ANTHROPOMETRIC STUDY OF HIP-PLANE MORPHOLOGY AND CORRELATION RELATIONS OF ITS PARAMETERS WITH CEREBRAL AND FACIAL CRANIUM MEASUREMENTS

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The aim of the investigation was to determine the orientation of occlusal plane by morphometric parameters of cranio-facial complex, to study the morphology of HIP-plane and correlation relations with cerebral and facial cranium measurements.

Materials and Methods. The crania with mandibles were fixed in craniostat, and measurements were made using thickness and sliding calipers, vernier calipers of various designs. We took scaled photos of all crania using support stand, with equal approximation, in three views (coronal view, lateral view, skull base view). Digital material was computer processed.

Results. We developed craniometric technique to analyze the morphology and topography of HIP plane (Hamulus–Incisive Papilla) . Transverse facial size was found to be 1.2 times less compared to the transverse cranial diameter, and transverse facial size between zy–zy (zygion) points — 2.5 times larger than the distance between H (hamular notcher) points right and left. Facial n–gn (nasion–gnation) size was found to have medium correlation relationship with the altitude of HIP triangle. Anthropometric ipp (incisive papilla posterior) point appeared to be by 10% more stable than ip (incisive papilla) point. Therefore, for HIP-plane determination we recommend using not incisive papiila (ip), but the point, which is 3 mm distal (ipp point) and located on distal bony edge of the incisive canal opening. The analysis of the lateral view of cranium showed the relations of occlusal plane of maxilla and HIP-plane to be characterized by strong positive correlation. The inclination angle of Camper's plane to HIP did not exceed 6°. HIP-plane appeared to be more stable to determine the orientation of maxillary occlusal plane position.

Key words: HIP-plane, Frankfurter plane; Camper's plane; occlusal plane; anthropometric cranial measurements.

Methods of morphometrical studies of the head and its separate parts have been known in stomatology since ancient times. Presently, an up-to-date computer analysis is used for this purpose [1–3].

Anthropometric investigations based upon the laws of skull structure formation (facial and cerebral), proportionality rations of different parts of the head and their relations to certain planes are also known [4, 5]. It has been estimated, that dimensions of the dental arches correlate with the parameters of the jaws, facial skeleton and the body as a whole [6, 7].

Occlusal plane occupies a certain position relative to cranial bone structures and neuro-muscular apparatus of the stomatognathic system [8]. Traditionally, Frankfurter and Camper's planes have been used in orthopedic stomatology to determine orientation of the occlusal plane in the facial skeleton, though in recent years the use of these planes is subjected to criticism [4, 9, 10].

In 1955 H.N. Cooperman, S.B. Willard [11] examined over 10 thousand skulls belonging to the people of modern age. Studying the occlusal surface of the upper jaw with a pathologic abrasion, the investigators found anatomic orienting marks, which corresponded to the natural occlusal plane. It was the way HIP-plane (Hamulus-Incisive Papilla) appeared, the supporting points of which were incisive foramen and pterygognathic fossae (bone marks of the cranium base).

R. Schwartz [12] was the first to apply this plane to determine the orientation of the occlusal plane in the facial skeleton, having related it to the Camper's one. Later H. Rich proved in his research [13] that in 84% of cases the divergence between HIP-plane and the occlusal one did not exceed 4%. Cephalometric analysis made by H.D. Karkazis, G.L. Polyzois [14] proved that HIP-plane, upon the whole, is parallel to the occlusal plane and their divergence angle is less than 9°.

Data on interrelationships of the craniofacial complex elements with the occlusal plane in adults and the position of HIP-plane depending on the cranium form are not up till now complete and systematized. This encouraged us to carry on our own morphological investigations.

The aim of the investigation was to develop methods

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for determination of occlusal plane orientation according to morphometric parameters of the craniofacial complex, to study HIP-plane morphology and correlations of its parameters with the dimensions of the cerebral and facial parts of the cranium.

Materials and methods. The objects of craniological investigation were 100 certified crania with low jaws (50 females' and 50 males') belonging to people at the age of 30–60 years from the collection of the fundamental museum of the Department of Normal Anatomy of the Medical Military

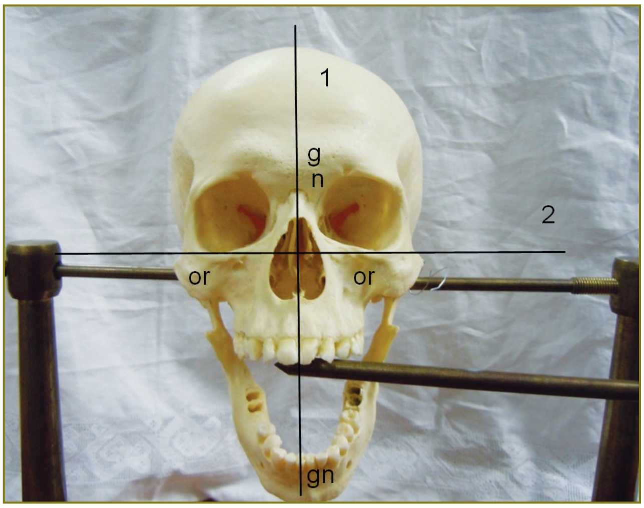

Fig. 1. Frontal surface of the skull: *1* — medial line of the facial section of the skull; *2* — a line connecting the lowest points on the orbit margins on the right and left (or–or) — orbital plane; point *n* (nasion) — site of frontal and nasal bone junction or the deepest site of the outer contour of this junction; point *g* (glabella) — the most projecting point on the nasal process of the frontal bone; point *gn* (gnation) — the most protruding point of the mentum, determined when making a tangent parallel to a section of a straight line between point: the most anteriorily projecting point of the mentum and the lowest point of the mandibular symphysis

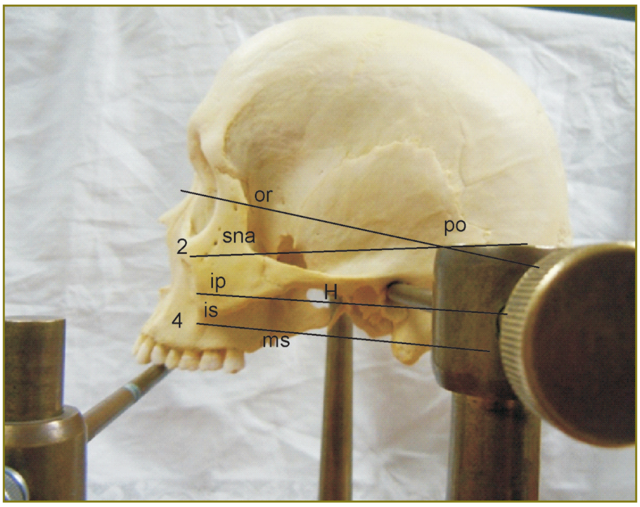

Fig. 2. Lateral surface of the skull: *1* — Frankfurter horizontal (o–op); *2* — Camper's plane (sna–po); *3* — HIP plane (ip-H); *4* — occlusal plane of the maxilla (is–ms) — this plane was drawn only on 15 skulls with remained teeth

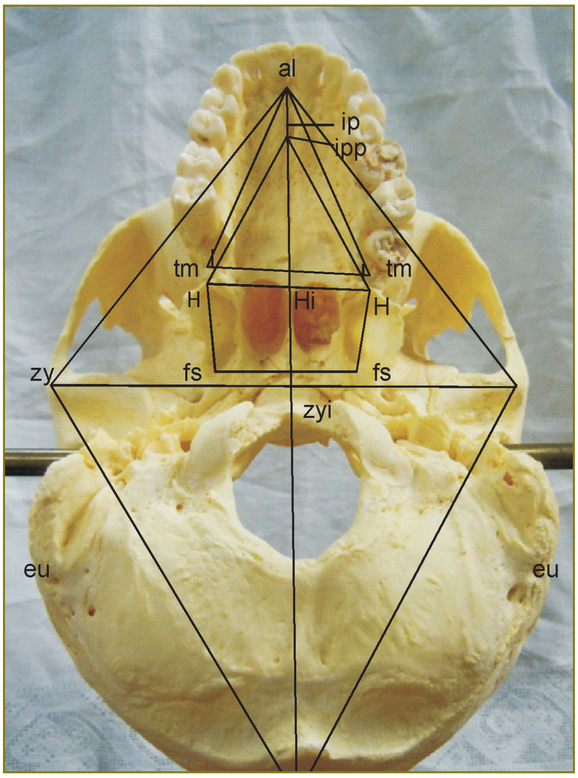

Fig. 3. Investigated craniometric points and bone orienting points, located on the outer base of the skull (bottom view): *al* (alveolare) — the lowest point of the alveolar edge of the maxillar between the central incisors; *ip* (incisive papilla) — a point located in the center of incisor canal foramen, projection of the incisive papilla; *ipp* (incisive papilla posterior) — a point, located on the distal margin of the incisor canal foramen; *tm* (tubor maxillae) — the most distal point of the alveolar process of the maxilla; *H* (hamular notches) — pterygoid notch; *Hi* — a point located in the middle of the line, connecting pterygoid notches *H–H*; *fs* (fossa scaphoidea) — scaphoid fossa; *zy* (zygion) — the most laterally projecting point on the malar arch; *ops* (opistocranion) — a point on the occipital bone being the most distal from the glabella in the median plane; *zyi* — a point lying in the middle of the line connecting the most laterally projecting points on the malar arch; *eu* (euryon) — the most distal point from the median plane on the lateral surface of the skull

Academy after S.M. Kirov (St. Petersburg, Russia) and the Department of Normal Anatomy of Nizhny Novgorod State Medical Academy (Nizhny Novgorod, Russia). The owners of these skulls lived in the middle regions of Russia and were rather a homogeneous object for investigations. Craniometric technique and biometric processing of the digital data by PC using Adobe Photoshop program were applied in the studies. Measurements were made with a precision up to 0.1 mm.

33 linear and angular measurements were performed on each cranium. For craniometric measurements each preparation was first fixed in the craniostat in the auricle-orbital plane (Frankfurter horizontal). Different designs of calipers commonly used in craniology were used for making measurements.

Scaled photos of all skulls were taken from the stand with equal approximation in three projections (frontal, lateral and cranium base) (Fig. 1, 2, 3) using professional reflex camera Canon EOS 7D Kit 15-85 IS (Japan).

The data obtained were processed using statistical programs Excel 2000 and Biostatistica (StartSoft, Inc., USA). Methods of descriptive statistics were used to characterize the obtained data.

Results and Discussion. The examined skulls were divided into three groups depending on their morphometric types of the facial skeletal structure. The 1st group included 33 skulls which had facial index more than 90 (leptoprosopes), in 34 skulls of the 2nd group facial index was 84.1– 89.9 (mesoprosopes), the 3rd group covered 33 skulls with the facial index less than 84 (euryprosopes).

The facial index was determined according to Garson formula: (*n–gn*)·100/(*zy–zy*). Index of more than 90 characterizes narrow faces that of 84.1–89.9 is typical for faces of an average width, index less than 84 is for wide faces.

The form of the head was defined by Izard cranium index: (*eu–eu*)·100/(g–ops). Index 76 is typical for dolichocephalic form of the head, that of 76.1–80.9 — for mesocephalic, and more than 81 — for brachycephalic one.

Conformity of the head form relation to the facial index in different morphometric face parameters has been estimated. Mesocephalia correlates with leptoprosope type of the face (in 46% of cases), brachycephalia — in 35%, dolichocephalia occurred not so often (19%). In the skulls with mesoprosope type of the face mesocephalic and brachycephalic form of the head occurred approximately with the same rate and was 45 and 41%, accordingly, dochocephalic — 14%. Brachycephalia (64%), mesocephalia (30%), dolichocephalia (6%) correlate with euryprosope type of the face.

All male skulls are estimated to have practically all morphological parameters larger than female, and the difference was statistically significant.

Interrelation between transversal dimensions of the dental arches and cranio-facial complex has been found. Thus, transversal dimension of the face is 1.2 times smaller than transversal diameter of the skull, transversal dimension of the face between points zy–zy 2.5 times more than the distance between points H to the right and left. Facial size n–gn has been revealed to have an average degree of correlation with the height of triangle HIP (0.624).

With the help of coefficient of variation it was estimated that point ipp, located on the distal margin of the incisor canal foramen, is 10% more stable than point ip, located in the middle of the incisor canal foramen and being projection of the incisor papilla. That is why all further calculations and HIP-plane construction were made, orienting to point ipp.

Morphological analysis of the outer skull base projection enabled us to construct three important anthropometric triangles: 1 — HIP; 2 — zy–zy–ops; 3 — tm–tm–al. In our investigation these triangles were of great importance, since the first one characterized the studied plane HIP, the second — the main anatomo-anthropometric orienting point, while the third triangle presents the dimension of the maxilla, so important in stomatology. All sides, angles, heights, as well as areas of these triangles were analyzed. Pair correlation coefficient of the area of triangle 1 and 2 equaled to 0.879, for triangles 1 and 3 — 0.932. These coefficients are close to one, which shows a strong direct correlation (See the Table).

Analyzing interrelations of parameters, characterizing position of plane HIP relative to the outer skull base it was found that increase of the distance between points H to the right and left led to directly proportional increase in transverse dimension of the face (zy–zy), in the dimension of the pterygoid bone between the scaphoid fossas, as well as in the height of triangle 3. These findings are confirmed by the three coefficients of correlation with a high level of significance ($p<0.05$). The height of triangle 1 shows moderate relation with that of triangle 2 (zyi–ops) and a high degree of relation with the dimension of the cuneiform bone (Hi–zyi).

The analysis of 15 skulls with remained teeth in the maxilla in the lateral view (Fig. 4) showed, that the inclination of planes HIP (Cv=30.45), Camper's (Cv=19.7), occlusion plane of the maxilla (Cv=39.21) to Frankfurter's horizontal has a strong variability of values. HIP-plane has an average degree of variability (Cv=11.32) relative to Camper's one, while the occlusal plane of the maxilla (Cv=12.5) showed less stability. Occlusal plane of the maxilla (Cv=9.2) was more stable relative to HIP-plane.

In all other skulls, which did not have or had partially remained teeth in the upper jaw on the lateral view, variability of inclinations of Frankfurter's, Camper's and HIP planes relative to each other have been also analyzed (Fig. 5). The most stable values showed the inclination of

Interrelations of parameters specifying the position of plane HIP relative to the outer skull base, were calculated using coefficients of Spearmen's, Kendall's rank correlation, and pair correlation ($p<0.05$)

Parameters	Coefficients	Hi-zyi	fs-fs	zy-zy	zyi-ops
ipp–Hi	Spearmen's	0.817			0.507
	Kendall's	0.646			0.345
	Pair correlation	0.803			0.529
H–H	Spearmen's		0.793	0.755	0.809
	Kendall's		0.605	0.561	0.611
	Pair correlation		0.747	0.772	0.750

HIP-plane to Camper's one, and the most variable inclination was that of HIP-plane to Frankfurter's.

Thus, the conformity of the proportion of the head to the type of the face in its different morphometric parameters has been estimated. Mesocephalia correlates to the more extent with leptoprosope type of the face, mesocephalic and brachycephalic forms of the head occurred with mesoprosope type of the face approximately with equal frequency, brachycephalia correlates mainly with euryprosope type.

Transversal dimension of the face has been found to be 1.2 times less than the transversal diameter of the cranium, the transversal size of the face between points zy–zy is 2.5 times more than the distance between points H (hamular notches) to the right and left. Facial dimension n–gn has an average degree of correlation with the height of triangle HIP (0.624).

The difference between points ip and ipp has been revealed (anthropometric point ipp appeared to be 10% more stable) which is of great practical value. For determination of HIP-plane we recommend to use a point 3 mm more distal (point ipp) located on the distal bone edge of the incisor canal foramen rather than incisor papilla.

Interrelations of occlusion plane of the maxilla and HIP-plane, according to the lateral view of the skull, are characterized by a strong positive correlation, i.e. there are close morphogenetic correlations between them. Inclination angle of Camper's plane to HIP-plane did not exceed 6°.

Conclusion. The analysis of the obtained data of the skull lateral view showed that interrelations of the maxilla occlusal plane and HIP-plane are characterized by a strong positive correlation.

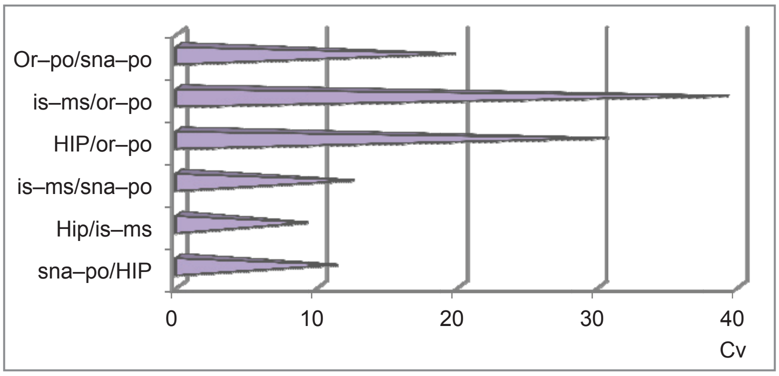

Fig. 4. Variability of inclination of cephalometric planes relative to each other in 15 crania with remained teeth in the maxilla in the lateral view

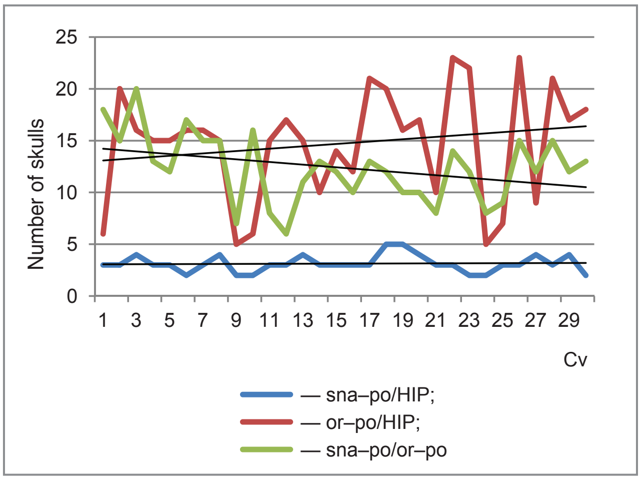

Fig. 5. Variability of inclination of Frankfurter's, Camper's and HIP planes relative to each other in the skulls in lateral view

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