FORENSIC ODONTOLOGY AT A GLANCE
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ABSTRACT

Forensic Odontology is a science mainly used for human identification and bite marks. The present review article focus on various techniques currently applied in the field of forensic odontology.

Keywords: Forensic Odontology; identification; violence; teeth

The term ‘forensic’ implies ‘court of law.’ Forensic Odontology is the forensic science that is concerned with dental evidence. Forensic odontology has been defined as that branch of dentistry, in the interest of justice, deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of dental findings. The roles of any forensic scientist are to collect, preserve and interpret trace evidence, then to relay the results to the judicial authority in a form of a report. Despite of the advances in modern technology, medical breakthroughs in the new millenium, crime still persists and has grown in all aspects of our lives. The apprehension and subsequent prosecution of the perpetrator(s) is essential to maintain law and order. Through the specialty of forensic odontology, dentistry plays a small but significant role in this process.

Forensic Odontology, as a science, did not appear before 1897 when Dr. Oscar Amoedo wrote his doctoral thesis entitled “L’Art Dentaire en Medecine Legale” describing the utility of dentistry in forensic medicine with particular emphasis on identification. Forensic odontology has played a key role in identification of persons in mass disasters (aviation, earthquakes, Tsunamis), in crime investigation, in ethnic studies, in identification of decomposed and disfigured bodies like that of drowned persons, fire victims, and victims of motor vehicle accidents. The most common role of the forensic dentist is the identification of deceased individuals. Dental identification takes two main forms. Firstly, mostly a comparative identification is made, to establish (to a high degree of certainty) that the remains of a deceased and a person represented by antemortem (before death) dental records are the same individual. Information from the body or circumstances usually contains clues as to who has died. Secondly, in those cases where ante-mortem records are not available, and no clues to the possible identity exist, a postmortem (after death) dental profile is compiled by the forensic dentist suggesting characteristics of the individual likely to narrow the search for the antemortem materials. The various methods employed in forensic odontology include rugoscopy, cheiloscopy, bite marks analysis, tooth prints, radiographs, photographic study, DNA analysis and molecular methods. This article gives a brief overview of some of the roles undertaken by Forensic odontologists.

Forensic odontology has three major areas of utilization: 1. Diagnostic and therapeutic examination and evaluation of injuries to jaws, teeth, and oral soft tissues. 2. The identification of individuals, especially casualties in criminal investigations and/or mass disasters. 3. Identification, examination, and evaluation of bite marks which occur with some frequency in sexual assaults, child abuse cases, and in personal defense situations.

Human Identification: Identification is based on comparison between known characteristics of a missing individual (termed ante-mortem data) with recovered characteristics from an unknown body (termed post-mortem data). The diversity of dental characteristics is wide, making each dentition unique. The dental enamel is the hardest tissue in the body, and would thus withstand peri- and post mortem damage. Hence teeth are considered excellent post-mortem material for identification with enough concordant points to make a meaningful comparison. For dental identification to be successful, ante-mortem data need to be available. This relies heavily on dental professionals recording and keeping dental notes, radiographs, study models, clinical photographs etc. The availability of dental records will allow comparing the dental characteristics of the person during life with those retrieved from the person after death. Individuals with numerous and complex dental treatments are often easier to identify than those individuals with little or no restorative treatment. Typically, human remains are found and reported to the police who then initiate a request for dental identification. Often a presumptive or tentative identification is available (ie wallet or driving licence may be found on the body) and this will enable antemortem records to be located. In other instances, the geographical location in which the body is found or other physical characteristics and circumstantial evidence, may enable a putative identification to be made, frequently using data from the missing persons’ database. Antemortem records are then obtained from the dentist of record. The use of radiographs, dental casts, prosthetic or dental appliances, type and no of restorations present, may help to identify the victim. Similarities and discrepancies should be noted during the comparison process. There are two types of discrepancy, those that can be explained and those that cannot. Explainable discrepancies normally relate to the time elapsed between the antemortem and post-mortem records. Examples include teeth extracted or restorations placed or enlarged. If a discrepancy is unexplainable, for example a tooth is not present on the antemortem record...
but is present on the postmortem record then an exclusion must be made.\textsuperscript{5,26-28} A range of conclusions can be reached when reporting a dental identification. The American Board of Forensic Odontology recommends that these be limited to the following four conclusions.\textsuperscript{6,29-33}

**Positive identification:** The antemortem and postmortem data match in sufficient detail, with no unexplainable discrepancies, to establish that they are from the same individual.\textsuperscript{27,32-34}

**Possible identification:** the antemortem and postmortem data have consistent features but, because of the quality of either the postmortem remains or the antemortem evidence, it is not possible to establish identity positively.\textsuperscript{32,33}

**Insufficient evidence:** The available information is insufficient to form the basis for a conclusion.\textsuperscript{32,33}

**Exclusion:** the antemortem and post-mortem data are clearly inconsistent.\textsuperscript{32,33}

In cases where dental records are not available, Forensic Odontology can still contribute to establishing the identity by creating a profile of how the deceased person was during life.\textsuperscript{4} This includes any unusual oral habits, type of diet, socio-economic status, but most importantly the age of the person at time of death. Dental aging is based on the chronology of formation and eruption of teeth.\textsuperscript{4} This helps in determining the age for persons up to 15 years-old in a fairly accurate manner. After 15 years of age, dental aging relies on modifications that take place during life, such as attrition, cementum formation and root transparency.\textsuperscript{4,35}

**Dentists’ Role in Mass Fatality Incidences:** Mass fatality incidences represent a big challenge to local authorities. Another challenge is the damage inflicted on infra-structure that includes hospitals, transportation, communications etc. which impede recovery.\textsuperscript{4} Victims with no dental records can be identified by photographic superimposition, if a photograph showing upper anterior teeth was provided, or by narrowing down possible matches for the DNA and fingerprint teams through dental aging.\textsuperscript{4,35}

**Bitemark Analysis:** Injuries induced by teeth and left on objects, such as skin, have a distinctive pattern. Those patterned injuries (bitemarks) are useful for judicial purposes as they help in reconstructing past events that surrounded the biting process.\textsuperscript{4} For example, bitemarks indicate a violent interaction between the perpetrator and the victim, and even might tell us about the criminal intentions of the perpetrator, whether sexual, child abuse, or other forms of assaults. Also bitemarks are the only patterned injuries that can indicate (with different levels of certainty) who the biter was.\textsuperscript{4} By comparing the locations and measurements of teeth marks in a bitemark with those of the suspect(s), Forensic Odontologists can exclude or include persons suspected of causing the bitemarks.\textsuperscript{4} New research is underway to allow digital comparison of teeth and bitemarks at a 3-dimensional level.\textsuperscript{36} This novel technique is aimed to overcome perspective distortion, a significant morphological factor in bitemark analysis that results from reducing 3-dimensional objects to 2-dimensional images.\textsuperscript{4}

**Role of DNA in dental identifications:** As dental tissues are quite resistant to environmental assaults, teeth represent an excellent source of DNA material.\textsuperscript{37,38} With the advent of the polymerase chain reaction (PCR), a technique that allows amplification of DNA at pre-selected, specific sites, this source of evidence is becoming increasingly popular with investigators.\textsuperscript{2,19} PCR-based analysis produces a DNA profile that can be compared with known antemortem samples or paternal DNA.\textsuperscript{7,38,40} Besides, this technique may also help criminal investigators to link victims to crime scenes once the body has been removed and incinerated.\textsuperscript{36,38}

**Genomic DNA:** Genomic DNA is found in the nucleus of each cell and represents the DNA source for most forensic applications, (there are no nuclei, and hence there is no DNA, in red blood cells).\textsuperscript{5,7,36} When body tissues have decomposed, the structures of the enamel, dentine and pulp complex persist. DNA can be extracted from calcified tissues of teeth even in cases of root canal treated teeth.\textsuperscript{5,41}

**Mitochondrial DNA:** In addition to genomic DNA, cells contain mitochondrial DNA (mtDNA), the sequence of building blocks of which can be determined to assist in identification.\textsuperscript{39} The main advantage of mtDNA is that there is a high copy number in each cell caused by the high number of mitochondria present in each cell. In cases where genomic DNA is too degraded to be analyzed, mtDNA may be present in sufficient quantity. In addition to its higher copy number, mtDNA is maternally inherited.\textsuperscript{7,42} This maternal inheritance pattern confers the same mtDNA sequence, barring mutations, upon siblings and all their maternal relatives. This has important implications for the identification of individuals for which there is no antemortem comparison sample available.\textsuperscript{5,43}

**Other methods of dental identification:** Besides the processes explained above some more novel and innovative techniques of dental identification have been applied. Few have been mentioned here.

**Labeling of dental prosthesis:** The NHS provide a fee for dentists who label their patients dentures, although this is often only used in instances where the wearer is a resident in a care home or other establishment with a central sterilizing system for dental prostheses.\textsuperscript{38,39,47} Labelled dentures can be of great assistance in the identification of individuals.\textsuperscript{5,7,10,38,44,45} Other dental appliances, such as removable orthodontic braces have also been used for identification purposes.\textsuperscript{38,45,46}

**Study of Palatal Rugae (Rugoscopy):** Palatal rugae comprise about three to seven ridges radiating out tangentially from the incisive papilla.\textsuperscript{47,48} These ridges can be classified as curved, straight, wavy, and branched. The pattern of these rugae is considered unique to an individual. In instances where post-mortem dental identification is not possible, as in edentulous mouths, palatal rugae can be used as a supplement.\textsuperscript{3,5,49}
Examination of Lip Prints (Cheiloscopy): The external surface of the lip has numerous elevations and depressions that form a characteristic pattern, referred to as lip prints. Lip prints can be obtained at the crime scene from clothing, cups, glasses, cigarettes, windows, and doors. Using lip prints for personal identification in forensic odontology is an accepted method in the criminal justice system worldwide. The various patterns identified include vertical, intersected, branched, reticular, and undetermined. The anatomical landmarks of the lip include chelion (the lateral most point in mouth opening), stomion (the contact of upper and lower lips in mid-sagittal plane), and labrale superius and labrale inferius (the highest and lowest points of upper and lower lip margins in the mid-sagittal plane, respectively).

Forensic dentistry plays a major role in the identification of those individuals who cannot be identified visually or by other means. The unique nature of our dental anatomy and the placement of custom restorations ensure accuracy when the techniques are correctly employed. Dental practitioners should be aware of the forensic application of dentistry. Dental records that are used to provide patients with optimal dental service could also be very beneficial to legal authorities during an identification process. Therefore, all forms of dental treatments should be recorded and kept properly.

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