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Review Article

Forensic Dentistry in Disaster Victim Identification

Juan Manuel Vázquez Villa [1*], Pedro Arcos González [1], Rafael Castro Delgado[1]

[1]*Unit for Research in Emergency and Disaster, Faculty of Medicine and Heath Sciences, University of Oviedo.*

**Corresponding author: Dr. Juan Manuel Vázquez Villa, Unit for Research in Emergency and Disaster, Faculty of Medicine and Heath Sciences, University of Oviedo, Campus del Cristo, E-33006 Oviedo, Spain, Tel: +34 648 28 27 06; Email: jmvv_88@hotmail.com*

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Abstract

This review summarizes the main aspects of forensic dentistry and its contribution to the identification of disaster victims. In order to do this, ten disasters which have occurred over the last forty years have been studied in which forensic dentistry was used as a method of identification.

A bibliographic revision has been carried out on the application of forensic dentistry techniques in disasters. In order to achieve this, Pub Med and Scopus databases have been used as information sources.

Keywords: Forensic dentistry; disasters; disaster victim identification

Introduction

Victim identification in the aftermath of a disaster is a fundamental process for a number of medical and legal reasons. And it is also of utmost importance to reveal the identity of the human remains found, so they can be returned to their families and they can start the grieving process [1].

Because millions of people move from place to place every day, it is increasingly likely that when a disaster occurs the people involved will be from different countries, which makes it essential to use the best identification techniques available.

To improve the identification process, INTERPOL published its first Disaster Victim Identification Guide in 1984. The objective of this guide was to increase effectiveness and efficiency in disaster management, particularly in identification processes. It offers recommendations on the procedures to follow, with special consideration given to preparation, prior intervention and personal experience [2].

In order to be able to transcribe all the information gathered during the investigation process into a single format, INTERPOL has designed forms to collect all the data in a more practical and structured way. These forms are published in all official INTERPOL languages: Arabic, Spanish, English and French. An international colour code is also being adopted: yellow for the AM (ante-mortem) forms, and pink for the PM (post-mortem) forms [2].

The techniques used for identification in disasters must offer high degree reliability [3]. Therefore, the primary identification methods recognised by INTERPOL are: fingerprint study, DNA analysis and forensic dentistry.

Fingerprints are unique for each person. They do not change during a person's lifetime or after their death. They

can be obtained directly from the body itself or through any of the victim's personal objects left behind [2]. During the identification process after the Madrid bombings on the 11th of March 2004, the comparative analysis of fingerprints contributed to the identification of 145 out of 191 victims (76%). It was possible to take fingerprints directly from the bodies, as most of them had not been severely damaged. The identification process was also facilitated by the fact that all Spanish citizens have their right hand index fingerprint (which is taken when issuing the compulsory national ID card) on file at the Spanish National Police records [4].

DNA profile analysis is one of the most accurate methods of identification, as a lot of information can be gathered by a relatively small sample [5]. One good source of DNA can often be the victim's teeth. Primary teeth can be a good alternative in order to obtain a biological sample for comparison, as most cultures preserve teeth once they have fallen out; also the dentin-pulp complex is protected by the hard structures of the tooth. Good results can often be obtained if the teeth have been stored for less than 18 years [6].

There are also other methods of secondary identification, such as photographs, personal objects, or visual identification. They can all contribute to verifying the match made by the other methods, but they are insufficient for establishing definitive identification on their own.

Body identification by a relative can be an extremely traumatic experience due to the fact that the bodies in these situations often have numerous injuries and trauma that make them difficult to identify. Therefore, this option should be discarded, and every effort should be made to use primary methods of identification instead [2].

Forensic Dentistry

The application of Dentistry in human body identification has been used for more than 2000 years ago, and dates back to the time of Nero's Empire. However, it has not been a generally recognised scientific technique until the last couple of centuries [7].

The origin of forensic dentistry in disaster victim identification dates back to 1897, after a fire at the Paris Charity Bazaar (an annual event where women from high society sold products in order to raise money for people in need) occurred. A total of 126 people died in the fire, and most of the bodies were burnt beyond recognition. At that moment, the Paraguayan Consul decided to call in the best Parisian dentists in order to help with the identification process. Many of the dental identification cases involved in this disaster were recorded by Dr. Oscar Amoedo in his 1898 Doctoral Thesis titled *"L'Art dentaire in Médecine Légale"*. He is now considered to be the father of forensic dentistry, as his thesis was the first and most complete work on this discipline until then [8].

Teeth are the most durable and resistant tissue in the human body. Their high level of calcification allows them to resist extreme weather situations or even decomposition. Therefore, they are one of the most important methods to identify bodies that have been severely damaged [9].

Cheekbones, lips and tongue are a protective barrier against high temperature during the first few moments of fire exposure. When the temperature has risen considerably, these tissues are destroyed, exposing the front teeth. These teeth will be generally more damaged than the back teeth [10].

When bodies are burnt beyond recognition, decomposed, or dismembered, forensic dentistry is the main identification method used [11].There are two methods of forensic dentistry investigation:

- First, there is the *comparative dental record identification*. It is used to establish with a high degree of certainty that the human remains, together with the ante-mortem data collected from the missing person, correspond to the same individual. Its success depends first on the existence of sufficient and good quality ante-mortem data; and second on retrieving enough information from the dental record exploration found at the scene [12]. After registry comparison, the findings are classified as a *positive identification*, *possible identification*, or *insufficient evidence* or *excluded identity [5].*
- The second type of forensic dentistry investigation is the *dental profile* that is carried out when there is no ante-mortem dentistry records to compare with, and no other method of identification is available. The study of the victim's teeth provides information about age, sex, race, socio-economic status and even their eating habits, profession or any illnesses that they may have suffered [5].

Material and Methods

The present essay consists of a small review of ten different disasters which have occurred in the last forty years, but a larger sample of disasters would probably be necessary in order to make it more representative.

A bibliography search was carried out using Pub Med and Scopus databases. Terms such as "forensic dentistry", "disasters" and "disaster victim identification" were used in the search.

The publication dates of the articles were limited to the years between 1990 and 2014, in order to increase the probability of finding disasters which happened at different times, with

the objective of finding the possible differences in the methods used in the identification process.

The selected articles all make reference to forensic dentistry as being one of the principal methods of identification.

Results

Pub Med:

- 311 articles were found under the selected key words
- 32 articles were selected for their titles, which were related to forensic dentistry and/or disasters
- Abstracts of these 32 articles were read, and 21 were selected provisionally
- Finally, 14 of those 21 articles were selected definitively.

Scopus:

- 416 articles were found in Scopus under the selected key words
- 30 articles were selected for their titles, which were related to forensic dentistry and/or disasters
- Abstracts of these 30 articles were read, and 20 were selected provisionally
- Finally, 14 of these 21 articles were selected definitively
- 10 of these 14 articles were also found in the search on the Pub Med database; therefore, 4 new articles were chosen.

A total of 18 articles were selected from the two databases.

A revision of the bibliographic references in the selected articles was carried in order to get additional information. Thanks to this, 5 more articles were added to the bibliographic references.

All in all, 23 articles have been used in the writing of this essay.

Forensic Dentistry and Disasters

This is a selection of 10 natural, technological and human caused disasters. Each of which took place in different parts of the world, at different periods of time; in order to demonstrate, in each case, how forensic dentistry has contributed to the task of victim identification.

- **Los Rodeos Air crash (Tenerife, Spain):** [12].

It is considered to be one of the most serious accidents in aviation history. Two 747 airplanes (Pan American flight 1736 and KLM flight 4085 crashed into each other, resulting in 583 fatalities.

A total of 326 victims of Pan Am flight were returned to the USA. Of the victims returned, 212 were identified as Pan Am passengers; 4 as KLM passengers and 110 were not identified.

187 of the 212 victims (88%) were identified either by the use forensic dentistry alone or in combination with other methods.

- **Arrow Airways Flight 950 Accident (Canada):** [13].

In this accident 248 American Army soldiers and 8 aircrew members died. Dental and medical records were travelling on board as well, and most of them were destroyed.

Despite poor weather conditions, all of the bodies were recovered, and identified. Forensic dentistry contributed to the positive identification of 180 of the 256 victims (70%).

- **Lockerbie Air Disaster (Scotland):** [14].

It is one of the worst terrorist attacks to have occurred in Europe. The explosion of Pan Am Flight 103 caused the deaths of a total of 270 people between the passengers and the inhabitants of town of Lockerbie, where most of the subsequent plane wreckage had fallen.

A total of 253 of the victims were ultimately identified. Of these, 209 (82%) were identified with forensic dentistry combined with other methods; despite the lack of consistency in dental records.

- **USS Iowa Disaster (Puerto Rico):** [15].

The explosion of USS Iowa battleship during training manoeuvres caused the death of 47 people. Their bodies suffered severe damage due to both burns and fragmentation.

All of the victims were identified. In the identification of 45 of the 47 victims (96%), the main method used was dental identification, with the aid of fingerprinting in some cases too.

- **"Scandinavian Star" Ferry Disaster (Norway):** [16].

On April 7th 1990, an arsonist set a fire on board of the

ferry "Scandinavian Star Ferry", travelling from Norway to Denmark. 158 of the 494 passengers who were travelling on board were killed.

Most of the bodies were burnt beyond recognition, and others were severely damaged, as a result of the blaze.

All of the victims were identified. A total of 107 of the victims were identified with the aid of forensic dentistry (68%). One of the reasons for this low amount was due to the fact that a number of the victims were young and had never had any dental treatments done.

- **"M/S Estonia" Ferry Disaster (Finland):** [17].

The M/S Estonia cruise ship, on route to Sweden via Estonia sank on the 27th September 1994. Only 138 of the 989 passengers from 17 nationalities were rescued alive, and one of them died later in hospital.

Only 94 of 852 victims were eventually recovered.

All of the bodies that were recovered were identified. Forensic dentistry contributed in the identification of 57 of the 94 victims (60%).

It should be noted that 97% of the Swedish victims had full dental records, compared to only 27% of the Estonian victims.

- **Bus accident in Bailén (Jaén, Spain):** [18].

A car collided with a bus causing both vehicles to catch fire. The resulting fire caused the deaths of 28 of the passengers on the bus. All of the bodies were severely burned.

60% of the passengers were under 20 years of age, and therefore had very few dental treatments.

Despite this, 16 of the 28 victims were identified with the aid of forensic dentistry; but not only by matching dental treatments. The evaluation of dental age and oral pathology findings proved very important as well.

- **Bus accident in Illescas (Toledo, Spain):** [19].

A tourist coach with 12 Japanese citizens was travelling to Toledo, when it crashed into a station wagon. The collision caused a fire which resulted in the deaths of 8 of the 12 tourists and both of the Spanish drivers. The bodies were completely burnt beyond recognition.

Fingerprints were taken of the two Spanish victims.

8 of the remaining 10 victims (80%) were identified by dentistry. The ante-mortem dental records of the Japanese citizens were excellent, which was essential during the identification process.

- **Indian Ocean Tsunami (Thailand):**

On the 26th of December 2004, an underwater earthquake in Banda Aceh (Sumatra), measuring a 9.0 magnitude on the Richter scale, resulted in a tsunami which caused the deaths of over 200.000 people in 12 countries around the Indian Ocean. In Thailand, mostly of victims were foreign tourists [20].

Initially, international teams were in charge of the identification of the bodies of the tourists. Thai teams were put in charge of identifying the locals [21].

The ante-mortem records obtained of the foreign population (dental history, radiographies) were mostly of very high quality. However, there were very few dental records of the Thai population [22].

Depending on the source cited the rate of dental identification ranges from 54 to 67%.

- **Christchurch Earthquake (New Zealand):** [23].

A 6.3 earthquake on the Richter scale in the region of Christchurch caused the deaths of 181 people from 22 different nationalities.

The rescue work was complicated by the danger of aftershocks and risk of building collapses.

A total of 177 victims were eventually identified. Of the remains that were in good condition: 43% of the identifications were made based on fingerprints, and 33% with the aid of odontology.

Discussion

Forensic Dentistry played an essential role in the identification of victims in all these aforementioned disasters. The identification rates obtained oscillate from 33% to 96%.

In disasters where the bodies are in good condition, with no external damage, such as the New Zealand earthquake, fingerprint registry is a feasible and efficient way to carry out the identification process. A minimal amount of equipment is needed to obtain the results and the work can be done very quickly.

On the other hand, it must be taken into account that in some countries, such as the United Kingdom, there is no official fingerprint registry of all citizens, which can make the process

more difficult. Fingerprints taken from personal objects belonging to the victim is another way to obtain results in certain cases.

However, in disasters where the bodies have suffered severe damage due to high burning temperatures, or if they are fragmented, or are in the process of decomposition, the soft tissue can be damaged which makes it nearly impossible to take fingerprints. In these cases, DNA tests or forensic dentistry are the best available options.

DNA testing has proven to be very accurate testing method in identification process. Moreover, results can be obtained from a very small sample, as long as it is well preserved. However, the cost of processing each sample is quite high, and it takes several days to obtain the results. Investigation teams use this method only when it is not possible to obtain a positive identification by other means.

Forensic dentistry has proven highly effective in body identification, seeing as how it is both easier and less expensive to carry out than other available methods.

Dental structures are very resistant. In most of the cases mentioned above, the bodies were exposed to very high temperatures; some of them were even burnt beyond recognition. However, their teeth survived those extreme conditions, and, in some cases, teeth were the only remains that survived for the investigators to work with.

Information regarding existing treatments can be also a valuable source of information as to any shape or size anomalies, gaps, etc. Teeth are not unique and invariable like the fingerprints or DNA, but with so many possible variations, they can often create very unique combinations.

Regarding this, one of the limitations that investigators find during identification work, is that the amount of dental treatments, particularly in younger people, is quite low. Due to better dental healthcare and prevention techniques this is likely to continue in the future.

In such cases, different methods must be used in order to find the necessary information. These can include the stage of dental eruption, or the degree of radicular development, both of which are good indicators of the victim's age. In these cases, ante-mortem records (dental history and radiographies) are essential, but they are not always available.

The main limitation found in most of the aforementioned disasters was the lack of good quality ante-mortem records, which hampered the identification process.

Therefore, it would advisable to establish a common standardized framework of the procedures for dental professionals to follow when establishing a basic dental profile of a patient. In some of the disasters studied, there were inconsistencies in the dental treatment nomenclature, even among dental records from the same dental professional. In other cases, the records contained an insufficient amount of information in order to find out if they had been treated or not. It is for that reason that identification teams have repeatedly asked for changes to the laws, in order to improve both the quality and consistency of medical records.

Over time, another major advance in the field has been the creation of computer programs that can compare ante-mortem and post-mortem records. Examples of these programs include CAPMI, which was used during the investigation of the air accident in Tenerife (Spain); and Plassdata, used during the identification process after the Tsunami in Thailand as well as the New Zealand earthquake.

It is vital that strict quality control standards must be outlined and followed in all investigations. In order to achieve this, teams of professionals with different degrees of experience should be created. This would help to minimise the errors in the process, and would also allow professionals the opportunity to learn from each other.

Conclusions

Forensic Dentistry has proven to be very useful in cases in which human remains have been burnt beyond recognition, fragmented or decomposed, due to the unique characteristics of the dental structure.

The success of dental identification varies depending on the type of disaster, the condition of the remains, the country of residence of the victims, and the quality of dental records, among other factors.

In conclusion, it must be mentioned that all these procedures ultimately work toward a common objective: the identification of all disaster victims, so that their remains can be returned to their families.

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