24.18 and 21.11 mm, mean extra-orbital distance 88.46 and 80.76 mm.

DISCUSSION

The orbit is a craniofacial structure that can be affected by a large number of congenital, traumatic, neoplastic, vascular, and endocrine disorders. In these cases, the measurement and a description of the orbital shape may have important clinical applications for estimating craniofacial asymmetry, the severity of injury, and possible complications in preoperative planning and in post-operative evaluation (Acer *et al*, 2009). The magnetic resonance imaging scan is favoured due to the lack of radiation exposure, especially in cases of children and normal subjects (Chau *et al*, 2004), but CT scans delineate better the bony structures, and are thus more widely used (Fan *et al*, 2007). With CT images printed on films in square frames, a point-counting method can easily be used to measure the surface area of the orbital cavity in each section (Acer *et al*, 2009).

The point-counting method cannot be used to measure linear parameters or curved parameters, however, such as the lengths of the orbital walls, which need to be measured simultaneously. During the past few years, a CT-based 3D-reconstruction method has demonstrated advantages for direct measurements on a 3D model and has therefore led to a trend to substitute the 3D reconstruction method for two-dimensional measurements (Park *et al*, 2006). The reliability and accuracy of this method have been verified in a previous study (Regensburg *et al*, 2008). The test for the reliability of the software used in our study also showed stability of each measurement and high reproducibility of this measurement technique.

Most studies performed on normal subjects found that the dimensions and position of the orbital soft tissues were sexually dimorphic, modified between childhood, adolescence and young adulthood, and even after young adulthood into the eighth decade of life, and had some ethnic-related characteristics (Fang *et al*, 2011; Farkas *et al*, 2007). Most of previous anthropometric studies were performed on Caucasoid people, and just scanty data on Asian subjects could be found. Considering the most recent investigations and the relevant literature reviews, data on soft tissue orbital anthropometry were reported for 27 Caucasoid groups, but for only 11 Asian and Indian groups, and just 10 African groups (Sforza *et al*, 2009; Price *et al*, 2009). Also, extensive data collections and analyses, covering various ethnic groups, have been mostly reported for adult people, and children have been scantly analysed. This is particularly true when ethnicities other than the Caucasoid are considered.

The mean area of the orbital foramen was significantly larger in males than in females, which is consistent with previous studies. Moreover, according to the results of our study, all orbital parameters were significantly larger in males than in females. Therefore, sexual dimorphism in the orbital foramen area was confirmed, and the whole set of orbital parameters can also be used as a sexually dimorphic trait (Pretorius *et al*, 2006).

CONCLUSIONS

The data obtained from this study may help to develop a database to determine the normal orbital values. This reference data can be used for quantitative assessment of orbital disease and orbitofacial deformities, both for preoperative planning and for assessing postoperative outcome. The present findings are particularly important because there are no similar investigations aimed at Iraqi populations in previous studies. Future studies are planned to improve this measurement technique and to application of this method to the investigation of pathologic orbits.

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