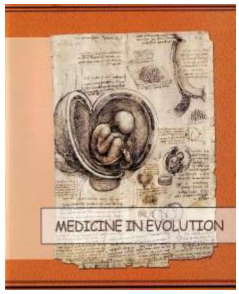
Anthropometric measurements of the orbit. A study on 332 orbital cavities using dry skulls



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Abstract

The orbit is one of the most complex and variable anatomic structures; hence the assessment of orbital dimensions in the normal population is essential not only from an anthropologic point of view but also for the surgical management of different diseases. The objective of the study was to measure important orbital dimensions in dried skulls using a digital Vernier Caliper and define the effects of gender on orbital anthropometry.

Materials and methods: We measured orbital width, height, depth, length of the medial and lateral wall, biorbital and interorbital diameter and orbital index in 166 adult skulls (332 orbital cavities) and compared right and left sides and male to female.

Results: The mean orbital index was 83.28 ±5.46. The population belongs to the mesoseme category. The orbital height, width, biorbital and interorbital widths, length of the medial and lateral walls were higher in males than in females and the differences were statistically significant ($p<0.001$). Orbital depths were comparatively evaluated between gender groups and no statistically significant difference was found. No differences were found between the orbital index of male and female orbits.

Conclusions: The study revealed important differences of most orbital dimensions between genders but it also provides an important baseline of anthropometric data for multidisciplinary clinical and surgical use.

Keywords: direct measurements, orbital dimensions, Vernier Caliper, orbital index, mesoseme

INTRODUCTION

The orbit is one of the most complex structures of the human skull. The interest for measuring the diameters and volume of this highly variable and complicated anatomic structure started more than a century ago and there is still no standardized method approved worldwide. Measurements of the orbit are vital given the multitude of pathology involving this anatomic region. Traumatic orbital fractures, congenital diseases, intraorbital tumors, inflammatory diseases are frequent and this explains the multidisciplinary interest in correctly measuring and quantifying the orbital contents [1]. Knowledge of the anatomy, gender and racial variations of the human orbit are essential in diagnosing, evaluating and treating patients [2].

Anthropometry is a technique of quantitatively expressing the form of the human body and skeleton [3].

In 1875, Paul Broca described the orbital index by measuring orbital height and width in order to evaluate the orbital size and shape as a quantity [3]. Patnaik et al. [4] calculated the orbital index and showed the relation between width and height of the orbit. He defined 3 orbital categories: *megaseme (large)* — the orbital index is 89 or higher; it is found in the yellow race except the Eskimos [3]; *mesoseme (medium)* — the orbital index ranges between 89 and 83 and it is found in the Caucasian race [3]; *microseme (small)* — the orbital index is 83 or lower; this type is found in the black race [3].

The purpose of this study was to research the anthropometric variation of the orbit in the normal population using direct measurements of different orbital diameters.

MATERIAL AND METHODS

In order to achieve our goal we examined a total of 166 preserved adult human skulls (n=166) from the collection of Craniology of the "Fr. I Rainer" Institute for Anthropology in Bucharest, Romania.

Measurements were performed manually by a single investigator using a digital Vernier Caliper (*Fig. 1*). Standard anatomical points were determined and used for the measurement of the orbital width, height, biorbital and interorbital diameter, depth, length of the lateral and medial wall and the orbital index.

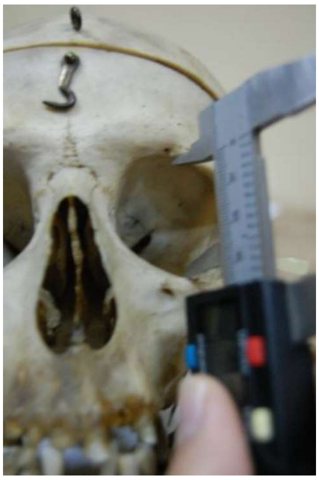

Figure 1. Direct measurement of the orbital height using the digital Vernier Caliper

Orbital height - the maximum distance between the superior and inferior orbital margins.

Orbital width: distance between the midpoint of the medial margin of the orbit to the midpoint on the lateral margin of the orbit.

Orbital index - orbital height/orbital widthX100.

Biorbital width **-** distance between left and right midpoint of the orbital lateral margin.

Interorbital width **-** distance between the midpoint of the medial margin of the left and right orbits

Orbital depth **-** distance between the optic foramen and the midpoint of the line defining the orbital width

Length of the lateral wall - distance between the optic foramen and the midpoint of the lateral margin.

Length of the medial wall - distance between the optic foramen and the midpoint of the medial margin (on the anterior lacrimal crest).

All measurements were recorded and expressed as Means ± Standard Deviation and range (min value- max value). For all the statistical analyses we used the SPSS 20.0 version software. To evaluate the gender differences between the groups we used the Mann-Whitney U-test. $P<0.05$ was considered significant.

RESULTS

From the 166 preserved human skulls 86 (51.8%) were female and 80 (48.2%) male. The average age of the group was 44.57 (±16). For the female group the average age was 44.84 (±17.55) (18-85) and for the male group it was 44.29 (± 14.30) (23-82).

The heights and widths of the orbits were as follows: mean right orbital width 40.0 ± 2.01 mm and mean height 33.3± 2.53 mm; mean left orbital width 39.7 ± 1.77 mm and mean height 32.98 ± 2.28 mm. When left and right orbital heights and widths were comparatively evaluated between gender groups, left and right orbital widths and heights were higher in males (mean right orbital width 40.73 ± 1.90 mm and mean height 33.92± 2.68 mm; mean left orbital width 40.38± 1.63 mm and mean height 33.48± 2.28 mm) then in females (mean right orbital width 39.32 ± 1.88 mm and mean height 32.86± 2.29 mm; mean left orbital width 39.12 ± 1.68 mm and mean height 32.52 ± 2.20 mm) and the difference was statistically significant ($p < 0.001$).

The orbital index (orbital height/orbital width × 100) on the right side is 84.49 ± 5.66 and on the left side 83.06 ± 5.27. The orbital index in the male group was 83.33 ± 5.97 for the right orbit and 82.96 ± 5.61 for the left orbit and in the female group it was 83.65 ± 5.38 on the right side and 83.16 ± 4.96 on the left side. When orbital indexes were comparatively evaluated between gender groups, no statistically significant difference was found ($p > 0.05$) (*see Table I*).

Table I. *Dispersion of orbital height, width and orbital index according to genders and right/left sides*

	Right Orbit			Left orbit			
Gender	Height	width	Orbital Index	Height	Width	Orbital index	Total
Female	32.8698 (2.2907)	39.3255 (1.8828)	83.65 (5.38)	32.5278 (2.2036)	39.1273 (1.6817)	83.16 (4.96)	86
Male	33.9266 (2.6881)	40.7336 (1.9039)	83.33 (5.97)	33.4826 (2.2805)	40.3870 (1.6347)	82.96 (5.61)	80
Total	33.3791 (2.5384)	40.004 (2.0149)	84.49 (5.66)	32.988 (2.2849)	39.7344 (1.7705)	83.06 (5.27)	166

The depths and lengths of the medial and lateral walls were as follows: mean right orbital depth 43.42 ± 2.45 mm, mean right orbital length of the medial wall 45.15± 2.33, and mean right orbital length of the lateral wall 45.89± 2.57; the mean left orbital depth was 43.01± 2.39, mean left orbital length of the medial wall 45.33± 2.32, and mean left orbital length of the lateral wall 45.49± 2.55 mm. When left and right orbital depths were comparatively evaluated between gender groups, no statistically significant difference was found (p=0.9, p>0.05). When lengths of the right and left medial and lateral wall were comparatively evaluated between gender groups they were higher in males (mean right orbital length of the medial wall 45.82 ±2.30, and 46.87 ±2.68 of the lateral wall and mean left orbital length of the medial wall 46.09±2.33, and 46.53 ±2.55 of the lateral wall) then in females (mean right orbital length of the medial wall 44.53 ±2.19, and 44.97 ±2.09 of the lateral wall and mean left orbital length of the medial wall 44.62±2.09, and 44.52±2.14 of the lateral wall) and the difference was statistically significant (p < 0.001) (*see Table II*).

Table II. *Dispersion of orbital depth, lenght of medial and lateral walls according to genders and right/left sides*

	Right orbit			Left orbit			
Gender	Depth	Length of the medial wall	Length of the lateral wall	Depth	Length of the medial wall	Length of the lateral wall	Total
Female	43.4677 (2.2263)	44.5312 (2.1978)	44.9749 (2.0912)	42.9127 (2.2184)	44.6230 (2.0965)	44.5284 (2.1450)	86
Male	43.3721 (2.6895)	45.8238 (2.3010)	46.8764 (2.6835)	43.1294 (2.5809)	46.0935 (2.3348)	46.53 (2.5577)	80
Total	43.4216 (2.4533)	45.1541 (2.3330)	45.8913 (2.5708)	43.0171 (2.3950)	45.3317 (2.3275)	45.493 (2.5512)	166

The average biorbital width was 94.76± 4.52 mm, and the interorbital width was 15.02 ± 2.88 mm. When the biorbital and interorbital widths were evaluated comparatively between gender groups, they were found higher in males (97.27 ± 4.01 and 16.15 ± 2.69) than in females (92.42 ±3.63 and 13.96 ±2.66) and the difference was statistically significant (p < 0.001) (*see Table III*).

Table III. *Dispersion of biorbital and interorbital width according to genders*

Gender	Biorbital width	Interorbital width	Total
Female	92.4222 (3.6313)	13.9694 (2.6626)	86
Male	97.2771 (4.0160)	16.1565 (2.6939)	80
Total	94.7619 (4.5206)	15.0234 (2.8859)	166

DISCUSSIONS

Our current study revealed important anthropometric differences of the orbit between genders. The average orbital index of the whole group was 83.28 ±5.46 (83.40 ±5.17 in the female group, and 83.14 ±15.78 in the male group). These results place the group in the mesoseme category. The orbital index in the male group was 83.33 ± 5.97 for the right orbit and 82.96 ± 5.61 for the left orbit and in the female group it was 83.65 ± 5.38 on the right side and 83.16 ± 4.96 on the left side. We found that the orbital height and width were higher in males than in females and the differences were statistically significant (p<0.001). When orbital indexes were comparatively evaluated between gender groups, no statistically significant difference was found (p > 0.05).

In our study we also measured the sagittal diameters of the orbit (depth, length of the lateral and medial walls) which we consider to be among the most important in the management of surgical pathologies. The depths of the right and left orbits were 43.42 ± 2.45

mm and 43.01± 2.39. Interestingly when compared between gender groups, no statistically significant difference was found ($p=0.9$).

The length of the medial and lateral walls for the right and left eye were 45.15± 2.33, 45.89± 2.57, 45.33± 2.32 and 45.49± 2.55 mm. When they were comparatively evaluated between gender groups all the diameters were higher in the males than the females and the differences were statistically significant ($p<0.001$).

An interesting result is that even though most of the distances measured were higher in males than females (orbital width, height, lengths of the lateral and medial walls) there was no difference between genders when the mean depth of the orbit was calculated. This result was similar to the one obtained by Karampatakis et. al. in a study published in 1997 [5].

Too few anthropometric studies have included the sagittal diameters of the orbit but knowledge of these measurements could improve surgical safety and accuracy of different interventions, like retrobulbar anesthesia.

Katsev et al studied the needle path length in retrobulbar anesthesia on 120 human orbits and found the distance from the inferior temporal orbital rim to the optic foramen to be between 42 and 54 mm concluding that 11% of the population is at risk for perforation of the optic nerve when the common 38 mm needle is used. He recommends placing the needle less than 31 mm behind the orbital rim [6].

Karampatakis studied the orbital depth in relation to retrobulbar anesthesia in 50 adult skulls. He found the distance from the inferolateral orbital rim to the optic foramen varied from 4.4 to 5.7 cm in males (mean 5.024±0.272) and from 4.5 to 5.5 cm in females (mean 4.9± 0.204). Similar to our study he found no difference between males and females ($p>0.05$). He concluded that individuals with shallow orbits are more susceptible to optic nerve injury than those with deep orbits [5].

Chang et al studied 71 pediatric patients (4 months-17.8 years) and performed quantitative measurements of the orbital depth, biparietal and nasion-occipital distances and found a very strong linear correlation between these distances with a correlation coefficient of 0.83 ($p<0.0001$). They also found a strong nonlinear exponential correlation between age and depth of the orbit (0.88 $p<0.0001$). They concluded this information could improve surgical safety in pediatric patients [7].

In our study the average biorbital width was 94.76± 4.52 mm, and the interorbital width was 15.02 ± 2.88 mm. When the biorbital and interorbital widths were evaluated comparatively between gender groups, they were found higher in males (97.27 ± 4.01 and 16.15 ± 2.69) than in females (92.42 ±3.63 and 13.96 ±2.66) and the difference was statistically significant ($p < 0.001$). In a similar study Gosavi et al [8] found a biorbital distance of 95.65 ± 3.48 mm and interorbital distance of 19.49 ± 3.35 mm and compared it to other studies. They suggested the biorbital diameter determines the width of the upper face and the differences in interorbital and biorbital diameters need to be considered during facial cosmetic surgery, nasal bridge reconstruction and also in the design of spectacle bridges, frames and protective equipment for the eye. In the French population [9] the biorbital-interorbital distances were 98.97 and 19.81 mm.

In the present study we found that the orbital height, width, biorbital and interorbital widths, length of the medial and lateral walls were higher in males than in females and the differences were statistically significant ($p<0.001$). We found no statistically significant difference between gender groups when the depths of the orbits were evaluated ($p=0.9$, $p>0.05$). When orbital indexes were comparatively evaluated between gender groups, no statistically significant difference was found ($p > 0.05$).

The orbital index was presented by Broca in 1875 and based on the different values obtained three categories of orbits have been described for the human populations. Cassidy (1913) attributed the megaseme (orbital index over 89) to the yellow races (except for the

Eskimos) and the microseme (orbital index 83 or less) to the black races. The third category, mesoseme (between 83 and 89) was attributed to the white races. [10].

The orbital index determines the shape of the face. The populations with larger indexes will have round orbital openings (width and height almost equal) and narrow faces. In microseme populations the width is larger than the height and the orbital opening is rectangular.

More recent studies found a great variation of the orbital index with gender, age, race, regions within the same race and also period of evolution making it even more difficult to estimate the dimensions of the orbit within a population by just using this classification. A study on the orbital dimensions of the Malawi population found an orbital index of 95.15±4.56 (90.63-99.75) placing it in the megaseme category, contrary to the Casidy classification. Ukoha et. al. [2] studied a Nigerian population and described it as megaseme. Fawehinmi [11] also found an orbital index of 89.21 in the Nigerian population studied. In another study in Port Hacourt Nigeria, Fawehinmi et al studied a population that was also in the megaseme category. Studies in different regions of China performed by Black (1928) [12], Harrower (1928) and Hisaschi (1982) [13] found all three categories of orbits in the Chinese population proving once again the high regional variability within the same race. [14].

Studies on different populations in Japan (Kanto and Kinki region) classified the group as microseme (79.26-80.33). Measurements on prehistoric men in Japan found orbital indices of 65.2-66.7 and in the Neolithic men of 76.39-75.11, thus proving the evolution has a major role in the facial skeleton development. Although facial skeleton is genetically determined it can be modified before (in utero) or after birth in response to environmental and epigenetic factors like climate or masticatory function [15].

Our results are similar to other studies [16, 17] which found that the orbital height, width, biorbital-interorbital widths were higher in males than in females but opposite to our findings the orbital index was also higher in males than in females. Hussmann et al [2] found the orbital index higher in females than in males. In our study we found no statistically significant difference between gender groups when orbital indexes were compared ($p > 0.05$).

A study similar to ours was conducted in India on 64 skulls using a digital Vernier Caliper to measure the orbital height, width, biorbital and interorbital distance and the orbital index. The mean orbital height was 32.31 ± 2.52 mm. The mean orbital width was observed as 39.46 ± 2.57 mm. hence the Orbital index was calculated as 81.88 mm. The studied population was classified as microseme. The mean biorbital distance was 95.65 ± 3.48 mm (range – 88.5 – 102.5 mm) and the mean interorbital distance was 19.49 ± 3.35 mm (range – 11.8 – 27.6 mm) [8].

The growing need for anthropometric studies of the orbit within the local population is due to the great complexity and variability of this anatomic region. Knowledge of its anatomy is of vital importance in different pathologies and specialties (ophthalmology, ENT, oral and maxillofacial surgery and neurosurgery) both in diagnosing and treating patients.

CONCLUSIONS

The orbit is one of the most complex anatomic regions of the human body and the understanding of its anatomy is essential and vital in many surgical specialties like ophthalmology, ENT, maxillofacial surgery and neurosurgery. Its variability with gender, race and ethnicity also makes it important in forensic medicine. To our knowledge this is the first study on the orbital dimensions of a population from Romania and due to the large number of cases we were able to have very statistically relevant results. The study revealed important differences of most orbital dimensions between genders but it also provides an important baseline of anthropometric data for multidisciplinary clinical and surgical use.

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