Review Article

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Forensic Facial Reconstruction: The Final Frontier

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ABSTRACT

Forensic facial reconstruction can be used to identify unknown human remains when other techniques fail. Through this article, we attempt to review the different methods of facial reconstruction reported in literature. There are several techniques of doing facial reconstruction, which vary from two dimensional drawings to three dimensional clay models. With the advancement in 3D technology, a rapid, efficient and cost effective computerized 3D forensic facial reconstruction method has been developed which has brought down the degree of error previously encountered. There are several methods of manual facial reconstruction but the combination Manchester method has been reported to be the best and most accurate method for the positive recognition of an individual. Recognition allows the involved government agencies to make a list of suspected victims'. This list can then be narrowed down and a positive identification may be given by the more conventional method of forensic medicine. Facial reconstruction allows visual identification by the individual's family and associates to become easy and more definite.

Keywords: Combination manchester method, Facial modeling, Forensic art, Forensic science

INTRODUCTION

If a skull is accidentally recovered from a garden, forest etc, a positive identification will be needed. This is essential not only for legal purposes but also aids in the family's in overcoming their grief and bring a sense of closure to them. In such cases, where traditional methods of identification like dental records examination, radiography, DNA analysis etc. cannot be used or have been ineffective due to some problems such as lack of proper information, condition of the remains, cost etc. Forensic facial reconstruction can be used as an important forensic tool which may help in facial recognition of the skull and ultimately lead to positive identification of an individual [1].

Forensic facial reconstruction is a combination of both scientific methods and artistic skill. It can be used to reconstruct the soft tissues onto the skull in order to obtain the image of an individual for his/her recognition and identification [2-4]. Some reviewers considered that forensic facial reconstruction is a method of facial approximation, i.e. various facial patterns can be established from the same skull. Other researchers on the other hand felt that each skull can only produce one face and this would hence lead to positive identification of an individual, they used the term "Facial Reconstruction" [5].

Forensic facial reconstruction is used in both forensic science and Archaeology. In forensic science, this method is used in the identification of an individual where the conventional\usual methods of identification are unsuccessful. In Archaeology, it is used to identify the faces of the people from the past, bone remains, embalmed bodies, etc [6].

The face of an individual has several different types of exclusive features and thus, is of great importance in identification and recognition of a person. When an unidentified body is found, a facial photograph is clicked. This photograph is sometimes digitally processed so that it becomes suitable for the witness to identify or for the newspaper to publish legal which may ultimately leads to identification of the corpse. The victim's family, friends/or acquaintance are required to visually identify the victim and the only body part uncovered for identification is the face. Sometimes, a dead body cannot be identified as its face cannot be recognized due to destruction by animals, physical attacks or decay caused by environmental factors. Forensic facial reconstruction is an alternative method in the identification process where there is little or no other evidence available [7].

The reconstruction techniques can be divided into two types: Two dimensional (2D) and three dimensional (3D) techniques [1]. They are carried out and analysed either manually or by using specific software (computerized). The 3D manual methods used in forensic facial reconstruction are the Anatomical (Russian), Anthropometrical (American) and Combination Manchester (British) methods which were developed by Gerasimov, Krogman and Neave respectively [2,8,9].

DISCUSSION

The first facial reconstruction was done by a German anatomist Wilheim His in 1895. He reconstructed the face of German composer Johann Sebastein Bach [2,10]. Welcker, a German physiologist and anatomist documented average tissue depth thickness from studying cadavers, he inserted a small surgical blade into various anthropometric landmarks on the face and then measured the depth of penetration. This is called as "Welcker Facial Reconstruction Technique". Facial reconstruction of Schiller, Kant and Dant was done by Welcker by using the same technique. During the late 1880's and early 1890's, Wilheim further modified this technique by inserting a thin sharp needle which had a small piece of rubber on its tip instead of using wider blade. This reduced the amount of tissue distortion and lead to more accurate results. Later in 1946, Wilton Maria Krogmann defined five basic principles to modify the methods of reconstruction of soft tissues of the face i.e. the relation of eyeball to orbit, the shape of nose tip, the ear location, the mouth width and the ear length [10].

With the improvement in 3D technology, rapid, efficient and cost-effective computerized facial reconstruction software was developed. The software imitates the manual method of facial reconstruction. Computerized reconstruction was first studied at London College University in the 1980's where a cranial reconstruction procedure was carried out by using a laser like scanner and video camera. The data was collected and used to build a library of 'Living subject' facial surfaces [5].

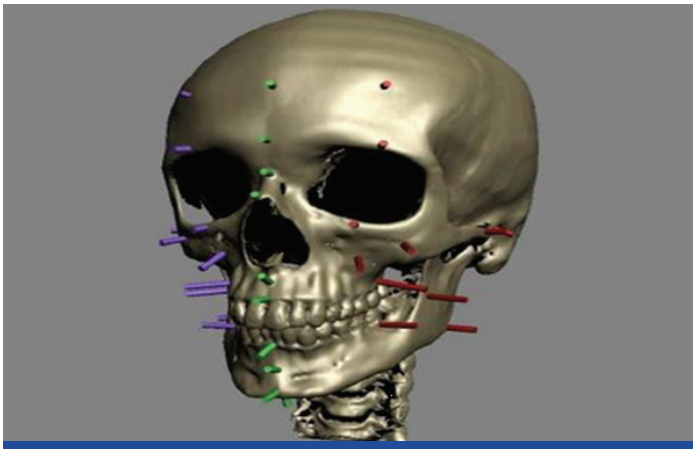
Two-dimensional reconstruction: This is used to recreate a face from the skull with the use of soft tissue depth estimates. This method was first developed by Karen Taylor in Austin, Texas during the 1980's. This method requires an artist and a forensic anthropologist to work together on the facial reconstruction and is based on antemortem photographs and the skull which is to be reconstructed [11]. This method is also used in identification of the deceased from skeletal remains.

Now a days, various computer software programs like CARES™ or CARES (Computer Assisted Recovery Enhancement System) and FACES (Forensic Anthropology Computer Enhancement System) etc quickly produce 2D reconstruction which can be edited and manipulated. They work by capturing and digitalizing radiographs, photographs and images of skulls and producing an electronically altered version of the image. These programs speed the reconstruction process and produce more generic images [11].

Three-dimensional manual reconstruction: This method also needs both an artist and a forensic anthropologist. In manual methods, facial reconstruction is done by using clay, plastic or wax directly on the victim's skull or more often a replica of the skull which has to be identified. This method is similar to two dimensional methods as it also requires the use of tissue depth markers of specified lengths to represent different soft tissue depths. The markers are inserted into small holes on the skull cast at specific strategic points or landmarks. In the computerized method, computer software produces reconstruction by using scanned and stock photographs [12].

METHODS OF MANUAL 3D RECONSTRUCTION

1. **Anthropometerical American Method/ Tissue Depth Method:** This was developed by Krogman in 1946. Through this method, soft tissue depth data is considered. This method was commonly used for reconstruction by law enforcement agencies [10]. Fine measurements were obtained by the use of needles, X-rays or ultrasound. As facial muscles are recorded in a proper anatomical manner, this method requires highly trained personnel [7], so this technique is not preferred now a days.
2. **Anatomical Russian Method:** This method was developed by Gerasimov in 1971. Here soft tissue depth data was not considered but facial muscles were used in anatomical position. In this method, reconstruction was done by shaping muscles, glands and cartilage onto the skull layer by layer. This technique is not commonly used in these days. This method is much slower than the American method and a greater degree of anatomical knowledge is required. Reconstruction of fossilized skulls have been achieved by this method [13].
3. **Combination Manchester Method/ British Method:** This method was developed by Neave in 1977 and is the most accepted method for facial reconstruction today. In this technique, both soft tissue thickness and facial muscles are taken into consideration. Once the cranium and mandible are articulated and the skull is mounted on an adjustable stand in the Frankfort Horizontal plane, facial tissue pegs or markers [Table/Fig-1] are then added on the skull, either by placing them directly on the skull or by inserting them on previously drilled holes on the cast at 90 degree using a 3mm drill bit [8]. Each peg length represents the mean tissue depth at the anatomical point. The facial tissue depth is determined by the age, gender, build etc. of the individual. The muscles of mastication and facial expression are constructed out of the modeling material and positioned on the basis of their origin and insertion on the skull. The shape and size of various muscles are determined on the basis of the underlying hard tissues. Plaster or prosthetic plastic eye balls of 25mm diameter are placed into the orbits. The prosthetic eye balls are positioned in the orbit in such a way so that a tangent taken from the mid supraorbital margin to the mid infraorbital margins touches the iris. The inner canthus are placed 2mm lateral to the lacrimal crest and the outer canthus are placed 4mm medial to the malar tubercle. When the malar tubercles are absent, the outer canthus is placed 10mm below the line of frontozygomatic suture and 5-7mm from the orbital margin [1]. The maximum width of the nose is determined by the bony nasal aperture at its widest point as three-fifths of the overall width of the soft nose. The profile of the nose and the shape and the size of the alae are determined by the nasal aperture. The maxillary canine and first premolar are placed near the corners of mouth and width of the mouth corresponds to six anterior teeth. The thickness of lips is determined by upper and lower anterior teeth [12]. The length of the ear is predicted by the length of the nose and the ear canal is positioned by using external auditory meatus as the reference point. Muscles of the face are usually modelled on the skull which is to be reconstructed in clay one by one, then a layer of clay is added over the musculature to represent the skin, subcutaneous fats and strips of clay are then rolled, shaped and added over the muscle/fat structure to create the finished face by maintaining the length of the pegs as a guide to the final tissue guides over the face [7].



[Table/Fig-1]: Photograph showing tissue-pegs attached to the surface of the skull at the anatomical landmarks [1]

4. **Computerized 3D Forensic Facial Reconstruction:** With the advancement in 3D technology, a fast, efficient and cost effective computer aided forensic facial reconstruction method was developed. In this method, the operator used 3D computerized models using manual clay model techniques. Some computerized systems used 3D animation software (Free Form Modelling Plus™; Sensable Technologies, Wilmington MA) to model the face onto the skull while other system used virtual sculpture system with Haptic feedback (Phantom Desktop™ Haptic Device; Sensable Technologies). Haptic feedback system has the ability to feel the surface of the skull during analysis and also provide important skeletal details for facial reconstruction such as muscle attachment strength, position of eye, position of malar tubercle etc. This system though requires both anthropological and computer modelling skills. It decreases practitioner's subjectivity and skill. This method also creates multiple images of the same face quickly and efficiently [6,11,14,15].

CONCLUSION

Forensic facial reconstruction is a rapid, non-invasive and efficient method where reconstruction can be repeated at any time if required. This technique is not only used for identification of individuals from skeletal remains but is also used for archaeological research purposes. Visual identification by the individual's family and associates thus becomes easy and more defined. For the classical manual technique, various methods are used but the Combination Manchester Method was found to be the best and most accurate method for the positive identification of an individual. The manual methods on the other hand are labour intensive. Computerized forensic facial reconstruction can also mimic the manual method of facial reconstruction. Computerized remodeling of missing individual is also significantly easier as compared to the manual method and also decreases practitioner training.

REFERENCES

[1] Fernandes CM, Pereira FD, da Silva JV, Serra Mda C. Is characterizing the digital forensic facial reconstruction with hair necessary? A familiar asssessors' analysis. *Forensic Sci Int*. 2013;229:164.e1-e5.

[2] Lee WJ, Wilkinson CM, Hwang H. An Accuracy assessment of forensic computerized facial reconstruction employing cone-beam computed tomography from live subjects. *J Forensic Sci*. 2012;57(2):318-27.

[3] Fernandes CM, SeeraMda C, da Silva JV, Noritomi PY, Pereira FD, Melani RF. Tests of one Brazilian facial reconstruction method using three soft tissue depth sets and familiar ascessors. *Forensic Sci Int*. 2012;214:211e1-1e7.

[4] Cavanagh D, Steyn M. Facial reconstruction: Soft tissue thickness values for South African black females. *Forensic Sci Int*. 2011;206:215e1-e7.

[5] Wilkinson C. Computerized forensic facial reconstruction: A review of current systems. *Forensic Sci Med Pathol.* 2005;1(3):173-77.

[6] Wilkinson CM. Facial reconstruction- anatomical art or artistic anatomy? *J Anat*. 2010;216(2):235-50.

[7] Kreutz K, Verhoff MA. Forensic Facial Reconstruction-Identification based on skeletal finding. *DtschArztebl*. 2007;104(17):A1160-65.

[8] Short LJ, Khambay B, Ayoub A, Erolin C, Rynn C, Wilkinson C. Validation of a computer modelled forensic facial reconstruction technique using CT data from live subjects: a pilot study. *Forensic SciInt J*. 2014;237:147.e1-.e8.

[9] Quatrehomme G, et al. A fully three-dimensional method for facial reconstruction based on deformable models. *J Forensic Sci*. 1997;42(4):649-52.

[10] Omstead J. Facial reconstruction. *Uni West Ont Anthrol.* 2011;10(1):37-46.

[11] Yadav N, Panat RS, Aggarwal A. CT scans- a compelling tool in forensic facial reconstruction. *J Dent Sci Oral Rehabil*. 2010;1:39:42.

[12] Abate AF, Nappi M, Tortora RG. FACES: 3D facial reconstruction from ancient skulls using content based image retrieval. *JVis Lang Comput*. 2004;15:373-89.

[13] Kahler K, Haber J, Seidel H. Re-animating the dead: Reconstruction of expressive faces from skull data. *ACM TOG*. 2003;22(3):554-61.

[14] Wilkinson C, Rynn C, Peters H, Taister M, Kau CH, Richmond S. A blind accuracy assessment of computer-modeled forensic facial reconstruction using computer tomography data from live subjects. *Forensic Sci Med Pathol.* 2006;2:179-88.

[15] Turner W, Tu P, Kelliher T, Brown R. Computer-aided forensics: facial reconstruction. *Stud Health Technol Inform*. 2006;119:550-55.

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