International Journal of Medical Toxicology & Legal Medicine
e-ISSN: 0974-4614
p-ISSN: 0972-0448

Volume 27, No. 1, 2024
DOI: https://doi.org/10.52710/ijmtlm.14

Article Submitted: 27-02-2024; Revised: 22-04-2024; Accepted: 06-05-2024

Advancements and Challenges in Dental Forensics for Disaster Victim Identification: A Comprehensive Review

Ningombam Jyostna [1], Deepak Bhargava [2], Parul khare[3]

1,2, 3 Department of Oral & Maxillofacial Pathology & Oral Microbiology, School of Dental Sciences, Sharda University, Greater Noida, India

Corresponding Authors

Dr Parul Khare, MDS, MSc FO, FPFA

Assistant Professor,

Department of Oral & Maxillofacial Pathology & Oral Microbiology

School of Dental Sciences, Block 3, Room no: 10, Sharda University, Knowledge Park 3 Greater Noida, UP

Email: parul.khare@sharda.ac.in

Dr Deepak Bhargava, MDS

Professor & Head Department of Oral & Maxillofacial Pathology & Oral Microbiology

School of Dental Sciences, Block 3, Room no: 10, Sharda University, Knowledge Park 3 Greater Noida, UP

Email: deepak.bhargava@sharda.ac.in

Abstract

Mass disasters whether manmade or natural have severe consequences. One of the most challenging aspects is the identification of the victim. Conventional and visual method identification is very difficult, so forensic methods become essential, and dental forensics plays a pivotal role in the identification of the victims. Forensic odontologists actively participate in every stage of the identification process, adapting to emerging challenges by incorporating modern scientific methods into their approaches to identification. The success of the identification process hinges entirely on the presence of well-preserved dental remains following the disaster and the accessibility of corresponding dental records. To achieve a scientifically supported positive identification, capable of withstanding international legal scrutiny, a meticulously organized and pre-planned management of the mass disaster victim identification process is necessary. This should adhere to the guidelines set forth by the international Interpol Disaster Victim Identification (DVI) Standing Committee. This paper describes the utilization of dental evidence for identification purposes exploring existing and prospective techniques that could enhance the efficiency of the identification process and outlines recent advances.

Keywords: Mass disasters, dental forensics, Disaster Victim Identification (DVI).

1. Introduction

Disasters are unanticipated catastrophes that frequently cause large amounts of harm due to their unforeseen nature and the potential for widespread and unpredictable levels of damage. Effectively responding to and managing such events remains a persistent and significant hurdle for communities.[1] Man-made disasters, in particular, are often unpredictable, leading to significant casualties and injuries among large numbers of people.[2] It is acceptable to say that in such occurrences, standard mortuary operations cannot be used to manage the bodies of victims.[3] Disaster Victim Identification (DVI) involves the comprehensive protocols employed to identify deceased victims in the aftermath of mass calamities.[4] Following disasters, individual victim identification through dental methods is among the most dependable approaches that plays a pivotal role. In cases of severe burns or extensive disintegration, visual identification becomes challenging as facial features and fingerprints may be completely destroyed. In such instances, the identification process often relies on the use of hard tissues

like the human teeth and jaw bones, for their resistance to destruction. Additionally, individuals who have been deceased for an extended period before discovery, as well as those found in water, pose challenges for visual identification, making the process unpleasant and difficult.[5]The identity of a victim can be established by comparing unique dental features that match both before and after death. This comparison often results in positive recognition or compelling evidence that eliminates a specific identity. Pathological conditions such as disruptions in tooth eruption, malocclusions, and past dental treatments also heavily relies in the identification process. The distinctiveness of an individual's mouth is shaped by age-related alterations, pathological conditions, developmental irregularities, or dental interventions.[6]

This review aims to aware medical and dental professionals about the vital contribution of dentists in the process of 5 phases of DVI (figure 1). It also seeks to inspire aspiring dental specialists to explore the opportunities and career prospects within this distinctive discipline. The review will underscore the advancements in science and technology that have transformed this field into an essential component of DVI.

Dental Identification for DVI

Teeth, being hard and resistant in nature play a significant role for identification as they are retained through several physically harmful occurrences.[7,8] The involvement of forensic odontologists in the integrated identification of the victim is evidently a crucial role DVI, can be defined as the process of identifying individuals by examining dental records and characteristics. This involves comparing information gathered from investigating both before and after-death records. Forensic odontologists are tasked with creating comprehensive and precise reports of their findings to facilitate thorough comparisons between antemortem and post-mortem data.[9] Dental identification process comprises a systematic set of procedures. It is necessary to identify the dental evidence that is accessible and to collect, investigate, evaluate, and preserve the evidence that has been acquired. To allow accurate interpretation and achieve the high-quality findings required by the DVI instructional authority, it is essential that the gathered data go through strict quality control.[10] Gathering and documenting information which includes a comprehensive evaluation of each tooth's clinical condition, including whether it is filled, decayed, or healthy. In the absence of teeth, it’s essential to determine whether it has occurred before or after death. Radiographs and photographs that depict additional characteristics play a very crucial role. Moreover, examination of an individual's dental history can unveil distinct pathological conditions (e.g., supernumerary teeth, impactions) that, when considered alongside other evidence, contribute to improving the precision of identification.[11] Periapical radiographs that display the tooth apices serve as a means for age estimation particularly in instances involving juveniles with limited or no dental work. Additionally, in some circumstances, it may be possible to remove an entire tooth in order to collect DNA samples from the protected pulp and aids in the identification procedure.[11] The main goal is to determine all those involved in the accident, whether or not they have dental records, and if so, how to get them.[10] In odntological investigations, radiographs provided by the victims families or their dental practitioners are examined and scrutinized and compared with the dental characteristics of the victim for confirmation.[12] The use of radiographs for comparing ante-mortem and post-mortem information (Figure 2) are recommended and recorded in data charts.[13,14]

For over two decades, INTERPOL (International Criminal Police Organization) has been instrumental in the field of Disaster Victim Identification (DVI). The first manual was released in 1984 and undergoes routine updates, being consistently disseminated among member countries.[15] It is recommended to utilize standardized dental identification charts, encompassing both AM and PM records, as part of the identification process.[9,16] Various digital software applications have been utilized in previous instances to document ante-mortem and post-mortem information in the aftermath of a disaster.[17] Nevertheless, a relatively recent software known as PLASSDATA, recommended by Interpol, is currently implemented for dental charting in the more recent processes of disaster victim identification.[15, 18] other software that are well accepted globally for DVI are WIN ID and UVIS/UDIM have there advantages and limitations.

Plass Data Software- INTERPOL

It has the capability to conduct advanced searches on all entered information, encompassing DNA and dental findings. The system is crafted to facilitate the comprehensive display of intricate dental records. In individual cases, there's the potential to transmit a dental description with the aim of identifying a deceased individual in another region or country. In incidents involving multiple victims, rapid registration of highly specific details is achievable, enabling the system to pinpoint potential matches swiftly. These matches are subsequently subject to manual scrutiny before conclusive identification. Additionally, automatic batch matching for all dental data can be initiated, with results easily reviewed and validated through graphical dental comparisons. The system seamlessly integrates with the reconciliation status (Figure 3).

Figure 1: Overview of Dental Teams and Phases in DVI

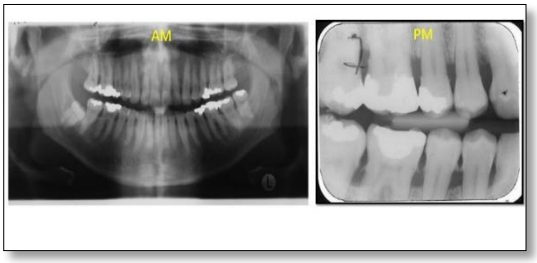

Figure 2- AM -PM radiographs matched; Description/legend- OPG matched with bitewing radiograph wrt 15,16,17,46 and 47Phases in DVI

Win ID3

Deployed in various mass disasters, such as the terrorist attack on the World Trade Center, Hurricanes Katrina and Ike, and the EF 5 tornado in Joplin, this program, based on Windows, is a robust tool. WinID3 integrates dental charting with a comprehensive radiographic/photographic record, establishing a seamless and integrated system for case review and comparison. In the realm of postmortem examinations, this feature enables real-time capture and viewing of radiographs and photographs while examiners chart and assess the victim's dental conditions. The program is versatile, available as a standalone application or accessible as a "Cloud" application through the WinID3 website. Users can access WinID3 conveniently through its website (Figure 4)

UVIS/UDIM

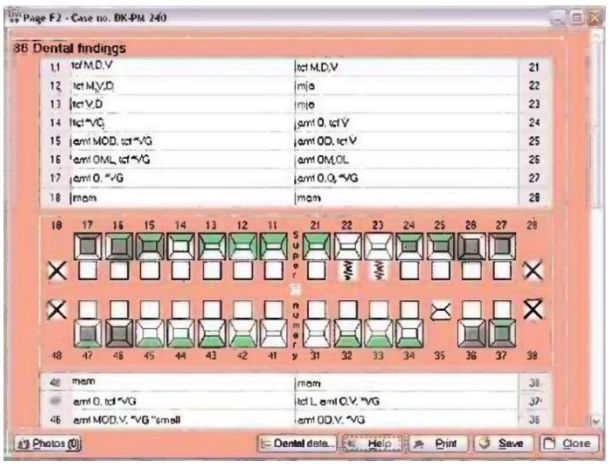

Figure 3: PLASS DATA SOFTWAREDVI

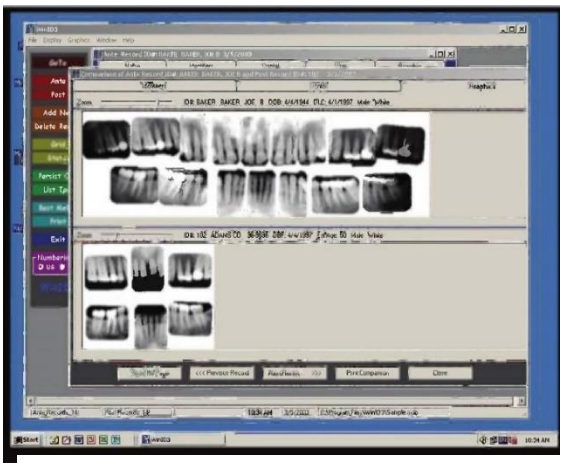

Figure 4: WinID www.WinID3.com.free-standing

UVIS (Unified Victim Identification System) is a robust mass disaster management system that manages and coordinates all of the activities related to victim identification and missing persons reporting.

UDIM (UVIS Dental Identification Module) is the dental recording/search component of the system

UVIS/UDIM is not designed to be used on a stand-alone laptop. It requires both a web server and SQL server as well as some expertise to get it installed and running. Include touch screen capabilities and the ability to switch from FDI to Universal dental coding. (figure 5)

Figure 5: UVIS/UDIM

https://uvistraining.com/

2. Recent Advancements in Forensic Identification Technology

The advancement in technology and its applications in the field of forensics have grown steadily and significantly during the previous several decades. Because of these developments, odontology's capacity to aid in the identification of victims is now significantly more important than it was in the past in terms of its speed, precision, and sensitivity.[19,20] Several advances which include Photographs: Charts, dental casts, dimensions, and morphological analysis were manually compared using conventional rulers and protractors. Previously, study models were employed to maintain the integrity of evidence by facilitating the relative positioning of hard structures, particularly in cases where tissue breakdown was a concern.[21] CAT scanning, along with CAD/CAM technology, has been extensively documented for the examination of teeth and jaws. A variety of individual distinctive features to CAT scan data can be measured and compared, significantly expanding the capability to collect informative data beyond the limitations of traditional planar films.[22] Barcoding: The incorporation of barcodes into dentures and other prostheses has been utilized in the past, given their ability to store comprehensive information about the individual. However, one drawback of this method is that the acrylic resin's thickness may make it difficult to read the barcode itself. [23] RFID Radio Frequency Identification tags: a wireless communication tool that may be used to identify a person, animal, or item when appropriately tagged. Using an RFID tag to contain a microchip's serial number and data that is placed into a person's denture to identify them is the most popular application for these tags. The information stored in the chip is transmitted via an antenna to a reader, which uses the appropriate software to transform the digital data into interpretable text. [24] 3D scanning: to document evidence at the crime scene is now widely accepted.[25] This method has proven successful, in identifying teeth imprints on chocolate. The idea of using this method to get a tool or tooth impressions left on things or people has also been discussed.[25]Recent developments in 3D scanning and comparison methods have been introduced for bite marks examination and identification in food (Silvio et al., 2011).[26] Utilizing 3D scanners, researchers investigated time-dependent changes associated with identifying perpetrators through bite marks on various foods such as buttered bread, apples, cheese, and chocolate bars. The study revealed that it may be possible to identify individuals based on tooth imprints left on different foods, even after a span of 7 months According to the study, it may be possible to identify someone even seven months later using dental impressions found on various meals. In clinical settings, instruments like the Lava chair-side intra-oral scanner (COS) are employed to digitally capture impressions of dentitions.[27] Intra-oral 3D "maps" are introducing a level of high-resolution and accuracy details in dentistry that was previously unprecedented. In recent years, this technology has facilitated the precise replication of dental images and data. It would be worthwhile to explore whether 3D scanners could be employed to test the feasibility of reconstructing missing fragments of jaws discovered at disaster zones.[28] The utilization of these latest advanced technologies and innovations, in disaster victim identification facilitates a more efficient, rapid, precise, and secure process for the collection and interpretation of data.

3. Future Implications

Globalization has led to frequent mass disasters involving victims from diverse nationalities. This requires the engagement of DVI teams from various regions, each with different levels of expertise.[15,29] Ensuring adherence to the rules and Standard

Operating Procedures (SOPs) outlined in the Interpol DVI Guidelines is of utmost importance. Additionally, it is crucial that all specialists participating in DVI possess suitable qualifications and are assigned to roles that align with their expertise. Internationally accepted common minimum training standards would be advantageous for the global community. To accomplish this, accredited specialists are tasked with conducting training programs and establishing a framework for quality control within their respective specialties in the DVI process. Future disaster management plans and the DVI guide should take into account previous mass casualties.[30-33]

4. Conclusion

This review emphasizes the significance of advanced innovations in forensic odontology, which have the potential to reduce both the working time and the required number of investigators at the actual disaster site. By adopting these innovations, the resources needed to create a secure working environment for investigators could be reallocated to the restoration efforts of the disaster zone. In many cases, forensic odontologists from various countries may be involved in the process of disaster victim identification.[9] Although such information is beneficial while exchanging, it's also important to consider that it adds to overall expenses. Newer technologies like 3D imaging and scanning directly at the disaster zone could offer a solution. Collected data can then be transmitted to remote locations for detailed analysis, reducing the need for a large number of investigating personnel on-site. Besides, regional dental practitioners could receive training to operate these 3D scanners, sending all data to a centrally located server. be trained to use these 3D scanners, sending all dental data to a centrally located server. This approach would enable investigative teams to start their analysis more efficiently than traditional methods. These scanners might also be used to store evidence, keeping it from deteriorating over time or acting as a backup, bringing a methodical approach to the process as a whole.

5. Conflict of Interest:

There are no conflicts of interest.

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