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Three-Dimensional Reconstruction of the Head after the Skull, Morphological Data and their Applications

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The basic role and meaning of the skull morphological information and the way of its application in the 3-D reconstruction of the head soft tissues are pointed out. The methodological principles about the use of morphological data are traced out. The peculiarities and the difficulties in the re-creation of the lateral face parts are pointed out, as well.

Key words: skull, plastic reconstruction, face.

The motives underlying this presentation are the reports submitted to the 1st International Conference on Reconstruction of Soft Facial Parts held in Potsdam, Nov. 10-12, 2003 [21]. Sufficient grounds are also provided by my 30-year long practice and experience in the application of the plastic anthropological reconstruction of the head after the skull dating back to 1974 [7].

Anthropological plastic reconstruction of the head after the skull renders the possibility for visualization in three dimensions the image of the individual whose skull has served as basis for the reconstruction. This is a specific activity in which the human face is restored on the basis of anatomo-topographic and anthropological data obtained in the study of the concrete cranium. The reconstruction of the head after the skull is based on established dependencies between the thickness and relief of the soft tissues of the face, on the one hand, and the anatomical peculiarities of the cranial bones and the relief of their surfaces, on the other. This approach can be expressed in the unity of three parameters of the metric (quantitative) characterization of the skull (anthropometry, craniometry) ⇔ thickness of the soft tissues in the variety of spots and portions of the head ⇔ descriptive characteristics of the skull (cranioscopy, relief of the skeletal surfaces). The existing linkage is confirmed by a multitude of the studies and statistical data obtained in the measurement of the thickness of the soft tissues on many sites of the head in individuals differing in sex, age, morphological types and nationality [1, 2, 4].

My profound and final conviction is that plastic anthropological reconstruction of the head after the skull must be categorically based on the complete morphological information obtained from it (and from the postcranial skeleton as well).

The main approach in the collection, registration and analysis of the data from the skull studies and their utilization in the reconstruction is the anatomo-topographical one. The most important data are in the field of anatomical achievements. The layer by layer topography, holotopy, syntopy and skeletotopy as well as the differences between the representatives of both sexes and the changes taking place with growth and ageing are of practical importance in the analysis of the dependences between shape, size and interrelationships of the soft tissues of the head and the cranial bones in the human [2, 5, 6, 8, 9, 10]. It should be emphasized that the application of this approach gives the opportunity of encompassing all parts of the human head taking into account the influence of all (the deep ones including) morphological structures on its outside relief (glandula parotis, the fatty body of the cheek, the submandibular saliva gland, etc) [21].

— Each human face displays an individual logical construction of its outside relief and as a rule the combination of the separate facial features follows this logic. If the balanced shape of the human head, face respectively is assumed as initial basis i.e. the mean statistical ratio between lengths, widths and heights its change towards elongation or shortening would account for the situation and size of the facial elements and partially the soft tissue relief. Taking into account the logic of the human face the individual peculiarities defining the concrete instructions for the soft tissue underlying bone linkage should not be ignored.
— The manifestation and degree of asymmetry and symmetry respectively of the human face yield to the greatest degree its individual characteristics — an imperative in their investigation and observation in the 3D anthropological reconstruction. It should be borne in mind that the degree of asymmetry manifestation in the facial cranial part (according to the studies for most sizes asymmetry is in the right direction being in that sense a partial case of the total body asymmetry) is greater in parts formed by several bones, for example the orbital entrance [12, 13, 14, 15, 18].
— There exist concrete relations of identity and differentiation between the sizes of the different elements of human head which are directly maid use of in the anthropological reconstruction of the head after the skull. This relation between the values of constant anatomical dimensions in the facial cranial part, human face respectively has been long well-known and its beginning can be found in the canons of the fine art. In the practical application of the existing dependencies their manifestation should be obligatorily taken into account in both sexes and the age-related changes [3, 5, 6, 10, 11, 17, 19].
— The accepted values of the soft part thickness in the different regions and sites of the head and face in particular taking into account their differences due to sex, age and racial type of the individuals only stress upon and confirm the unity of the human species using the classical methods of His, Kollman and Büchli and modern techniques of ultra-sound investigation and computerized scanning tomography.

From the above-presented it becomes clear that the morphological information obtained from the studies on the skull is the scientific and solid basis for undertaking a 3D reconstruction of the soft parts of the head i.e. this is the methodology.

When applied in the practice it renders possibilities for: usage not enough precise which is a methodological error; precise usage but with incorrect technical equipment which is a personal error of the author; and the worst variation is the combination both the methodological and personal errors.

The widely accepted term used for naming this activity is "reconstruction of the soft parts of the face" based on data from the skull. "Plastic anthropological recon-

struction of the face", "reconstruction of the face", "three-dimensional reconstruction of the face", etc. are other terms often used. Here I can express two opinions of mine:

— Reconstruction (restoration) of the soft tissues I would assume as the right one since it reflects the essence of the process and the term "plastic" is unnecessary the relief of the head being in itself plastic. Besides "plastic" in this sense is "three-dimensional".

— The reconstruction of the soft tissues based on data from the skull is their morphological reconstruction, considering the anatomical and anthropological information and is obligatory referred to as a whole to the head and face in particular.

Besides, the reconstruction of the neck and its upper part in particular is absolutely obligatory because it is of great importance. In the extended program the use of information from the extracranial skeleton, in our case the cervical compartment of the spine, sternum, claviculae, shoulders, etc. is recommended.

More appropriate though a bit wider is the definition "reproduction of the soft tissues of head and neck based on data from the skull and skeleton".

In the method described and applied by M. Gerasimov [1, 2] the reconstruction of the soft tissues of the head is performed on one half of the head, the other one being used as a source of information. It is quite appropriate for the modelling to be carried out on the whole skull because [4]:

— It is impossible to reconstruct for example the half of the outside nose, half of the mouth or half of the chin.

— The modern materials for imprinting and casting give an almost absolute precision in the production of the copy of the skull serving as a basis for the reconstruction. Thus, the authentic cranium remains as a tool for observation and measurements, while the modelling is carried out on its copy.

Graphic reconstruction of the profile introduced by M. Gerasimov [2] which takes into account the data about the soft tissue thickness after the profile and observing the bone base is an objective and relatively fast method for obtaining visual information. But the graphic drawing of this profile is already rife with in exactness since it is two-dimensional and the extent of the shadow (white-gray-dark-black) is exceptionally subjective and in many cases untrue. The graphic reconstruction of the profile and the half-profile (introduced by myself) [20] should be used but only to the degree of its outlined control.

In certain skulls, of the Americans for example, the modelling of regio parotideo masseterica is carried out "en masse", i.e. the soft tissue thickness is recorded and applied from the surface of the mandibular angle, ramus respectively, including the body of m. masseter, the tissues underlying the skin and the skin itself. This approach, however, ignores the information about the size and thickness of muscle body, the direction and situation of its two parts (superficial and deep) about which there is objective information — the ratio between the two dentures, the two jaws respectively, i.e. of the mandibulae to the facial part of the skull; the relief of angulus mandibulae and the characteristics of tuberositas masseterica; the development, situation and relief of the lower edge of arcus zygomaticus. The right approach is when the genuine chewing muscle is modelled individually together with the temporal one and the other muscles of the neck and the soft tissues lying over.

In some other techniques certain muscles of the mimic are modelled — for example m. orbicularis oculi; orbicularis oris, m. zygomaticus major, m. zygomaticus minor, m. levator anguli oris, mm. levator anguli oris et alaeque nasi, etc. Their mass, volume (with certain exeptions) is very small and when taking the data, their thick-

ness is registered "en masse". That is why their reconstruction is due to be made in the same way — "en masse". The development of some of them — m. zygomaticus major et minor might be judged about from the relief of their insertion places on the cheek-bone and the maxilla. Their development affects the relief and mimic of the face but not its shape. For example the development of the relief in the surroundings of glabella may yield information about the characteristics and function of m. procerus and m. corrogator supercilii which can be reflected in the facial relief but not in the thickness of the surrounding tissues in the glabella region.

There is a lot of data collected about many elements in the facial area; the techniques for their reproduction are elaborated but the case with the cheek area (regio buccalis), i.e. the lateral part of the face makes an exception. That is why my mentioning the deeper structures such as the fatty body of the cheek (corpus adiposum buccae) and glandula parotis was not incidental in summing up the morphological principles of the reconstruction.

The complexity in the reproduction of this part of the human face becomes still greater owing to the lack of metric data about the soft tissue thickness in regio buccalis as well as its transition in the adjacent regio nasalis, regio orbitalis, regio oralis, regio mentalis and regio parotideomasseterica. The relief of the lateral facial part is formed on the borders between them. From above along the Frankfurt horizontal plain the thickness of the soft tissues (arcus zygomaticus, orbital edge) has been restored starting from the medial side — from the lateral edges of apertura piriformis and from angulus oris; underneath — from the lower edge of the mandibulae, behind — from m. masseter. The area between them is only left. The assessment of the development of m. buccinator and m. rizorius on one hand and the development of m. zygomaticus major et minor and the volume of corpus adiposum buccae on the other is of great importance. Information about these elements from the lateral facial part can be found in the relief the underlying bone surfaces. The relief of the lateral facial part is also characterized with the presence and expression of sulcus nasolabialis passing through its medial side which is most often reflects the vertical and horizontal profiling of the face.

The above thesis sets the modest task of presenting the morphological consideration on the reconstruction of the soft parts covering the head and face respectively, taking into account all data about the bone matrix.

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