Morphometric Analysis of the Orbit in Dry Human Skulls in Northeast Brazil

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ABSTRACT

Introduction: the orbit is present in pair in the skull. It is a bone cavity that has important clinical implications, characteristics of sexual dimorphism and is anthropologically relevant in the definition of ethnicity. The objective of the present study was to analyze the morphology of orbits in cadaveric skulls of two different populations in Northeast Brazil.

Material and Methods: skulls of two different states of Brazil (Ceará and Paraíba) were categorized into three types: Megaseme, Mesoseme and Microseme. The quantitative analysis was performed by a digital caliper and included the following measurements: (1) OH: Orbital Height; (2) OB: Orbital Breadth; (3) OI: Orbital Index. The data underwent statistical analysis using the IBM SPSS 23 software, with a significance level of 5%.

Results: after excluding skulls with damaged orbits, 115 skulls were included, totalizing 230 orbits. Of these, 91 skulls were from Paraíba and 24 from Ceará. Both populations apart and together are in the microseme category. No differences were found in quantitative analysis between genders, sides or populations, except OB and OI that showed differences between the two populations studied.

Conclusion: the study of orbit is essential for the surgeon, clinician, anatomist, radiologist and professionals from other specialties, since it is a region of important clinical and surgical significance, as it may undergo morphometric changes depending on the population.

Keywords: Anatomy; Orbit; Skull; Osteology.
The quantitative analysis included the following measurements: (1) OH: orbital height, which corresponds to the largest vertical diameter of the orbit; (2) OB: orbital breadth, which is the transverse diameter from the point called dacryon (d) – intersection between the frontal, lacrimal and maxilla bones – to the point called ectoconchionec (ec) – intersection of the lateral edge of the orbit with the line that divides the orbit along the longest axis; (3) OI: orbital index, obtained by dividing OH by OB and multiplying the result by 100. (Figure 1)

A comparison of the variables OB, OH and OI was performed between the genders of both study populations, as well as between both sides. In addition, comparisons were also made between diameters of both populations (UFPB and UFC), with both genders and sides together.

The data underwent statistical analysis using the IBM SPSS 23 software. Categorical variables were described by frequencies. The normality analysis was performed by the Kolmogorov-Smirnov test, the difference between medians of nonparametric variables by the Wilcoxon and Kruskal-Wallis tests and the difference between means of parametric variables by the Independent Samples t Test. Values of p≤0.05 were considered significant.

Results

After excluding skulls with damaged orbits, 115 skulls were included, totaling 230 orbits. Of these, 58 (50.4%) were female and 57 (49.6%) were male. The sample consisted of 91 (79.1%) skulls from the Morphology Department of UFPB and 24 (20.9%) from UFC. UFPB had 46 female skulls and 45 males, while UFC had 12 male and 12 females. (Table 2)

The qualitative analysis was done considering each population studied and both. Using the OI, both populations apart and together are in the category microseme, according to the standard classification by Patnaik, Bala and Singla. On UFPB, 85.16% of the orbits were Microseme, 12.64%, Mesoseme and 2.2%, Megaseme. On UFC, 58.3% were Microseme, 25%, Mesoseme and 16.7%, Megaseme. Considering both populations, 79.6% of the orbits were Microseme, 15.2%, Mesoseme and 5.2%, Megaseme. (Table 3)

Table 3. Distribution of orbits’ categories according to Patnaik, Bala and Singla in skulls of Northeast Brazil. N = 250 orbits.

| Population | Median OI (%) | Category | Distribution |
|------------|--------------|----------|--------------|
| UFPBa      | 78.28        | Microseme| 85.16% - Microseme; 12.64% - Mesoseme; 2.2% - Megaseme |
| UFCb       | 82.16        | Microseme| 58.3% - Microseme; 25% - Mesoseme; 16.7% - Megaseme |
| Total      | 78.78        | Microseme| 79.6% - Microseme; 15.2% - Mesoseme; 5.2% - Megaseme |

a – Federal University of Paraíba; b – Federal University of Ceará.

Without differentiating gender, side or population, linear measurements showed that the mean of orbital breadth (OB) was 41.87mm ± 2.50 (31.13 - 48.52) and the median of orbital height (OH) was 33.00mm, IQR = 3.00 (28.60 - 41.20). In addition, the median of orbital index (OI) was 78.78mm, IQR = 7.04 (53.70 - 115.28) (Table 4)

Considering the side, orbits were divided into left and right. On the left, the median of OH was 33.20, IQR
Considering the gender, orbits were divided into female and male. On female, the median of OH was 33.00, IQR 2.73 (28.60 - 31.50) and the mean of OH was 32.80 ± 2.34 (28.30 - 36.20). On male, the median of OH was 32.80, IQR 2.40 (28.90 - 39.00) and the mean of OH was 32.80 ± 2.54 (31.00 - 34.70). There were no differences between genders (p<0.05). (Table 4)

Then, the orbits were divided into two populations: UFPB and UFC. On UFPB, the median of OH was 32.90, IQR 3.10 (28.60 - 35.00) and the mean of OH was 32.52 ± 2.28 (29.92 - 34.20). On UFC, the median of OH was 33.52, IQR 2.28 (28.92 - 34.20), the median of OI was 78.30, IQR 6.42 (66.35 - 103.50) and the mean of OB was 41.79 ± 2.54 (31.30 - 48.52). There were no differences between genders (p<0.05). (Table 4)

According to the standard classification by Patnaik, Bala and Singla4, the mean OI of both populations (UFC and UFPB) in the present study belongs to the Microseme category. Pires et al have also studied a Brazilian population, in the Southeast region, and have reported a higher mean OI (88.72)4. This group can be placed under the Mesoseme category, different to our results. The reported difference may have occurred due to regional, genetic and environmental factors or due to the smaller sample analyzed in their study (n = 77). (Table 6)

Mekala, Shubha and Rohini carried out their study in a South Indian population, which can be placed under the Mesoseme category, also different to our results, given that they found higher values of OI. Dhanwate and Gaikwad had the same classification finding as the previous study, but in a population from the West of India6. Kumar and Nagar also conducted a study in an Indian population, but in the North, with findings that correlate to the Microseme category, the same found in our study9. This difference between North and South may have happened due to the same reasons as in Brazil and shows that, in the same country, different regions may present different orbit types. (Table 6)

Other studies had different orbit types considering ours. A study in China with CT scans placed the population in the MesoSeMe category10. In Nigeria, a study had the MegaseMe classification11. On the other hand, studies in Egyptian and Kenyan populations had the same classification as this study, MicroseMe5,12. (Table 6)

The present study analyzed 230 orbits and concluded that there were no differences between the parameters when comparing the right orbit with the left one, as well as between genders. Regarding the orbit index, in the female gender it had a higher value compared to the male gender. (Table 4). This difference, however, does not present statistical significance to associate

**Discussion**

Skull morphometric parameters, including orbital height, breadth and index, are important for ophthalmology, oral and maxillofacial surgeons and neurosurgeons, as well as to distinguish an individual’s gender and ethnicity. These measures vary due to age, sex, race and regions3,4. Prior knowledge of these measures is crucial for their correct clinical application, given that it varies from one population to another.

**Table 4.** Morphometric analysis, considering the gender and sides of orbits in Northeast Brazil. Data were expressed as Mean (mm) ± SD (Minimum - Maximum) for OB measurement and Median (mm) - Interquartile Range (Minimum - Maximum) for OH and OI measurements. N= 250 orbits.

| Variables | Left | Right | p value | Female | Male | p value | Total |
|-----------|------|-------|---------|--------|------|---------|-------|
| OH        | 33.20 - 2.67 (28.60 - 41.20) | 32.70 - 3.10 (28.92 - 39.82) | .157c | 33.00 - 2.73 (28.60 - 41.20) | 32.80 - 3.40 (28.90 - 40.50) | .196e | 33.00 - 3.00 (28.60 - 41.20) |
| OI        | 78.72 - 758 (53.70 - 108.57) | 78.79 - 6.76 (67.57 - 115.28) | .767e | 78.91 - 6.42 (66.35 - 115.28) | 78.30 - 7.40 (53.70 - 115.28) | .454e | 78.78 - 7.04 (53.70 - 115.28) |
| OB        | 42.08 ± 2.64 (31.13 - 47.60) | 41.66 ± 2.34 (33.76 - 48.52) | .198d | 41.96 ± 2.46 (31.13 - 47.60) | 41.79 ± 2.54 (31.30 - 48.52) | .621e | 41.87 ± 2.50 (31.13 - 48.52) |

OH – Orbital Height; OI – Orbital Index; OB – Orbital Breadth; IQR – Interquartile Range; c – Wilcoxon test; d – Independent Samples t Test; e – Kruskall-Wallis test.

**Table 5.** Morphometric analysis, considering the orbits of two different populations in Northeast Brazil. Data were expressed as Mean (mm) ± SD (Minimum - Maximum) for OB measurement and Median (mm) - Interquartile Range (Minimum - Maximum) for OH and OI measurements. N= 250 orbits.

| Variable | UFPB | UFC | p value for comparison |
|---------|------|-----|-----------------------|
| OH      | 32.90 - 3.10 (28.60 - 40.50) | 33.52 - 2.28 (29.92 - 34.20) | .1194e |
| OI      | 78.28 - 6.83 (53.70 - 108.57) | 82.16 - 8.62 (70.86 - 115.28) | .0000025a |
| OB      | 42.28 ± 2.28 (36.3 - 47.6) | 40.30 ± 2.71 (31.13 - 48.52) | .000015d |

OH – Orbital Height; OI – Orbital Index; OB – Orbital Breadth; IQR – Interquartile Range; e – Kruskall-Wallis test; d – Independent Samples t Test.
with sexual dimorphism in these populations. This higher value found for OI in females is similar to that found in other studies carried out in India, Egypt and Kenya3,5,8,10,12. (Table 7)

In this study, there were no significant asymmetries between the OI of right and left orbits, as also seen by studies in India, Egypt and Nigeria3,5,11. The same was found by Ji et al, in their study carried out in the Chinese population, as well as Mekala et al, in a population of South India, where OI on the right side is a little higher than the left side8,10. These variations in OI inside the same population may be due to genetic and environmental factors and also to different craniofacial growth patterns arising from ethnic and racial differences. (Table 7)

Regarding the OB and OH diameters, no significant differences were found between genders. These results are similar to the discoveries of Dhanwate and Gaikwad, in a population of India, that also found no significant differences between the OH and OB diameters when comparing the sexes. A study in Brazil with CT scans found a statistically significant difference in OB between genders, but not in OH, like studies in Egypt and China5,10,13. Other study in India, on the other hand, found significant differences between the genders in both parameters (p < 0.001)8. (Table 8)

When comparing the OH and OB diameters on the right and left orbits, it is noted that the left side presents higher values than the opposite side. However, this difference is not statistically significant. This difference was also not statistically significant in studies in Brazil, China, Nigeria and India, but, in these last 3 countries, the right side generally presented higher values, which is the opposite of our study8,10,11,13. Other study in India found that the only statistically significant difference was that the right orbital breadth was higher than the left one, which is different to the findings of our study3. (Table 8)

Considering the two populations of our study, when comparing the values of the right and left side of the OB diameter of both sexes between the two populations studied, it was observed that the orbits of Ceará showed a smaller breadth compared to Paraíba (p <0.001). (Table 5). This difference may be due to environmental and genetic factors, given that Ceará people are known to have a flat head10.

In addition, it is noted that the orbit index (OI) also showed differences when comparing the two states (p <0.001). The importance of the orbital index lies in its use for the interpretation of fossil records, the classification

### Table 6. Comparison of orbit types with previous studies.

| Study                          | Skull number | Population         | OI (%) |
|-------------------------------|--------------|-------------------|--------|
| Pires et al, 20166             | 77           | Brazilian (Southeast) | 88.72  |
| Mekala; Shubha; Rohini, 20159  | 200          | Indian (South)     | 85.8   |
| Dhanwate; Gaikwad, 20161      | 98           | Indian (West)      | 87.47  |
| Kumar; Nagar, 20144            | 68           | Indian (North)     | 79.65  |
| Ji et al, 201550              | 64 CT scans  | Chinese            | 87.42  |
| Ukoha et al, 201111            | 70           | Nigerian           | 89.21  |
| Fetouh; Mandour, 20145        | 52           | Egyptian           | 83.50  |
| Jeremiah; Pamela; Fawzia, 20133 | 150          | Kenyan             | 83.48  |
| Present Study                 | 115          | Brazilian (Northeast) | 78.78  |

OI – Orbital Index.

### Table 7. Comparison of OI (%) between both sexes and sides with previous studies.

| Study                          | Skull number | Population        | Female OI | Male OI | Right OI | Left OI |
|-------------------------------|--------------|------------------|-----------|---------|----------|---------|
| Dhanwate; Gaikwad, 20161      | 98           | Indian (West)    | 87.88     | 87.47   | 87.28    | 87.66   |
| Fetouh; Mandour, 20145        | 52           | Egyptian         | 83.50     | 82.27   | 82.62    | 82.72   |
| Mekala, Shubha; Rohini, 20159  | 200          | Indian (South)   | 85.46     | 84.62   | 85.22    | 84.82   |
| Jeremiah; Pamela; Fawzia, 20133| 150          | Kenyan           | 83.48     | 82.57   | -        | -       |
| Ukoha et al, 201111            | 70           | Nigerian         | -         | 89.21   | 88.54    | 89.91   |
| Ji et al, 201550              | 64 CT scans  | Chinese          | 87.42     | 83.33   | 85.55    | 85.46   |
| Present Study                 | 115          | Brazilian        | 78.91     | 78.30   | 78.79    | 78.72   |

OI – Orbital Index.
of the skull in forensic medicine and the explanation of trends in evolutionary and ethnic differences. Normal values of orbital indexes are vital measurements in the assessment and diagnosis of craniofacial syndromes and post-traumatic deformities. Knowledge of normal values of a particular region or population can be used to treat abnormalities and produce the best aesthetic and functional results.\textsuperscript{10,14,15} Regarding the OH diameter, there were no statistically significant differences between the two populations.

Thus, comparisons with different studies demonstrate that there is a wide variability in orbit morphometry, due to genetic, environmental, ethnic, racial factors, measurement methods and sample sizes. It is important to note that this variability occurs between different countries and inside the same country.

Conclusion

This study shows that, considering the orbital index, the orbits of the studied populations can be placed under the Microseme category. There were no differences between the sides and no sexual dimorphism in orbits analyzed. In addition, when comparing the two populations studied, no differences were found between the height of the orbits, however, there were differences in the breadth and the orbital index, possibly being related to environmental, regional and genetic factors.

The study of orbit is essential for the surgeon, clinician, anatomist, radiologist and professionals from other specialties, since it is a region of important clinical and surgical significance, as it may undergo morphometric changes depending on the population.

Table 8. Comparison of OH and OB between both sexes and sides with previous studies.

| Study                      | Skull number | Population  | OH (mm) | OB (mm) |
|----------------------------|--------------|-------------|---------|---------|
|                            |              |             | Male    | Female  | Left   | Right  | Male    | Female  | Left   | Right  |
| Dhanwate; Gaikwad, 2016\textsuperscript{2} | 98           | Indian (West) | 32.52   | 32.43   | 32.39  | 32.64  | 37.3    | 36.96   | 37.08  | 37.52  |
| Pereira et al, 2019\textsuperscript{19} | 113 CT scans | Brazilian   | 34.92   | 34.35   | 34.67  | 34.67  | 44.15   | 42.00   | 43.22  | 43.20  |
| Fetouh; Mandour, 2014\textsuperscript{5} | 52           | Egyptian    | 35.57   | 35.12   | -      | -      | 43.25   | 42.37   | -      | -      |
| Ji et al, 2015\textsuperscript{9} | 64 CT scans  | Chinese     | 33.35   | 33.22   | 33.28  | 33.45  | 40.02   | 38.00   | 39.1   | 38.94  |
| Mekala; Shubha; Rohini, 2015\textsuperscript{8} | 200         | Indian (South) | 36.20   | 36.50   | 35.30  | 35.50  | 42.90   | 40.5    | 34.98  | 36.03  |
| Ukoha et al, 2011\textsuperscript{11} | 70           | Nigerian    | -       | -       | 31.45  | 31.9   | -       | -       | 34.98  | 36.03  |
| Present Study             | 115          | Brazilian   | 32.80   | 33.00   | 33.20  | 32.70  | 41.79   | 41.96   | 42.08  | 41.66  |

OH – Orbital Height; OB – Orbital Breadth.

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