The Role of Forensic Dentistry in the Management of Mass Disasters

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Abstract

This review article focuses on mass disaster situations that may arise from natural or manmade circumstances and the significant role of forensic dental personnel in human identification following such occurrences. The various forensic dental modalities of identification that include matching techniques, postmortem profiling, genetic fingerprinting, dental fossil assessment and dental biometrics with digital subtraction were considered. The varying extent of use of forensic dental techniques and the resulting positive impact on human identification were considered.

The importance of preparation by way of special training for forensic dental personnel, mock disaster rehearsal, and use of modern day technology was stressed.

There is a growing interest in and a necessity for utilizing the skills of forensic dentist in mass disaster. Further training and education of dental practitioners is needed in order to fully integrate general dental practitioners into the trauma team and to change the current attitude to admit a meaningful role for dentists in a mass casualty situation.

Key words: Forensic odontology; Mass disasters; Dental identification.

Introduction

Mass casualty situations arise in the most unpredictable manner. Mass disaster may be caused by natural events such as severe flooding, earthquake or volcanic eruption. It may also be caused by human activities such as mishaps involving mass transport by land, sea or air; other causes include war, boundary disputes, ethnic or religious conflicts[1, 2,]

The roles of the forensic dentist include criminal investigation using bite marks, dental cast and saliva analysis; dentists also assist in resolving parental contentions with DNA profiling. The most common role of a forensic dentist is the identification of deceased persons either for crime resolution or for social, matrimonial, or financial reasons[3].

The forensic odontology is of prime importance in mass disasters where trauma is likely to make visual identification impossible. Following mass disaster, identification of individual victims by dental means is one of the most reliable methods. In severe burn situations or following severe disintegration, visual recognition of facial features and fingerprints is often impossible due to extensive soft tissue destruction. Persons who have been diseased for some time prior to discovery and those found in water also present unpleasant and difficult visual identification[4]. The advantage of dental identification is that the teeth are the hardest and most resistant tissues in the body and can

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survive total decomposition and even severe fire, short of actual cremation.

The important role of dentistry in the identification process seems to be clear when taking into account the high percentage of victims identified via dental examination (61%) in the Tsunami disaster of 26th of December in 2004, north of Sumatra Island.[5]

This article highlights potential areas in which the forensic odontologist may take a greater role in a multidisciplinary team in a mass casualty situation in deceased identification.

Roles of the forensic odontologist in identification

Dental identification plays a key role in natural and manmade disaster especially in mass casualties. Dental identification is based on pathological conditions such as: disturbance of tooth eruption, malocclusions and/or previous dental treatments. Changes brought about by age, pathological conditions, and developmental disturbances or by intervention of the dental surgeon result in the mouth being unique to the individual[6].

The first and the most frequent investigation is the comparative examination used to establish to a high degree of certainty that the remains of deceased and the person represented by ante mortem dental records are the same individual (positive recognition).

The second investigation is for cases without previous ante mortem records and where no clues to positive identity exist (postmortem profiling).

Comparative Dental Identification

The central issue here is that postmortem dental remains can be compared with ante mortem dental records including written notes, study casts and radiographs to confirm identity.

Individuals with numerous and complex restorations are often easier to identify than those with little or no restorative treatment.

The teeth in as much as representing the suitable store of these unique identifying features also survive most post-mortem events that destroy or disrupt most body tissues,[7,8].

Forensic dentists produce post-mortem records based on careful charting and written description of dental structures and radiographs of the deceased.

Following a methodical and systematic comparison of ante-mortem and post-mortem records of each tooth and surrounding structures such as bony prominences and congenital defects followed by dental restorations, similarities and discrepancies are noted[9].

There are two types of discrepancies, those that can be explained and those that cannot. Explainable discrepancies are those related to time lapse between ante mortem and post-mortem records such as extracted teeth or extended or enlarged restorations while unexplainable discrepancies cannot be resolved by time lapse between ante-mortem and post-mortem records for example a post-mortem tooth which was absent on ante-mortem record.

Regardless of the method used to identify a person, the results of the comparison of antemortem and postmortem data lead to 1 of these 4 situations[10]:

(1) Positive identification: the ante-mortem and postmortem records match in details with no unexplainable discrepancies.

(2) Possible identification: - ante-mortem and postmortem data have consistent features but due to poor quality, identity cannot be positively established.

(3) Insufficient Evidence: - available information is insufficient to form basis for a conclusion.

(4) Exclusion: - the ante-mortem and post-mortem data are clearly inconsistent.

There is no minimum number of concordant points for positive identification – a single tooth containing unique features can be used for identification while a full mouth radiograph

may not reveal sufficient detail for positive conclusion

Post-mortem dental profiling

Post-mortem dental profiling is the process by which forensic dentists limit the likely population to which a deceased belongs in the absence of ante-mortem dental records. Post-mortem dental profile will provide information on age of deceased[11], ancestral background[12], sex, socioeconomic status[13] and dietary habits, dental and some systemic diseases as well.

The age can be established with an accuracy of ± 1.5 years to the actual chronologic age of the child with this method. [14] Some authors recommend the use of aspartic acid racemization method for determination of the age, which can reveal the age to an accuracy of ± four years.[15] The conclusion on the age of the individual can also be drawn by using charts such as those developed by Ubelaker which graphically give an illustration of the dentition (deciduous, mixed or permanent) right from the age of around five months in utero to 35 years after birth.

The findings on the teeth such as erosion, stains, or unusual wear patterns can help in determining the habits as well as their occupation. Erosions can be due to many factors like alcohol or substance abuse, working in an industry involving use of acids, excessive consumption of carbonated beverages. Stains on the teeth may suggest smoking, tetracycline use, betel nut and chewing of smokeless tobacco or even dental fluorosis.[16-19] The unusual wear pattern of the teeth may give an indication of personal habits or previous orthodontic treatment as well. [33]

Scanning Electron Microscope/Energy Dispersive X-ray Spectroscopy (SEM EDXS) is also used to examine restorative materials including resin in relation to age determination in cases where dental status of victims cannot be determined due to damaged dentition.

SEM/EDXS can analyze different resins and couple each spectrum to a specific brand name because the inorganic composition of resin is rarely altered; data obtained provides information about the time frame that the product was in market thus giving an idea of the remains chronology[20].

Sex determination is made most of the times with thorough examination of the skull as the sex differences in the morphology of the teeth are not very significant. The microscopic examination of teeth for the presence/absence of Y-chromatin and DNA analysis can reveal the sex with certainty.[21-22]

The identity of the race and sex to some extent can be made by careful examination of the skull for its shape and form. These features of the skull may enable a forensic dentist put the individual into one among the three major racial groups, Negroid, Mongoloid or Caucasoid. Along with shape and form of the skull, other features like cusps of Carrabelle, Shovel shaped incisors, multi cusped premolars; talon's cusp, taurodonts, etc may assist in determination of the race.

Dental biometrics

Dental biometrics automatically analyzes dental radiographs to identify the deceased individuals. Observations such as distinctive shapes of restoration, root canal treatment, buried root tips, bases under restorations, tooth and root morphology, and sinus and jawbone patterns can be identified only by examination of radiographs. The method used in dental biometrics is the matching of unlabelled post-mortem radiographs against the labeled ante-mortem radiographs. If the set of teeth in a post-mortem radiograph sufficiently matches the teeth in an antemortem radiograph, the identity of the deceased in the post-mortem radiograph is obtained[23].

There are two stages for dental biometrics, feature extraction, and matching.

During feature extraction, the tooth contours and the dental work shapes are extracted. Extraction of tooth contour involves radiographic segmentation and gum line detection.

Matching has three steps at the first step; the tooth contour and dental work shapes of the neighboring teeth are matched. The second

step is matching at the contextual level; this step reduces the searching scope and enhances the matching accuracy by binding neighboring teeth into groups. The final step is matching at subject level, every unidentified subject has several post-mortem images and every ante-mortem

Figure 1a: Antemortem radiograph.

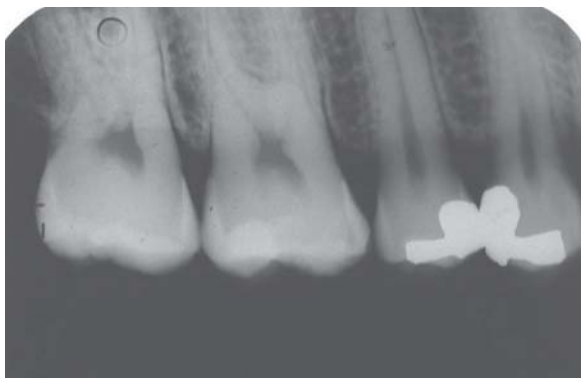**Figure 1b: Postmortem radiograph of the same person as in Fig. 1a**

image in the database belongs to a subject. The matching at the subject level is to obtain the identity of a group of post-mortem images that marches the supposed ante-mortem image of the subject[24].

Genetic fingerprinting

Dental tissue is resistant to incineration, immersion, trauma, mutilation and decomposition so it represents an excellent reservoir of DNA materials. When conventional dental identification methods fail, biological material such as DNA may provide necessary link to establish identity. [25, 26]

Genetic fingerprinting or DNA profiling is a technique used to distinguish between individuals of the same species using only samples of their DNA. Genetic fingerprinting is used in forensic science to match suspect's sample to samples of blood, hair, saliva or teeth, this can lead to identification of dead bodies[24].

With the advent of Polymerase Chain Reaction technique that allows amplification of short tandem repeats (STR are selective, highly polymorphic regions of DNA) at pre-selected sites the biological material extracted even from a root filled tooth will be sufficient to make a conclusion on the identity of a person.[27] Here the DNA extracted from human remains at the site of disaster is matched with the ante mortem sample derived from any of the sources of DNA such as a tooth brush, hair brush, blood sample, biopsy material, clothing or any other personal belonging of the deceased. If the genomic DNA is not in sufficient concentration to draw a conclusion on the identity, then mitochondrial DNA, present in high copy number in each cell and maternally inherited, will be of great help. The analysis of mtDNA is a powerful tool in the forensic case work if there is no ante mortem comparison sample owing to the maternal inheritance pattern of mtDNA which can be matched with parents or siblings of the deceased. [28]

In highly destructive disasters in the magnitude of the 11th of September 2001 air disaster, where most of the nonmetallic contents including human bodies were converted to homogenous dust DNA becomes the most useful tool for human identification.

Labeling of prosthesis

In many instances, some innovative techniques such as labeled dentures or orthodontic appliances, the unique restorative materials can easily narrow down the search for identity of the deceased.[29] This method of labeling the prostheses or any other appliance

is a noble thought which will be of great help in identification process especially at times of mass disasters.

Dental team

In case of a disaster, a coordinated approach starts with a successful cooperation with dentists in order to obtain the possible antemortem records of the victims. According to Clark[30], this can be achieved through the division of labor into two separate dental teams. The first, mentioned as "home" team, will reside at the coordinating center, having a close relationship with the police. Its aim is to obtain information from the antemortem dental records of those believed missing or involved in the catastrophe[30]. This information builds the basis of the work of the "away" team.

Problems arising [30, 31]

1. In many cases the name of the dentist with the antemortem records of those believed missing or dead is not known by their relatives.

2. The time that elapses before the information that was gained from the antemortem records is transferred to the home team. This may be due to the requirement for processing the data also to the police. It may be also a matter of distance, as many disasters, in particular aircraft disasters, involve foreign citizens.

3. In cases where the victims are foreign citizens, it is difficult to localize the dentists of the victims.

4. In countries where the standard of living is very low, it is very difficult to obtain useful information for the comparison[5].

5. Different charting systems of the dentition can be overwhelmed by a standard charting dental form for the antemortem record. In this manner, a "crown chart" can contribute to a more easier and quick reference system for the comparison of ante- and postmortem records.

Discussion

Planning is crucial for successful identification of victims in mass disasters and a special identification team should be responsible for the work. Identification (ID) commissions in many countries may consist only of police officers with forensic pathologist and forensic dentist being called upon only when deemed necessary

and sometimes these professionals are not specially trained and have little influence in the final identification [32,33]

The organization of a record system for the dental status of individuals, that will be part of the health system of every country, will contribute to the minimization of the expenses of the policing agencies and to more rapid and accurate identification process[34].

For the most effective identification following mass disaster, identification work must start at the scene of the accident; special equipments including radiographic machines should be available at the scene of accident as the most careful handling of charred bodies may cause the jaws to crumble[35]. The INTERPOL DVI (Disaster Victim Identification) form was designed by experts from various countries and recommended by INTERPOL for international use as it allows for uniformity and standardization of records following mass disaster. The yellow form is for transcribing information from ante-mortem records while the pink form is for post-mortem record. To minimize errors, transcription of ante-mortem dental information should be done independently by two forensic dentists so as to double check for discrepancy.

The success rate of dental identification will vary considerably depending on the nature of the accident, the degree of dental injury, the incidence of dental treatment and the availability of adequate dental records which is a function of the nationality and country of residence of victims[36].

Conclusion and Recommendations

Dental examination is a powerful tool in the identification of deceased. The key to successful mass disaster identification is planning and preparedness.

All emergency management agencies should have forensic dentists incorporated in the emergency response team. Professionals in the team should be exposed to state of the art equipments such as computer based ID programmer and laboratory analyzer for speedy visual and electronic comparison by regular training and mock disaster scenarios for emergency preparation. Routine dental check up with appropriate radiography should come under primary care service in all countries, this will afford reasonable generation of broad based national ante mortem dental records for comparison at mass disaster instances, This routine check up by legislation should be included in the admission criteria into primary, secondary and tertiary institutions and also serve as a prerequisite for employment worldwide.

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