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Research Article

Can Cranium Size be Predicted from Orbit Dimensions?

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Abstract

Aim: The morphometry of skeletal remains is of importance to anatomists, forensic experts, and anthropologists. One of the most preferred skeletal remains is the cranium. Orbital morphometry in the cranium and cranium allows us to have information about parameters such as age, gender and lineage. This study was carried out to seek an answer to the question of whether cranium sizes can be estimated from orbital sizes.

Material and Methods: In the study, 21 dry skulls belonging to the were used. Length and width measurements of the cranium and orbit were made. A precision digital caliper was used for measurements.

Results: The ratio of the diameters of the cranium and orbit was calculated as 4.56 on the sagittal axis and 3.35 on the transverse left axis and these ratios were accepted as a related ratio (RR). $Orbit_{RR}$ values were calculated by converging the orbit to the cranium in RR ratios. Statistical validity (Bland Altman Plot) and reliability (Intraclass Correlation Coeffidency) analyzes were performed to evaluate the agreement between the measurements. There was no statistically significant difference between $Orbit_{RR}$ and cranium diameters ($p>0.05$). Since there was no statistical difference, validity and reliability analysis was performed. It was observed that there was statistical validity between $Orbit_{RR}$ and cranium diameter in the sagittal and transverse axis. In the reliability analysis results, low agreement ($r=0.405$) was detected in the sagittal ($r=0.391$) and transverse axis ($0.30<r<0.50$).

Conclusion: There is validity in estimating cranium sizes using orbital measurements. In forensic medicine, cranium dimensions may be estimated based on orbital dimensions in cases without skull integrity.

Keywords: Cranium, orbit, morphometry, prediction, forensic anthropology

INTRODUCTION

Various situations, whether natural or accidental, may require the use of anthropometry. Some of these are situations such as war or accident (1). Forensic anthropology determines data such as gender, age and ethnicity over bone remains. This field of study undertakes more and more important tasks in finding answers to the "who" and "how" questions that form the basis of forensic events (2). Cranium morphometry is also frequently used to obtain these data. While the most reliable skeletal remnant is the pelvis for sex estimation, the secondary reliable method is the skull bone (3,4). The reason for the preference of the skull bone; it is resistant to burning, rotting and deterioration (1).

Age, sex, lineage and evolutionary periods are effective in the development of orbital dimensions, which is one of the formations in the cranium.5 Therefore, orbital measurements are important in forensic anthropology (4,5).

It is very important to obtain personally identifiable data from unknown human bone remains. The integrity of the individual's skeleton is essential in order to obtain accurate results from bone remains. However, it is rare to reach all of the bones of the skeletal system in good conditions (6-8).

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Since deformation and deficiency may occur in the skeletal remains to be studied, the measurement of every formation cannot be made directly. In our study, we sought an answer to the question of whether the deformed cranium dimensions can be reached from skeletal remains whose orbit has not been deformed?

MATERIAL AND METHOD

Design

In our study, macroscopic observations and measurements were made on 21 skulls in the form of dry bones of adult individuals. Cranium length with 0.1 mm precision digital caliper: sagittal diameter (accepted as the distance between glabella and opisthocranion) (Figure A1) and cranium width: transverse diameter (The skull width was measured between the two most remote points located on the right and the left side of the skull) were measured. (Figure A2). Also left orbit (O) width: transverse diameter (The laterally sloping distance from dacryon to ectoconchion) (Figure B1) and left O length: sagittal diameter (distance between the upper and lower edges of the orbit; perpendicular to its width and similarly bisects the orbit) (Figure B2) were measured.

Cranium index (9) and orbital index (10) were calculated from the measurements made with formulas suitable for the literature.

Cranium Index: Cranium width/Cranium length×100

Orbital Index: Orbital length/Orbital width×100

Measurements in the transverse and sagittal planes were used for the new indices in the study. The related ratio (RR) between the measurements was determined by the Cranium/Orbit formula. Cranial Width/Orbital Width formula was used in the calculation of the index in the transverse axis, and Cranial Length/Orbital Length formula was used in the calculation of the index in the sagittal axis.

Statistic

The means and standard deviations of the normally distributed data were obtained. The averages were compared with each other. Orbital and cranium measurements were proportional to each other and relative ratios were calculated. Proportional values were subjected to normal distribution analysis using 5 parameters (Skewness-Kurtosis, Mean/Std, Histogram Q-Q Polts, Shapiro Wilk Test). Normally distributed data were subjected to the related samples T-Test. When it was determined that there was no difference between the data (p>0.05), validity and reliability analysis was performed. The Bland Altman Test was used in the validity analysis, and the Intraclass Correlation Coefficient (ICC) test was used in the reliability analysis. In the Bland Altman test, the data for the difference between two measurements were calculated and the Simple Scotter Dat graph was drawn. The reliability (r) value in the ICC test was interpreted according to the literature (11).

RESULTS

While the ratio of the length of the cranium to the length of the orbit in the sagittal axis is approximately 4.56 (RR1≅4.56); The ratio of the width of the cranium to the width of the orbit in the transverse axis was calculated as approximately 3.35 (RR2≅3.35). The findings of the measurements are in Table 1.

Table 1. Descriptive data of orbit and cranium

Axis	Orbit (mm)	Cranium (mm)	Ratio
Sagittal	35.39±1.96	161.08±7.80	4.56
Transvers	39.27±1.88	131.44±6.17	3.35

Parametric data were presented as mean±standard deviation (MEAN±STD). Related Ratio=Cranium/Orbit calculated

In order to find an answer to the question of whether cranium sizes can be calculated using orbital ratios, validity and reliability analyzes were performed after T test (Table 2) was applied to the dependent variables.

Table 2. Comparison of proportionalized orbit and cranium diameters

Axis	$Orbit_{RR}$ (mm)	Cranium (mm)	Sig. (p)
Sagittal	161.38±8.95	161.08±7.80	0.908
Transvers	131.57±6.31	131.44±6.17	0.948

Parametric data were shown as MEAN±STD. Statistical analysis of dependent variables was done with Paired Samples T Test

$Orbit_{RR}$ values were calculated by converging the orbit to the cranium at RR ratios. There was no statistically significant difference between $Orbit_{RR}$ and Cranium diameters (p>0.05). Since there was no statistical difference; validity (Figure 2 and Figure 3) and reliability (Table 3) analyses were performed.

Table 3. Reliability analysis between orbit and cranium

Axis	ICC	95% Coiffence	Sig. (p)
Sagittal	0.405[a]	(-0.533) (0.762)	0.136
Transvers	0.391[a]	(-0.571) (0.757)	0.147

Intraclass Correlation Coefficient (ICC) test was applied for reliability analysis. a; low agreement for reliability test 0.30<r<0.50

It was observed that there was a validity agreement between $Orbit_{RR}$ and Cranium diameter on the sagittal axis (Figure 2).

It was observed that there was a validity agreement between $Orbit_{RR}$ and Cranium diameter in the transverse axis (Figure 3).

After these data were obtained, the reliability of calculating cranium diameters using orbital ratios was examined (Table 3). Intraclass Correlation Coefficient (ICC) test was applied for reliability. There is a low agreement between $Orbit_{RR}$ and cranium on the sagittal, likely the transverse axis.

According to the data we obtained from our study, Cranium Index is (CRI)=81.71±4.28 (95% CI 79.75-83.66); Orbital Index (OI)=111.15 ±5.91 (95% CI 108.46-113.85).

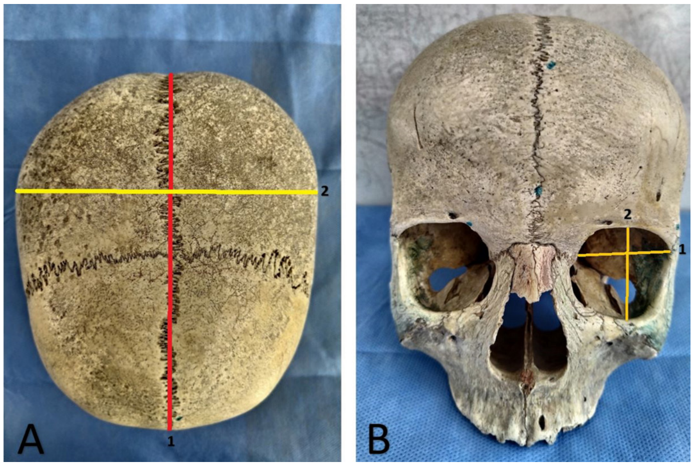

Figure 1. A, B. Measurement of the cranium (A) and orbital (B) dimensions (A1.Sagittal diameter, A2. Transverse diameter) (B1. Transverse diameter, B2. Sagittal diameter)

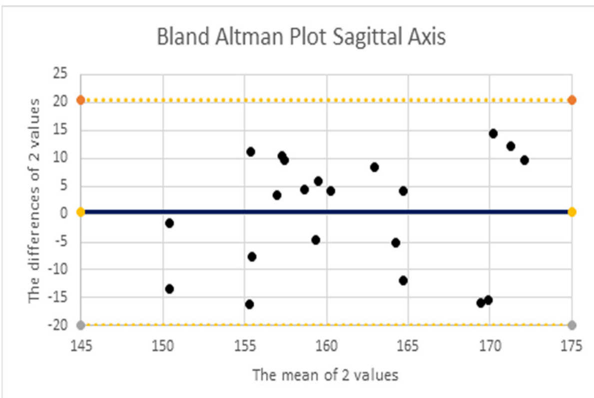

Figure 2. Demonstration of validity agreement between $Orbit_{RR}$ and Cranium diameter on the sagittal axis with Bland Altman Plot (Scotter Dot graphs)

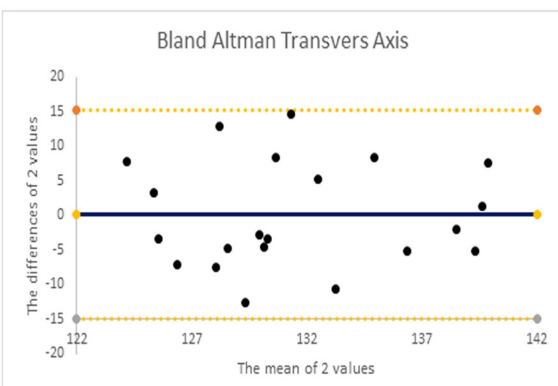

Figure 3. Demonstration of validity agreement between $Orbit_{RR}$ and Cranium diameter on the transverse axis with Bland Altman Plot (Scotter Dot graphs)

DISCUSSION

By using craniofacial dimensions, parameters such as gender and age can be determined from bone remains (12,13). The most important craniofacial dimension is the width and length used to determine the cranial index (14). The cranial index is widely used in forensic anthropology analyzes to predict an individual's ancestry (12,13).

Differences between species provide an important perspective on forensic anthropometry (15). Orbit has been used to predict individuals' race and gender for more than a century (16). The orbital index, which is obtained from the height and width of the orbit, is an extremely important anthropometric tool in forensic research, in the analysis of ethnic and racial relations and in gender estimation (15,10).

According to Mahakkanukrauh et al. (17) in their study on 200 Thai dry skulls (100 males, 100 females), the cranium length and width values were 164.02±6.76 mm, 138.68±5.33 mm (CRI: 84.55) in females and 172.64±6.23 mm, 144.44±5.69 mm (CRI: 83.66) in males, respectively. In the same study, orbital width=38.23±2.10 mm and length 33.57±1.55 mm in women. (OI: 113.88). Orbital width and length in males were 40.49±1.82, respectively; It was reported as 34.69±1.73 mm (OI: 116.71). The CRI value for men obtained according to the data in the study is close to the results of our study and is within the confidence interval. The CRI value in females is close to our study results. According to the data in the study, we found that the OI obtained was close to the confidence interval in women and higher in males.

Ramamoorthy et al. (18) in their study of 70 South Indian populations, reported the cranial length and width values as follows: length for females 170.5±6.84 mm, width 128±6.15 mm (CRI: 75.07) and length for males 178.3±8.13 mm, the width is 13±6.22 mm (CRI: 74.59). In the same study, orbital height in males was 34.1±2.42 mm; the width was reported as 45.1±4.90 mm (OI: 132.25), while in women this length was reported as 34.6±1.69 mm and width as 43.8 mm. It was seen that the CRI and OI values obtained according to the data in the study were quite different from our study.

Sangvichien et al. (19) in their study on 101 Thai dry skulls (66 men and 35 women), the cranium length in men was 175.68±6.83 mm; reported its width as 145.82±5.20 mm (CRI: 83.00). In females, cranium length and width were 168.80±7.18, respectively; It is 144.66±5.29 mm (CRI: 85.69). In the same study, orbital width in men was 40.10±1.89; its length is 33.44±2.33 mm (OI: 119.91). In females, this width was reported as 38.09±2.25 mm and length as 32.89±2.28 mm (OI: 115.81).

Marinescu et al. (20) made osteometric measurements an adult modern Romanian population sample. In this study, cranial length was 174.1 and cranial width was 144.1 in men (CRI: 82.76); The orbital length is 33.1, and the orbital width is 39.9 mm (OI: 120.54). In the same study, cranial length was 166.7 mm and cranial width was 138.4 mm (CRI: 83.02) in women; The orbital length was reported as 32.6 mm and the orbital width as 38.1 mm (OI: 116.87). According to the results obtained from the study data, while the CRI results in men and women were within the confidence interval, it was seen that the OI in both men and women was higher than the index in our study.

Toneva et al. (21) made measurements similar to our study on cranial CT images of 393 (169 males and 224 females) Bulgarian adults. In this study, cranial length was 185.50±7.09 mm and width: was 137.93±7.34 mm in men (CRI: 74.35); right orbital width was reported as 41.18±2.07 mm and left orbital width as 41.29±2.12 mm. In the same study, cranial length was 175.61±6.07 mm and cranial width was 134.56±6.15 (CRI: 76.62) mm in women; right orbital width was reported as 39.66±1.80 mm and left orbital width 39.96±1.96 mm. Orbital length calculation points in the study were not included in the discussion because they were not the same as our study. The CRI obtained from the data in the study was lower than our index values in both women and men.

Rooppakhun et al. (22) 91 on computed tomography images of Thai dry skulls (56 males, 35 females), cranial length 173±4.74 mm, width 144.13±5.45 (CRI: 83.31) and orbital width (left) 40.95±1.86 mm, orbital width (right) in males while it was 41.43±1.75 mm; Cranial length was reported as 165.15±6.61 mm, width 140.83±5.40 mm (CRI: 85.27) and orbital width as right 39.66±2.00 mm, left 39.36±2.30 mm in women. The orbital length measurement was not performed in this study. According to the results obtained from the study data, the CRI results in men were within the confidence interval, while the index in women was higher. It has been shown again by studies that the values of CRI and OI vary according to gender and both indices are large in men.

Ulcay et al. (23) measured both foramen magnum and cranium dimensions in their study of 60 dry bones belonging to the Turkish population without gender discrimination. They reported the length of the cranium as 162.45±6.20 mm and the width as 129.45±4.99 mm. According to the reported values, CRI:79.68. In our study, we found the length and width values of the cranium to be close to the present study. The CRI in our study and our results were very close to each other closeness of the results supports the existence of race-specific cranium size. Bones from the Turkish population were used in both studies. It was observed that the values of CRI and OI showed both racial and gender specific differences.

The results of our study were compared with craniometric studies performed in different and same races. It was observed that the OI and CRI values of men and women in the studies were different. Cranial and orbital dimensions in similar breeds were close to each other.

CONCLUSION

To the best of our knowledge, our study is the first in the literature to prove that the cranium size, which is important in forensic medicine, can be reached through the orbital dimension, and that this is proven by validity-reliability analysis.

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Conflict of Interest: *The authors have no conflicts of interest to declare.*

Ethical approval: *Since the skull in the form of dry bone in the anatomy laboratory was used in the study, the decision of the ethics committee was not required. However, Permission was obtained from Erciyes University Faculty of Medicine Anatomy Department.*

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