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Original Article

PHOTO-ANTHROPOMETRIC STUDY OF LATERAL WALL OF FULLY OSSIFIED DRY HUMAN ORBITAL CAVITIES

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Abstract:

Context: *Accurate knowledge of orbital morphometry is essential for the evaluation, diagnosis, preoperative planning, and intraoperative management of craniofacial syndromes, post-traumatic facial deformities, and orbital abnormalities, with the goal of achieving optimal aesthetic and functional outcomes. This knowledge is also relevant to anesthesiologists performing ocular surgeries, particularly when employing various nerve blocks, and is valuable to anthropologists, ophthalmologists, anatomists, forensic experts, and maxillofacial and reconstructive cosmetic surgeons. Safe and effective orbital surgery requires a thorough understanding of the bony orbit's anatomy and the morphometric relationships within it.*

Objective: *Primary objective: To perform a photo-anthropometric analysis of the lateral wall of fully ossified dry human orbital cavities by measuring selected anatomical landmarks.*

Secondary objectives: *To evaluate the morphometric differences between the right and left lateral orbital cavities and to establish baseline morphometric data for anatomical, forensic, and clinical application.*

Materials & Methods: *A cross-sectional analytical study was conducted in the Department of Anatomy, Dhaka Medical College, Dhaka, from July 2014 to June 2015. The study was performed on 200 fully ossified dry orbital cavities from 100 human skulls. Results: In the present study, the mean distance from the frontozygomatic (FZ) suture to the lateral margin of the optic canal (OC) was 46.65±2.75 mm on the right side and 46.41±2.44 mm on the left side. The difference between the right and left orbital cavities was significant (p<0.05). The mean distance from the frontozygomatic (FZ) suture to the closest margin of the superior orbital fissure (SOF) was 38.83±3.25 mm on the right and 38.69±3.16 mm on the left. No significant difference was observed (p>0.05) for this distance. Conclusion: The lateral orbital wall exhibits significant asymmetry in FZ–OC distance (p<0.05). These normative data serve forensic experts in skull identification and trauma analysis, anthropologists in ethnic and evolutionary studies, and anatomists in surgical education and morphological reference. The validated photographic method (MAPE <3%, ICC >0.95) offers a reliable, non-invasive alternative to direct caliper measurement.*

Keywords:
Photo-anthropometry, lateral wall, orbital morphometry, forensic anatomy, craniofacial anthropometry, fully ossified.

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Introduction

Morphometric parameters of the orbit are of significant value in many specialties, including ophthalmology, optometry, oculoplastic surgery, traumatology, and oral and maxillofacial surgery. Orbital indices are also important predictors for the assessment and treatment

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of craniofacial syndromes and post-traumatic deformities. This knowledge is also relevant in various other fields, such as the analysis of fossil records, classification of skulls in forensic medicine, and explanation of trends in evolutionary and ethnic differences. Therefore, detailed knowledge of orbital anatomy is essential.[1,2] Sexual dimorphism of the orbit has been documented in various populations, with significant implications for forensic identification.[1u]

Anthropometric studies can be divided into three categories: (1) manual anthropometry, (2) two-dimensional (2D) photography, and (3) three-dimensional (3D) photography.[3] Each method has its own advantages and disadvantages. Direct anthropometry is performed using calipers and tape measures.t ,u The examiner must possess adequate skill, and during measurement, some errors may occur.v Nowadays, most anthropometric studies are carried out by imaging and computer software analysis.[1],w Computed tomography-based orbital morphometry has been validated as an alternative to dry skull studies.[1v] The limitations of anthropometric devices and advances in technology have driven researchers to use digital methods. With the advent of digital technology, many anatomists have chosen to study using photographic methods.x ,y Three-dimensional stereophotogrammetry has emerged as a gold standard for craniofacial anthropometry.[1t]

The lateral wall of the orbit is formed by the greater wing of the sphenoid bone along with the zygomatic process of the frontal bone. Morphometric study of the lateral wall is important during orbital decompression, infratemporal fossa surgery, exploration of fractures, lateral craniotomy, and modified craniofacial resection.[1p] ,[11] Orbital decompression surgery specifically requires detailed knowledge of lateral wall anatomy to avoid neurovascular complications.[1x] A comprehensive knowledge of orbital anatomy is very important to understand the various disorders of this region and their surgical management. Understanding of orbital disease demands a clear concept of normal orbital anatomy. Safe and effective orbital surgery requires extensive knowledge of the anatomy of the bony orbit and the morphometric relationships that exist within it. The orbit's complex anatomy has been detailed in standard clinical anatomy texts, providing foundational knowledge for surgeons.[12,13]

Orbital morphometry varies significantly across different ethnic and geographic populations. Studies on Nigerian,[1w] Indian,[1u] ,[1v] and Bangladeshi[2],u populations have demonstrated population-specific normative values, emphasizing the need for regional baseline data.

Materials and Methods

This cross-sectional, analytical study was conducted on 200 fully ossified dry orbital cavities obtained from 100 human skulls of unknown sex and age. Skulls were collected from the Department of Anatomy, Dhaka Medical College, as well as from other government and non-government medical colleges in Dhaka city, during the period from July 2014 to June 2015. Skulls with evidence of fracture, erosion, or postmortem breakage involving any orbital wall were excluded. All eligible specimens were cleaned, dried, and labeled. The lateral wall of each orbital cavity was examined, and measurements were recorded at predefined anatomical landmarks.

Measurements:

Two linear distances were measured on each orbital cavityx :

1. From the frontozygomatic (FZ) suture to the lateral border of the optic canal (OC).
2. From the frontozygomatic (FZ) suture to the closest margin of the superior orbital fissure (SOF).

Physical measurements (reference standard):

A validation subsample of 10 randomly selected skulls (20 orbits) underwent physical measurement using a digital slide caliper (Mitutoyo, Japan; 0.01 mm resolution).[3] Both distances were measured twice by Observer A, blinded to the photographic data, and the mean was recorded.

Photographic method and conversion factor:

Each skull was placed on a flat table 120 cm from a fixed digital camera (Sony Cyber-shot, 16.1 MP). A scale bar was included in every image. Images (RAW to TIFF) were analyzed using Adobe Photoshop (version 10) by Observer B, blinded to physical measurements.[2]

The conversion factor (CF) was calculated for each orbit using both distancesy :

CF = Physical measurement (mm) / Photographic measurement (pixels)

The mean CF from the 20 orbits was applied to all photographic measurements:

Photogrammetric measurement (mm) = Photographic measurement (pixels) × Mean CF

Validation:

Agreement between the photographic (after CF) and physical methods was assessed using Bland-Altman analysis (bias ± 1.95 SD limits)[1],[3],v ,[1]y ,[2]p intraclass correlation coefficient (ICC) and mean absolute percentage error (MAPE). A two-way random-effects, absolute-agreement ICC model (ICC(2,1)) was calculated following the guidelines of Koo and Li.[22] Intra- and inter-observer repeatability were evaluated on 10 orbits (5 skulls).[2],[1]p Lens distortion was checked using a steel ruler.u MAPE <3% and ICC >0.95 were set as acceptance criteria.[2] Reliability and reproducibility of measurement errors were assessed as described by Bartlett and Frost.[21]

Statistical analysis:

A paired t-test compared photographic vs. physical measurements. Bland-Altman plots, ICC, and MAPE were calculated using SPSS version 19.0 (IBM Corp., Armonk, NY, USA).[1],v Significance was set at $p<0.05$. The Bland-Altman limits of agreement method followed the approach described by Giavarina.[2]p

Results:

Comparison of distances on the lateral wall of the right and left orbital cavities:

The mean distance from the frontozygomatic (FZ) suture to the lateral margin of the optic canal (OC) was 46.65±2.75 mm on the right side and 46.41±2.44 mm on the left side. The range of this distance was 39.21–50.14 mm on the right and 40.12–51.13 mm on the left. The difference between the right and left orbital cavities was significant ($p<0.05$). The mean distance from the FZ suture to the lateral border of the OC was higher in the right orbital cavity compared to the left.

The mean distance from the frontozygomatic (FZ) suture to the closest margin of the superior orbital fissure (SOF) was 38.83±3.25 mm on the right and 38.69±3.16 mm on the left. The range of this distance

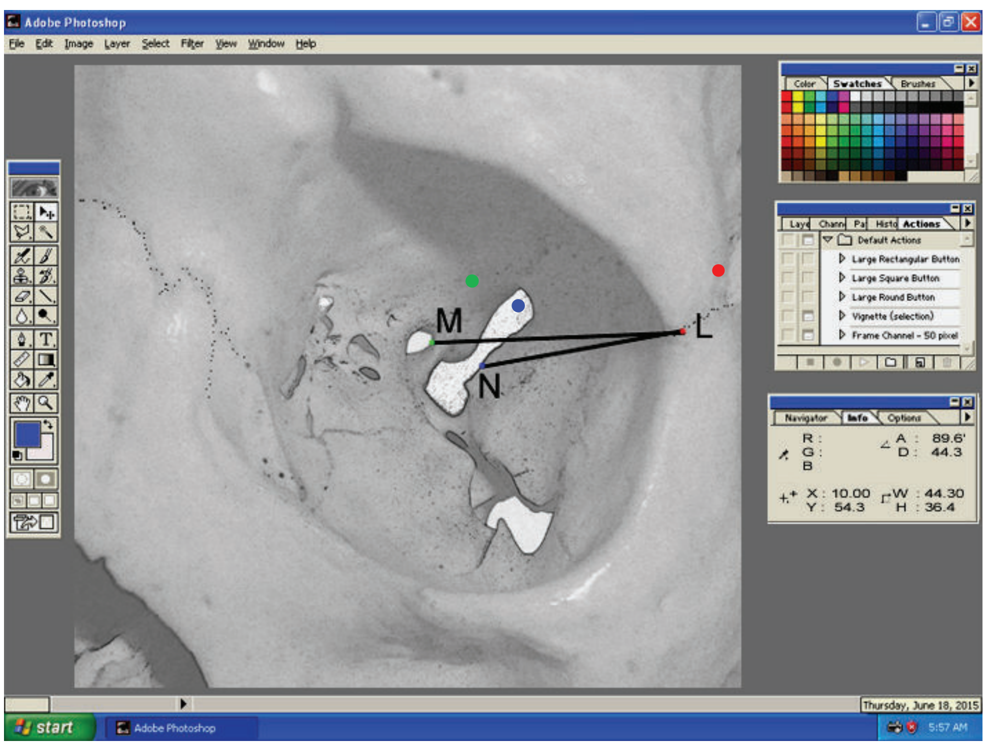

Figure 1: *Photograph showing distance of different foramen in the lateral wall of the left orbital cavity. L (red dot) – Point in the frontozygomatic suture (FZ). M (green dot) – Point in the lateral border of the optic canal (OC). N (blue dot) – Point in the margin of superior orbital fissure (SOF) closest to the frontozygomatic suture. L- M – Distance from the frontozygomatic suture to the lateral border of optic canal. L – N – Distance from the frontozygomatic suture to the closest margin of superior orbital fissure.*

Table-I

Comparison of distances on the lateral wall of the right and left orbital cavities

Side	FZ to OC (mm) Mean±SD (Range)	FZ to SOF (mm) Mean±SD (Range)
Right (n=100)	46.65±2.75 (39.21–50.14)	38.83±3.25 (26.50–44.53)
Left (n=100)	46.41±2.44 (40.12–51.13)	38.69±3.16 (26.22–43.32)
p-value	0.019*	0.194^{ns}

Comparison between right and left sides was performed using the paired Student's t-test.
*p<0.05 (significant); ns = not significant (p>0.05)

was 26.50–44.53 mm on the right and 26.22–43.32 mm on the left. No statistically significant difference was observed between the right and left orbital cavities for this distance (p=0.194).

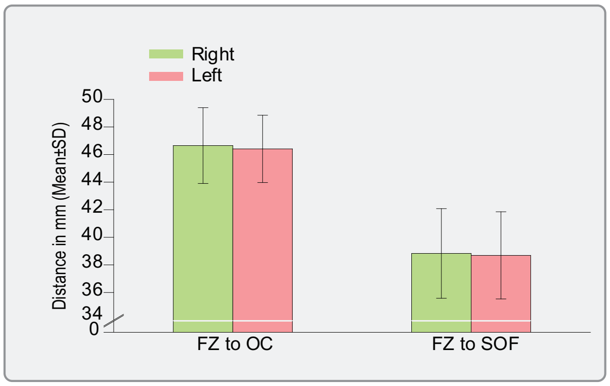

Figure 2: *Distance on the lateral wall of the right and left orbital cavity from FZ to OC and FZ to S OF*
FZ : Frontozygomatic suture
OC : Optic canal
SOF : Superior orbital fissure

Discussion

The present work was undertaken to study various morphometric variables of both orbital cavities using 100 fully ossified dry human skulls. All skulls were collected from the Anatomy Department of Dhaka Medical College and from other government and non-government medical colleges in Dhaka city. The main aim of the study was to determine whether any difference exists between the right and left orbital cavities. The study revealed some statistically important findings regarding morphometric variations between the right and left orbital cavities.

However, no published work on anthropometric measurements of the orbital cavity using photographic images is available in our country. Therefore, the present study could not be compared with any previous similar study conducted in Bangladesh. Hence, a comparative discussion of the results of different variables of orbital cavity measurements on both sides was made with those of various authors and researchers from other countries.

The observed morphological parameters showed both similarities and dissimilarities with available publications. The findings of the present study are similar to those reported by Coroleucă et al.[1], who used laser scanning morphometry on dry human skulls to measure orbital communications, including the optic canal and superior orbital fissure. Singh et al.[1]u reported orbital morphometric data for sex determination in North Indian population, while Udhaya et al.[1]v provided CT-based normative values for South Indians. Oladipo et al.[1]w studied orbital dimensions in adult Nigerian skulls, demonstrating ethnic variations in orbital indices. Nayak et al.[11] reported orbital morphometric data from 200 Indian dry skulls, with mean FZ-OC distances of 45.92±2.81 mm (right) and 45.78±2.69 mm (left), which are slightly lower than our findings (46.65±2.75 mm and 46.41±2.44 mm, respectively), possibly due to ethnic differences. These similarities and differences may be attributed to the use of fully ossified dry skulls, racial variation, differences in sample size, and the use of different measurement techniques (direct caliper vs. photographic method). The present study also shows some dissimilarities with the studies reported by Ferdousi et al.[2] and Karthick et al.[3], who conducted research on Bangladeshi and South Indian populations, respectively.

In the present study, the mean (±SD) distance from the frontozygomatic (FZ) suture to the lateral border of the optic canal (OC) showed a significant difference (p<0.05) between the right and left orbital cavities. No significant difference was observed (p>0.05) in the mean distance from the FZ suture to the closest margin of the SOF. This finding was similar to that of

Corvino et al.t , who carried out an anatomical study examining the frontozygomatic suture as an anatomic landmark for the superior orbital fissure. Their research validated the clinical importance of this relationship during lateral orbital approaches. However, when compared with the present study, the mean distance from the FZ suture to the closest margin of the SOF showed a significant difference (p<0.0001) in both orbital cavities from their reported values. Corvino et al.t found no significant difference in the mean distance from the FZ suture to the lateral border of the OC between the right and left sides.

According to Biswas et al.u , who studied orbital symmetry in the adult Bengali population, no significant differences were observed (p>0.05) in the mean distance from the FZ suture to the lateral border of the OC or to the closest margin of the SOF. These findings are partially dissimilar to those of the present study. When the findings of the present study were compared with those of Biswas et al.u , a significant difference was observed (p<0.0001) in the mean distance from the FZ suture to the lateral border of the OC on the right side, but the difference on the left side was not significant (p>0.05). On the other hand, the mean distance from the FZ suture to the closest margin of the SOF showed significant differences (p<0.0001) in both orbital cavities.

Lee et al.[1]x emphasized the importance of orbital decompression surgery and the need for precise anatomic knowledge, which supports the clinical relevance of our normative data. Standard clinical anatomy references by Moore et al.[12] and Patel et al.[13] provide comprehensive descriptions of orbital anatomy that complement our morphometric findings.

The photographic method employed in this study demonstrated high agreement with physical measurements, with a mean absolute percentage error (MAPE) below the predefined acceptance criterion of 3% and an intraclass correlation coefficient (ICC) exceeding 0.95. These findings are consistent with recent validation studies in craniofacial anthropometry, supporting the reliability of two-dimensional photographic methods when proper calibration and conversion factors are applied.[1]t Fourie et al.[1]t evaluated the accuracy of different three-dimensional scanning systems, while Gibelli et al.[1]u conducted a systematic review of optical devices for facial description. Cavanagh et al.[1]v performed a longitudinal stereophotogrammetry study of facial growth in healthy children.

The statistical methods used in this study follow established guidelines for method comparison studies. Bland and Altman[1]y introduced the limits of agreement approach, which Giavarina[2]p further explained for clinical researchers. Bartlett and Frost[21] discussed reliability and reproducibility of measurement errors, while Koo and Li[22] provided guidelines for ICC selection and reporting.

Conclusion

The lateral orbital wall shows significant asymmetry in FZ–OC distance between the right and left sides (p<0.05). The FZ–SOF distance is a reliable surgical landmark. Photographic morphometry is a valid alternative to direct caliper measurement (MAPE <3%, ICC >0.95). These normative data are important for forensic experts, anthropologists, and anatomists and support safer orbital decompression, lateral orbitotomy, fracture repair, and craniofacial resection.

Ethical Clearance:

The study was approved by the Ethical Review Committee of Dhaka Medical College, Dhaka

Conflict of Interest:

None to disclose.

Limitations :

This study has several limitations: unknown sex and age of specimens, a single geographic population (Bangladesh), use of 2D photography lacking depth information; a small validation subsample (n=20 orbits), a single observer for physical measurements, no comparison with a 3D imaging gold standard, measurement of only two orbital distances, and data collection completed in 2015, which may not reflect contemporary populations. These factors should be considered when interpreting the findings.

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