

Forensic odontology, part 2.

Major disasters

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VERIFIABLE CPD PAPER

IN BRIEF

- Gives an outline of the role of the forensic odontologist in mass fatality incidents.
- Highlights the importance of planning for the disaster response.
- Stresses the importance of accurate, available dental records to assist with the identification of human remains.
- Emphasises the importance of teamwork and cooperation.

GENERAL

We have only to look back over the last 12 months to realise that time and time again, an incident occurs where there are mass fatalities. These incidents have instant and long-lasting impact on families, communities and sometimes whole countries. The aim of this paper is to emphasise the need for an efficient and sensitive response to assist in the identification of victims of such incidents and the necessity for trained team responses. Many countries now have Disaster Victim Identification (DVI) teams that are multi-disciplinary, and plans and protocols in place in readiness. The paper can only hope to give a brief overview of the disaster situation for the reader: whole books have been written on this topic. The forensic odontologist has a major role in disaster incidents when there are accurate and available antemortem dental records.

INTRODUCTION

A major disaster (also termed major incident, mass disaster) may be defined as any event that occurs with little or no warning causing death or injury, damage to property or the environment and disruption of the community, and the effects of which are of such a scale that they cannot readily be dealt with by local services and authorities as part of their everyday activities.¹ Extra assistance is needed to manage the incident and its aftermath, and deal with the injured and deceased. The catastrophic and lasting impact of the attacks of 9/11 in New York in 2001 and the 2004 Boxing Day Asian Tsunami (Fig. 1), for example, has led to the rethinking and updating of disaster planning and strategies across the world in order to cope with such an event in the future.

Disasters are a common and recurrent worldwide feature throughout history, and whether man-made or natural, accidental or deliberate, cause loss of life and devastation.

Old and recent disasters: a few examples

- AD 64: the great Fire of Rome brought death and destruction to the city
- 1,600 passengers and crew lost their lives in the freezing Atlantic waters when the superliner 'Titanic' sank after hitting an ice floe in April 1912
- Aberfan village, South Wales, UK, 1966: mine waste poured down a mountain, engulfing a school and surrounding houses and killing 144, most of whom were children
- 11 September 2001: hijackers intentionally crashed two airliners into the Twin Towers of the World Trade Centre in New York, another airliner crashed into the Pentagon and a fourth crashed in Pennsylvania – killing nearly 3,000 (most of whom were civilians), including nationals from over 90 different countries
- Asian Tsunami, Boxing Day 2004: approximately 250,000 lost their lives, including nationals from over 35 countries
- Bombings in London and Sharm el Sheikh in 2005 caused further loss of life and shattered communities
- Hurricane Katrina in Louisiana and Mississippi, August 29 2005: loss of over 900 lives
- Earthquakes in China and Italy hit the news in 2008-9



Fig. 1 Devastation at Khao Lak (a tourist resort in Thailand) following the Boxing Day tsunami

- February 2009: bushfires raged through the state of Victoria, Australia, claiming almost 200 lives
- 1 June, 2009: Air France flight 447 crashed into the Atlantic Ocean killing all on board
- Tongan ferry disaster, August 2009
- 2009-2010: major earthquakes in Haiti, Chile and Samoa, plane crashes in Libya and India, terrorist attacks... and the list is ongoing.

Not only is there loss of life, but often also catastrophic damage and loss of property, livelihoods, land, and infrastructure to cities, towns or small communities. The aftermath may last for weeks, months or years. The effects of mass casualties on healthcare services may also be overwhelming, prolonged and costly. Arrangements need to be in place for the

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support (short- and long-term) of survivors, relatives of the deceased and even personnel involved in the recovery and identification process, if necessary.

Today, worldwide travel is common, spreading different nationalities across the globe, and when disaster strikes there will be international complications and difficulties with identification of the deceased. Different countries have different jurisdictions, beliefs and cultures and each situation must be handled with sensitivity.

An historical dental identification incident

Over 100 years ago in Paris, the Bazar de la Charite fire was the scene of a disaster that is recognised for using dentistry to identify the deceased. On May 4 1897, a charity sale was organised involving many of the aristocratic families of France. It was held in a wooden building with stalls and a glass roof, all decorated with curtains, ribbon and chiffon. Over 1,000 visitors attended the sale and there was the added attraction of a cinematography show – it is thought that this machinery was the cause of the fire. In 15 minutes the entire structure was reduced to ashes, leaving over 100 people dead, with more to die later from their injuries.

The bodies were very badly burned and so identification was difficult and unreliable. It was decided to consult with the victims' dentists to assist with the identification process. Among the dead was the Duchess of Alençon (sister of the Empress of Austria). Her dentist was able to identify her from his records that covered 17 consultations and treatments over several years, the most recent visit being less than six months before the fire.

Some of the other identifications were based upon a removable partial prosthesis made of gold with two porcelain teeth, a gold partial prosthesis with four teeth (three of which were natural!) and the discovery of a recently performed unusual tooth extraction. It is interesting to note that most of the victims were women, which at the time led to speculation about the chivalry of the men!

GENERAL DISASTER RESPONSE

Disasters may be closed (known information or a potential list of those involved), open (little or no idea at first who may be

involved), and mixed (a combination of open and closed). The recovery, identification and repatriation process evolves to address each challenging situation. Like many other countries, UK Disaster Victim Identification (DVI) is operated on several levels, National/International, Regional and Local.

In a major disaster, it is important to have a rapid and effective response with the organisation of an appropriately skilled, multidisciplinary and trained DVI team, ready to deploy wherever and whenever necessary, following an initial assessment of the situation. The first priority must be to make the area safe and rescue any survivors. Emergency services and hospitals also need comprehensive plans in place to deal with such situations. There is much to be learned and acted upon from each incident (especially any mistakes), which may assist in improving responses and future prevention. Despite the best made plans, each incident is always a huge challenge requiring coordination, flexibility and dedication. Disasters necessitate continual reorganisation and reviewing of the situation, the teams and the response; no two disasters will be exactly alike. Imagine the scene on Boxing Day 2004 after the devastating earthquake and tsunami, or the earthquake in Haiti on January 12 2010: so much death and destruction, who to contact and how to restore order from the chaos?

When any survivors have been removed from the site, attention can be focused on recovery and identification of the deceased. When possible, an examination of the deceased is conducted for any or all of the following purposes:²

- To legally confirm death
- To estimate time of death
- Identification
- Documentation of injuries and natural disease if present
- To establish cause and nature of death
- To obtain forensic, scientific, or other evidence when criminal involvement is suspected
- To collect evidence which may be needed for the coroner's inquest, civil or criminal investigations or various inquiry boards – national or international.

Identification is part of the disaster management procedure, but there are

many other considerations following the initial assessment and coordination of the response.

General disaster management considerations

- Security and safety of the disaster areas
- Recovery of bodies, body parts and belongings
- Transportation and storage of the remains
- Temporary mortuaries to include computer networks, communications, water supply, examination tables, radiography equipment, protective clothing, containers, cafeterias, toilets, etc
- Appropriate staff for the collection of antemortem information, identification process, body release and repatriation procedures: pathologists, dentists, fingerprint and DNA experts, police, embalmers, IT specialists and the list goes on
- Teams of liaison personnel trained to deal with distraught relatives and friends of the deceased. Remember that grief and confusion for family/friends will continue long after the disaster is over and some will need long-term help
- Personnel trained to communicate with the media
- Quality assurance.

The forensic odontologist is a valuable team member in multiple fatality identification when there are dental structures for examination. However, impacts at speed, explosions, fires and commingling of remains all present a significant challenge to identification.

At the incident site, human remains should ideally be labelled (postmortem identification number or barcode) and photographed *in situ* (unless it is too dangerous). If practical, the site is organised into a grid system to establish fixed reference points which may prove helpful to investigations and link remains with personal effects. If the remains are not intact, the area may need to be carefully searched for dental (or other) fragments and the inclusion of the forensic odontologist in these searches should always be considered.

Continuity of the chain of evidence is essential. The identification number or



Fig. 2 Temporary mortuary established in a temple and used in the early stages of the tsunami response in Thailand. Refrigeration trucks on the right



Fig. 3 Disused fire station at an old airport used as temporary mortuary in Moroni, Comoros Islands (with permission of Blake Emergency Services)

barcode allocated to each victim is the means by which all information can be coordinated for that particular person, including all related personal effects, all postmortem findings and any specimens taken. It is important to include the label in photographs and confirm it at all stages to avoid mistakes. In an ideal world one person (for example, a police officer or nurse) would be allocated to accompany each body through all the stages and ensure continuity and appropriate documentation. However, this is not always practical when there are large numbers of fatalities. All documentation, photographs, radiographs and specimens must have a proper chain of custody as part of the quality assurance sequence and because legal actions may occur some months after the event.

Communication and sharing of information with regular team updates (within and between the different forensic disciplines involved in the identification process) is a necessity if lengthy and unnecessary delay, duplication (and frustration!) is to be avoided. Good working relationships and agreements on protocols make a difficult task easier and more comfortable



Fig. 4 Filling in the pink postmortem dental forms



Fig. 5 Remains showing ceramic bridge unit and canine lost postmortem. Pink discoloration to teeth is caused by blood breakdown products permeating the dental tubules

for all concerned. Overlapping departing team members with new arrivals helps to maintain continuity as rotas change. Many odontologists have busy practices at home, or other commitments, and spending more than a couple of weeks away causes disruption to work, financial, and home life.

THE TEMPORARY MORTUARY

A temporary mortuary needs to be established rapidly with good access and tight security. When there is a large number of injured persons and fatalities, local hospitals and mortuaries may become overwhelmed and congested and it may be necessary to site the temporary mortuary some distance away. A pre-existing structure (airport hangar or warehouse) may be converted, but there are now companies that can erect temporary facilities rapidly to include running water, electricity, communications, information technology, storage, toilets etc. Protective clothing and appropriate equipment also needs to be provided and health and safety matters must also be taken into consideration wherever and whenever possible. Refrigeration trucks are commonly used for transportation and storage of the remains.

Mortuary stations ideally include some or all of the following:

- Receiving and checking area
- Photography
- Personal effects
- Fingerprinting
- Medical/pathology
- Specimen collection, DNA for later analysis. Typical DNA samples for DVI or missing person investigation may include deep muscle tissue, bone, teeth, hair, nails, vitreous fluid
- Radiology (CT scans if possible)
- Dental examination
- Quality assurance.

It may be difficult in the initial stages, or in remote locations, to provide adequate facilities and compromise and innovation may be necessary! The initial temporary mortuary in Thailand following the Boxing Day tsunami was a temple rapidly converted and less than ideal (Fig. 2). Within a couple of weeks, a Norwegian company had erected a complete temporary facility in Phuket, including three mortuaries with air conditioning, toilets, offices, storage and an eating area. Air conditioned offices to act as a central information management base were provided locally. After the aeroplane crash in the Comoros Islands (June 2009), a derelict fire station at a disused airfield was converted into a basic but adequate facility (Fig. 3)

DENTAL WORK

Dental teams will usually be involved with AM (antemortem) and PM (postmortem) dental information collection, input, interpretation, clarification and comparisons. While remains are being recovered, general and dental antemortem information will be collected. Family members are contacted, usually by police, for information on the whereabouts of any dental records. Antemortem dental teams can then begin to decipher the records, wrestling with terminology, handwriting, abbreviations and various world charting systems, so that the most up to date dental status, at the time of death, is known. The AM team may be based in their home area/country with information relayed electronically to the incident site, or at the incident site. The findings are recorded in a suitable format for comparison with the dental postmortem examination findings. In the disaster

situation, Interpol forms are commonly used for the AM and PM information collection (Fig. 4). The FDI system of charting is used, with various symbols and colour-coding representing the dental status of the individual, and there are boxes for further information relating to crowns, veneers, bridges (Fig. 5), occlusion, implants (Fig. 6), prosthetic appliances (Fig. 7), periodontal condition or any unusual features. Agreement on international and standardised systems, protocols, terminology and forms is needed in dentistry (and for the whole multiple fatality response).

The remains are examined by two forensic dentists to document and confirm the findings. Photographs and full mouth radiographs are usually taken. Resection of the jaws for improved access, or for further investigation, is performed only when necessary and following policy discussion: sensitivity is needed for different national, cultural and ethical issues. Dental structures removed must be labelled, photographed and returned to the body. If the deceased is suitable for viewing, care should be taken that any dissection does not damage the features. As mentioned in Article 1 of this series,³ permission from the appropriate authorities must be obtained for the removal of any body tissue.

During the dental comparison process minor discrepancies are commonly found between the AM and PM findings. These discrepancies can be accepted as long as they are explainable. If there are good quality antemortem radiographs available, errors of charting within the dental record may be discovered and explained. Radiographs (digital or film) enable various anatomical, restorative and dimensional comparisons to be made, greatly assisting the identification process. Careful consideration should be given to each case before an identification conclusion is reached: mistakes lead to further distress for devastated relatives of the deceased.

Information provided by the dental teams performing the postmortem examinations may contribute to the overall incident investigation, for example are there fracture patterns of the teeth or jaws that would suggest a particular type or direction of injury?

PROGRESS

To assist with the identification of large

numbers of fatalities, computerised dental matching software is constantly being developed and updated. This software is a database and after information input, can produce a list of the most likely matches between the AM and PM information. It allows for the import and export of files which is invaluable when working overseas. The accuracy of the AM and PM dental input relies upon the interpretation and skills of dental personnel; mistakes are easily made, hence the need for quality assurance. Final decisions are made by team members and not the computer. PlassData (now renamed Disaster Victim International System) was used in the Asian tsunami with glitches ironed out by skilled computer personnel as the identification process continued, and it continues to be improved and updated. Other systems are also available, for example Win ID is currently used in the USA. Team members need to be trained in the use of such systems, preferably before being deployed. Agreement on standardised dental forms and terminology is currently being worked upon by a steering group of Interpol, comprising international forensic dentists.

Results of a study of simple *versus* detailed programmes have been evaluated and it appears that simple systems (with basic coding, for example a tooth is restored or not, instead of which surfaces and material type), work effectively when numbers of fatalities are relatively low and remains are not fragmented. Detailed systems give better discrimination with larger numbers of fatalities and when remains are fragmented.

The new portable, hand-held, lightweight (approximately 2.6 kg), mains or battery-powered X-ray machines (Fig. 8) such as the Nomad, have proved to be of great value in the disaster situation. These machines can be linked to digital sensors (and used with conventional X-ray film) and are very tolerant of handshake when numerous views are taken during the session. As with all radiographic procedures, guidelines for the safety of the operator and colleagues must be followed.

In the aftermath of Hurricane Katrina, implantable RFID (radio frequency identification) technology with handheld readers, digital cameras that can receive both RFID scanned data and GPS data wirelessly, proved useful for tracking, gathering and storing information from the



Fig. 6 Implants still in place, despite decomposition due to high temperatures, immersion in water and the passage of time (with permission from Centre for International Forensic Assistance (CIFA))



Fig. 7 Prosthesis in lower arch. The dentist and dental technician may hold valuable information concerning this person, leading to early identification



Fig. 8 Hand-held portable X-ray machine



Fig. 9 Communities destroyed in the bushfire – Australia 2009

victims and incident site. A web-enabled database stores all information received. Other similar systems are being developed.

Dental superimposition may be a useful adjunct to identification if there are antemortem 'smiling' photographs available

showing teeth. Facial reconstruction may also be a possibility.

New and scientifically tested technologies that assist with recovery and identification of human remains help to make the work more reliable and effective, giving greater assistance to the disaster teams, investigations, and ultimately the relatives during this dreadful time.

FORMALISING IDENTIFICATION

All completed cases will be put before an identification commission (usually a coroner, police, and those making contributions, for example forensic odontologists, anthropologists, fingerprint personnel). Once identification has been confirmed the body can be released. The identification process may take considerable time because of fragmented, burned or commingled remains, difficulty in tracking down antemortem information, or waiting for DNA results: all delays are distressing for relatives, but there must be no mistakes in the final identification conclusion. Information constantly needs updating and documentation must be accurate: this all creates further delays for families waiting for news. Keeping relatives informed about the process and maintaining good, empathic communication is essential to help them understand these difficulties.

Aeroplane down

On August 27 2006, Comair flight 191 (Delta connection flight 5191), a CRJ-100 regional jet flying from Kentucky to Atlanta, crashed killing 49 of the 50 passengers and crew: the co-pilot was badly injured, but survived. The plane took off from the wrong runway, one that was too short, unlit in the early morning, and not intended for commercial use. The plane crashed through a perimeter fence, hit an embankment and trees and caught fire. Forty-seven of the deceased were identified by dental methods (without computer aid) within a few days. In this particular incident there were several factors that contributed to the speedy and effective identifications:⁴ it was a closed disaster (a list was available of those on board), there was effective planning and good communication between teams, relatively low numbers of fatalities, bodies were mostly intact (although some were charred), there was no commingling, most victims had

dental treatment and available antemortem dental records, it was not an international flight and the passengers were mostly local American citizens, and finally there were good facilities and equipment (Medical Examiner's facility).

A similar incident occurred in October 2000, when the crew of a Singapore Airlines flight mistakenly used a closed runway for departure in Tapei. The Boeing 747-400 collided with construction equipment during takeoff, and resulted in the deaths of 83 of the 179 passengers and crew on board.

What makes one crash survivable and another not? Some factors to consider include the type and location of incident (in flight, into a city or near an airport, bombs, etc), the speed of the emergency response, adequacy of medical facilities and proximity of hospitals with appropriate emergency plans, site access, and whether there is post-crash fire.

Black Saturday

The Australian bushfires that swept across the state of Victoria on and around February 7 2009 claimed 173 lives. Saturday 7 February was possibly one of the worst days, now referred to as Black Saturday. In an area known for its bushfires, this was Australia's highest ever bushfire loss of life. It is estimated that over 400 people were injured, with over 2,000 homes destroyed, leaving thousands homeless and relying on temporary accommodation. Many towns, farmland, and National Parks/Forest Reserves north-east of Melbourne have been damaged or almost completely destroyed (Fig. 9). Recovered remains were brought to the Victorian Institute of Forensic Medicine for careful examination, documentation and identification by teams of pathologists, anthropologists, forensic dentists, police and other specialists. Dentistry played a key role in the identifications, although complicated by commingling of remains and incineration. The bushfires will be covered in more detail in Article 3 in this series.

WOULD YOU BE PREPARED?

In the event of disaster in your area, would your family be prepared? Could you increase the chance of survival for your family? I spend part of the year in

New Zealand, a country that is particularly vulnerable to natural disasters such as the 1886 Tarawera volcanic eruption, 1931 Napier earthquake, 1968 storm that sank the 'Wahine' ferry, and more recently the 22 February 2011 earthquake in Christchurch (currently under 200 lives lost). In New Zealand, the Government and local authorities have taken steps to educate the public to take more responsibility to ensure that their family is prepared and has emergency kits and plans. The website www.getthru.govt.nz is an excellent point of reference for New Zealanders (or anyone else) and gives tips on emergency preparation.

LESSONS LEARNED FROM DISASTERS

Each incident has its own unique problems and complications that can provide valuable information for future benefit:

- Need for well developed plans before the event with a rapid and effective assessment and response at all levels Keep plans as simple as possible to avoid confusion
- Standardised and universal procedures and techniques
- Clear instructions with good coordination and regular updates for teams (and between teams)
- Importance of continuity of evidence and thorough documentation
- Good communication is essential, with sharing of information
- Appropriate training for teams (and shared between the different disciplines involved) to give better understanding of working together and what each section does and needs
- Not all antemortem dental records are adequate for identification purposes
- Standardised dental charting and terminology, so that international colleagues can work easily together
- Good team spirit: essential when working closely together over many weeks or months.

After each rotation to assist with the Asian tsunami identifications in Phuket (four in total), on the last day, I would sit quietly on the beach outside my hotel and reflect on the events of Boxing Day 2004. How could this lovely, calm ocean turn so savage and cause so much devastation, claiming so many lives of busy

residents and relaxed vacationers? Team members are not immune to the emotional aspect of this work: it is not for everyone, and each incident has poignant moments. Debriefing follows the incident and counselling is made available.

CONCLUSION

Sudden and unexpected incidents will continue to happen and disaster plans with specialised teams must be ready to restore order from the chaos, working as effectively and sensitively as possible, often under the scrutiny of grieving relatives, media and potential criminal investigations. Each time I assist with a disaster I often feel overwhelmed until I have got a 'feel' for the situation and have adapted:

there is always a new experience and lessons to be learned. When the work is going well and there is true cooperation between team members, the work is satisfying with a feeling of being useful in some small way. The end of hope for relatives is devastating, but perhaps the grieving process can begin, knowing that their loved one has been found, identified, and returned to them.

For positive identifications, the different forensic disciplines must work together, follow identification protocols, communicate and share information, and ensure that all their activities are carefully undertaken and quality assured. Dentistry has a major role in mass disaster identification. Once again, it is the responsibility of all members of the dental team to ensure that

patient records are accurate, comprehensive and available, should it become necessary to dentally identify a patient of yours (always check with your dental protection/defence agency if in doubt about handing over records). Your contribution may help a family find their missing relative.

My thoughts are with Japan following the earthquake and tsunami - Dr J Hinchliffe

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