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VIRTOPSY: A NEW DEVELOPING SCIENCE IN FORENSIC ODONTOLOGY

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ABSTRACT

Background 'Virtopsy' is made up of two words 'virtual' and 'autopsy'. 'Virtual' means digitally available, while 'autopsy' means examination of deceased to find out the cause of death.
Objective This review aims to provide an overall view about virtopsy in forensic odontology.
Data sources A narrative review was performed with a literature search in the PubMed and Google Scholar electronic databases.
Study selection Reference lists included full papers of any study design, published in peer-viewed English till June 2022.
Data extraction Current literature indicates various methods and applications of virtopsy in forensic odontology. Moreover, recent advances in forensic odontology are discussed.
Data synthesis Virtopsy is a virtual alternative to traditional autopsy. Conventional autopsy has its own pitfalls as it is an invasive procedure and not socially as well as emotionally accepted in certain religions. Virtual autopsy is a better adjunct for conventional autopsy. Virtual autopsy has its own advantages as digital storage of data can be done. Virtopsy used in forensic odontology is known as 'Virdentopsy'. Various equipment and robotic science have also developed in this field of Virdentopsy.

KEYWORDS

Dental autopsy; Forensic odontology; Human identification; Virdentopsy; Virtopsy

1. INTRODUCTION

In the field of medicine, conventional autopsy procedure has a mainstay role. It aids in establishing the final diagnosis, relates the cause of death to the associated pathologies as well as it explains the interaction between them. According to underlying purpose of this procedure, there are mainly 2 types of autopsies: Clinical and Forensic. Clinical autopsy is one which is performed in a clinical set up, by the pathologist with the positive consent of the family members of deceased to find out the cause of death. Forensic autopsy is performed in case of suspicious, violent, mass disaster or unknown cause of death [1]. Conventional autopsy is an invasive procedure which includes dissection, interpretation and cataloguing [2]. The corpse is handed over to family for last rituals after performing conventional autopsy procedure and thus, it is not possible to re-examine the decision if needed, while practicing conventional autopsy [3]. Sometimes, family of the deceased may not give consent for conventional autopsy owing to possible mutilation involved and also for certain religion believes [4,5]. These drawbacks of conventional autopsy led to genesis of emerging branch, virtual autopsy procedure, namely "Virtopsy" [6]. Because of the Covid-19 pandemic, the whole world is being adjusting itself to the "new normal" things. Social distancing has become major part of day-to-day life as well as medical field. Thus, it is desirable to have every procedure touch-free and online during victim identification for forensic purposes as well. Virtopsy is a step forward in this direction. The research question formulated was 'Can virtopsy be equally efficient as conventional autopsy in forensic odontology?'. This literature review focuses on history, equipment, robotic science, methodology, application, advantages and disadvantages of virtopsy in forensic odontology.

2. METHODOLOGY

A literature search was performed for the narrative review in the PubMed and Google Scholar electronic databases. Reference list included full papers on the subject of virtopsy published in English language till June 2022.

3. RESULTS

Out of 30 references, 19 review articles, 5 original articles, 4 books, 1 case report and 1 active trademark are included. 10 review articles are concentrated in Indian subcontinents.

Peer-Reviewed Article
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Review Articles

4. DISCUSSION

"Virtopsy" is combination of two terminologies 'virtual' and 'autopsy' [6]. Virtopsy can be employed for broad and systemic examination of whole body. As an alternative of conventional autopsy, virtopsy is less time consuming, aids better in final diagnosis and render respect to religious sentiments [7].

4.1 History

Way back to 3000 BCE, the ancient Egyptian civilization practised mummification, the removal and examination of internal organs of human for religious causes. In 44 BCE, after famous Julius Cesar's murder by rival senator by stabbing him 23 times, his official autopsy was conducted. In 150 BC ancient Romans had established parameters for the legal practice of autopsy [8].

Dissections of dead bodies were done by Erasistratus and Herophilus to study organ and nerves [9]. "The seats and causes of disease" book including 700 autopsies performed by Giovanni & Morgagni was published in 1761 [10]. Credit for teaching autopsy as a part of medical education goes to William Osler (1800) [11].

German physicist Wilhelm Rongten first discovered plain X-rays were on November 8, 1895. In 1999 first body scan was done for high-profile case using project names such as "digital-autopsy" or "scalpel-free autopsy" [12]. Prof. Richard Dirnhofer, the former head of Institute of Forensic Medicine of the University of Bern, Switzerland got registered trademark for the term 'Virtopsy' on 9th November 2001 [13].

4.2 Equipment for virtopsy in forensic odontology

Various types of records are used for virtopsy in forensic odontology. Digital Dental records are used to compare ante-mortem records with post-mortem records which aids in personal identification.

Digital photography has a major role in practicing virtopsy in forensic odontology. It aids in cases involving identification, human abuse and most significantly, bite mark cases. Digital photography is essential for evidence collection and preservation which plays major role in future legal processing [14]. 3D digital scanning of bite marks enables accurate and fast recording of the bite marks in soft substances such as cheese, chocolate, pears, apples, and human skin without further distortion of the evidence during impression taking [15,16]. Exposure to pathogens can be minimized and several steps can be eliminated using digital scanner [17]. Computer-assisted overlays in bite-mark analysis is useful in case of personal assault and rape cases. It preserves 3D information in 2D.

Digital dental radiography aids in dental practice as well as forensic odontology. It can be intraoral or extraoral radiography. It has advantages over conventional radiography such as lower exposure to radiation, ease of storing of images and elimination of chemical processing [18]. Digital dental radiographs can be used to find out if the victim had undergone any restorative or endodontic treatment. In most of the cases, it can serve as unique identity of an individual if ante-mortem records are present.

Computer Tomography-scan is used to examine hard tissues within the body: the teeth and skeleton. They are much easier to interpret than conventional radiographs as it shows two-dimensional views of three-dimensional objects. It helps in age estimation, identification, trauma analysis and disaster victim identification [19].

Magnetic Resonance imaging features soft tissue condition. Soft tissue changes can be identified with the help of MRI. It is used to explore the cause of death as an alternative to traditional autopsy [20].

3D Surface Scanning photogrammetry is a science of making measurements using photographs. Numbers of photographs are taken from different angles and analysed by software [6].

Cone Beam Computed Tomography serves as a reliable source of evidence for ante-mortem and post-mortem records and assists in age estimation, gender determination and personal identification. Figure 1 shows equipments used for virtopsy in forensic odontology.

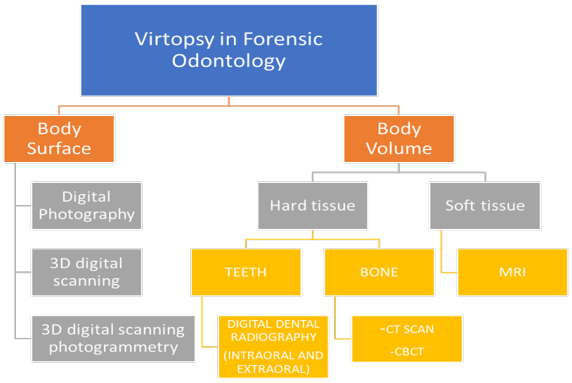

Figure 1. Equipments used for virtopsy in forensic odontology

4.3 Robotic science for virtopsy

Robotic science is used in many fields. Along with the conventional imaging techniques, robotic science can also be utilized to perform virtopsy. Many robotic smart devices such as Virtobot, Virto mobiles and smart glasses are used to perform virtopsy.

Virtobot is an all-in-one machine. Virtobot is developed by PROFACTOR GmbH (SteyrGleink, Austria) according to Iso-9283: 1998. [21] It integrates the various imaging modalities to practice virtopsy. Within a single 3D space, combined surface and body volume acquisition can be done with Virtobot. With the help of Virtobot, interpersonal inaccuracies can be avoided [22]. They are gigantic machines of which their utility in field of disaster is not always feasible [6].

Virto mobiles are relatively new to this field dating from late 1990s to early 2000s [23]. Vitro mobiles are compact devices as compared to Virtobots. They work almost similar to Virtobots. They are mounted on a trailer which makes its transport easy at the site of disaster [24].

Smart glasses are also being used for practicing virtopsy. While one forensic expert examines the corpse wearing these glasses and team of forensic experts (who are not present at the site of disaster) can examine the same thing online on their respective computer devices [2].

Virtopsy table is a large touch-sensitive liquid crystal display screen. It represents the operating table

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displaying the image of the body [19]. It was developed by Dr. Anders Perrson.

Virtopsy Table allows medical professionals to explore the inside of human body without need for invasive procedures. A large touch sensitive liquid-crystal display (LCD) screen represents the operating table displaying the image of the body. At the swipe of a finger, layers of skin and muscle are dissected. Also zooming in and out of the organs for their assessment and slicing through tissue using a virtual knife are possible [27]. Virtopsy table is well suited for medical training programs and police departments.

4.4 How to perform virtopsy?

Virtopsy includes 3D imaging techniques as well as 3D surface scan and all other digital recording techniques for mapping external surface of the body [26].

4.4.1 3D-Surface Scanning

With the help of virtobot, the corpse is first prepared. Virtobot places markers on exterior surface of the body accurately for the alignment of surface scan and interior scans more easily. After placement of markers, virtobot creates 3D colour model of corpse. Scan uses stereoscopic cameras to capture colour image. It takes 10 seconds for robot to move over the body and create 3D image.

4.4.2 3D-Imaging

After 3D surface scanning, the body(corpse) is double-covered inside a blue bag through which x-rays can easily pass through and it also prevents contamination, it respects privacy of deceased person, maintenance of hygiene and to remain undisturbed by non-forensic personal in room. X-ray, CT-scan, CBCT, MRI can be done. All data is then stored in computer.

Forensic odontologist can study the records anytime and images can adjusted up and down & rotated at various angles, which provides flexibility which is absent in conventional autopsy.

4.4.3 Biopsy

After 3D surface scanning and 3D-imaging, needle biopsy can be done if internal body samples are needed. All data of biopsy also can be scanned and saved in computer.

4.5 Applications of virtopy

The preliminary results, based on concept of 'Virtopsy' are promising enough. Radiological investigations can be used in Disaster Victim Identification in cases such as cranial, skeletal or tissue trauma. With the help of MSCT (Multi-slice computed tomography) and MRI, some forensic vital reactions can be diagnosed [12]. Applications of virtopsy include determining cause of death, gender & age determination in difficult forensic cases, identification of distinct foreign bodies and injuries, forensic 3D reconstructions, bullet tract identification, investigation of bite marks and for research purposes [27].

4.5.1 Determining the timing and cause of Death

MSCT and MRI can be used to determine timing of death in head injury cases.

4.5.2 For identification of individuals

Gender, age and personal identification is a challenge in difficult forensic cases. Disaster victim identification can be done using dental identification procedures by comparing post-mortem data with ante-mortem data, dental deoxyribonucleic acid techniques and development of dental post-mortem victim details.

Post-mortem dental data plays major role in dental identification. Visual examination is difficult in victims with charred bodies and damaged oral cavities. In such cases, virtopsy comes to our aid.

Smith et al. (2002) published a case report of positive identification of deceased individual which was accomplished by performing a CT scan on unidentified cranium and comparing multiple landmarks, images with corresponding features in an ante-mortem CT scan of a missing man [28].

4.5.3 For toxicological examination

In cases of drug abuse, Virtopsy can be used as a tool to determine the death of person.

4.5.4 Virtopsy in road traffic accidents and assaults

Post-mortem MSCT and MRI can be used in cases of fatal blunt head injury. Identification of foreign bodies, bullet tract can be done. 3D reconstruction of face can be done in case of completely mutilated bodies. Comparison of bite mark on human body or any other object can be done.

4.5.5 Virtopsy in hanging or manual strangulation

Post-mortem MSCT and MRI helps in identification of strangulation signs in victims of hanging or manual strangulation.

4.5.6 Virtopsy in death due to burns

Radiological methods of MSCT and MRI made it possible to document the injuries caused by burn as well as forensic relevant vital reactions (air embolism and blood aspiration).

Post-mortem imaging is a good forensic visualization tool with a great potential for forensic documentation of completely charred bodies.

4.6 Advantages [29,30]

- As it is a scalpel-free, it is a fast procedure
- It has a better social acceptance as it is a minimally invasive procedure
- Minimal risk of infection to the forensic experts and associated workers
- 3D analysis can be done
- Effective visualization and localization of fracture lines
- Depthof invasion of foreign body can be assessed
- Autopsy result with all the details can be digitally stored, thus amenable for re-examination and second opinion even after a long time
- Results will be observer independent

4.7 Disadvantages [29,30]

- Instruments and set-up used to practice biopsy are expensive
- Artefacts are difficult to identify
- Very fine structures cannot be studied
- Odour and colour change cannot be recorded
- Irregularity of body shape may affect screening
- Some loss of details can get while merging of data

Review Articles

Table 1. Difference between traditional autopsy and virtopsy.

TRADITIONAL AUTOPSY	VIRTOPSY
1. Invasive procedure and results in destruction of tissue.	1. Minimally invasive procedure and does not cause destruction of tissue.
2. Examination can only be done by experts present at the time of procedure.	2. Creates an objective 3D data set that can be shared with other experts who are not present at the time of procedure.
3. Less social acceptance	3. More social acceptance
4. Inter-observer variation can be present in results.	4. Results are independent of Inter-observer variation.
5. High risk of infection to experts & associated workers	5. Minimal risk of infection to experts & associated workers.
6. No digital storage of details. So, re-examination and second opinion cannot be done after long time.	6. Digital storage of details. So, re-examination and second opinion can be done even after long time.
7. Difficult to access depth of invasion of foreign body	7. Feasible to access depth of invasion of foreign body
8. Odour and colour change can be examined.	8. Odour and colour change cannot be examined.
9. Cost effective	9. Investment of expensive instruments is needed.

5. CONCLUSION

Virtopsy emerges as a useful tool for forensic investigations. With the help of virtopsy, improved data collection can be made. Without damaging the body, one can visualize 3D anatomical structures thoroughly. After covid-era, absence of contamination from cadaver's substances is also beneficial for forensic experts' health. Computed approach in virtopsy provides the review of the case even after several years of death, improved data organization and communication between the forensic experts. Recently, the term VIRDENTOPSY has been coined that merges the "virtual' and "dental autopsy". It is a registered brand by Nuzzolese E in 2021 with a dedicated website in order to offer a remote forensic odonatological assessment of post mortem dental data of unidentified human remains.[25] Virtopsy still remains underused in forensic odontology requires further exploration to maximize its benefits to expand its space in dentistry.

CONFLICT OF INTEREST

The authors have certified that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

RP, BS: reviewed articles. **RP, DV, BS:** critically revised revised the manuscript.

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Questions

1. What is the purpose of performing autopsy?

❑a. Clinical;
❑b. Forensic;
❑c. A and B both;
❑d. None of the Above.

2. Which of the following is an invention of robotic science?

❑a. Virtobot;
❑b. 3D surface scanning;
❑c. MRI;
❑d. Intraoral radiographs.

3. Who registered the trademark for Virtopsy?

❑a. Wilhelm Rongten;
❑b. William Osler;
❑c. Prof. Richard Dirnhofer;
❑d. Giovanni & Morgagni.

4. Which of the following is not an advantage of Virtopsy?

❑a. Better social acceptancel;
❑b. Odor and color change can be recorded;
❑c. 3D analysis can be done;
❑d. Minimal risk of infection for the forensic experts and associated experts.