

Forensic Identity of the Unknown

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Abstract

Forensic art is a technique of reconstruction using little or no evidence available to solve a certain case. Usually, it is carried out by reconstructing tissues on the skulls for the identification. Forensic art is basically divided into few categories including composite imagery, image modification/identification, demonstrative evidence and reconstruction/post mortem drawing which is then further divided into 2 dimensional and 3 dimensional. The forensic facial sketches include the forensic and composite sketches. The facial reconstruction basically involves five principles including ear location, mouth width, eyeball to orbit relation, nose tip shape, ear length. Initially Welcker facial reconstruction technique was used but later being taken over by 3D computerized facial reconstruction technology. The procedure involves technical phase of reconstruction, then followed by development of features of face of the individual finally the drawing from the skull is used for victim's identification. 2D has advantages in identification of deceased skeletal remains as well. The 2D images are developed using CARES and FACES software. But a disadvantage includes the depth of the face cannot be determined in 2D. Whereas in 3D reconstruction manual method using clay, wax etc., is done where the depth can also be identified. 3D includes various methods including tissue depth method, anatomical method, British method (combination method), computerized 3D forensic facial reconstruction. But 3D method is only carried out after 2D method. For the checking of the accuracy of these methods face pool, resemblance ratings and morphometric comparison is usually done.

Keywords: Forensic art • Facial recognition • Forensic artist • Facial reconstruction

Introduction

Forensic art is an alternative method in the identification process applied when there are little or no other evidences available to solve the case. forensic facial reconstruction also used in Archaeology for identifying the faces of the people from the past, bone remains etc. Forensic facial reconstruction is used to reconstruct the soft tissues on to the skull which generates the image and then proceed further [1]. Some researchers considered it as facial approximation as they thought one skull could generate many patterns but others believed that each skull would generate only one pattern which can lead for identification of human. The facial reconstruction method which involve forensic sketch artists, where the artists have to undergo some years of training to become a professional forensic artist who can draw sketches based on witness description which can have good accuracy but only few hours can be needed for a police to become a proficient in handling the composite sketch software, these software techniques will rely on some basic components of facial components like eyes, nose and mouth based on the information of witness description [2-5].

The forensic art is divided into 4 main categories

Composite imagery: The human face is developed through graphic images described by an individual. This method includes images generated through computer or images hand drawn, it includes full body drawings or only objects.

Image modification/identification: In this method the photographic images are categorized and it also includes methods like manipulation, enhancement and comparison.

Demonstrative evidence: It can be trial display where visual information will be used as evidence for court purposes, which can be generated through computer or hand drawn.

Reconstructive/post-mortem drawings: It is the method to identify human remains in different types of decompositions. The reconstruction is divided into 2 types

2 Dimensional (2D)

3 Dimensional (3D)

The forensic facial drawings used to solve the crime cases is divided into 2 categories:

Forensic sketches: In this method the facial drawings are based on witness description, these are used in 19th century.

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Composite sketches: In this method the facial drawings are generated using software kits. This method became more popular and used as alternative method to forensic sketches (Figures 1 and 2).



Figure 1. Forensic sketches.



Figure 2. Composite sketches.

Literature Review

Techniques

The first facial drawing was done in 1895, by German anatomist Wilhelm Von Waldeyer where he constructed the face of German composer Johann Sebastian Bach. Hermann Welcker, a German physiologist he used technique called "Welcker Facial Reconstruction Technique", in this method he measured the depth of penetration by inserting a small surgical blade into different anthropometric landmarks on face, through studying cadavers he has analysed the average tissue depth thickness. The same technique was used for facial reconstruction of schiller, kant and Dant by Hermann Welcker [6]. In early 1890's Wilhelm von Waldeyer had developed this method by inserting a thin needle which consists of rubber on its tip instead of using wider blade which has increased in accuracy. later in 1946 Wilton Maria Krogmann had proposed 5 basic principles to develop the facial reconstruction of soft tissues the ear location, the mouth width, the relation of eyeball to orbit, the shape of nose tip, and the ear length [7]. Through developing 3D technology, the cost-effective computerized facial reconstruction method became popular. Computerized reconstruction was studied at London college university in 1980's, where the cranial reconstruction procedure was carried using laser like scanner and video camera [8].

The facial reconstruction developed through artistic skills of forensic artist is different and involves a different procedure, while solving the case where there are no other evidences or leads the forensic artist will interview the witness about the suspect who is involved in crime. Through investigation on different features of face, he documents these features and creates 2D dimensional of suspect. The composite image may include clothing, accessories, tattoos etc.,

which aid in investigation. The developed composite image will be circulated through media to general public which helps to identify the suspect. Hence, the composite image is very important methods to solve the cases. The forensic artists are useful to generate the post mortem drawing or facial reconstruction from skull [9-12]. The investigators use this technique when human remains are found but they are unable to identify the body. Based on conditions of body remains the forensic artist will decide to proceed further with either developing post mortem drawing using morgue photos or develop 2-Dimensional or 3-Dimensional reconstruction from skull. The post mortem drawing method will be used by forensic artist when there is enough soft tissue left on skull and when body is severely decomposed facial reconstruction from skull this method would be best choice [13]. The procedure involved in this method is as follows:

- Firstly, the technical phase of reconstruction is done, here the vinyl eraser strips are cut to match the length of tissue depth date chart of an individual. In 1980 the tissue depth chart is developed by Rhine and Campbell through examine the tissue depth of cadavers. The parameters effected this study were fatty tissue and connective tissue, skin thickness at a particular morphological landmark on the skull and thickness of muscle. Then the resulted tissue depth markers are glued to skull using cement glue at appropriate landmarks later the glue is removed using acetone. Finally, then placing the skull in Frankfurt Horizontal position (which is done by placing the bottom of eye orbit horizontal to top of bony ear hole) the photographs were taken.
- This step deals with development of individual features of face where artists are involved, where they place a piece of opaque paper over the print of the skull. Here the tissue depth markers will act as guide to develop the features of face. The artist will look upon the muscle attachment sites on the skull while drawing, here the skull act as template for the sketch to be drawn. The placements of teeth, eye-orbits and nasal openings will depict the proportion in the finalized drawing.
- The finally created drawing of suspect from photograph of the skull is used for identifying the victim.

The 2-Dimensional and 3-Dimensional techniques used for facial reconstruction involves different methods to generate the facial drawings.

Two-dimensional reconstruction: It was developed in 1980's by karen taylor in Austin, Texas. In this method it involves forensic anthropologist and artist, who will reconstruct based on the antemortem photographs. The 2D method is also useful for identification of the deceased from skeletal remains. Through developing technology, the computer software programs are used to generate 2D images which later can be edited. They basically generate the image based on digitalizing radiographs, photographs and images of skull and develop an electronically altered version of image. The software system programs used are "CARES Computer Assisted Recovery Enhancement System" and "FACES Forensic Anthropology Computer Enhancement System" etc.,

Three-dimensional manual reconstruction: This technique also involves a forensic anthropologist and artist. The facial reconstruction is created using plastic, clay or wax directly on victim skull this method known as manual method. This technique also uses 2-dimensional method where it analyses the depth of different soft

tissues, here the markers are inserted at specific landmarks on skull. In this 3-Dimensional technique the computer software generates images using stock and scanned photographs. There are different types of methods in 3D reconstruction [14].

Tissue depth method: It is also known as Anthropometrical American Method. It was proposed in 1946 by Wilton M. Krogman as mentioned above. This method is most popularly used in crime investigations by law enforcement agencies. The specified measurements were obtained by using needles, ultrasound or x-rays. Since this method requires highly trained personnel hence it is not a good choice now a days [15].

Anatomical russian method: This method was developed in 1971 by Mikhail Mikhaylovich Gerasimov. This method commonly used to reconstruct fossilized skull, where method facial muscles are used in anatomical position instead of soft tissue depth which are not considered. The reconstruction was created by shaping glands, muscles and cartilage on skull layer by layer. This Anatomical Russian method is much slower than American method, which also needs good degree of anatomical knowledge.

British method: It is also known as combination Manchester method. This method was developed in 1977 by Richard Neave, which is the most accepted method till today. In this method both facial muscles and soft tissue are taken into consideration. Firstly, the cranium and mandible should be positioned perfectly on skull then the skull should be adjusted in the Frankfurt Horizontal plane and then the tissue markers are placed either directly on skull or inserting on drilled holes on cast at 90 degrees using 3 mm drill bit. The Each and every tissue marker represent the mean tissue depth at anatomical point. An individual facial tissue depth is determined by the gender, age, build etc., the shape of various muscles is determined by underlying hard tissues. The facial expression is created using modelling material and placed on the basis of their origin and insertion on the skull. The prosthetic eye balls are positioned in orbit in a way that tangent taken from mid supraorbital margin to mid infraorbital margin which touches the iris and which is 25 mm in diameter. The outer canthus positioned 4 mm medial to malar tubercle whereas inner canthus is positioned 2 mm lateral to lacrimal crest. In case of absence of malar tubercles, the outer canthus is placed 10 mm below the frontozygomatic suture and from orbital margin it is at a distance of 5-7 mm, to know the placement of nose, where the maximum width of nose is determined by the bony nasal aperture which widest point is three-fifths in compare to overall width of soft nose. The nasal aperture is main part which determines the profile of nose, the shape and the size of alae. The width of the mouth is similar to six anterior teeth, the mouth corners are occupied by maxillary canine and first premolar, whereas the lower anterior teeth determine the thickness of lips. The length of nose will also predict the length of ear where the ear canal is placed using reference point as external auditory. The muscles of face modelled on skull using clay which is reconstructed using clay one by one, then a layer of clay should be added which depicts the skin over musculature, subcutaneous fats and strips of clay are rolled, then these are placed over the muscle to generate the final face while considering the length of markers as a guide to final tissue which depicts over the face [16].

Computerized 3D forensic facial reconstruction: It is cost effective and fast computer aided forensic facial reconstruction.

The person uses 3D computerized models with help of manual clay model techniques. The computerised software's sensible technologies, "free form modelling Plus™ and Wilmington MA" which use 3D animation to create face onto skull but other software's uses virtual sculpture system which has haptic feedback like "phantom desktop™ haptic device" and sensible technologies. The haptic feedback system has some important skeletal details for forensic facial reconstruction like position of eye, muscle attachment strength, position of malar tubercle etc. But this technique needs both the computer modelling skill and anthropological skill. It also generates multiple images of the same face accurately and efficiently.

Accuracy

Before knowing the process of facial reconstruction in detail, the level of accuracy of this technique is very important for the persons involved in art and law enforcement agencies. As we know that facial reconstruction technique is playing a crucial role in forensic investigation as many individuals were successfully identified, though the practitioners report the varying success reports still it is unclear about the accuracy of this technique from success rate like how exactly facial reconstruction is directly responsible for identification and recognition of the individuals. As different methods were employed to know the accuracy of this technique which includes face pool assessment, resemblance ratings and morphometric comparison.

Face pool assessment is a method by comparing the image of reconstruction with that of pool face photographs which includes other number of faces of similar age, sex etc and then asked to pick a face from the pool that most resembles with that of the reconstruction face, to determine the recognition. The level at which it was recognized is said to be the accuracy of the facial reconstruction. This method is currently encouraged as it gives more meaningful results for the accuracy of facial reconstruction. The resemblance ratings assessment method has been criticized as it is misleading and forming insensitive [17].

Other method to assess the accuracy of facial reconstruction is the morphometric comparison by comparing the reconstruction and target face. With the help of CT imaging and computerized images it can compare the surfaces of the reconstruction and target face with 3D modelling soft, the laboratory studies of these Manchester methods suggests that most of the facial reconstruction are recognized by a close friend or a family member. From the skull a portrait cannot be produced and many details of the face cannot be determined, but it should be estimated that most of the facial feature are from the skeletal detail [18].

As we know that there are other methods to complete a facial reconstruction which include two dimensional drawings, three-dimensional clay models and more in advance is the three-dimensional computerized modelling. The accuracy of facial reconstruction using these methods have produced results varying over years and using Cone Beam Computed Tomography (CBCT) which utilises the data from the live objects and also has the ability of accuracy of the three-dimensional computerized facial reconstruction technique.

To make the facial reconstruction process simple they developed computerised technologies and three-dimensional craniofacial imaging which alternatively led to the development of 3D computerised modelling technique. With this they might be more efficient and possible variations in the reconstruction process. The success of the recognition may be directly affected by the accuracy of the forensic facial reconstruction. On small cases the accuracy of this technique is replaced using both face pools or using the CAD software for comparing the facial soft tissues of reconstruction to that of the actual individual.

The main aim was to validate the accuracy of a 3D computerised modelled forensic facial reconstruction technique in live subjects using Cone Beam CT (CBCT) data and other methods.

Recent case studies

Case 1: Case solved by face pool method: When a staffer of Mumbai's VG Vaze college stepped out for lunch, he found a body behind the college which was decomposed and the face was completely burnt. So, the ambarnath police used a method—forensic facial reconstruction to identify the individual. On April 10 last year, Ambarnath police another body with no identification marks and a disfigured face. Through a forensic expert they came to know that people can be identified through dental marks and skeletal remains. With help of these many cases could be solved easily like example—A gang rape at Mulund in 2014 to match the bite marks on the woman's body with that of the accused.

While recreating the face of an individual in a facial reconstruction process three main markers are important which are gender, race and age. From the skull remains sex of the individual can be identified for example; the angle of the lower jaw is sharper in men when compared to women and the forehead also is slightly curved in men whereas in women it is straighter. Once the gender and race are known, with the help of the teeth a person age can be determined and depending upon the age, wrinkles can be added. Forensic facial reconstruction began as an art form in Europe, until its use in science was completely understood it was very much useful over past few years in crime cases where there were no clues of that person or when the person's face has been damaged.

The reconstructed face model was created using Plaster of Paris (POP), for eyes, nose, ear, earlobes and hair the thickness of the POP should be increased and for lips the thickness depends on the structure of the teeth. Once these are decided, soft tissues like skin are added on to the POP and according to the age the wrinkles are added on the skin and several hairstyles can be generated on the computer. Now the complete picture is sent to police for further investigation which usually takes around 3-4 weeks. When pictures of the created model were circulated to Ambarnath police, they identified the individual as Brindesh prajapati, a driver who worked in Ambarnath was murdered by his wife with help of her paramour and his friend [19].

Case 2: Case solved using 2 dimensional: This case is about Sheena Bora who was identified with help of 2D Facial reconstruction. In may 23, 2012, the details of what exactly happened to her remained gloomy but it was sensational murder case. The Raigad police collected most of the parts like skull, remains of bones, tissue and teeth samples were sent to

Mumbai's JJ Hospital for identification and they had preserved those remains and was handed over them to Mumbai police.

The entire skull was in police custody and police found whether she ever went to a dentist's each person will have a unique dental pattern with those records will help forensic experts to match with Sheena's and a complete facial reconstruction was done by using advanced method of digital superimposition photography which was available in KEM hospital in Mumbai.

Two-dimensional facial reconstructions are usually based on ante mortem photographs and the skull. The skull radiographs are used but ideally many cranial structures are not visible at the correct scale which usually requires a forensic anthropologist. Other methods like three dimensional reconstructions and superimposition help forensic facial reconstruction when the skeletal remains are completely unknown. After this Sheena Bora can be identified with help of 2D facial reconstruction with the skeletal remains. They can even collect the DNA samples of her mother, father or siblings and match with Sheena Bora.

Case 3: Case solved using manchester method: This case is about a young girl of 11 years and is resident of 430 BC Athens, who died from the plague that devastated her home city and no specific information was available about her, so she was named as Myrtis by the forensic archaeologists in charge. The original skull was replicated via three-dimensional modelling and rapid prototyping techniques. The reconstruction followed the Manchester method, laying the facial tissues from the surface of the skull outward by using depth-marker pegs as thickness guides. Her skull was found in an excellent condition with a complete mandible and all of her teeth were intact. After the dental and orthodontic treatments, her case attracted so much attention from the scientific community and general public, so it was decided to perform a facial reconstruction through her skull. The general form and shape of the major features of her face followed the bone structure of her skull and can be considered more or less precise. In addition to this the colour of Myrtis eyes and hair was randomly selected to match a common color for Greek female. As there was precise relevant available data which was limited and was affecting the accuracy of the reconstruction process. There were few reservations regarding the thickness of the facial tissues of Myrtis. According to the average values taken from respective reference tables for age, sex and race they could reconstruct her nose, lips and ears. Though ears and nose were not reconstructed properly because they were not supported by bone tissue, so the ears, nose and lips were created with some artistic subjectivity in their form and shape.

It is true that Myrtis case, she lived in modern times, would want orthodontic treatment. The reconstructed face of Myrtis should not be compared with images of persons who are in the classical period of ancient Greek art. In this case study, each step of Myrtis face reconstruction was done [20].

Overall, this reconstruction of Myrtis offeren chance to many scientists and general public to come face to face with a lay Athenian who was born in most glorious time of ancient Athens and did not have a chance to grow up because of her death from the Plague which contributed to the ending of the Athenian predominance in the ancient world.

Case 4: Case solved by forensic artist: The world's most successful forensic artist- Lois Gibson. She is a graduate of the university of Texas at Austin, she teaches this profession at the institute of forensic art in Houston, Texas. Her experience as the victim of serial rapist driven her to this passion, her sketches have helped law enforcement to identify more than 751 criminals (Figure 3).

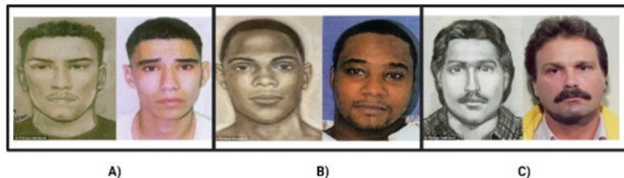


Figure 3. Case 4 case solved by forensic artist.

Courtsey: By Hayley Peterson, Forensic sketch artist reveals how her own rape 37 years ago drove her to help solve world-record 1,260 crimes published in 8 November 2012

- In 2002, Jeffrey Lynn Williams was executed for killing a woman and raping her nine-year-old daughter, who gave his description to Ms Gibson for help with this sketch
- 17-year-old Robert Hidalgo carjacked a woman who gave his description to Ms Gibson
- Lois Gibson drew this image of rapist Donald Eugene Dutton after he escaped from prison in 1991

Case 5: Case solved using anatomical method: In this case, the Pennsylvania state police approached the National Centre for Missing and Exploited Children (NCMEC) in Alexandria, USA 2015. as a last resort to identify remains from a cold case. The remains of a mixed race young female between the ages of 11 and 15 were due for a 3D forensic facial reconstruction. She had been found at Westmoreland county in September 1967, and her case went cold for nearly 50 years. the anatomical method used here relies on virtually modelling every muscle of the face onto the skull. Anatomical. The anatomical method of facial reconstruction was developed by Gerasimov, a Russian anthropologist who was convinced that developing an anatomical approach involving modelling each facial muscle onto the skull before applying a layer of skin was more accurate for forensic purposes. this method was later adapted and taught by Prag and Neave, Iscan and Helmer. They have used sensible technologies freeform modelling plus system which includes the phantom desktop haptic device. Once the skull is imported into the software, pieces can be moved, duplicated, reattached which is much faster and quicker than when the remains are handled manually. The virtual technique of modelling with the haptic device allows the forensic imaging specialist to feel all the surfaces of the modelled skull that is being sculpted on screen, and to produce an intuitive interaction with the digital process. The different objects imported and those sculpted into the software will be easily manipulated into different shapes in space, on a solid or see through plane for better accuracy and precision purposes. This technique also provides important skeletal details for facial reconstruction such as position and measurements of different characteristics of the skull.

Application

Amy danning a sculptor, who is aware of facial anatomy work as forensic anthropologist and develop skeletal features which can reveal the person's age, sex, and ancestry, and anatomical features like facial asymmetry, evidence of injuries (like a broken nose), or loss of teeth before death (Figure 4).

Flowchart of the procedure used by sculptor to gain a outcome

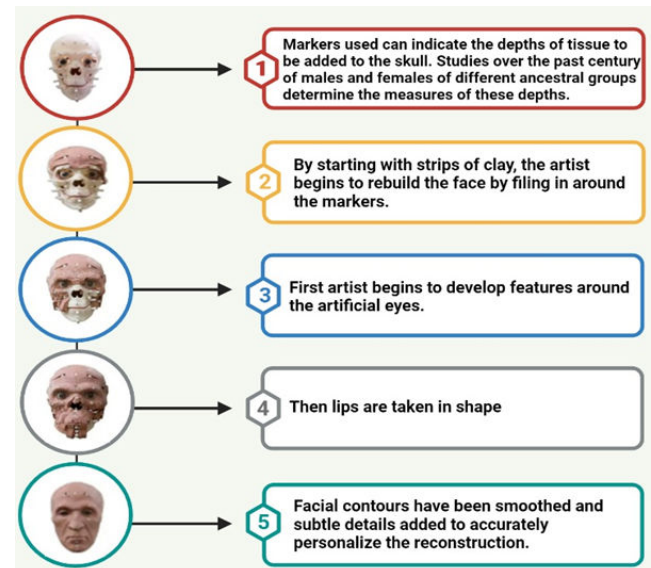


Figure 4. Flowchart of the procedure used by sculptor to gain a outcome.

The final outcome of face developed by her can reveal only approximates actual appearance because the cranium does not reflect soft-tissue details, but facial reconstruction can put a name on an unidentified body in a modern forensic case or, in an archaeological investigation

Discussion

The application of art in court to identify the victim or unknown person through using different technique is an absolute challenge. Over the period of time, as the development occurs the modified or developed technique is used to get good and better accuracy. However, there are still scientist in this field who are unable to understand the role of forensic artists as the accuracy is a bit low but it would be great if they both collaborate and developed the technique which can give an accuracy of 90-95% then those methods can best and in use and can be used as crucial evidence in court of law. Hence court can rely on this evidence and solve the case accordingly.

There also challenges in facial reconstruction like the improper information related to tissue thickness data and no proper standard methodology to use. According to Tng Ching Hwa not only age but the weight of the person would have influence on soft tissue. However, many research paper suggest that to know relationships between cranial and facial features to obtain nearly acceptable resemblance to the victim. The solutions of these challenges and which can give a better outcome can be our future works.

Conclusion

Forensic art is an efficient and non-invasive technique used in the investigation process to identify the unknown person using different techniques which can be 70-80% accurate. Forensic facial reconstruction is not used in legal enforcement but also used in archaeological research purposes. From the classic manual method which involve forensic artist to the new developed methods like- 2 Dimensional and 3 Dimensional-tissue depth method, anatomical Russian method, British method/combination manchester method and computerized 3D forensic facial reconstruction. The combination manchester method was found to be best and more accurate than other methods and also computerized re-modelling of missing individual is easier method compare to manual methods and decrease the practitioner training.

However, the main aspect where the forensic facial reconstruction is taken back is the accuracy. The accuracy of method and result are not 100% where a court can completely rely on. As we mentioned above the accuracy is a key role, face pool assessment is one of method which can give good accuracy up to 80-90% but not 100%. Therefore, the forensic art can be used best co-evidence or in support of other evidence, but in future the techniques can be developed which can give good accuracy so that forensic art can be useful evidence but not co-evidence.

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