INTENSIVE COURSE IN BIOLOGICAL ANTHROPOLOGY
1st Summer School of the European Anthropological Association
16–30 June, 2007, Prague, Czech Republic

EAA Summer School eBook 1: 233-239

FACE APPROXIMATION AND INFORMATION ABOUT FACIAL SOFT TISSUE THICKNESS

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Introduction

The present paper deals with the problems of facial approximation from the skull. Presently, the term "face reconstruction" is widely replaced by more accurate term "face approximation". The reason is simple. The term "reconstruction" can be understood as "restoration" but also "the exact recreation of ante mortem look". In praxis, it is impossible to obtain exact appearance, because some of the features can not be predicted only from skull. In the best case, the practitioner can only approximate to the real appearance. Techniques of facial approximation are used mainly in Forensic Anthropology. Practitioners combined the scientific and artistic skills.

Identification of human remains has been a major problem for the medico-legal system. Detailed examination of recovered unknown skeletal remains answers the questions about basic characteristics such as sex, age, ethnicity and overcome traumas. It is mostly the only way to find out more information about individual characteristics, which could lead to identification of potential victim. Forensic anthropology is also able to illuminate the last minutes of deceased. Results of examination make up mosaic of deceased's life, individual characteristics and death. If there is no clue for potential identity the most precise comparative techniques fail, because of impossibility to compare questioned remains with possible familiar material. In those cases one of the last chances is effort to recreate ante mortem appearance by face reconstruction. Publication of the reconstructed appearance can trigger recognition by relatives and allow further comparative analysis to be carried out for establishing identity.

Applicability of face approximation techniques is conditioned by human ability to recognize a look as known in spite of the fact that the appearance is not identical with acquaintance's face. It means that for recognition some facial areas are more important, than the others. Human brain perceives similarity in spite of reality that questioned reconstructed look and possible ante mortem appearance is not absolutely similar. Why is the human face so important for interpersonal communication? Importance of face can be seen also in children drawings. According to age of little painter the persons are drawn as circle with few lines. These present simplified face with nose and eyes. It shows that child's view of person begins with face. Dominant role of human face is obvious also for adults. For example, our first memory of someone is connected with image of his face. The names of relatives are also primary associated with appearance. Injuries, which damaged original facial appearance, belong to the most mentally harmful. In this point of view the effort of some people to change their faces by plastic surgery is very interesting. I mean the efforts, which are not conditioned by health problems or esthetical reasons, but with efforts to get someone's famous and successful appearance. This is probably connected with expectations that changed look will also change the personality.

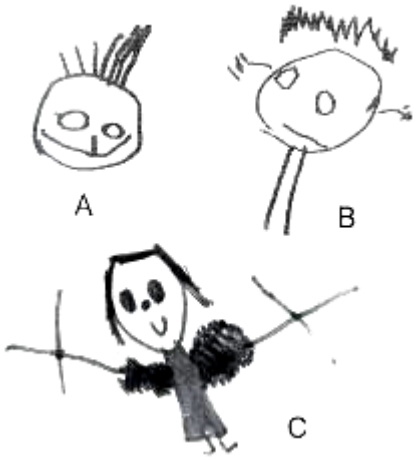

Figure 1: Children drawings – age of 2 years (A), age of 3 years (B), age of 4 years (C; Wilkinson, 2004).

Face Approximation

It will probably never be possible to describe and predict all the huge amount of face variations. Nevertheless, it is necessary to study relationships between cranial and facial features. Inseparable part of these surveys should be also the study of facial soft tissue thickness.

Tables of facial soft tissue thickness provide information about dependence of tissue thickness on age at certain anthropometric landmark. Another important influencing factor is body constitution. It seems to be true, that gender is not so obvious significant factor.

Nowadays the number of surveys about facial soft tissue thickness is increasing. They differ from each other by selection of imagining technique and level of statistic evaluation. Differences can be found also in number of landmarks, their position, as well as sample size. The medical imagining techniques usually involved in study of facial soft tissue thickness are RTG – Roentgenographs; MRI – Magnetic Resonance Imagining; CT – Computed Tomography and US – Ultrasound. All of them have some advantages and some disadvantages. One of the most accurate is CT and MRI. Unfortunately it is impossible to use them for measuring the tissue of voluntaries, because of radiation and possible threat for health. RTG techniques have limitations for the same reason. Furthermore, on roentgenograms only landmarks in a sagittal plane are measurable.

If we consider skull as a mechanical support for face and than assume, that morphological shape of skull predetermines shape of head and furthermore face appearance, it looks so that measuring out the distances between accurately defined points on the skull and referring points on the face could lead to recreation of approximate shape of face (İşcan, 1993). In addition the process of evolution, which is driven by functionality, has shaped the facial pattern. Consequently, skull shape is created by in vivo internal and external forces exerted upon it by the soft tissue and by evolutionary soft-tissue development (Rynn, Wilkinson, 2006). In the present time there are several approaches how to recreate ante mortem appearance. The majority of current facial reconstruction techniques relies on the same method; the application of soft tissue depths to a skull a subsequent formation of a face to cover them. Facial soft tissues consist from muscles, subcutaneous fat and skin. This thickness is measured in defined anthropometric points. It is common that deceased's skull is damaged by engraving or by attacker's strikes. Some parts of bones can be missing. In those cases the practitioners attempt to reconstruct them. As the damaged area is bigger, the result of approximation would be less precise and accurate.

The techniques of approximation can be categorized into two-dimensional (2D), three-dimensional (3D) and computer generated methods. Computer methods allow practitioner to create alternative looks depended on different body constitution (slender, normal or obese alternative) or age changes (Clement a Marks, 2005).

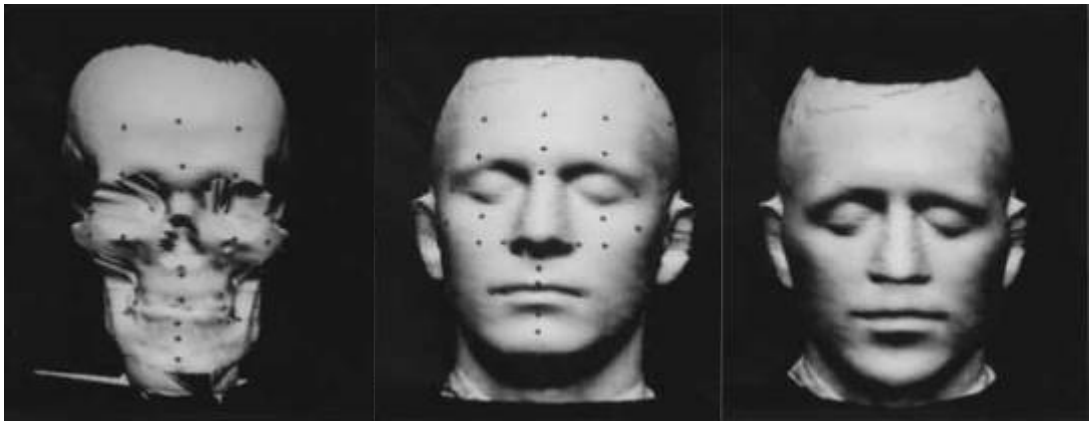

Figure 2: Example of the computer generated methods.
From the left: investigated skull – template – final result of approximation (Vanezis et al., 2000).

If the hair were persisting on the skull, it would be very helpful. It simplifies selection of appropriate type and colour of hair. On the other hand hair attached to skull can be affected by type of soil or other taphonomic factors. Body decomposition causes that jewelleries, glasses and clothes are in contact with soil. Therefore Briggs a Wood (1998) emphasizes to collect also soil from locality. This increases chance that the personal property would be found and become useful for investigation process. Jewelleries can be used directly by reconstruction process. Detailed investigation of locality often leads to discovery fallen out teeth.

These are very important for correct glowing mandible to cranium. Ante mortem teeth loss influences the jaw bony relief and leads to changing of facial proportions (it can be seen mostly by elderly people). Many prediction guidelines exist in facial approximation for determining the soft tissue features of the face (Caldwell, 1986; Aulsebrook, 2000; Taylor, 2001; Wilkinson, 2004). They differ from each other and lead to various success (Malá, Novotný, Eliášová, 2006). Outcome of approximation depends also on experience and skills of practitioner (Stephan, Arthur, 2006).

2D face approximation

At the beginning of 2D approximation process the skull is photographed. Therefore is manipulation with skull minimised and it is protected for further expertises. That is the reason why Taylor (2001) emphasises 2D approximation for fragile or damaged skulls. The manipulation with the skull is reduced in comparison with three-dimensional approximation. Nevertheless the skull should be available for visual evaluation of morphological features that could be unclear on the photograph. During three-dimensional approximation the original skull is used for obtaining plaster cast.

Different alternatives looks are available by using transparent papers with different hairstyles and colour. 2D face approximation is time demanding and also limited by necessity of manipulation with several different transparent papers.

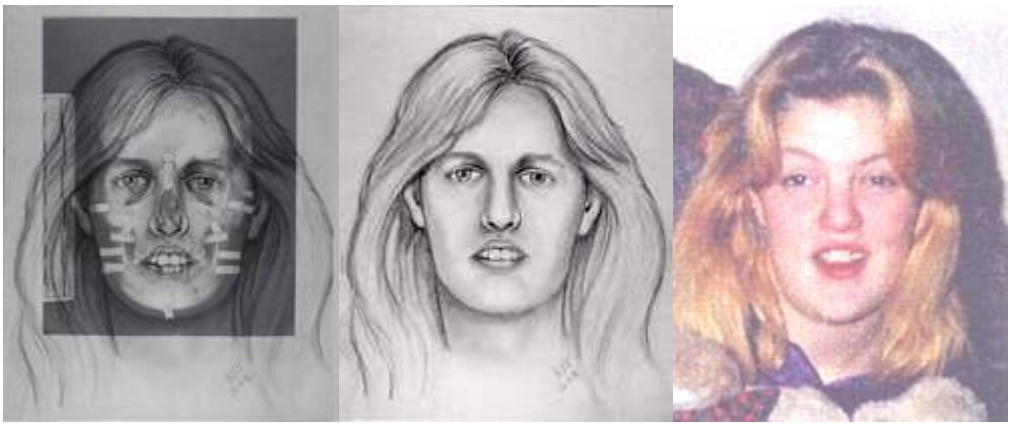

Figure 3: Comparison between outcome of reconstruction and identified (Taylor, 2001).

3D face approximation

3D approximation is more popular than two-dimensional one. The reason probably is, that bust looks more alive and allows look from the different sides. Also the manipulation with alternative hairstyles presented by wigs is faster and less complicated. German anatomists developed sculpting methods in eight decade of 19th century. Later were these techniques modified by Russian anthropologists and spread over the world (Quatrehomme, İşcan, 2000). One of the most famous practitioners of facial approximation is head of Russian school of anthropology – M. M. Gerasimov. It is believed that Gerasimov achieved deceased look by building the face “muscle by muscle“. But it seems to be not true. On almost every picture showing Gerasimov during his work it can be seen that on the bust only musculus massetericus, musculus temporalis and musculus buccinator are modelled (Stephan, 2006). The genuine mimic muscles probably weren’t modelled. According to Ullrich (1958), former pupil of Gerasimov, the Russian master found that modelling of individual muscles onto the skull is highly unsuitable and inaccurate. Furthermore, Gerasimov collected his own average soft-tissue depths, not only in the sagittal plane (metopion; glabella; nasion; rhinion; mentolabial sulcus; pogonion) but also about the Frankfurt horizontal and at five other single different landmarks, and used this information to construct his busts. Exact averages were not always used by Gerasimov but often adjusted according to bony relief displayed by each individual skull in an attempt to predict the face morphology more accurately. Nevertheless the German origin of this approach, it is called according to Gerasimov nationality as “Russian method”. As the opposite of so-called “Gerasimov approach” exists, “American - Facial soft tissue thickness method” markers (rubber or wooden pegs) are places at the landmarks sites corresponding to tissue depth values dictated by reference table. The strips of clay are placed between the landmarks to graduate between adjacent markers. It is believed that this approach relies only on markers of thickness, but this also seems to be not true: The believed founder of this method W. Krogman (1948) stressed the need to keep an eye on the general architecture of the skull, and a minds eye focused on the sculptress own sense of touch and proportion, developed through anatomical studies and art training.

Figure 4: Gerasimov working on the facial approximation (Taylor, 2001)

Both of mentioned methods have several synonyms. The anatomical method is also called "Russian method (because of Gerasimov)" or "Morphological method". "The Method of soft tissue thickness" is called also "American method" (because of its leader – Krogman) or "Morphometrical method". Nowadays Caroline Wilkinson (2004) and the other practitioners (Taylor, 2001) introduce a relatively new method. It is called "Combination method". In its approach the markers of facial soft tissue thickness are glowed to the skull. The values of the markers are just informative for practitioners. It is not necessary to use average values of soft tissue thickness. The rebuilding of the facial mass started with the osteological analysis – estimation of sex, age and also body stature. In according to body stature the appropriate value can be chosen.

Some Problems which Occur among the Surveys of Facial Soft Tissue Thickness

The values of soft tissue thickness are widely used for manual approximation, autonomy computer reconstruction but also during evaluation of superimposition.

But until these days no agreement exists upon the number of chosen landmarks, name of the landmarks and also their correct position (Brown et al., 2004). But in several cases the variable authors call the same landmarks in a different ways. For example can be the landmark "rhinion" (Lebedinskaya, 1993) – end of nasals (Rhine et al., 1980) and "the nasale" (George, 1987). Brown et al. (2004) criticizes the reality that many of anthropological teams call the landmarks in their native languages. It makes difficult the comparisons between the results of several surveys. And of course, using native language assumes the general knowledge from different sites. For example: "end of nasal" (Phillips and Smuts, 1996), "middle of the bony nose" (Helmer, 1984) and "angle of mouth" (Aulsebrook et al., 1996).

Nelson and Michael (1998) point on the fact that using the names which refer more on the face than skull can be tempting during the obtaining data of soft tissue thickness but can be confusing during the process of approximation. For example Aulsebrook (1996) uses the landmark „mid-masseteric". He locates it to the middle of *musculus midmassetericus*. Landmark can be easily found on the cheek, but not on the skull.

Previously mentioned disunion of choice of certain landmarks, their number and names makes comparison of results from different studies difficult.

The first attempts to obtain data of facial soft tissue thickness were done on cadavers' heads. Rhine and Campbell (1980) took measurements of American negroids cadavers, using the needle and ruber-stopper technique. They used unbalmed cadavers (deceased no longer than 12 hours. Rhine and Moore (1982) produced similar work detailing the tissue depth for Caucasian. Suzuki (1948) produced table for mongoloids using the needle technique. Later the practitioners started to use medical imagining techniques which allow *in vivo* soft tissue measurements – X-ray, 3D ultrasound, magnetic resonance imagining and computer tomography technique. George (1987) used lateral craniographs to record the depths of tissue at the midline antropometric points. Auselbrook et al. (1995) combined lateral craniographs with ultrasound to produce a suite of 54 measurements. Another team which used ultrasound was Manhein team (Manhein et al., 2000). Their sample consisted of children and adults of sexes, varying ages and different varieties. El-Mehallawi and Soliman (2001) measured a soft tissue thickness on adult Egyptians.

They used also ultrasound. De Greef et al. (2006) conducted study of Belgians using mobile ultrasound. Studied sample consists from 967 Causasian subjects of both sexes; varying age and varying body mass index (BMI) were studied. Also MRI (Magnetic Resonance Imagining) was used by Sahni et al. (2002) to study soft tissue thickness of Indians. One of the most accurate measurements can be obtained by using CT (Computed Tomography), but it belongs to invasive techniques because of radiation. Data of mixed population of South Africa was obtained by Computed Tomography (Phillips and Smuts, 2001). They compared their results with data from study of negroids (Rhine and Campbell (1980) and caucasoids (Rhine and Moore (1982). But the way how Phillips and Smuts (2001) compared their data with the others is from the statistical approach a little bit confusing. They compared the average value of each landmark to referenced landmarks from mentioned studies. And just say whether the value is higher or not without any statistical relevant tests. But it is impossible to conclude that soft tissue depth at landmark glabella was in mixed women 5.5 mm and in negroids women 7.5. So that mixed women have higher tissue depth about 2 mm from mixed population.

Sample

The preliminary study has produced and analyzed set of facial soft tissue depth data obtained by using CT medical imagining techniques – Computed Tomography.

The measurements are tabulated based on gender and further subdivided into the age brackets. Tables with the average thickness values for each landmark, as well as standard deviation, range, median and modus are reported.

Sample consists of data of 160 patients (80 women and 80 men) obtained by using CT scanner Siemens – Somatome Volume Zoom on Radiodiagnostic ward FNsP Ružinov in Bratislava. I had information about gender and age of patient. Patients were scanned for diagnostic purposes but the pathologic cases were excluded. Reason for CT scan can be also trouble sleep or problems with *sinus paranasalis*, which are not displayed on facial soft tissue thickness. Patients without incisors were excluded. The average age of women was 47.4 years. The youngest was 15 years old and the oldest was 85. Men's age range was 18–87 years with average value 48.3. Sample was divided according to gender and age to subgroups ($x < 30$; 31–50; 51–60; $61 < x$).

Methods

CT scanner Siemens – Somatom Volume Zoom works on principles of helical multidetector computed tomography. Pitch was 2:1 and interval between slices was 1.5 mm. Because of elimination of radiation scans were centralised on paranasal sinusis. That caused that it was enable to measure the depth on landmarks on lower jaw. According to Schwaninger et al. (2003) for the recognition is the most important upper third of face including eye region. And I was able to measure this part.

During the measurements three planes are available – frontal, sagittal and transversal. Precise localization of landmarks was enable by using function *SSD (Shaded Surface Displayed)* – which displays the tomographs as 3D image and allows movement with objects. It also provides reconstructed image of skull or head so it is possible to control the exact position of measured landmark.

I studied 6 landmarks on sagittal plane (supraglabella, glabella, nasion, rhinion, mid-philtrum, upper lip margin) and 8 bilateral landmarks (supraorbital, suborbital, lateral zygomatic, occlusal line, inferior malar, supraglenoid and supra M2). Bilateral landmarks were evaluated distinctively for right and left side.

Results of Preliminary Study

There were observed significant sex differences between the facial depths of men and women. In the majority of landmarks males had thicker soft tissues than females. The only exception was landmark "lateral orbit", on *os zygomaticum*, which showed the significant larger values in women. Nevertheless significant differences, data of both sexes were widely overlapped. This fact indicate that while male and female means at craniofacial landmarks differ slightly, and even at statistically significant levels, individual male and female soft tissue depths are often the same or very similar (Stephan, Norris, Hennenberg, 2005). It also suggests that sex specific means previously reported in the literature can be combined, so the sample size would be increased.

The correlation between facial soft tissue thickness and age was also observed. Mostly at forehead region, nose region, eyes and cheek region. The negative correlation with increasing age was observed at mouth zone. Significant differences between age brackets were found in some landmarks. But these differences were probably more influenced by body constitution than age.

This study is first of its nature in Slovakia. It would be asset to continue in this study with larger sample size based on voluntaries. In this way it could be possible to obtain information about body stature in form of BMI as well. Although the age had influence on facial soft tissue thickness, it is likely that weight would have bigger influence.

Published data should be applicable for forensic facial reconstruction. The expert – practitioner can choose not only the mean values, but also maximum, or minimum values, based on conclusions of osteology survey.

Conclusion

At the end I would like to emphasize that mentioned techniques are used for obtaining of possible look of deceased. It would be unrealistic to expect that outcome of approximation would be the precise copy of questioned person. It would be better to look at these techniques as at the powerful tool for communication with public. Without any comparative material is any accurate comparative technique useful. Particularly the publication of approximated look can be helpful for searching for this comparative material. CT and MRI imagining techniques provide the much needed simultaneous visualisation of hard and soft cranial tissue. But it is questioning whether it should be used for studies with voluntaries. Nevertheless it is helpful for studying relations between cranial and facial features for yet existing studies of no pathologic patients previously scanned for diagnostic purposes not connected with facial changer (e.g. nasal polyps).

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