RESEARCH ARTICLE

AN OVERVIEW ON FORENSIC DENTISTRY

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ABSTRACT

Forensic odontology is the forensic science that is concerned with dental evidence. It is a relatively new science that utilizes the dentist's knowledge to serve the judicial system. Forensic identification based on assessment of prosthodontic appliances is assuming greater significance, as labeling of dentures and other prosthetic appliance could provide vital clues for patient identification. This article presents a review of available literature highlighting the fact that how a prosthodontist can play a key role in identification of a deceased individual.

INTRODUCTION

Forensic was born when the body of Charles was identified in the battle of Nancy by the absence of a tooth in the lower arch. Later, in 1835, prosthetic importance in forensics came into thepicture when a burned body was identified by the gold denture of the victim (Ling, 1998; Jain, 2015). Then in 1970's Keiser-Neilson defined forensic dentistry as ''that branch of forensic medicine which 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 (Kareker *et al*., 2014; Chapter 10 : Forensic dentistry). The main mission of forensic odontology was "identification"; to apply dental knowledge to civil and criminal problems (Frederick, 1995; Basavanna, 2016). Identification of a dead or missing person is highly important in case of major disasters like earthquakes, fire, plane crashes, etc.

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It is essential for any medicolegal investigation because a wrong identity may pose a problem in delivering justice. The American Board of Forensic Odontology guideline indicates that most dental identifications are based on restorations, caries, missing teeth and/or prosthetic devices. In this process, Prosthodontists play a very vital role, as they are concerned with the fabrication of various prosthesis which can serve as an important tool for identification (Kareker *et al*., 2014; Frederick, 1995). There are many ways of identifying the bodies by the forensic experts in which the dentistsin generaland prosthodontists, in particular, plays a major role by identifying the victims with their natural teeth, caries teeth, restorations on the teeth like filling dental prostheses including crowns, partial, or complete dentures. Labeling of all dentures is recommended by most international dental associations and forensic odontologists. In fact, in some countries and certain states of the USA, the labeling of dentures is regulated by legislation. (Alexander *et al*., 1998) the obligation of the profession, a dental practitioner needs to maintain meticulous dental records of his patients. This would include documenting the identity of dentures.

At times the only identifiable remains are a victim's partial or complete dentures (Kareker *et al.*, 2014; Thomas *et al.*, 2014). (Richmond and Pretty, 2006) The identification of the victims during natural calamities and accidental deaths is a very difficult task and the early identification is of prime importance. Bridges and implants (Thomas *et al* and Berkata *et al.*, 2010). The experts also utilize palatal Rugoscopy and D.N. Aanalysis as an aid for the identification purpose. (Ohtani *et al* 2008; Inoue *et al.*, 2000) All these will become easy when the antemortem records are available, i.e., documentation of the patient details or the prosthodontic work. If a complete code, such as the social security number, is too long to be marked on a single crown, the first five numbers can be marked on the crown. Even this reduced code will considerably shorten the research time needed for complete identification of the person. When more than one crown is available, the social security number may be marked in its entirety of nine numbers (Kareker *et al.*, 2014; Rathee *et al.*, 2014; Dentures in Forensic Identification-AReviewofMethodsBenefits.pdf.; Ahmed Hilal Sheriff, 2015).

Medicolegal Importance of Denture Marking Systems (Ahmed Hilal Sheriff, 2015):

- Identification of the dead or deceased when all other means have failed.
- Identification of individuals for forensic, social and legal reasons.
- Victim identification in case of mass disasters like terrorism, bombings, earthquakes, hurricanes, typhoons, air crashes and other transportation mishaps.
- Identification of mutilated and decomposed bodies when all other parameters like scars, tattoos, and facial features have failed.
- Without a valid entity to solve the ensuing problems of the death certificate, disposal of diseased property, claiming of accrued money or insurance policies, claim for compensation (in case of traffic accidents) denture marking will definitely help in positive identification of victims.

METHODS OF IDENTIFICATION

Earlier many body characteristics were used to identify an individual. Recognition included using visual, scars, deformities, and tattoos methodologies (Chapter 10 : Forensic dentistry; Ata-Ali, 2014).

Visual recognition: Most common method. It is reserved for instances in which no real doubt exists about the identity of the individual and death did not occur under unusual circumstances. Its drawbacks occur when changes in appearance because of illness, fire, water immersion, or decomposition make ID quite difficult and therefore, are considered an unreliable means of identification in the medico-legal death investigation of the deceased individual.

Scars: This method is useful in some cases. Surgical scars are probably the most commonly found but are of the least value since they are seldom distinctive.

Deformities: May be either soft tissue alterations or because of bony abnormalities.

The bony deformity must be significantly distinctive, however, to be of value as a means of ID.

Tattoos: Multiple tattoos would increase the likelihood of positive identification. Again tattoos are soft tissue evidence and therefore are prone to easy destruction by the environmental effect. For many reasons, tattoos should be used only as a secondary means to a positive ID.

Skeletal Remains: It can provide positive proof of identity that is acceptable in a court of law. Identification by skeletal remains requires matching of postmortem radiographs with radiographs that were taken before death. Features that can be used for ID by skeletal remains would include healed fracture sites, pathologic lesions, and medical hardware. The main problem with ID skeletal remains is the fact too few individuals in the general population have such characteristics. This makes it difficult to rely on as a routine method of the ID of an unknown body.

Fingerprints: Of all the methods of ID, fingerprints are probably the best known. Fingerprints are an excellent means of positive ID. Many individuals will argue that fingerprint ID is the most definitive means of identifying an unknown set of human remains, and it is generally accepted that no two individuals have the same set of fingerprints. Fingerprint ID, therefore, is always acceptable in a court of law.

DNA analysis: DNA analysis, also known as DNA fingerprinting, is a fairly new technology that may replace dental identification and fingerprint identification as the most definitive means of identifying unknown remains. It will be fully implemented when an adequate database of DNA specimens can be established.

Dental identification: Dental ID, like fingerprint ID, is a definitive means of positive identification of unknown human remains. It also is routinely accepted as evidence in court. It has several significant advantages, and only a few disadvantages when compared with fingerprint identification.

Dental tissues in forensic odontology: Dental evidence tends to survive much better than does soft tissue evidence such as facial characteristics or fingerprints. Teeth are calcified structures and are the hardest substance in the human body, even harder than bone. Thus teeth are not destroyed by immersion in water, by desiccation (drying up), or by decomposition. Even in cases of skeletalization of remains, teeth are available for ID purposes. In addition, teeth are relatively resistant to destruction by fire. In addition to the teeth, the materials used for dental restorations are also resistant to destruction by the environment, even more so than the natural teeth themselves.

Teeth: A bite mark is defined as 'a mark caused by teeth either alone or in combination with other mouth parts' and serves as a source of forensic evidence in crime investigation. Based on etiology McDonald has classified bite marks as tooth pressure, tongue pressure and tooth scrape marks. Various steps in bite mark investigation include preliminary questions, evidence collection from the victim, case demographics, visual examination, photography, saliva swab, impression making, evidence collection from suspect, bite mark analysis, comparison and drawing conclusion (Van der Velden *et al.*, 2006).

Methods of Denture Marking (Kareker, 2014; Rathee *et al.*, 2014)

Surface marking methods	Inclusion methods
• Complete dentures • Engraving method • Embossing method • Invisible ink method • Fibre tip pen method • Heaths method • Stevensons method • Weckers electro pen method • Laser etching method • Onion skin paper method • Denture bar coding method • Fixed partial dentures • Engraving ceramic crowns	• Lose inclusion method • Youngs method • Dippenars method • Reesons method • Clear acrylic T bar method • Olivers method • Lenticular card method • Bar coding method • Radio frequency identification tag • Lead foil method • Metallic band according to Swedish Guidelines • Photograph inclusion method • Min I Dent method • Data matrix code • Microlabelling • Cast embossed identification plate • Memory card method

Some of the methods in details are

METHODS	ADVANTAGES	DISADVANTAGES
COMPLETE DENTURE **SURFACE METHODS (Kareker *et al.*, 2014; Matsumura, 2002; Reeson, 2001)** • **Engraving Method:** In this technique, letters, or numbers are engraved with a small round dental bur on the fitting surface of the maxillary complete denture • **Embossing Method:** The patient's initials are scratched with a dental bur on the master cast. This technique produces embossed lettering on the fitting surface of the denture • **Invisible Ink Method:** Harvey described a method wherein the patient's details are written with an invisible ink that is rendered visible by ultraviolet light. **INCLUSION METHODS (Thomas *et al.*, 2014; Reeson, 2001; Agüloğlu, 2009; Agüloğlu, 2009; Dimashkieh, 1993)** •**Denture Bar coding:** Applicable to dentures consists of a machine-readable code of a series of bars and spaces printed in defined ratios. • **Lenticular card method:** Lenticular lens is used to produce images with an illusion of depth, morph, or the ability to change or move as the image is viewed from different angles. **ID band method (Christos Stavrianos, 2007):** Stainless steel metal band containing an identifiable coding system representing patient details is placed in a shallow recess prepared in the denture base. The band is covered with clear acrylic resin, trimmed and finished in the usual manner. **Paper Strip method (Thomas, 1984):** It utilizes onion skin paper. The acrylic resin fitting surface situated adjacent palatally between the ridge and the center of the palate is moistened with monomer on a small brush. The strip of typed paper is laid on this surface and the paper is moistened with the monomer. Clear resin is then placed over the paper before final closure of the denture flask.	• This technique is easy to operate. • It is economical. • This technique is economical. • This is useful on acrylic resin dentures of those patients who object to normally visible identification marks. • Denture bar coding can be used with crown and bridge restorations and can survive temperatures above 600°C, which can be encountered in plane crashes. • Denture bar coding gives exact information in every situation regardless of whether fire or water is involved. • Denture bar coding is easy to perform and not very expensive. • Lenticular printing is a simple, cheap and quick method. • This method can store a large amount of information. • The labels showed no sign of fading or deterioration. • The lenticular card stores the patient's information has two or more images that can be viewed by changing the angle of view. • It is easy to perform and not very expensive. • The ID band method can withstand deterioration by fire. • This method is economical. • This method is easy to perform. • This procedure is easy, inexpensive and time-effective •	• It can cause food entrapment, bacterial infection and irritation. • This technique has been associated with malignancy due to continuous irritation of tissues. • The mark is not readily visible and examination under special conditions is required to determine its presence. • It requires expensive special equipments.

T bar method (Ryan *et al*., 1993): A T-shaped clear PMMA resin bar is constructed by cutting baseplate wax and then is processed and finished in clear PMMA.An identification printed label (reduced in size, print-face inward) against the flat section of the bar is fixed. It is then surface polished to produce a clear window displaying the ID label. **Laser etching (Nambiar *et al*., 2003):** Copper vapor laser is used to etch the non impression surface of denture with patient's information.	• Faster method	• This method is expensive and requires specialized equipment and technicians to perform the procedure.
FIXED PARTIAL DENTURES: Engraving ceramic crowns (Dimashkieh, 1993): After baking the opaque layer of porcelain, dentin porcelain is applied and initials of name of the patient or letters are carved with the brush. Stains are applied on carved initials followed by enamel porcelain application shaped with soft brush so that the initials are maintained. Few initials can be carved in crown and bridges due to lack of available space.	• A removable prosthesis can be easily dislodged and lost. A dental identification that is rigidly fixed in the oral cavity is more desirable.	

Palatal Rugae: Pattern of palatal rugae is unique for every individual similar to finger print and hence could provide forensic information. Thomas *et al* has classified rugaepattern as diverge, converge, curve, wavy, straight and circular (Kapali *et al*., 1997; Ibeachu *et al*., 2014). Palatal rugae is a moderately accurate tool in establishing identity of Indians as proposed. M Ohtani *et al* (2008) analysed the limitations of using palatal rugae for person identification in edentulous patients. In their study, although 90% of the 48 cases analysed were matched correctly the three misleading factors were found to be (i) poor demarcation of palatal rugae (ii) non complex pattern of rugae (iii) changes in palatal height. Palatal rugae patterns can also aid in gender differentiation and race differentiation (Ohtani *et al*., 2008).

Lip prints: Lip prints are an important forensic evidence in the scene of crime similar to finger prints. The study of lip prints is called cheiloscopy. Tsuchihashi et al[16] have proposed six different types of groove patterns in the lip which could be useful in crime investigation. However it has been shown that even prosthesis like removable partial denture and FPDs can also beused to identify deceased individuals. For this the identification mark should be specific, technique should be simple and the mark should be fire and solvent resistant (Chapter 10 : Forensic dentistry; Charles *et al*., 2017; Perry, 1974; Agüloğlu *et al*., 2009).

History: The earliest recorded case of forensic dentistry concerns a female associated with Emperor Nero, who was identified after her death through the uniquearrangement of her teeth. In the year 66 A.D, Nero's mistress Sabina got his wife killed by her soldiers and demanded to see the head of the victim in a dish. She recognized the head with a black anterior tooth. Later in 1775, Paul Revere identified victims of a revolutionary war by their teeth and dental work. He also identified the body of Joseph Warren by identifying a Walrus tusk used as a pontic for his missing maxillary canine (Devor, 1977). In 1977, the body of Hitler and his wife Eva Brauma were identified using dental records with radiographs and prostheses. Sansare K and Dayal PK in their review in 1995 have mentioned that according toElphinstone, M. Raja Jayachandra Rathore of Canouj, died on the battlefield in 1191. His body was identified by his false anterior teeth. This was probably the first case of identification using dentition from India (Sansare, 1995; Bagi, 1977). Thousands of people lost their lives in the world trade center disaster in the U.S.A on September 11, 2001.

DeoxyriboNucleic Acid (DNA) extracts from toothbrushes of the victims were used in the identification of some victims (Devor, 1977; Sansare, 1995; Bagi, 1977).

DISCUSSION

Prosthodontist can become part of forensic team and render their services in a better way. There are various process and systems employed for identification, among them is denture marking system (Rathee, 2014; Coss, 1997; Bhardwaj *et al*., 2017). Denture marking or labeling is a recent concept in prosthetic and forensic dentistry and the forensic experts have urged its routine practice. The need for labeling is to confirm personal identification in victims of fire, mass disasters, etc. Various techniques like inserting a laminated label, usually containing the name of the individual or the hospital number, etc., or surface marking on the dentures can be used (Oliver Brian, 1989).

Some proposed requirements for marking dentures are (Oliver Brian, 1989; Stavrianos *et al*., 2007; Mohan *et al*., 2012):

- The strength of the prosthesis must not be jeopardized.
- It must be easy and inexpensive to apply.
- The identification system must be efficient.
- The marking must be visible and durable.
- The identification must withstand humidity and fire.
- The identification mark should be cosmetically acceptable.
- The identification mark should be biologically inert (when incorporated into the denture).

The recent advances in denture marking use, of bar codes and QR codes. In a developing country like India, an insufficient database of the citizens, antemortem medical and dental records have challenged the forensic science (Agüloğlu *et al*., 2009). The 2D barcode can hold voluminous information like case sheets and images. They can be very useful in dental hospitals with large patient volumes and where students have multiple complete denture patients at any given time ensuring rapid recognition and minimal risk of denture exchange and cross-infection. From the forensic point of view, dentures with barcode markers recovered from the deceased may be easily recognized by the help of a mobile camera.

Since the 2D barcode can hold photographic details. The denture can also be connected with antemortem photographic records to facilitate identification. Nevertheless, thermal tests revealed that the photographic marker and barcode were only resistant to around 200 300°C, which is considerably lower than for the metal matrix band (1050°C), this being similar to that of other metal marker. That's why the metal markers are considered as most ideal for postmortem identification (Agüloğlu *et al*., 2009; Agüloğlu, 2009; Agüloğlu *et al*., 2009). A similar method like using bar code as a denture marker is the QR code. It has many advantageous characteristics, such as simpler and handy technique, cost-effectiveness, and large data storage capacity. QR Code like any other marker is accurate as such, but its effectiveness in unfavorable conditions determines the clinical application. Instead of clear auto polymerizing acrylic resin, clear acrylic sheets were used to cover the label as the probability of QR Code getting distorted by the monomer content is high and the porosity of auto polymerizing acrylic resin would affect the scanning result. Barcodes and QR Codes, which are usually associated with commercial products on the market, were applied in denture identification systems, which contributes greatly to forensic science (Poovannan *et al*., 2016; Shakil *et al*., 2015; Karteek *et al*., 2015).

Dental implants in forensic identification: Identification of victims by dental implants is the emerging field in forensics. Dental implant is a component that is placed within the jaw bones to aid support for the dental prosthesis by means of osseointegration. Recently dental implants are more often used in dental identification especially for cases where dentition is entirely constructed from implants. These dental implants fuses with bone through the biological process called osseointegration. Some of the materials like titanium and ceramic help in bone integration rather causing foreign body reaction. Recent advances like implant recognition software, radiographic recognition of dental implants and assessment of batch numbers help the forensic odontologist in identifying the victims by comparing with the ante mortem records of the affected victims. Implant software recognises (IRS) implants according to the specifications provided that makes the procedure efficient when it is used along with the radiographic techniques. Various identifying modalities have been followed by the odontologist for implant recognition. IRS adds to the general dental practioners in identifying the unidentified implants (Deepalakshmi, 2014; Michelinakis, 2006).

Summary

The different and unique nature of our dental anatomy and the placement of custom restorations ensure accuracy when the techniques are correctly employed. Prosthodontist plays a vital role in Forensic dentistry for the identification of those individuals who are not identified visually or by other means. Denture marking or labeling is a concept that is routine practiced and has been urged by forensic dentists internationally for many years. Among the two methods mentioned, the surface method appears to be applicable and relatively cheap, but it disappears very easily and requires reapplication. It is obvious that only by marking a person's prosthesis one's identity can be revealed when all other methods fail. This in itself is reason enough to justify the implementation of ID marking in prosthesis. The dentist must inform the patient of the benefits of labeling the prosthesis and motivate him to do the same.

To summarize, the justification and advantages of identification in dentistry are

- Patient identification
- Appliance identification
- Recording and storage
- Quality assurance and quality control
- Retrieval of dental records
- Complete and assurance documentation
- Improved accountability for purchasers/providers
- Improved inventory cost management
- Diagnostic and decision support
- Education
- Accurate billing
- Ability to trace suppliers, materials, equipments.

Conclusion

From the overview it was clear that the prosthetic appliances with identification marking can be taken as important evidence in forensic investigation and in various medico legal issues. The acceptance of denture marking is probably population-specific and may be influenced by socio-demographic factors such as education level. The reason for not marking denture were cost, lack of awareness of standards and recommendations and a belief that it was of little importance. In dental education, education at undergraduate level is needed regarding the social and forensic value of marking denture. There is a need to offer patients a method of marking the identification according to aesthetic requirements and also to be permanent and inexpensive.

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