Review Article

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Maxillofacial Imaging in Image guided Virtual Autopsy and its applications in Forensic Identification

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Abstract:

Every human being lives to die another day and it is imminent, at few occasions forensic examination of deceased becomes a necessity.Autopsy is the primary investigation that is performed in every medico legal case. Because of mutilation technologies, traditional autopsy technique is most disturbing in terms of emotions and rituals of relatives. Forensic radiology plays an important role for identification of humans in mass disasters, criminal investigations, and evaluation of cause of death. The introduction of radiological modalities in autopsy techniques is a complementary tool for forensic identification and is known as virtual autopsy. Virtopsy is an emerging technology in the field of forensic medicine which incorporates imaging technology that relies on certain fundamental pillars which include three dimensional surface scanning 3D/CAD photogrammetry, MSCT multi slice computed tomography, MRI magnetic resonance imaging and Magnetic resonance imaging spectroscopy.Utilizing virtual autopsy for orofacial forensic examination is an emerging specialty which holds a plethora of potential for future trends in forensic science. Being a noninvasive technique, it is a rapid method which facilitates the medico legal process and aids in the delivery of justice. This review describes the role of maxillofacial imaging in imageguided virtual autopsy.

Keywords: Forensic identification, Imaging, Maxillofacial Imaging, Virtual autopsy

Introduction:

Recent scientific technologies have reached a point of advancement wherein different disciplines are interconnected to solve problems in medical field, especially in establishing reasons for death.[1] The branch of forensics has made exemplary and path breaking contributions to solve these problems. Forensic Odontology or forensic dentistry is a major challenging and fascinating branch of forensic science and it was defined by Keiser Neilson in 1970 as "that branch of forensic medicine which in the interest of justice deals with proper handling and examination of dental evidence and with the proper evaluation and presentation of the dental findings.[2] Forensic Odontology is an important investigation that involves the application of dental sciences in the identification of deceased individuals through the comparison of ante and post mortem records.[2,3] The dental tissues are most durable organs in the bodies of vertebrates and humankind's and therefore their characteristics can often survive long periods of immersion under water, burial under soil, fire and exposure to biological agents in the natural environment.[2]

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Autopsy is derived from two Greek terms Autos which means "self" and opsome means "I will see". Hence, it literally means to see with "one's own eyes". Autopsy is utilized in registering all the external injuries, anatomic dissection, histologic studies and cultures.[4]

On the other hand, the term Virtopsy was coined by Thali et al which is composed of virtual and autopsy where virtual is derived from the Latin word "virtus" which means "useful, efficient and good" and elimination of autos, i.e., "self". Virtopsy is a transdisciplinary technology that associates different branches as forensic medicine, pathology, radiology, image processing, physics and biomechanics.[4]

The Virtopsy or "Virtual Autopsy" was developed by Richard Dirnhofer, a former Director of Forensic Medicine, Berne, which was then continued by his successor, Michel Thali and his colleagues at the University of Berne's Institute of Forensic Medicine, Switzerland. "If you are doing an autopsy, you are always destroying the 3D geometry of the body," says Thali, the forensic pathologist and project manager for Virtopsy. "Using this cross section imaging technique, it is possible to document the same findings in a non invasive way."[5]

Image guided virtual autopsy or Virtopsy is a new technique which consists of internal examination of dead bodies using computed tomography (CT) and magnetic resonance imaging (MRI) without opening the body or body parts.[6] It also allows the reconstruction of a three dimensional view of the analyzed cadaver, thereby helping in answering main forensic questions without autopsy.[7,8] The teeth has been a primary means for individual identification in single cases as well as mass disasters that includes comparing postmortem dental radiographs to ante mortem records. The use of CT is a new modality for this purpose.[7] CT scans are performed using mobile CT scanning equipment. Maximum intensity projection (MIP) is a very fast imaging technique which takes just several minutes to create a radiographic model of the dead bodies to be investigated.[8] This review aims to update the knowledge of dental professionals about the use of maxillofacial imaging in image guided virtual autopsy and its applications that are helpful in forensic identification.

History[4]

- 1977- Forensic application of computed tomography (CT) scan described first as the pattern of a gun shot injury to the head by Wullenweber.
- 1989- Kalender et al. introduced spiral CT opening the door for three-dimensional (3D) data acquisition and processing.
- 1990- Concept of objective, non- invasive documentation of the body surface for forensic purpose with the development of photogrammetry.
- 2000- Observer independent documentation of the body surface is combined with observer independent documentation of the interior of the body.
- This is now has made been possible by the virtopsy project of the institute of forensic medicine, diagnostic radiology and neuroradiology at the University of Bern, Switzerland by the team led by Richard Dirnhofer, Thali et al.

Background:

Virtopsy combines very powerful scanning and radiographic technology with the power and resolution of modern computers. It is a key tool that helps in establishing the manner and cause of death. Furthermore, it avoids the need to physically dissect the corpse allowing the examiners and investigators to discover important clues, more quickly and effectively. The saved scans can be replayed that would allow investigators to bring in more experts.

Virtopsy Tools[4]

Virtopsy basically consists of:

a. Body volume documentation and analysis using CT, magnetic resonance imaging (MRI)

b. 3D body surface documentation using

f forensic photogrammetry

c. 3D optical scanning

Virtopsy is based on the principle of triangulation in which 3D imaging is used in postmortem victims.[9]

Methods of Virtopsy[6]
Computed tomography

CT is the most frequent imaging tool in forensic sciences. With modern scanners, 2D and 3D reconstructions based on slice thicknesses of 0.5 mm are not only possible, but are

becoming routine standard. It is used for detection of foreign bodies, fractures, gas, and fluid accumulations such as blood. It also demonstrates calcifications such as coronary sclerosis and larger vessels easily and can be used in conjugation with postmortem angiography.

Magnetic resonance imaging:

Contrast based MRI is a nonionizing imaging modality which can illustrate softtissue injuries and pathologies clearly and is also useful when examining living victims of assault, such as manual strangulation.

Postmortem biopsy:

This method uses a biopsy gun, to obtain samples of organs of interest, e.g., the heart, or specific pathologies seen in CT or MRI. It also aids in collection of tissue and fluid samples that can be collected for toxicological and microbiological examinations. Besides the manual sampling, image-guided sampling with a dedicated robot has been introduced recently.

3D photogrammetry–based optical surface scanning:

It uses a surface-scanning unit, which projects a fringe pattern over a surface and is in turn recorded by two cameras; a 3D image can be calculated using special software. True color 3Dsurface reconstructions are then obtained by adding digitalphotography of the surface from different angles which areadded to the data. It is an accurate documentation that candocument structures less than 1 mm in size.

Virtual Autopsy Table[4]

- Dr. Anders Persson, director of the Linkoping University Centre for Medical Imaging Science and Visualization, Sweden has created “the Virtopsy table”.
- A large touch- sensitive liquid- crystal display screen represents the operating table displaying the image of the body.[10]

Procedure[4]

Step 1: Prepare the body for imaging.
Step 2: Virtobot, marks on the external of the cadaver.
Step 3: After marking virtobot takes a 3D color model to the body.
Step 4: Uses stereoscopic cameras for capturing the color image and then a projector cast a mesh pattern on the body.
Step 5: After the creation of the image picture can be manipulated on a computer screen for further identification of the tattoos by the investigators.
Step 6: Tripods and cameras are placed by virtobot at various points around the body. The robot then glides over the body creating a 3D image.
Step 7: After the surface scanning the body is carried to the CT and MRI labs doubly enfolded in blue bagsthrough which X-rays can be passed.
Step 8: The bag remains closed while the body is scanned and hence the body's privacy is protected, and cleanliness in the room is also maintained.
Step 9: X-ray slices of the body are reconstructed by the computer within 19 min into detailed images ofbone and tissue.
Step 10: There are color coding as pockets are blue, soft tissues are beige, blood vessels are red, and bone is white.
Step 11: Manipulation of patterns and images can be done and turned to various angles.
Step 12: The virtobot can also perform needle biopsies if body samples are required[.10]

Virtopsy: Advantages and Disadvantages[6]

Advantages:

1. Virtopsy provides a fast and noninvasive bloodless visualization of region of interest with excellent accuracy regarding the size, volume, and orientation of damaged organ or foreign body.
2. It provides contamination free sampling (poisons, infections, tissue, etc.) as there is no mutilation of dead bodies.
3. It also produces detailed 3D records that demonstrates the cause or manner of death with intact tissue and avoids human intervention.
4. It is an easy method for identification in mass disaster cases where bodies are severely damaged.
5. Three dimensional forensic facial reconstructions can be carried by Virtopsy techniques and can be used for medicolegal purposes.
6. The digitally stored data is very precise and can be helpful in further investigation of cases

Disadvantages:

1. Virtopsy cannot provide information about the status of infection, texture of tissue, and color changes.
2. It is still less informative than the conventional invasive autopsy as it depends upon radiographic interpretation and sometimes minor tissue injuries may get missed.
3. This technique is cost effective, technique sensitive, and require highly skilled radiologists.
4. It has limited feasibility and judiciary acceptance among professionals.

Virtual Autopsy: A Cutting Edge[13]

Studies conducted to compare Autopsy and Virtopsy revealed the cutting edge of Virtopsy in determining the cause of death, eliciting relevant traumatological and pathological findings, vital reactions, reconstruction of injuries and visualization of forensic cases. This also led to an opportunity to utilize the data for expert witness reports, teaching, quality control and telemedical consultation.[14]

Applications[6]

Identification of deceased: Virtopsy in the form of postmortem CT is a rapid examination technique that enables identification of dead by providing accurate anatomical details including degenerative changes or surgical implants if any.

Foreign body: Virtopsy accurately identifies foreign body in 3D manner. It describes the entry point of foreign object (bullet tract) and exit pattern of wounds, pattern of bony fracture, and soft tissue damage. Postmortem CT enables the measurement of the radiopacity of foreign bodies precisely in HU. Postmortem MRI can be used to diagnose soft tissue injury, contusions, hematoma, and neurological as well as non-neurological trauma.

MRI spectroscopy is a new technique that is helpful in detecting changes in metabolic activities in order to determine the death timing and is also helpful in detecting death due to electric shock.

Adjuvant to autopsy: It has many advantages over autopsy as it does not impose a physical contact or severing of tissues in order to observe findings. It is useful in assessment of multiple comminute fractures as it does not tamper with preexisting structures. In cases of gas poisoning and decomposed bodies, there is collection of pathological gases which can be easily recognized by means of Virtopsy.

Comparison of postmortem data to the antemortem records is an important tool in Virtopsy.

Forensic facial reconstruction using Virtopsy provides more valuable information.

Emerging Applications of Virtopsy[6]

1. Robotic virtual autopsy is a multifunctional system that can perform automatic postmortem and three dimensional surface scanning which qualitatively increase the improvement in the outcome of forensic investigations. The robotic virtual autopsy also helps in detecting the change in color of tissue.[11,12]

2. Volume-analysis software used in virtopsy helps in accurate estimation of mass of internal organs.

3. Postmortem angiography is a virtopsy technique that is helpful in visualization of the cardiovascular system that includes infusion of contrast medium with the aid of peristaltic pump and contrast medium.[12]

Virtobot and Virtual Autopsy[13]

Current advances in the field of medicine are crossing milestones contributing enormously in various fields of science. Virtobot is a Robotic technology that carries out Virtopsies. They are multifunctional robotic system that serves to perform 3D surface scanning and automatic post mortem image guided biopsies. Emerging as a newest technology the virtobot bridges forensic science, diagnostic imaging, computer science, automatic technology, telematics and biomechanics thus is a qualitative reflection improving the outcome of forensic investigations.[15]

Effectiveness of Virtopsy[16]

The presentday literature supports the accuracy of virtopsy. Virtopsy has about 80% concordance between cause of death

identified with conventional autopsy and virtopsy. It not only has a high potential of accuracy but also scores over conventional autopsy in the identification of fracture lines. The base of the skull pathologies are better visualized by virtopsy. Explicit details about primary and secondary trauma, depth of injury, microbone injuries are better visualized by virtopsy.[17]

Conclusion;

Virtopsy using maxillofacial imaging establishes a new technical tool in both research and forensic identification and reconstruction. This review concludes that the virtopsy using maxillofacial imaging favours the development of future forensic investigations and is helpful in medicolegal cases.[6]

References:

1. Raj Kumar Badam, TriekanSownetha, D. B. Gandhi Babu, ShefaliWaghray, Lavanya Reddy, KomaliGarlapati, and SunandaChavvaVirtopsy: Touch-free autopsyJ Forensic Dent Sci. 2017 Jan-Apr; 9(1): 42.
2. *Jayanth Kumar Vadivel* **Virtual Autopsy International Journal of Forensic Odontology ¦ June 2016 ¦ Volume 1 ¦ Issue 1**
3. Preethi S, Einstein A, Sivapathasundharam B. Awareness of forensic odontology among dental practitioners in Chennai: A knowledge, attitude, practice study. J Forensic Dent Sci 2011; 3:63-6.
4. TejavathiNagaraj, Haritma Nigam, SitaGogula, C. K. Sumana, ArundhatiBiswas**VIRTOPSY: An emerging tool***Journal of Advanced Clinical & Research Insights* (2018), 5, 38–40
5. Rajeev Kumar1 Virtopsy complementing traditional autopsy IP International Journal of Forensic Medicine and Toxicological Sciences 2020;5(2):39–42
6. ShaluRai, DeepankarMisra, KuberTyagi, MukulPrabhat, PurwaGangwalImage Guided Virtual Autopsy: An Adjunct with Radiographic and Computed Tomography Modalities – An Important Tool in Forensic Identification, 2018 Journal of Indian Academy of Oral Medicine & Radiology
7. Aghayev E, Staub L, Dirnhofer R, Ambrose T, Jackowski C, Yen K *et al*. Virtopsy - The concept of a centralized database in forensic medicine for analysis and comparison of radiological and autopsy data. J Forensic Leg Med 2007;15:135-40.
8. Rutty G. Are autopsies necessary□The role of CT as a possible alternative to invasive autopsies. Rechtsmedizin 2007;17:21-8.
9. Tejaswi KB, Periya EA. Virtopsy (virtual autopsy): A new phase in forensic investigation. J For Dent Sci 2013;5:146-8.
10. Navalkar AR. Virtopsy- The Scalpel Free Autopsy: A Review of Literature. J Contemp Dent 2015;5(3): 168-172
11. Jeelani S, Baliah J. Nanotherapeutics in oncology: Dendrimers the nano wonder. Journal of Scientific Dentistry 2013;3:54-8.
12. Tejaswi KB, Periya EA. Virtopsy (virtual autopsy): A new phase in forensic investigation. J Forensic Dent Sci 2013;5:146-8.
13. Jeelani S1, John Baliah2 **Virtopsy- A Moral Boon In Forensics** Journal of Scientific Dentistry, 3(1), 2013
14. Thali MJ, Yen K, Schweitzerw, Vock P, Boesch C, Ozdoba C, Schroth G, Ith M, Sonnenschein M, Doernhoefer T, Scheurer E, Plattner T, Dirnhofer R. Virtopsy, a new imaging horizon in forensic pathology : Virtual autopsy by postmortemmutislice CT and MRI – a feasible study. J. Forensic Sci 2003;48(2):386-403.
15. Ebert LC, Ptacek W, Naether S, Furst M, Ross S, Buck U, Weber S, Thali M. Virtibot – a multifunctional robotic system for 3D surface scanning and automatic post mortem biopsy. Int J Med Robot. 2010;6(1):18-27.
16. Joseph TI, Girish KL, Sathyan P, Kiran MS, Vidya S. Virtopsy: An integration of forensic science and imageology. J Forensic Dent Sci 2017;9:111-4.