Review Article

Oral and virtual autopsy in forensic dentistry

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Abstract

An examination of unidentified deceased individual and collection of evidence in forensics is a multiple process. "Autopsy is derived from the Greek word autopsy, meaning "the act of seeing for oneself." The involvement of forensic odontologist in the examination autopsy is called oral autopsy. Oral autopsy, virtual autopsy, and forensic facial reconstruction are added bench mark in forensic, which is judiciously helpful in criminal investigation and human identification. This review is to show the highlights of forensic oral autopsy in person identification and about the newer techniques used in this current era.

Keywords: Forensic autopsy, newer techniques, oral and virtual autopsy

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INTRODUCTION

The word "Forensic" is derived from the Latin word "Forensis" which means forum, a public place where, in Roman times, judicial proceedings were held. The intersection of forensic science and law provides new tools and methodologies for discovering the truth.[1] The forensic dentist plays an important role in identification, especially in mass disasters. The identification based on dental information is a highly efficient, reliable, and rapid procedure. Currently, forensic dentistry plays a major role in forensic research and identification of humans worldwide. Be it a manmade disaster or natural disaster, the important information obtained contributes to the identification of mass disaster and homicide victims.[2-8] To overcome the various challenges faced by experts, an alternative technique traditionally described by scientific articles as "Virtopsy" is introduced as an alternative or adjunct to the standard invasive procedure.[9,10]

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ORAL AUTOPSY

It involves the examination and dissection of a dead body to identify the deceased and determine the cause or time of death.[11] Oral autopsy refers to an elaborate examination of the oral cavity, as teeth are most resistant to decomposition and can be used as a reliable means of human identification. The comparison of ante-mortem and postmortem dental records, dental profiling, examination of oral structures (tongue, mucosa, palate, and teeth) and DNA extraction from teeth are some of the possible means to ascertain the identity of an individual. Furthermore, to some extent, time and cause of death can also be determined from teeth.[12]

TECHNIQUES OF ORAL AUTOPSY

Extraoral incisions (facial dissection), inframandibular incision, Stryker Autopsy Saw Method, Pruning Shears

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Method, and Mallet and Chisel Method (jaw resection). Different types of incision are shown in Figure 1.[13]

Gowda CBI (also introduced a simpler technique to obtain access to the oral cavity for examination [Figure 2].

PROCEDURE

Consent is to be obtained from the medical officer and also the investigative officer for performing an oral autopsy after explaining the complete procedure. This oral autopsy procedure is simpler, faster, and preserves facial configuration, which may help in the visual recognition of the remains by family members and other interested persons. The procedure includes: (1) Photographic records are needed before the procedure; (2) incision needs to be done from the angle of the mouth to the tragus of the ear on either side; (3) a careful folding of lip and cheek tissues; (4) sectioning of the muscles and the capsular ligament of the temporomandibular joint; (5) opening of the oral cavity by traction allowing visualization of the lower and upper dental arcades; (6) obtaining the photographic records of the case; (7) removal of prostheses, orthodontic, and orthopedic appliances, and any foreign object if present in the mouth; (8) charting of the mouth in the postmortem (PM) dental record; (9) description of the anomalies of shape, position, and size of the teeth; (10) Taking of adequate photographs to compare with ante mortem records; (11) the information obtained can be compared with the data offered by the family, dentists of the victims, and contributing private or public institutions (ante mortem data), and finally establishment of the identity.[12]

MODERN VIRTOPSY VERSUS CONVENTIONAL AUTOPSY

In the conventional method, the whole architecture of the body is preserved in this technique, which is not in case of conventional biopsy where all the organs are removed and examined. If the body is subjected to subsequent autopsy, it becomes a very tough job for the second autopsy surgeon to conclude with all the dislodged and dissected organs where the normal architecture is lost. In the initial period, virtopsy researchers use only computed tomography (CT) and magnetic resonance imaging (MRI) for the detection of the outcomes as adjunctive aids, but the new combined modern virtopsy method uses angiographic methods, CT scanning as such, photogrammetry or three-dimensional (3D) surface documentation and MRI. The application of multidetector or multislice CT and MRI, high-resolution micro CT and micro MRI, magnetic resonance spectroscopy, image-guided percutaneous biopsy, PM angiography, PM identification, PM ventilation, noninvasive tool, and data display control such as the integration of Kinect camera or 3D printing and rapid prototyping along with conventional virtopsy found continued interest for problems specific to clinical forensic medicine.[14,15]

PHOTOGRAMMETRY AND SURFACE SCANNING

The merging method of color photogrammetric surface scan and gray scale radiological internal documentation has the advantage of being observer-independent, nonsubjective, noninvasive, digitally storable over years or decades and even transferable over the web for the second opinion.[16,17]

POSTMORTEM COMPUTED TOMOGRAPHY ANGIOGRAPHY

Using the PM angiography, the whole cardiovascular system can be visualized. If there is any injury to a vessel, there will be spillage of dye to the surrounding tissues, making it visible in the CT images. Even though medical imaging techniques used in virtopsy is the same as methods

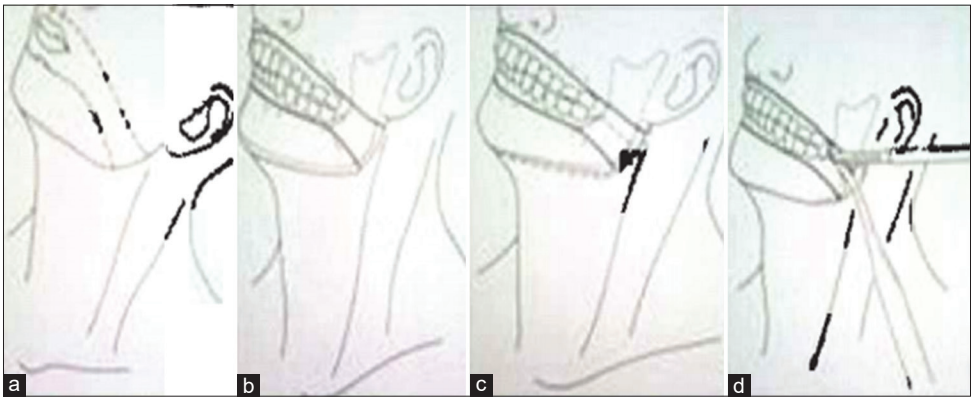

Figure 1: Different types of incisions. (a) Perioral incision. (b) Soft tissues removed. (c) Ramus bony cut and submental-mylohyoid incision. (d) Separating ramus and incision of the pterygoid muscles

used in clinical medicine, interpretation of PM image data sets has some differences. The changes common in deceased individuals can be mistaken for pathologies. This includes, but is not limited to: collections of gas due to decomposition, clotted blood, and internal lividity. MRI scans change their appearance if the body temperature is too low. Therefore, it is advisable that PM studies be evaluated by radiologists who are experienced in PM imaging.[18,19]

FORENSIC FACIAL RECONSTRUCTION

When conventional identification methods are not helpful, facial reconstruction comes to the rescue. It is used in forensic science as well as archaeology. It is the art and science of recreation of multiple facial structures using the bony remains of the deceased.[20] Facial reconstruction is at best a tool for producing images that are an approximation of what a face may have looked like in life.[21,22]

CRANIOFACIAL IMAGING AND RECONSTRUCTION

The virtual autopsy can be applied in a broad number of forensic situations, such as thanatological investigations, carbonized and putrefied body identifications, mass disaster cases, age estimation, anthropological examinations, and skin lesion analyses [Figure 3].

Figure 2: Incision given from the angle of the mouth to tragus of the ear and flap is reflectedf

In cases of drowned bodies, the CT information about the volume, density, size of the lungs, and the amount of liquid observed in them is helpful in diagnosing the cause of death. Cases of firearm projectile injuries are often difficult to examine because either sometimes the bullet is not in the body, or diverted by an anatomical structure, or it can be in unknown body parts. Therefore, knowing the location of the projectile before the autopsy is performed facilitates the examination.[23]

In mass disasters, forensic odontologists could be able to chart the PM virtual data and to start the AM triage and the AM/PM comparison, while forensic pathologists are performing the conventional autopsy procedures. Dirnhofer *et al.* in their study observed for human identification purposes, the use of adapted vehicles (e.g., Oshkosh Specialty Vehicles®, Clearwater, Florida, United States of America) with imaging machines allows for PM data collection on the disaster field.[24-26]

CASE REPORT AND ROLE OF FORENSIC ODONTOLOGIST

In 2006, a decomposing corpse, skeletonized and with no mandible, was found along the coast of Valderice, in the province of Trapani, Italy. The public prosecutor's office of Trapani authorized the autopsy, which was performed by a forensic pathologist working alongside a biologist. Various analyses, such as DNA sampling and the examination of the dimension and of the morphogenesis of the Mytilus edulis adhering to the body, were performed to estimate the length of permanence in the sea. In 2008, a human mandible was found in the same area where a corps with unknown identity had been found [Figure 4a and b].

In 2009, the public prosecutor's office of Trapani authorized new technical dental and anthropological examinations of the body (skull and mandible), which had not been

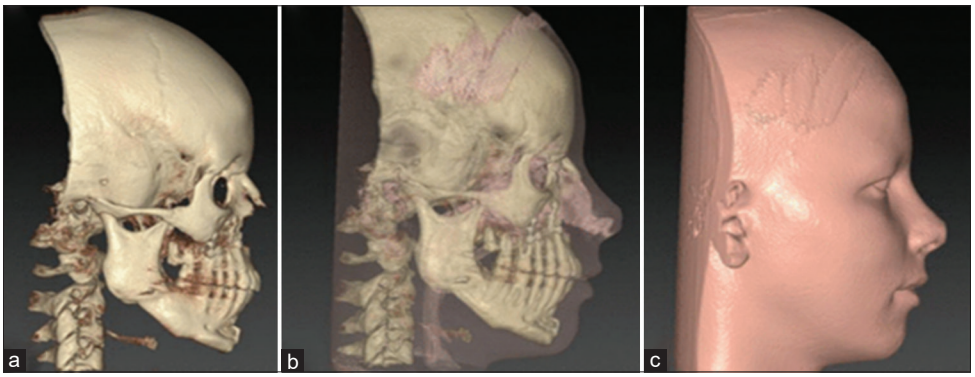

Figure 3: (a) CT image of craniofacial structure. (b) Processing for facial reconstruction. (c) Facial reconstruction done

Table 1: Techniques of forensic facial reconstruction

Superimposition	Two dimensional	Three dimensional
1. Comparison of the images of the skull with submitted photographs 2. Video: The method involves focusing of video cameras onto different images that can then be merged and displayed on a computer screen	1. Recreating the facial profile from the skull by using soft-tissue depth estimates 2. It was inspired from the idea that the relative positions of facial features are dictated by the skull and hypothesized that an individual's face could be formed by substituting an "average" face onto the skull. 3. Used soft-tissue depth markers and "average" face were computer-generated onto a known skull. The method requires an artist, anthropologist and medical expert to work together Advancements Computer software programs like CARESTM or CARES and FACES etc., produce 2D reconstruction which can be edited and manipulated Based on capturing and digitalizing radiographs, photographs and images of skulls and producing an electronically altered version of the image. Fast and accurate reconstruction process and produce more generic images	Manual methods: 1. Anthropometerical American method/tissue depth method: In this, fine measurements of soft-tissue depth were obtained by the use of needles, X-rays, or ultrasound 2. Anatomical Russian method: Soft-tissue depth data were not considered and reconstruction was done by shaping muscles, glands, and cartilage onto the skull layer by the layer 3. Combination Manchester method/British method: Most accepted method for facial reconstruction today. In this, both soft-tissue thickness and facial muscles are considered Computerized 3D FFR 3D computerized models are made using the manual clay model techniques. Computerized systems 3D animation software: to model the face onto the skull virtual sculpture system with haptic feedback Phantom desktop™TM haptic device Sensable technologies

CARESTM: Computer-assisted recovery enhancement system, FACES: Forensic anthropology computer enhancement system, FFR: Fractional flow reserve

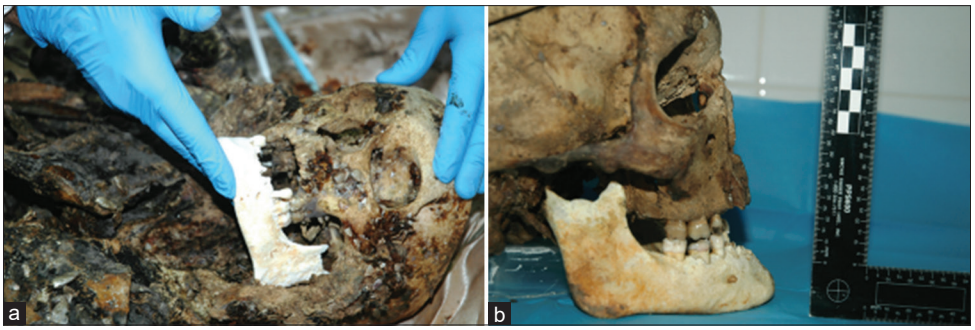

Figure 4: (a and b) Human dehydrated mandible and skull found along the coast of Valderice, in the province of Trapani, Italy. Perfect occlusion match can be observed

performed during the previous autopsy, to verify the compatibility of the human mandible with the previously examined body, thus integrating the existing profile written by the medical examiner with all those complementary elements which could lead to the identification of the body itself. The body was exhumed, and it underwent a dental and anthropological PM examination. To compile a forensic odontological profile, the following examinations were performed: A complete radiographic examination of the maxillary and mandibular arches, inspection by and without ultraviolet light (395 nm), photographic examination with and without linear referencing, impressions of the dental arches, sampling of dental enamel and sampling of dental material (composite resin and metal alloy taken from a dental inlay). All the technical examinations were performed in the mortuary of the cemetery in Trapani using the personal equipment of the author, among which, the portable radiographic unit (Nomad Examiner, Aribex Inc., USA), which was associated with a sensor for digital radiography and connected to a laptop [Figure 5 and Table 1].[27-29]

Figure 5: The portable radiographic unit (Nomad Examiner, Aribex Inc., USA) associated with a sensor for digital radiography

DISADVANTAGES

Although the technique has good reliability, there is a little of forensic importance that virtual autopsy cannot detect. It is not possible to distinguish all the pathological conditions, infectious status, AM, or PM wounds. It is also

difficult to appreciate the PM artifacts, color changes, and sometimes small tissue injury. No literature supporting the use of specific color resolutions for image analysis in full-body CTs could be retrieved.[25,30,31]

CONCLUSION

PM assessment, evidence, and data collection of any unidentified human remain of unknown nationality should follow Interpol Disaster Victim Identification (DVI) principles, and forensic odontologists should be involved not only in the PM data collection but also in the AM dental data input, comparison, and reconciliation. The failure to routinely employ forensic odontologists can lead to a delay in positive identification and human rights violations. Nevertheless, virtual autopsy is a new development in the field of investigations of death, and its acceptability in the court of law is yet to be proved.

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Conflicts of interest
There are no conflicts of interest.

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