

## Applications of Forensic Dentistry: Part-I

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**Abstract:** The purpose of this study is to review and present the aims and the applications of forensic dentistry. Dental science plays a vital role in the detection and solution of crime. Forensic dentistry compares and demonstrates post or ante-mortem dental findings to identify an unknown body. Facial reconstruction is a method used in forensic anthropology to aid in the identification of skeletal remains. Age estimation is a process of particular interest in cases of forensic dentistry. Root dentine translucency of single-rooted teeth is the only parameter giving accurate results for age estimation. Also, a dental practitioner must be able to identify and report to the authorities any kind of child or elder abuse and neglect. Thus, the analysis of bite marks is a major aspect for Forensic dentistry. Terrorism and mass disasters are sad realities of modern life. The Forensic dentist has the obligation to know how to provide immediate health care and how to collect and extract all findings. However, physicians receive minimal training in oral health, dental injury and diseases. This is the reason why they may not detect dental aspects of Forensic dentistry. Therefore, physicians and dentists are encouraged to collaborate so as to increase the prevention, detection and treatment of these conditions.

**Key words:** Forensic dentistry, identification, mass disasters, dental age, demonstrates, collaborate

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### INTRODUCTION

Forensic dentistry or odontology can be defined as the vital branch of dentistry that occludes its basic principles and knowledge in the field of urban and criminal cases and has as purpose the scientific expertise, the detection and solution of crime, widely existing social problems and finally to be a source of information for archeological and anthropological studies. The forensic dentistry relies on the ability to identify, collect, study and compare information from oral and facial structures (Vale, 1986; Bell, 1989; Sweet and di Zinno, 1996). The individualized dental and buccal characteristics after they are examined and they are evaluated duly, they compose identity that leads to recognition and identification. The value of these characteristics is still larger in potential absence of other individual traits consequently energies of perpetrators that aim in the hindrance of identification, or consequently harmful effects of factors (i.e., deformity of person, damage of pulps or fingers, badly burned bodies or skeletonized, advanced decay) (Strom, 1946; Cottone and Standish, 1982; Vale, 1986; Bell, 1989; Dorion, 1990; Barsley, 1993; Andersen *et al.*, 1995; Stimpson and Mertz, 1997; Weedn, 1998; Silver and Souviron, 2009). The purpose of this assignment is to demonstrate all the applications of Forensic dentistry as we know them today. These applications include:

- Identification of unknown decedents by the teeth, jaws and craniofacial bones
- Recognition of victims of mass disasters
- Age estimations of both living and deceased persons including neo-natal remains
- Analysis of bite marks found on victims of attack. Identification of bitemarks in other substances such as wood, leather and food stuffs. Analysis of weapon marks using the principles of bite mark analysis
- Investigation of family violence (marital abuse, children or elder abuse/neglect)
- Contribution in anthropological and archaeological research
- Dental jurisprudence including expert witness testimon

The dentist with special knowledge is the only one who can connect and evaluate all the skeletal/dental discoveries in a meticulously detailed way and with irreproachable scientific documentation that requires legal science in the resolution of problems. There are plenty of local, national and international organizations like. The American Board of Forensic Dentistry (ABFO) or British Association for Forensic Odontology (BAFO) that assist

law enforcement to communities. (Vale, 1986; Barsley, 1993; ABFO, 1994; Sweet *et al.*, 1996; Stimpson and Mertz, 1997; Herschaft *et al.*, 2006).

### HISTORICAL TRENDS

The process of using dental findings for identification has been used for more than 2000 years. The first recorded case was made between 49 and 66 A.D. The case reports Lollia Paulina a rich Roman woman who was associated primarily with Caligula and secondarily with Emperor Nero and was identified after her death through the unique arrangement of her teeth (a discolored anterior tooth or malocclusion served to confirm her identity). Folklore also ascribes the first use of bite mark identification to King William the Conquer, circa 1066 A.D. whose habit it was to secure his mail with sealing wax imprinted with bite. His anterior teeth were malaligned thus allowing verification of authenticity of his documents (Cottone and Standish, 1982).

The first forensic odontologist in the United States was Dr. Paul Revere who identified the extremed body of Dr. Joseph Warren, a revolutionary the British in 1775 through a bridge of silver and ivory that he had constructed 2 years previously. The first identification which was admitted in the U.S court system took place in Boston in 1849. Dr. George Parkman was established through dental evidence. The first case in which a lot of victims died, occurred in Paris. About >100 victims out of 126 were recognized from dental findings. Now a days in significant mass disasters like tsunamis and air destructions, forensic dentists play a vital role in identification (Cottone and Standish, 1982). The first treatise on forensic odontology was written by Dr. Oscar Amoedo in 1898 and was entitled L'Art Dentaire en Medicine Legale. Dr. Oscar is also known as father of Forensic Odontology. In 1946 Welty and Glasgow devised a system in which as many as 500 cards with dental data could be sorted in one minute by a computer. In 1937 in Chantilly, a murder was convicted on the evidence of the bite marks that the victim inflicted during her struggle for life. It was also used on Adolf Hitler and Eva Braun at the end of World War II, the New York City World Trade Center bombing, the Waco Branch Davidien siege and numerous airplane crashes and natural disasters (Cottone and Standish, 1982; Barsley, 1993).

Internationally, there is an obvious growth of interest in this field there are organizations such as the Scandinavian society of Forensic Odontology, the Federation Dentaire International, the Canadian Society of Forensic Sciences, the American society of Forensic Odontology and the American Academy of Forensic

Sciences. The international Journal of Forensic Dentistry and the Forensic Odontology Section of INFORM are important references for members of Forensic team involved in Odontology. At last, the necessity for guidelines in forensics was more than obvious. The American Board of Forensic Odontology (ABFO, 1994) adopted Guidelines for Bite Mark Analysis on February 21, 1984. The committee on Body Identification Guidelines has prepared a similar document for body identification (ABFO, 1994; Herschaft *et al.*, 2006).

### IDENTIFICATION

Historically, the major area that Forensic dentistry is involving in is the identification of deceased individuals. In modern societies before a death certificate can be issued, it is vital and civilized, the dead to be recognized. The majority of unknown bodies are recognized by their facial appearance. Also in other cases with severe damage to the face, fingerprints and palm prints are used for identification. When all prior methods cannot be applied or when the researchers want another way of verification, the identification can be established with dental criteria (Fig. 1) (Harmeling *et al.*, 1968; Clark, 1994;



Fig. 1: Recognition of unknown identity body (photograph before the oral autopsy)

Andersen *et al.*, 1995; Sweet and di Zinno, 1996; Sweet *et al.*, 1996; Stimpson and Mertz, 1997). The identification that is provided from Forensic dentistry is not the most objective compared to modern DNA analysis systems or fingerprints. On the contrary, it can be said that Forensic dentistry provides a quick, inexpensive and specific identification (Schwartz *et al.*, 1991; ABFO, 1994; Sweet and di Zinno, 1996; Pretty and Sweet, 2001; Silver and Souviron, 2009). The permanent teeth develop during the first decades of life, so inflections, disorders and treatments can be recorded in the oral tissues and remain there even for a lifetime. Also, it is widely known that adults have up to 32 teeth with 5 surfaces each which may or not have been filled with restorative materials.

In some cases, implants can be found in the dental arch. The use of radiography and the carefully dental and medical record keeping provides us with a large ante mortem data base (Cottone and Standish, 1982; Stimpson and Mertz, 1997). The most common way of identification is to compare the ante mortem dental findings with the post mortem. Sometimes, when the ante mortem dental records do not exist, it is very difficult for the forensic dentist to complete the identification.

In these particular cases, when the ante mortem dental data are not available, a post-mortem dental diagram which generates the biological profile of the victim is proposed from the forensic doctor (Harmeling *et al.*, 1968; Owsley *et al.*, 1993; Jones, 1998; Silver and Souviron, 2009). The Forensic dentist must be very careful when he/she creates the post mortem dental data. A systematic research of the oral cavity is necessary. All the dental structures and radiographs have to be written down very carefully. Moreover, the American Board of Forensic Odontology (ABFO) has prepared Guidelines for body identification. It is not a necessity for all the diplomates to follow these guidelines and this is not the purpose (ABFO, 1994).

According to ABFO, the collection and preservation of the post mortem dental evidence is under the direction of the coroner/medical examiner and has to follow a specific protocol. The condition of the unknown, identity bodies or skeletal remains plays a vital role in the procedure of extracting and preserving dental findings (ABFO, 1994; Herschaft *et al.*, 2006).

The first step in a dental identification is to collect all the dental evidence which is related with the unknown body. All the uncovered dental evidence must be retrieved and labeled. The Forensic human staff is obligated to prevent any infection and of course to wear sterilized gloves and masks. A careful visual examination of the entire body usually could provide us with information about the gender, race, species and

approximate age of the victim. The photograph documentation provides objective data. The photographs are taken intraorally and extraorally after appropriate cleansing. For full access to the dental detection, often jaw and facial resection or dissection is required (Vale *et al.*, 1975, 1987; Andersen *et al.*, 1995; Jones, 1998; Pretty and Sweet, 2001). The post mortem record must include the approximate age, race, social place, sex, condition, location, date and case number.

For the documentation, special designed documentation forms and odontograms are used (Harmeling *et al.*, 1968; Vale *et al.*, 1975). Finally, postmortem radiographs can provide significant data essential for identification. This is because radiographs demonstrate oral and perioral structures. The traditional method to determine the race is from the skull appearance or from some additional elements like the cusps of Carabelli or the shovel-shaped incisors. The three main racial groups are the: Mongoloid, Caucasoid and Negroid (Solomon, 1979, Pretty and Sweet, 2001).

The sex is usually identified from the cranial or from the presence or absence of the Y-chromosome after a DNA analysis. The human teeth have the root and the crowns are in same axis. Also, histologically the enamel prisms are linked, at the same time and are brought vertical to the dentin. Meanwhile, these research methods of identification are used and in others fields of Forensic dentistry like mass disasters and anthropological and archaeological research (Harmeling *et al.*, 1968; Stimpson and Mertz, 1997; Burris and Harris, 1998; Sweet and di Zinno, 1996; Sweet and Hildebrand, 1998).

When all the post mortem dental evidence is being extracted, collected and finally preserved from the unknown identity bodies or from the skeletal remains then begins the comparison with the ante mortem data for the identification (Fig. 2) (Jones, 1998; Grundmann and Rotzcher, 2000; Silver and Souviron, 2009). The ante mortem data may include dental radiographs, photographs (intraoral, extraoral, perioral) written dental and medical records. Denture marking is accepted as a means of identifying dentures and persons in geriatric institutions or post mortem during war, crimes, civil unrest, natural and mass disasters (Ling *et al.*, 2003).

Identification of a body is made more difficult if some or all of the teeth are missing, a situation which is all too commonly found in older age groups. Fortunately, some dentures are marked and can be traced to a particular owner but it is essential in such cases to demonstrate that the denture had been worn by the victim and was not discarded at the scene by someone else. The material from which a denture has been made sometimes assisted in identification and the type of the teeth fitted to the

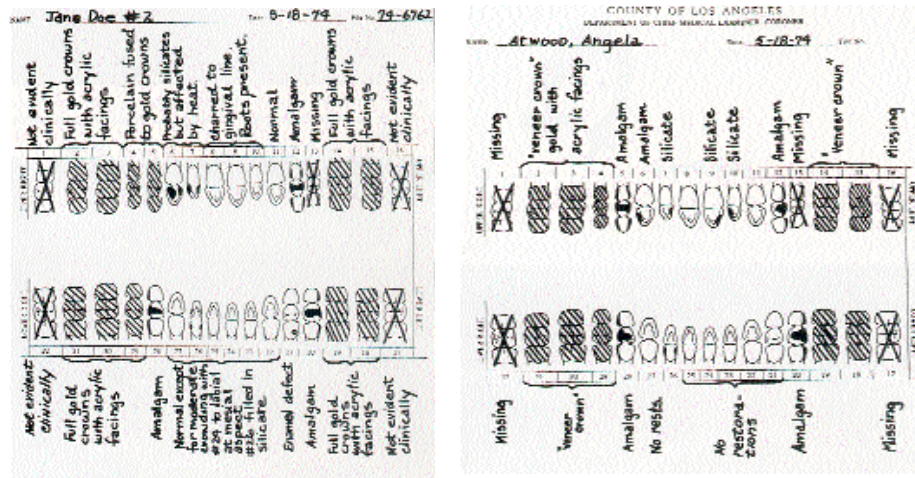


Fig. 2: Comparison between post and ante mortem dental findings (Case Patricia Hearst Symbionese Liberation Army Shootout, SLA, 1974 Los Angeles) (Vale *et al.*, 1975)

denture and the standard of workmanship may also be found useful pointers (Whittaker and MacDonald, 1989; Stavrianos *et al.*, 2007a).

The sources for the ante mortem data are the Federal Agencies (FBI), State Agencies and Local Agencies like, Hospitals, Dental Schools and Health Care Providers. The American Board of Forensic Odontology (ABFO, 1994) recommends that following conclusions:

**Positive identification:** When the ante mortem and post mortem data match in sufficient detail to establish that they are from the same individual. In addition, there are no irreconcilable discrepancies.

**Possible identification:** The ante mortem and post mortem data have consistent features but due to the quality of either the postmortem remains or the ante mortem evidence, it is not possible to positively establish dental identification.

**Insufficient evidence:** The available information is insufficient to form the basis for a conclusion.

**Exclusion:** The ante mortem and postmortem data are clearly inconsistent. However, it should be understood that identification by exclusion is a valid technique in certain circumstances (Stimpson and Mertz, 1997) (Washington (DC) office of justice programs: Technical working group for mass fatality forensic identification, mass fatality incidents: a guide for human forensic identification. This comparison between post and ante mortem dental findings determines the potential match

strength. As the 21st century dawns, everyone who gets involved with the forensic sciences has to keep in mind the role of DNA in dental identifications.

Now a days, the researchers can achieve comparison of DNA with the Polymerase Chain Reaction (PCR). The DNA can be collected from the teeth or from blood and hair (Sweet *et al.*, 1996; Sweet and Hildebrand, 1998; Sweet and di Zinno, 1996; Pretty and Sweet, 2001; Sweet and Pretty, 2001; Silver and Souvion, 2009).

## FACIAL RECONSTRUCTION

Late in the 19th century, anatomists, anthropologists and forensic odontologists began to study the correlation between the surface soft tissues of the face and the underlying bony structure of the skull. All the techniques of facial reconstruction rely upon this hypothesized relationship. The ultimate aim of all facial reconstructions for forensic purposes is to recreate an *in vivo* countenance of an individual, normally when no other identifying evidence is available, bearing a sufficient visual resemblance to the missing or deceased person, so that it may contribute to their recognition and lead to identification via the discovery of new evidence (Stavrianos *et al.*, 2007b).

Most of the methods are based on the knowledge of facial soft tissue thickness measured at selected anatomic landmarks as well as knowledge of particular morphologic features. It is possible to reconstruct the face from an identified skull. Face reconstruction is the reformation of a person based on anatomic characteristics of the skull. It



Fig. 3: The famous artist in medicine and life sciences in the Faculty of Medicine, Dentistry and Nursing at the University of Manchester Richard Neave. Face reconstruction of unknown person based on anatomic characteristics of the skull (Courtesy of Mr. R. Neave)

requires adequate stages and it is a combination of artistry and anatomy (Fig. 3). Essentially, a big section of the skull and the bottom jawbone should be saved. There are numerous techniques to sculpture a face onto the skull, all of which rely on the reproduction of a potentially recognizable face using the published soft tissue thicknesses in different racial groups (Neave, 1979; Lebedinskaya *et al.*, 1993; Prag and Neave, 1999). The facial model can also be reconstructed using 3D computer technology. Computerized methods for 3D facial reconstruction have been attempted to be established. These methods employ computer programs to transform laser-scanned 3D skull images into faces.

Although, the results are more reproducible than sculpted reconstructions, some subjectivity could remain in the pegging of a composite facial image onto the digitized skull matrix. The use of such a standardized image will reduce the influence of the individual shape of each skull which is after all, fundamental to the person's appearance. Computerized methods may be repeatable, fast and precise but as long as they employ the old data, the quality of the reconstruction will be undermined (Ubelaker and Donnell, 1989; Owsley *et al.*, 1993; Miyasaka *et al.*, 1995; Oliver *et al.*, 1995; Shahrom *et al.*, 1996; Herschaft *et al.*, 2006).

### RECOGNITION OF VICTIMS OF MASS DISASTERS

In the modern world the technological growth, the development of science is not capable to deter the mass destructions even these are caused from natural reasons (tsunami, earthquake, etc.,) or not (terrorist energies, fatal errors of type Chernobyl) (Clark, 1990; Morlang, 1996; NMWR, 2005). In the mass destructions when the corpses are:

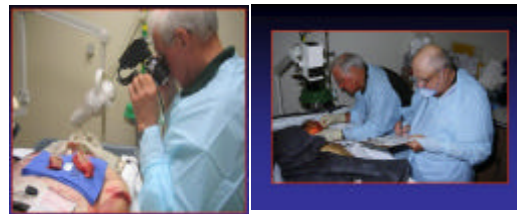


Fig. 4: Recognition of a victim of mass disasters. The photographs should be taken using digital and/or conventional photography. The famous Chief of Forensic Dentist and Dade County, Florida, Dr. R. Souviron (President of the ABFO, 1987-1988) is examining and the forensic odontologist next to him is recording the post mortem data (Courtesy of Mr. R. Souviron)

- Partially/Fully burned bodies
- Exposed in water (Fig. 4)
- In situation of decomposition
- There are skeletal remains
- When the reception of finger prints or palm prints and the optical recognition are not possible (Bell, 1989; Andersen *et al.*, 1995; Stimpson and Mertz, 1997; Grundmann and Rotzcher, 2000; NMWR., 2005; Silver and Souviron, 2009)

When the application of medical forensic methods it is impossible or it does not lead to identification then the recognition is possible with dental criteria. The identification process is roughly the same as in a routine comparative dental identification (Cottone and Standish, 1982; Bell, 1989; Clark, 1994; Herschaft *et al.*, 2006). The identification with dental criteria is complicated with a lot of problems such as problems of body fragmentation, vast amount of bodies, inadequate ante mortem dental records (Vale *et al.*, 1991; Silver and Souviron, 2009).

In the Mass Destructions the operation of Forensic Centre of Recognition among others forensic investigations departments is necessary. Each Dental Team of Recognition is constituted by three persons. The first examines, the second records and the third person observes and takes pictures. The process becomes in total three times.

The participant dentists change their roles very time (Cottone and Standish, 1982; Stimpson and Mertz, 1997). Problems of body fragmentation, mutilation, idiosyncratic dental records from numerous regions and stresses all confound the identification process. The key to successful mass disaster identification is preparedness (Pretty *et al.*, 2001).

**Technical working group for mass fatality forensic identification:** The forensic dentistry investigation teams participate in 3 phases. The first phase is the autopsy of space. The second is to create the list of speculated victims and in the collection of antemortem material. Finally is the realization of autopsy/necrotomy (Cottone and Standish, 1982). This process is time-consuming, requires attention and precision but it has high rates of success. In mass disasters, 70% of victims are recognized with dental evidence (Bell, 1989; Clark, 1994; Herschaft *et al.*, 2006; Grundmann and Rotzcher, 2000; NMWR, 2005). Now a days, it is crucial for the dentists to be aware of the terrorist attacks and their consequences. It is also widespread worldwide after the events of the fall of 2001 in USA that the correspondence should be immediate. Terrorism could act with explosive, chemical, biological, radiological or nuclear weapons. The Dentistry always played a significant and a vital role in other types of mass disasters like bio terrorism.

The Dentists with n the appropriate education around all the aspects of terrorism attacks could provide immediate medical and surgical treatment to the victims and to inform the local communities about the dangers and the symptoms of the attacks (the spreading of *Bacillus anthracis*). Finally, the response to bioterrorism and terrorism from the dentists should be immediate (Clark, 1994) (Washington (DC), office of justice programs: Technical working group for mass fatality forensic identification, mass fatality incidents: a guide for human forensic identification.

#### ESTIMATION OF DENTAL AGE

Forensic odontologists are often confronted with the problem of determining the age of unknown bodies as well as living persons. Age estimation is of great importance for the identification of unknown bodies or skeletal remains of accidents and crimes as well in disaster victims. In the case of living people who have no acceptable identification documents, such as refugees, adopted children of unknown age, verification of chronological age is required in order to be entitled to civil rights and social benefits. In archaeological search, estimation of age at death for skeletal remains serves as an aid in palaeodemography (Whittaker and Bakri, 1996; Amariti *et al.*, 1999; Sengupta *et al.*, 1999; Kinney *et al.*, 2005; Stavrianos *et al.*, 2008; Metska *et al.*, 2009). Many methods have been suggested such as cementum thickness, dental colour, tooth attrition, secondary dentine formation, periodontosis, apical resorption and

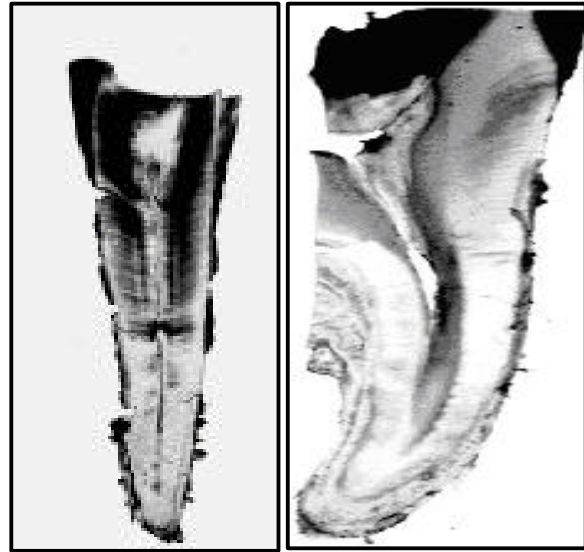


Fig. 5: Root translucency in age estimation. Human single-rooted teeth of the lower jaw. Real age: 77 years (Incisor). Translucent dental 43.59%. Molar Root dentine translucency. Real age: 47. Translucent dental, 70.72% (Stavrianos *et al.*, 2008)

many techniques have been employed but root dentine translucency remains the method of choice providing the most accurate results for age estimation. Root dentine translucency of single-rooted teeth is the only parameter giving accurate results for age estimation. The distribution of translucency in the roots of molars must be further investigated (Fig. 5) (Stavrianos *et al.*, 2008).

Different techniques and numerous studies have been published for age estimation, each one demonstrating various accuracy, precision and reliability. In all cases reproducible and reliable estimation results are possible when appropriate methods for each case are properly applied and used. Error is present in every approach. For this reason when investigating a case the forensic odontologist should apply different techniques available and perform repetitive measurements and calculations in order to reliable conclusion. Research into age estimation is ongoing. Forensic odontologists should continually watch the scientific presentations and journals that report new developments and validate or challenge existing techniques (Stavrianos *et al.*, 2008).

#### CONCLUSION

A forensic dentist in the cases mentioned before, carries a considerable responsibility since his scientific opinion is frequently asked when all other paths of

identification have been exhausted. There are instances in which teeth are the only preserved human remains and present the only means of age determination in order to narrow down the search within the missing person's file and enable a more efficient approach. In these cases final identification may depend on specific Odontological matching of pre and post-mortem dental data, DNA-typing and fingerprinting.

Teeth have the benefit to be preserved long after other tissues, even bone have disintegrated and also unlike bones they can be examined directly in living individuals (Sweet *et al.*, 1996; Sweet and Hildebrand, 1998; Pretty and Sweet, 2001). However, one must not forget that the more parameters taken into account the more accurate the determination of age is. For this reason clues from dentition must be correlated with clues found in the bones.

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