

Current Perspectives in Dental Identification - An overview

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ABSTRACT

Abstract

Forensic dentistry is a vital and integral part of forensic science that is most widely utilized for identification of the living and deceased persons. In recent times, forensic odontology has evolved as a new ray of hope in assisting forensic medicine. This is relatively a young science of dentistry and still in its infancy stage in India whereas in other developed countries it has acquired a recognized branch of dentistry in medical forensicology.

Introduction

Human beings have come a long way from the early caveman age to the present day of covering nothing less than astronomical heights to sea bed depths. His zeal to conquer new heights has created a world full of scientific advancement and technology. However, his intelligence has also led to a surge in crime rate, terrorism, wars, mass disasters, road traffic accidents and dreadful diseases. In all such incidents the identity of the deceased, assailant or the cause of death becomes important as the core of various investigations are based on these processes [1]. All humans have an identity in life; compassionate societies require that, this identity be recognized even after death. When a person dies there may be consequences, often financial, that must be dealt with. Forensic science plays an important role that can be used in a judicial setting and accepted by the court and the general scientific community to separate truth from untruth.

Forensic identifications, by their nature, are multidisciplinary team efforts that typically involve the coordination and cooperation of law enforcement officials, forensic pathologists, forensic odontologists, forensic anthropologists, serologists, criminalists and other specialists as deemed necessary [2]. Forensic dentistry is a vital branch of forensic science which deals with proper handling, examination and evaluation of dental evidence for identification of victims of crime, accidents or natural calamities [3]. The evidence that may be derived from the teeth, the age (in children) and identification of the person to whom the teeth may belong. Knowledge of forensic dentist requires encompassing of number of disciplines, since the dental records obtained can identify an individual or afford the information needed by the authorities to establish identification of the case.

Review of Literature

Definition

Keiser-Neilson defined forensic dentistry as “that branch of forensic dentistry that in the interest of justice deals with the proper handling and examination of dental evidence and the

proper evaluation and presentation of dental findings [4]. The word forensic is derived from Latin forensic (is): of or belonging to the form, public, equivalent to for (um) forum + ens – of, belonging to + ic.

There are three concepts that are important in all forensic sciences:

1. The first involves maintaining the proper “chain of custody” when dealing with evidence.

2. The second issue of concern that crosses all fields of forensic science involves the existence of legal standards for the admissibility of forensic tests and expert testimony.
3. The third issue that relates to all forensic science disciplines is the concept of the expert witness.

History

Dr. Oscar Amoedo was considered as the father of the forensic odontologist. The thesis done by him entitled ‘L’ Art Dentaire en Medicine Leagale’ to the faculty of medicine earned him a doctorate. This book is the first comprehensive text on forensic odontologist [5]. The table 1 and 2 depicts the detailed history about forensic dentistry.

Table 1: History of Forensic odontology

Year	Important Events happened
66 AD	Well-documented evidence to the use of teeth for identification began in AD with Agrippina and Lollia Pauline case. It was the first use of dental identification.
1193	The first forensic identification in India started in were Jai Chand, a great Indian Monarchy was destroyed by Muhammad’s army and Jai Chand; Raja of Kanauji was murdered and he was identified by his false teeth.
1758	Peter Halket was killed during French and Indian wars in a battle near Fort Duquesne. Halket’s son identified his father’s skeleton by an artificial tooth
1776	At the battle for Breed’s Hill in Boston, Dr. Joseph Warren was killed. His face was not able to identify as he suffered from a fatal head wound. A dentist, Paul Revere, identified Dr. Warren’s, dead body by a small denture that he had fabricated for him. First dental evidence was used in Webster-Parkman case in U.S. Court. Charred Fragments of mineral teeth fused to gold were identified in Dr. Nathan Parkman which led to hang Dr. Webster.

Table 2: History of Medical and Dental Forensics in India

Rajiv Gandhi assassination	In May 21st, 1991, the assassination of Rajiv Gandhi, a leading and dynamic person of India took place. The murder of Rajiv Gandhi was compared with the assassination of John F Kennedy of USA. In the investigation out of 18 bodies, 17 bodies inclusive of Rajiv Gandhi body were identified. The one body of dismembered parts which was correlated with skin, absence of body hair, same nail polish color on fingers and toe nails, and finally concluded that it was a female, who was the human bomber. And it also gave an indication that female carried the bomb in the abdominal belt.
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	The Dr. P. Chandrasekaran, Director, Tamil Nadu Forensic Science Laboratory, Madras which took 6 months for him to generate a full crime scene reconstruction document stated that DNA found in the charred muscle pieces and the skull on the suicide bomber, Dhanu showed identical pattern. So it was then provided the Dhanu was the bomber.
Veerappan identity confirmed	The trademark of Veerappan has the handlebar moustache on his face, which was missing when he was shot dead by Special Task Force personnel in Dharmapuri District of Tamil Nadu. This led to great confusion. But the experts of forensic are confirmed by the study of the external ear. Prof. P. Chandra shekhar, a principal investigator in Rajiv Gandhi assassination case, said that the anatomical structure of the external ear differs from person to person. He studied the structures of the external ear from ante and post mortem photographs of Veerappan, compared them and confirmed that it was sandal wood smuggler. There is a unique structure in Veerappan ear, which has flat tragus formation, and the tragus is continuous with a curved portion of helix.[5]

Forensic Odontologist

The forensic odontologist, is the key person in the forensic dentistry. The role of the forensic odontologist is numerous, but most frequently includes the following tasks. [6]

1. Identification of the deceased (to include the mass disaster situation)
2. Age estimation of both the living and deceased
3. Bite mark analysis
4. Abuse issues
5. Fragment comparisons
6. Archaeological studies
7. Cold cases
8. Presenting evidence to the courts

Dental Identification in Forensic Science

Dental identification of a person from dental records by a qualified forensic dentist has long been established and accepted by courts as a means to prove the identity of an individual. Identification of individual by forensic is one of the reliable methods in incidents like accidents and natural calamities, where these unfortunate incidents claim life of individuals coming from all round the world. The identification of the deceased, assailants or the cause of the death is an essential input, which forms the basis of various investigations as in mass disaster, accidents or deceased as it is difficult for the family members to identify the victims. The board-certified forensic

dentist interacts with other forensic and medical disciplines like anthropology, pathology, human anatomy and biological science. Typically, this multidisciplinary team involves the cooperation and coordination of law enforcement officials, forensic anthropologists, forensic dentists, forensic pathologists, criminalists, serologists, and other specialists as deemed necessary. There are a variety of techniques available from forensic pathology, anthropology, odontology, and entomology that may help to establish the deceased's identity, cause of death, factors contributing to death, and the timing of death.

In general, dental identification in forensic science has three different applications as mentioned below.

1. Comparative identification, in which the post-mortem dental records are compared with the ante-mortem records of an individual in order to establish whether both records correspond to the same person.
2. The obtainment of dental information to narrow the search for an individual when the ante-mortem records are not available and there are no possible data referred to the identity of the subject.
3. Identification of victims following mass disasters or catastrophes.

Traditionally, comparisons have been made between post-mortem dental records and the ante-mortem (living) records (presence of dental fillings, endodontic treatments, crowns or bridges, radiological studies to verify the clinical findings, the presence of malocclusions or dental fractures, etc.) to determine whether both records correspond to the same individual. Such techniques are now less widely used, however, due to the increased efficiency and availability of molecular biological techniques. In this context, the enamel and dentin layer isolate the pulp cavity from the exterior, thereby affording a valuable source of DNA. A number of identification techniques are used by forensic dentists, including rugoscopy, cheiloscopy (lip prints), the obtaining of imprints, or the use of molecular techniques such as polymerase chain reaction (PCR) for analysing the DNA contained in dental pulp tissue [7].

Steps in forensic dental identification

A step in forensic dental identification basically has two steps. The first step is comparison between an unknown evidentiary item and a known item having the forensic scientist render a judgment whether there is sufficient concordance to say there is a “match”. The second part to the identification analysis should give some meaning to concordance by providing a scientific statement that would allow the Trier of fact, a judge or jury, to weigh the significance of the matching association and answer a simple question for the benefit of the Trier of facts. Human identification is the forensic odontologist’s primary duty. This involves interaction with law enforcement agencies charged with the responsibilities of investigating the evidence from cases involving violent crime, child abuse, elder abuse, missing persons and mass disaster scenarios. In each context, dental evidence may produce compelling association to aid victim identity, suspect identity, and also establish facts that can affect the direction and ultimate outcome of investigate casework.

Types of Dental identification (Table 3) [7]

Table 3: Details of types followed in dental identification

Types	Description
Positive dental identification	Sufficient agreement between the antemortem and postmortem data to establish that they correspond to the same individual. Absence of unexplainable discrepancies; at least 12 coincident features. Probability of coincidence with another person $\leq 1 / 10,000$.
Probable dental identification	Strong evidence, though other biological, physical, technical or tactic data are needed. Between 6 and 11 coincident features. Probability of coincidence with another person $\leq 1/100$.
Possible dental identification	No sufficient characteristics for positive identification. Existence of explainable discrepancies. Absence of excluding characteristics. If there are 5 coincidences or less, other techniques must be used to determine the identity of the individual.
Discarded dental identification	Existence of an unexplainable discrepancy. Need for new data (such as X-rays) and definition of the identification technique used, in order to discard errors.

According to American board of forensic odontology, dental identification can be divided into four types (Table 4) [4].

Table 4: Dental identification types based on American Board of Forensic Odontology

Types	Description
1. Positive identification	The ante-mortem and post-mortem data match to establish that it is from same individual.
2. Possible identification:	The ante-mortem and post-mortem data have few consistent features, but because of quality of the records it is difficult to establish the identity.
3. Insufficient evidence	The data is not enough to from the conclusion.
4. Exclusion	The ante-mortem and post-mortem data clearly inconsistent.

Dental identification procedures

Whenever a human body or the remains of a human body are found, the police are called for further investigation. The police in turn may make a formal request to the dental authorities to help them identify the individual. At this point in time, a tentative identification is possible by considering the geographical location where the body was found, the physical features, the

available wallet or driving license or any other personal belonging of the deceased individual. This tentative identification may help in narrowing the search for ante-mortem records with which a possible identification may be established with a degree of certainty [8].

Dental identification of an individual can be made mainly by two methods as mentioned in Table 5 [3,9-34].

Table 5: Methods followed in Dental identification of an Individual

Methods	Procedures
Comparative method of dental identification	<p>Involves establishment to the highest degree of certainty that the remains of the decedent at the site of mishap or death and details in the ante-mortem dental records are of the same individual to confirm identity of the individual. Here, the forensic dentist prepares a post mortem dental record by careful examination, charting and written descriptions of all the dental structures along with the radiographs as additional supportive evidence. Radiographs needs to be punched with rubber dam, indicating ante mortem or post mortem, to avoid any sort of confusion in future. Once the post mortem record is complete, a systematic and methodical comparison has to be made between the ante mortem and post mortem dental records examining each and every tooth and surrounding structures.</p> <p>While dental restorations play a significant role in the identification process, other additional features may also be of help. The manual of American Society of Forensic Odontology (ASFO) and the guidelines for body identification by American Board of Forensic Odontology (ABFO) provide numerous such additional features to be looked for in the identification process.</p> <p>The similarities and discrepancies should be carefully noted at the time of comparison of the records.</p> <p>The discrepancies can be of two types.</p>

	<p>Explainable discrepancies - are the ones for which an explanation can be reasonably accepted keeping in mind the time elapsed between the recording of ante mortem and post mortem findings. Example, a tooth noted to be present in the ante mortem records which is missing in the post mortem records (might have been extracted after ante mortem findings were recorded and before death), a restoration which is mesio occlusal (MO) in ante mortem records being mesio occluso distal (MOD) in the post mortem records (a further distal extension may have been made in the time elapsed between the noting of ante mortem and post mortem records).</p> <p>Unexplainable discrepancies - are the ones for which the explanation cannot be provided for and hence, have to be excluded. Example, a permanent tooth recorded to be extracted in the ante-mortem finding to be present in the post mortem record. Most of the times, where ever dental identification is sought, this method of comparison between ante mortem and post mortem records is used for identification with certainty. At times this method may not be applicable for example, when there are no clues to make a tentative identification without which there is no way of searching for ante mortem records or the ante mortem records may be unavailable in spite of making a tentative or presumptive identification. In these circumstances a method known as post mortem dental profiling is used.</p>
<p>Post mortem dental profiling</p>	<p>In this method, the forensic dentist will help the authorities narrow down the search for ante mortem records by giving information on the deceased individual's race, age, sex, socio economic status, occupation, dietary habits, dental and some systemic diseases as well by careful examination of the deceased or the left-over human remains at the site of disaster. 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 dental features like cusps of Carrabelle, Shovel shaped incisors, multi cusped premolars; talons cusp, taurodonts, etc may assist in determination of the race [22-36]. 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. The age of the individual can be gauged by examination of the teeth and surrounding dental structures and their subsequent comparison with the developmental charts. The age can be established with an accuracy of plus/minus 1.5 years to the actual chronologic age of the child with this method. Some authors recommend the use of aspartic acid racemization method for determination of the age, which can reveal the age to an accuracy of plus/minus four years. 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.</p> <p>Erosions can be due to many factors like alcohol or substance abuse, working in an industry involving use of acids (because of continuous exposure to acid</p>

	<p>fumes in the working environment), excessive consumption of carbonated beverages or disorders like anorexia nervosa/other eating disorder/hiatus hernia. Stains on the teeth may suggest smoking, tetracycline use, betel nut and chewing of smokeless tobacco or even dental fluorosis as well. The notching of incisors (carpenters and cobblers), opening of bobby pins and cutting of threads (tailors) or because of placement of pipe stems, cigarette holders, hair pins etc. The unusual wear pattern of the teeth may give an indication of previous orthodontic treatment as well.</p> <p>The presence or absence of dental treatment (which gives information on the attitude and dental awareness of an individual) as well as the quality and quantity of dental treatment (type of restoration, type of prostheses or appliance) may give some clues on the socio-economic status of the individual. In short, we can say, in post mortem dental profiling, a forensic dentist looks for all possible methods to narrow down the identity of the deceased so as to enable search for the ante mortem records. This as a method of forensic dental identification is used when comparative and other methods of identification are not sufficient to establish the identity of the individual.</p>
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Advanced innovative methods in dental identification [14-16]

Although comparative dental identification or post mortem dental profiling are the most frequently used in forensic dental identifications, in many situations, some innovative techniques such as labelled dentures or orthodontic appliances, the unique restorative materials can easily narrow down the search for identity of the deceased person. There have been many scientific articles in literature to show how the labelled prostheses (labelling patient's name or patient's unique ID number), other dental appliances such as removable orthodontic appliances, unique composition of restorative material or the presence of Kevlar fibers in the denture have helped in the ultimate process of establishing identity of the individual. This method of labelling 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. So, the concerned dental organizations throughout the world should insist that dentists get their patients identity engraved or labelled in the respective appliance or prostheses.

Dental identification in mass disasters [17-36]

Dental identifications have always played a key role in natural and manmade disaster situations and in particular mass casualties normally associated with aviation disasters. The identification process in a mass disaster situation is fundamentally the same as that in a routine comparative dental identification of a deceased individual, but the conditions under which the process is under taken is more complex because of the physical and emotional nature of the situation.

Lack of standardization in the charting of dental records (because of which there will be wide variations in the way in which details are recorded in both ante mortem and post mortem records), the poor working conditions, the psychological stress, decomposition, mutilation of human remains at the site of disaster; all confound the process of identification. The fundamental requisite for proper handling of these situations is disaster preparedness. 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 (post-mortem identification number or barcode)

and photographed in situ (unless it is too dangerous). If practical, the site is organized 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 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.

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. The FDI system of charting is used, with various symbols and color coding representing the dental status of the individual, and there are boxes for further information relating to crowns, veneers, bridges, occlusion, implants prosthetic appliances, periodontal condition or any unusual features. Agreement on international and standardized 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. 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 their fracture patterns of the teeth or jaws that would suggest a particular type or direction of injury [6].

Future perspective in Forensic dentistry

The fact that physiological variations, pathoses and effects of therapy of dental hard and soft tissues are unique to every individual, forms the basis of this branch of medical science. In cases of medico-legal background, this is also very useful. Since the scope of forensic science is very broad and challenging, dental surgeons trained in FO can make unique contributions in the administration of

law and justice. A forensic dentist is concerned with the handling and collation of dental evidence and assists law enforcement agencies in the detection and resolution of criminal and civil proceedings.

Forensic odontology involves dentists' participation in assisting legal and criminal issues. Formal teaching in forensic odontology has existed for over 100 years. Over the last century, forensic odontology has evolved and, today, it is an integral part of undergraduate dental training in many countries. Forensic odontologist should have a thorough knowledge about basics of anatomy including dental anatomy. An awareness of forensic pathology and the methods of autopsy are merited. Furthermore, a comprehensive cognizance of the pertaining laws to the legal implications involved in it.

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