Morphometric analysis of the optic canal and the superior orbital fissure in a Brazilian sample – study in CT scans

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SUMMARY

The posterior wall of the orbit is composed by the sphenoid bone and exhibits the optic canal (OC) and the superior orbital fissure (SOF). The comprehensive knowledge of anatomical and morphometric observations of OC and SOF is vital for an accurate diagnosis and management of local pathology. The aim of this study was to conduct a morphometric analysis of the OC and the SOF in CT scans in a Brazilian population. A total of 40 computed tomography (CT) scans of dry human skulls were used (20 males and 20 females). The images were submitted to a segmentation in which the bony structures of interest in the orbit were selected. A three-dimensional reconstruction of the region and the measurements of the perimeter (mm) of the SOF and the volume (mm^3) of the OC were performed. The statistical analysis was performed to verify if there was a difference in sex on each side for each anatomical structure. Regarding the OC, for the left side, there was a statistical difference between the sexes. For the SOF, neither the right side nor the left side showed statistical difference between the sexes. The present study showed new data about anatomical structures of the human orbit, bringing relevant knowledge for surgical and diagnostic procedures in the region. Especially for those anatomical structures evaluated that allow the passage of blood vessels and nerves, specific knowledge of their dimensions in different populations is valuable to avoid injuries during procedures in the orbital region.

Keywords: Optic canal – Superior orbital fissure – Morphology – Computed tomography – Morphometry

INTRODUCTION

The orbit is formed by several bones, such as the frontal, ethmoid, sphenoid, zygomatic and lacrimal. The posterior wall of the orbit is composed by the sphenoid bone sphenoid bone and exhibits the optic canal (OC) and the superior orbital fissure (SOF) (Koenen and Waseem, 2022).

The OC is described as presenting an ovoid shape that is, in the anteroposterior direction, shorter medially than laterally (Rhoton, 2002; René, 2006; Abhinav et al., 2015). Its entrance is located at the medial and posterior end of the optic strut, just inferior to the level of the anterior root of the lesser wing of the sphenoid bone, and its ending is defined as the most anterior level on

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Submitted: October 19, 2022. **Accepted:** November 3, 2022

https://doi.org/10.52083/DRQP1689

the medial side of the optic strut (Abhinav et al., 2015). The OC links the anterior cranial fossa to the orbit and houses the optic nerve and the ophthalmic artery (Slavin et al., 1994).

Hart et al. (2009) evaluated the OC dimensions, and the degree of OC exposure to the sphenoid sinus were measured on sinus computed tomography images of 96 patients. A total of 191 optic canals were analyzed (111 female subjects and 80 male subjects). The average medial canal wall length was 1.48 cm (range, 0.7 to 2.3 cm). The length in male subjects was 1.61 cm (range, 1.1 to 2.3 cm), as compared to 1.39 cm (range, 0.7 to 2.0 cm) in female subjects ($p < 0.001$). They concluded that a wide variation in the medial canal wall length and exposure of the OC to the sphenoid sinus exist on computed tomography images.

The SOF is a very important region through which important nerves and vessels of the orbit pass. The SOF is found bounded by the body of the sphenoid bone and between the lesser wing and the greater wing of this bone (Govsa et al., 1999; René, 2006). It is a very significant structure, once it connects the middle cranial fossa and the orbit, houses various important vessels of the orbit and the III, IV, V, and VI pairs of cranial nerves (Govsa et al., 1999; René, 2006; Patel et al., 2021; Koenen and Waseem, 2022).

Patel et al. (2021) conducted a study on 30 dry skulls and computed tomography (CT) scans of 30 adult patients. They evaluated morphometric parameters including SOF length and width, distance from foramen rotundum to SOF and distance from the apex of petrous temporal bone to SOF. Most of the parameters did not show any significant differences between the left and right side in both dry skull and CT scan, except the distance of SOF to the foramen rotundum in dry skull, where the right-side distance was significantly higher.

It is important to note that the comprehensive knowledge of anatomical and morphometric observations of OC and SOF is vital for an accurate diagnosis and management of local pathologies. It also helps ophthalmologists and neurosurgeons not only during surgical procedures but also for newer technique advancement. For radiologists and neurosurgeons, the knowledge of morphometry and relation of OC and SOF is also very important (Govsa et al., 1999; Patel et al., 2021).

The aim of this study was to conduct a morphometric analysis of the OC and the SOF in CT scans in a Brazilian population.

MATERIALS AND METHODS

This research was approved by the Research Ethics Committee of Piracicaba Dental School – University of Campinas (Protocol number: 47768921.8.0000.5418).

Sample

A total of 40 computed tomography (CT) scans of dry human skulls were used (20 males and 20 females), aged between 18 and 80 years.

The CT scans were obtained using an Aisteion Multislice 4 CT System device (Toshiba Medical Systems Corporation – Japan), for skull protocol: 100 MA, 120KV, with 1mm slices. The CT scans of these dried human skulls belong to the "Osteológico e tomográfico Prof. Dr. Eduardo Daruge" Biobank from Piracicaba Dental School – University of Campinas (UNICAMP).

CT scans of intact skulls were used, without macroscopic deformities, fractures or any other pathological or surgical alterations.

Processing of tomographic images and obtaining measurements

The Mimics 18.0 (Materialise, NV, Belgium) software was used to perform the segmentation of the images of each CT scan. In the segmentation, the bony structures of interest in the orbit were selected. After segmentation, a three-dimensional reconstruction of the region was performed.

In the three-dimensional reconstruction, a measurement was performed to obtain the perimeter (mm) of the SOF (Fig. 1). In the axial section of the CT scan, the volume (mm^3) of the OC was measured (Fig. 2). Both the three-dimensional reconstruction and the acquisition of measurements were performed using the Mimics 18.0 (Materialise, NV, Belgium) software.

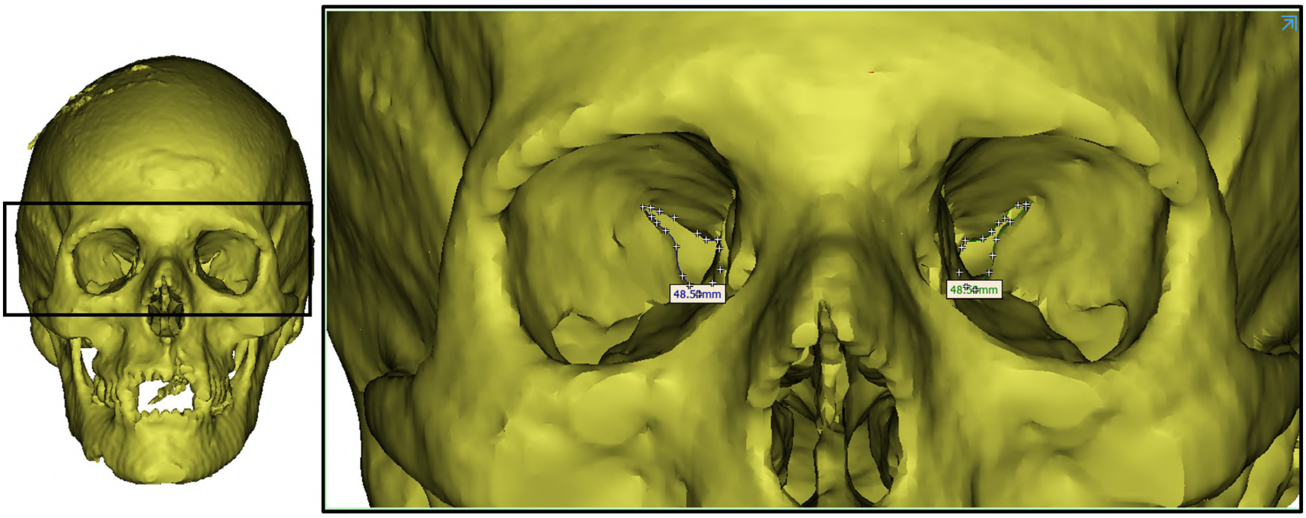

Fig. 1.- Measurement of the SOF perimeter (mm) in the three-dimensional reconstruction (Mimics 18.0 software - Materialise, NV, Belgium).

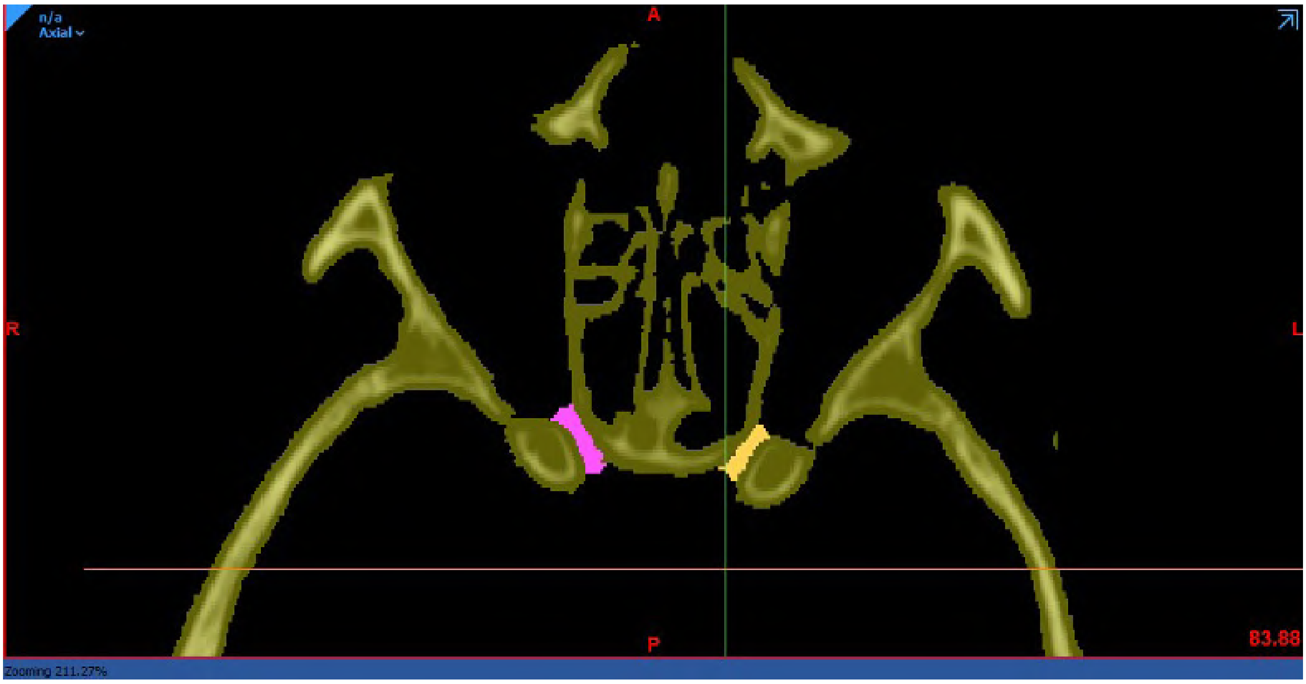

Fig. 2.- Measurement of the OC volume (mm3) in the axial section of the CT scan (Mimics 18.0 software - Materialise, NV, Belgium).

Statistical analysis

After collecting all the data, they were tabulated in the Microsoft Office Excel package. The non-parametric Mann-Whitney U test (two-tailed) was performed to verify if there was a difference in sex on each side for each anatomical structure evaluated (OC and SOF).

The descriptive statistical analysis was performed for both anatomical structures evaluated (OC and SOF). For all analyses, a significance level of $p<0.05$ was considered. All data were analyzed using GraphPAD Prism v.8 software (San Diego, CA, USA). The level of significance of $p <0.05$ was considered.

RESULTS

OC

The descriptive statistical analysis was performed (Table 1). The volume (mm^3) of the OC was obtained. For right side, the Mann-Whitney U test (two-tailed), showed no differences (P=

Table 1. Descriptive analysis of the OC volume (mm^3) in both sexes and both sides.

	Mean (Right side)	Standart deviation (Right side)	Standard error of mean (Right side)	Mean (Left side)	Standard deviation (Left side)	Standart error of mean (Left side)
FEMALE	88.07	28.88	6.458	84.73	30.51	6.823
MALE	107.9	33.99	7.601	105.1	27.43	6.133

0.1096) for the comparison between the sexes. For left side, the Mann-Whitney U test (two- tailed) showed a statistical difference between the sexes (P= 0.0263) (Fig. 3).

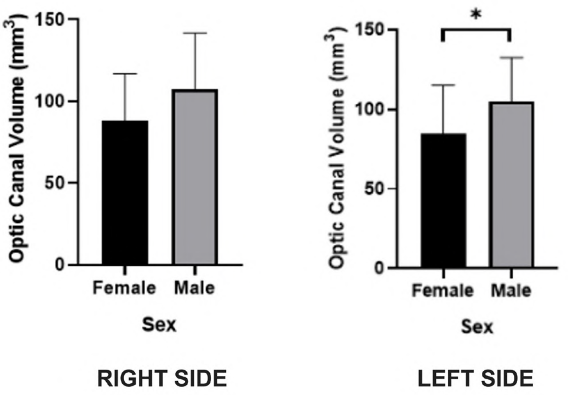

Fig. 3.- OC volume (mm^3) of both sexes and both sides. *Means statistically significant difference between groups. (P= 0.0263).

relationships of the orbit by morphological studies, such as the dimensions of the OC and SOF, can facilitate the diagnosis and treatment to different orbital diseases and can allow surgeons to develop a safe approach to a variety of techniques in this location, as well as to prevent some disorders (Slavin et al., 1994; Sinanoglu et al., 2016).

The risk of vascular and nerve structures injuries during a procedure is high, and detailed knowledge of this area is essential, mainly according to sex, side and populations. Due to its importance, studies have investigated the OC and the SOF and its different landmarks and variations (Govsa et al., 1999; Sinanoglu et al., 2016; Patel et al., 2021). The anatomic data about the OC and SOF has been studied by quantitative evaluations of human cadavers and morphometric parameters from skull CT scans (Habal et al., 1977; Berlis et al., 1992;

SOF

The descriptive statistical analysis was performed (Table 2). The perimeter (mm) of the SOF was obtained. For right side, the Mann-Whitney U test (two-tailed), showed no differences (P= 0.3834) for the comparison between the sexes. For left side, the Mann-Whitney U test (two- tailed), showed no differences (P= 0.1572) for the comparison between the sexes (Fig. 4).

DISCUSSION

The orbit is a target area of different medical and surgical procedures. Determining the anatomical

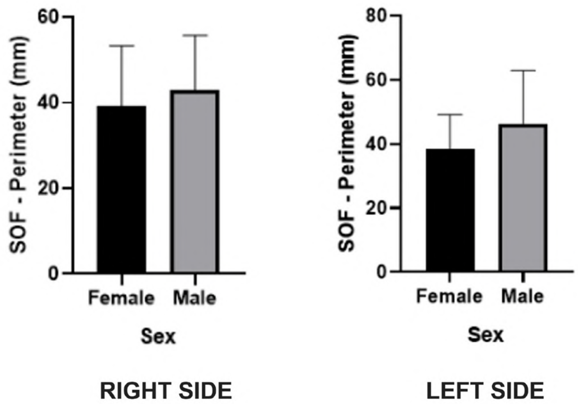

Fig. 4.- SOF perimeter (mm) of both sexes and both sides. (P= 0.1572).

Table 2. Descriptive analysis of the SOF perimeter (mm) in both sexes and both sides.

	Mean (Right side)	Standart deviation (Right side)	Standard error of mean (Right side)	Mean (Left side)	Standard deviation (Left side)	Standart error of mean (Left side)
FEMALE	39.20	14.07	3.147	38.32	10.87	2.432
MALE	42.92	12.79	2.860	46.45	16.46	3.681

Slavin et al., 1994; Govsa et al., 1999; Kazkayasi et al., 2003; Patel et al., 2021).

In the present study, when the volume (mm^3) of the OC was compared between the sexes (male and female), the results showed a significant statistical difference for the left side, and it was possible to note that the volume of the OC was higher in the male sample than in the female sample.

Some previous studies also reported significant differences in OC anatomy between the sexes (Hart et al., 2009; Liu et al., 2013; Sinanoglu et al., 2016). Hart et al. (2009) showed that the OC exposure to the sphenoid sinus exhibits anatomical differences between sexes. Liu et al. (2013) reported a sex influence in the distance between the cranium end of the OC and nasion. Sinanoglu et al. (2016) reported that sex exert influence on the orbit surrounding structures, such as the distance between the orbit end of the OC and nasion, with a male dominance. Although there are reports of significant differences between the sexes (Hart et al., 2009; Liu et al., 2013; Sinanoglu et al., 2016), there are no reports of differences between sides in the same sex (Sinanoglu et al., 2016). It's a consensus that the OC of male sex sample had a predominance of the dimensions.

Regarding SOF, in the present study there were no significant differences in its perimeter (mm) for the comparison between the sexes, neither to the right side nor to the left side. Patel et al. (2021) and Govsa et al. (1999) performed a series of measures in dry skulls, adult cadaveric heads and CT scans to characterize the morphology of the SOF. The authors reported that no differences were observed between the right and the left sides for the measurements (Govsa et al., 1999; Patel et al., 2021), except for the distance of SOF to foramen rotundum in dry skull in the study conducted by Patel et al. (2021). It is interesting to note that no studies were found comparing SOF dimensions between the sexes, only between the sides. Considering that the CT scans are important to visualize anatomical structures with accuracy (Deniz et al., 2018), the importance of the tridimensional bony assessments in clinical practice, and the specific quantitative variations of the populations, the present study showed new data about anatomical structures of the human orbit, bringing relevant knowledge for surgical and diagnostic procedures in the region. Especially for those anatomical structures evaluated that allow the passage of blood vessels and nerves, specific knowledge of their dimensions in different populations is valuable to avoid injuries during procedures in the orbital region. The morphometric analysis of present study in a Brazilian population may help professionals in the evaluation of patients of both sexes.

ACKNOWLEDGEMENTS

The authors sincerely thank those who donated their bodies to science so that anatomical research and teaching could be performed. Results from such research can potentially increase scientific knowledge and can improve patient care. Therefore, these donors and their families deserve our highest respect (Iwanaga et al., 2020).

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