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STUDYING SEXUAL DIMORPHISM IN MORPHOMETRIC PARAMETERS OF VISCERAL CRANIUM

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Abstract

Diagnostics of sex attribute of a visceral cranium and its bones is a major question of both anatomy and forensic medial osteologic examination. The study was conducted on 48 persons of the same age group with the aim of comparing the characteristics of morphometric parameters of the visceral cranium in male and female groups within the limits of a single age group. The work used the method developed by R. Martin based on standard craniometric points: zigion (zy) – the most protruding point of the jugal bridge; fronte-temporale (ft) – the point on the temporal lines in the location of their approach. In order to determine the form of the visceral cranium, upper visceral indicator was calculated, whose value was then used to divide the age group in to 3 subgroups: leptoprosopic (narrow and high facial forms with the index of 55 units or more), mesoprosopic (average forms, with the index between 51 and 54.5 units) and euryprosopic (broad and low forms, with the index of 50 or less). Dependences were found for such parameters as the shortest breadth of forehead, bizygomatic diameter and physiognomic facial height. In general, a good case can be made that there is a shift in cranium size from medium to narrow form of the visceral cranium, that is, there is a right-hand asymmetry in distribution.

Keywords: Skull, visceral cranium forms, upper facial indicator, craniometry, visceral cranium asymmetry

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1. Introduction

Studying variation in the human body structure is one of the most relevant directions of the modern science. Human visceral cranium is a special case in studying anatomic variability of different sized in various age groups. Human cranial form determines the form of the head, independent of race and sex attribution, while the head configuration (taken together with its muscular and fat structure) determines the form of the face (Dubovik, 2009). Morphological and functional changes taking place due to various internal and external causes create different facial forms, which reflect individual features of a person within the limits of physiological asymmetry.

Morphological studies of skull use craniological methods of research that are divided into cranioscopic and measuring (craniometry) methods.

The cranioscopic methods are used when it is impossible to measure some parameters. These attributes are evaluated in units in a three-unit system (weakly, medium and strongly pronounced). Determining descriptive features of a skull plays an important role in craniological research. Practical value of cranioscopy cannot be overestimated, as during surgical intervention, the surgeon may not have an ability to conduct exact measurements of the necessary structures (Dubovik, 2009).

Craniometric method provides an ability to determine an exact structure of the visceral cranium and reveal its features depending on sex attribute. At various age, manifestation of various cranial forms differ between men and women. Newborn boys often have dolichomorphism and brachimorphia, while girls are often born with a mesomorphic skull (Seroukh & Ziuzina, 2015).

Clinical physicians usually study the structural variants of the visceral cranium in order to get better understanding of complex spatial relations between separate structures in the facial region, which shall be taken into account during a surgical intervention. A set of bones of the visceral cranium determines a form of the face. Age-related and sexual variability in craniometric parameters of the visceral cranium is rather well-studied and covered in detail in multiple sources (Gaivoronskii et al., 2009a).

In 80 % of cases, male and female skulls significantly differ anatomically. When determining sex from a skull, racial typology shall be factored in as well: features typical of female skulls in one race may be typical of male skulls in another race. Multiple measurements of parameters of both cerebral and visceral cranium in men and women have shown that the right half of the visceral cranium in comparison with the left one has more pronounced transverse dimension, providing male faces with typical coarser, male-associated facial features. The left half of a face has more pronounced longitudinal dimensions, without coarse side contours, thus providing softness, smoothness and femininity of features. This asymmetry is largely caused by non-uniformity of cranial bones. Differences between male and female skulls are determined by large and medium sizes. A male skull is characterized with a more pronounced relief in comparison with that of a female skull. Men have a more developed, long and broad facial skull in relation to the cerebral skull. Female visceral cranium has thin jugal bridges and less developed superciliary ridges, as well as less roughness for muscle insertion, especially at the lower jaw (Aleshkina & Aleshkina, 2004; Gaivoronskii & Dubovik, 2008). Male skulls are characterized with a retreating forehead, an especially pronounced fronto-nasal angle, the fronto-nasal point is depressed, the root of nose area is prominent, while female skulls have a smoother transition from the frontal to the nasal bones,

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the fronto-nasal point is not depressed, root of nose is located in a plain, with some upper inclination, the depression at the root of nose area is almost invisible. Ridge of the nose is usually straight or somewhat concave and thin. Mastoid bones are more pronounced in male skulls, defined by small, medium and large degree of development with respect for a given skull. The top of the mastoid bone in male skulls is usually pointed, that in female skulls is usually blunt (Dubovik, 2009) A characteristic features of female skulls are more pronounced frontal tubers, small nasofrontal crease, almost vertical plain of the forehead, high eye sockets with rounded entrance and thin upper socket edges. Eye sockets in male skulls are lower, often rectangular, the upper edge is thickened and blunt. In the ridge of the nose, male skulls have a well-pronounced bony structure. The form of the ridge is somewhat convex, sometimes almost flat. With respect to the subnasal crease, the contour of the upper lip is somewhat convex. Male lower jaw is more massive that the female one, its tuberosity is more pronounced by means of insertion of wing, mastication and digastric muscles in the area of angles and the lower edge of the interior surface of chin. Additionally, male skulls have the branches of the lower jaw set more vertically, while the female skulls have them more horizontal (Petrovsky, 2018). Due to this anatomic feature, mandibular angle in men is almost right, while women have a more obtuse angle). An important anatomical feature of male skulls is lower jaw angles being outward turned. Female skulls rarely have this feature. As for the upper jaw, female skulls usually have so-called upper alveolar prognathism, where alveolar process of the maxilla significantly protrudes forward.

There is almost no data on the latter morphometric parameters with respect to sex (Gaivoronskii et al., 2009b).

Researchers from the University of North Carolina (USA), having studied hundreds of skulls of Spanish and Portuguese people covering 400 years, found out that cranial and facial differences between modern men and women are less pronounced than they were in the 16th century. Additionally, the specialist have discovered that the changes were more pronounced in women. For example, visceral cranium of a modern Spanish woman is significantly larger than that of a woman from the 16th century. These features may be related to improvement in nutrition, to environmental and social factors.

In the past, cranial deformation was a common way to change the appearance. In the Bronze Age, new-born girls had their head tightly bandaged, resulting in elongation of their skull with age. A vivid example of this practice is the deformed skull of Ancient Egyptian queen Nefertiti, who was considered an embodiment of beauty (Dubovik, 2009).

Thus, one may come to a conclusion that facial beauty is a complex concept that includes such indicators as form, dimensions, proportions, symmetry, color, expressiveness etc., that ensure its individuality.

2. Problem Statement

The study covered 48 human subjects, male and female of the same age group, who were preliminary made aware with all the features of the research and have given their voluntary informed consent to the research in accordance with the applicable legislative and regulatory documents. The measurements were conducted following the method based on standard craniometric points: zigion (zy) – the most protruding point of the jugal bridge; fronte-temporale (ft) – the point on the temporal lines in the

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location of their approach. Some for these points are used in clinical practice for planning reconstructive or corrective interventions with observation of existing requirements of craniometry for anthropological research: M.9 (ft-ft) is the shortest breadth of face, M.45 (zy-zy) is the jugal size; the point tr-gn, physionomical height of face, was also used in the measurements (Alekseev & Debets, 1964; Karaian et al., 2007).

In order to determine the form of visceral cranium the upper face indicator was calculated, that is a percentage ratio between the upper height of a face and the bizygomatic diameter; according to its value, the age groups were divided into 3 subgroups: leptoprosopic (narrow and high facial forms with the index of 55 units or more), mesoprosopic (average forms, with the index between 51 and 54,5 units) and euryprosopic (broad and low forms, with the index of 50 or less) (Gaivoronskii et al., 2009a, 2009b). The parameters were measured with a soft flexible ruler, a Canon EOS 650D camera, AdobePhotoshop 2020 software package. The studied objects were photographed with a digital camera in standard stackings in frontal and side projections, after which the images were transferred to a PC. This operation was conducted under artificial lighting with halogen lamps in a combination with camera built-in flash. The distance from the object to the camera on average amounted to 30–40 cm. Selection of photographing parameters was made by the camera's microprocessor in auto mode.

All the obtained data were processed with statistical methods. Accuracy of the measurements approached 0.5 mm.

For each attribute through the sample, an average value was determined, as well as maximum and minimum values, RMS deviation, the error of mean and variation coefficient. RMS deviation is the most important indicator of dispersion of a series. Its value grows with dispersion and reduces if it is low. The RMS deviation value shows an average characteristic of dispersion of individual values around the mean, providing a possibility to determine to what degree the mean is typical. For each group determined by sex of visceral cranium type, we calculated the mean, the error of mean and the variation coefficient. A degree of link intensity between various attributes was studied using Pearson's linear correlation coefficient (Pearson's r). The error of mean allows determining how close in the sampling average to the average of the general population (i.e., estimating representativeness of the sampling average). The variation coefficient expressed as a percentage is equal to a ratio of standard deviation to the mean multiplied by 100. The larger is the variation coefficient, the more variability the studied attribute has. Low degree of variability was recorded when the variation coefficient was under 30 %, average variability corresponded to the values between 30 % and 70 % and high variability corresponded to the variation coefficient of over 70 %. In order to find significant differences between the average values of the indicators, Student's and Fisher's parametric methods were employed (Khalafian, 2007).

3. Research Questions

In the studied sample, in both male and female group, mesoprosopic facial type (medium form) prevailed. Both female and male groups contained the same numbers of leptoprosopics (narrow faces) and euryprosopics (broad faces). Analysis of statistical indicators shows that there are differences between the following cranial dimensions: M.9, M.45, tr-gn in the form of the visceral cranium (eury-, meso- and leptosopics) in male and female groups. Statistical processing of data has shown that the most stable

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indicator is jugal size (M.45). In the male group this indicator varied between 110.0 and 180.0 mm, in the female group it varied between 90.0 and 200.0 mm. The mean values were 131.0± 0.33 mm in the male group and 134.0± 0.45 mm in the female group. The most variable dimensions are: physiognomic facial height (tr-gn): In the male group this indicator varied between 180.0 and 180.0 mm, in the female group it varied between 180.0 and 260.0 mm. The mean values were 233.0± 0.44 mm in the male group and 225.0± 0.39 mm in the female group. The shortest breadth of forehead (M.9): In the male group this indicator varied between 60.0 and 130.0 mm, in the female group it varied between 70.0 and 120.0 mm. The mean values were 110.0± 0.34 mm in the male group and 96.0± 0.33 mm in the female group.

4. Purpose of the Study

Analysis of the female sample has shown that the value of the upper facial indicator has a sinistral asymmetry of distribution, that is, female skulls more often have narrow or medium form of the visceral cranium.

Analysis of the male sample has shown that the value of the upper facial indicator has a symmetrical distribution, that is, male skulls with the medium visceral cranium amount to 19 %, while whose with a narrow or a broad cranial form amount to 21 % of the general sample size each.

5. Research Methods

In general, a good case can be made that there is a shift in cranium size from medium to narrow form of the visceral cranium, that is, there is a right-hand asymmetry.

As a result of statistical processing of the data, we proved that the difference between the right and the left sides are usually less than one sigma (94 % of indicators are within 1σ, 4 % are within 2σ, and only 2 % are within 3σ). It allows drawing a conclusion that most cases of identified asymmetry in visceral cranium are physiological and do not require correction (Dubovik, 2009).

6. Findings

Thus, a comparative analysis of morphometric dimensions of visceral cranium in accordance with the sex attribute was conducted. The set was checked for normality of distribution with the three sigma rule. A hypothesis of normal distribution of the attribute was confirmed, thus main statistical tools are applicable for further analysis of the values of the upper facial indicator (Dubovik, 2009). Dependences were found for such parameters as the shortest breadth of forehead, jugal size and physiognomic facial height. Analysis of the data has shown that variation of means for various structural forms of cranium is insignificant for both male and female groups. For each group of skulls formed by type and sex attribute, as well as by visceral cranium form and external nose form, there are not only mean values of indicators characterizing the corresponding indicators, but the most significant dimensions are also selected for these dimensions that determine and influence the former ones (factorial features, included in the regression model). The number of the factorial features included in the model shall be optimal. The practice developed a certain criterion that allows determining the optimal ratio between the number of

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factorial features included in a model and the size of the studied population. According to this criterion, the number of the factorial features shall be 5–6 times less than the population size.

Application of regression models to prediction requires caution in the cases where we see that the actual values of the factorial features goes beyond the limits of the values used for producing the regression equation. The results of the conducted correlation analysis allow revealing correlations of different degree and direction. The factorial analysis with the dominant component analysis allows systematizing the correlations between the visceral cranium dimensions and establishing the main directions in the visceral cranium morphogenesis (Dubovik, 2008).

Adequacy of application of the factorial analysis in medical and biological research confirms a possibility to describe the research object with a minimal number of non-correlated characteristics and a selection of the most informative of them, as well as establishing the principal trends and dependences of a studied process. The factorial analysis method is based upon evaluation of interrelation of attributes in a correlation matrix. Finding vectors (rows) of the matrix, that is the factors, allows ranking the attribute groups by their significance. Optimization of the obtained factorial model is conducted by rotating the factorial matrix with the varimaxrow method. The optimization results in obtaining the correlation coefficients and establishing the share of each attribute in formation of each resulting factor. Thus, possibility of broad application of the correlation regression analysis is simplified with application of special software (Excel, Statistica) (Dubovik, 2009).

7. Conclusion

In adult humans (after the processes of morphogenesis of the visceral cranium is finished) there is a sexual dimorphism in linear dimensions of the visceral cranium. In males, most sizes of the visceral cranium are larger than those in females. Variability of the shortest breadth of forehead and physiognomical facial height exists but is weakly pronounced. One may assume that asymmetry in the visceral cranium that is more pronounced in studied male skulls than in the female ones is determined by a significant development of bone structures and higher muscular tones of mimic muscles in males (STudopedia, 2019; Bakhareva et al., 2012).

The research results have practical significance as characteristic signs of the normal visceral cranium in humans, both as an integral structure and of its components, with account for sex and visceral cranium form, will allow using them in clinical practice (in x-ray diagnostics and computer tomography). They also witness that independent of sex and type, in 94 % they fall into the normal range, that is they are functional, and only 6 % of differences in dimensions of the visceral cranium from counterlateral sides are results of injuries, diseases or congenital defects (Bakhareva & Shantyz, 2011; Gaivoronskii et al., 2009b).

The obtained data will be useful in plastic and maxillo-facial surgery, cosmetology, for specialist in morphology, forensic medicine and anthropology. Besides, the results of the morphological studies may be useful in personal identification, in development of immediate access and facial reconstruction from bones.

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