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# Dental and Oral Features Useful in Identification

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**Abstract:** The ability of the teeth to survive in most of the conditions encountered at death and during decomposition has made forensic dentistry very useful in recognition of unknown bodies. Recognition can be reached by comparison of the postmortem and antemortem dental record and determination if the two records were made or could have been made from the same individual. Dental identification depends on the condition of the victim and the availability of antemortem dental records and therefore an accurate dental charting with radiographs is of high importance and can lead to safer conclusions. As in every identification, DNA can play a significant role in dental ones. Additionally, dental prosthetics and endodontic imaging are valuable sources of data useful in the whole process.

**Key words:** Dental records, radiography, removable/fixed prosthodontics, endodontics, forensic comparison, human identification

## INTRODUCTION

The teeth are the hardest substances in the human body and can survive in most of the conditions encountered at death and during decomposition even when the body is exposed to extreme forces and/or temperatures (Sweet, 2010; Cardoza, 2004). Based on experiments the limits of resistance of teeth microstructure at extreme temperatures range between 800 and 1000°C where enamel and dentine seem to lose their integrity and melt. In even higher temperatures reaching 1100 and 1200°C, teeth and bone microstructure decomposes completely (Holk, 1996). On the contrary, clement claims that although temperature reaching 1600°C can provoke skeletal mineral to melt, it does not have the same effect to teeth which retain their microstructure and tertiary architecture (Clement, 1998). It is however, common for the whole intact dentition to survive even after intense prolonged household fires (Sopher, 1976). That happens because of the bone and muscular structure of human face.

As temperature raises and the body heats up, the tongue projects between the teeth as a result from gases' production from the intenstines and stomach which are forced into the mouth (Botha, 1986; Borrman *et al*., 1994). In addition, teeth can be protected during prolonged exposure to extreme temperatures due to contraction of the masticatory muscles and cheek and lip musculature. Dentures *in situ* can be similarly protected (Fig. 1) (Taylor *et al*., 2002; Stavrianos *et al*., 2008a).


Fig. 1: Severely burned body after examination. Note the mandible removable partial denture and the metal identification code number on the right part

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This durability of teeth is a feature that makes forensic dentists regular participants in forensic investigation (Petju *et al*., 2007; Stavrianos *et al*., 2008b) and has made Forensic Odontology play a key role in the identification of large numbers of victims (Sweet, 2010). The dental identification of humans occurs for a number of different reasons mainly in those cases when the body is fragmentized or disfigured and visual recognition cannot be done. The advanced step of putrefaction disables determination of identity by recognition and dactiloscopy and therefore such cases require dental identification (Blakaj *et al*., 2010).

The first recorded medico-legal identification of a body using dental means took place in the 1780's and since then forensic dentistry has played a prominent role in the identification of victims in many cases such as the 2003, Cedar fire (California) when 15 people lost their lives (Cardoza, 2004), the multishooting incident at Port Arthur in Tasmania playing a role in the retrieval evidence and identification of the incinerated victims (Taylor *et al*., 2002) and the Indian ocean tsunami disaster in Thailand in 2004 (Petju *et al*., 2007). In the last case, the dental identification system could not work efficiently due to lack of dental records and insufficient recorded detail and this is a reason why it is very important for dentists to keep accurate and complete dental records. The comparison of a missing person's dental records, models and radiographs with the dental evidence from unknown human remains has long been recognized as one of the most reliable means of positive scientific identification. Though an individual's dental characteristics will often change during life (cavities, fillings, extractions, etc.), changes after death are very slow. In fact, the dental condition at death has been shown to last in some cases for centuries. The consulting forensic odontologist will evaluate and compare the two dental records, the postmortem and the antemortem material. It is their task to determine if the two records were made or could have been made from the same individual. Though, most will employ similar techniques and routines, there can be some variation in the way that this comparison is executed ABFO (American Board of Forensic Odontology) (1994), Stavrianos *et al*. (2009).

## MATERIALS AND METHODS

**Collecting dental information:** The bodies of victims of violent crimes, fires, motor vehicle accidents and work place accidents can be disfigured to such an extent that identification by a family member is neither reliable nor desirable. Persons who have been deceased for some time prior to discovery and those found in water also present unpleasant and difficult visual identification (Pretty and Sweet, 2001). There currently exist four general methods to identify deceased human remains: visual recognition, fingerprint comparison, DNA analysis and medical/dental comparison. When data gathered by the other methods are insufficient or inexistent, the dental information available can provide enough individual characteristics to be utilized during the narrowing process.

The missing person report begins with that first contact from a family member or friend in order to gather the necessary medical and dental information. The next step includes collecting the dental information. This will include:

- Complete written records or good quality, readable photocopies. The originals are preferred
- Original radiographs or good quality duplicates. Again the originals are preferred. If duplicates are provided they need to be accurately labeled as to left-right orientation and include all dates, etc.
- Plaster or stone models (study models) if available
- Photographs if available. Some offices have prints or videos of patients in various stages of treatment
- Any other information that is available concerning that patient

It is preferable to obtain records from more than 1 office if possible even if one is quite old. This will help to authenticate the antemortem evidence. Clearly, individuals with numerous and complex dental treatments are often easier to identify than those individuals with little or no restorative treatment (Pretty and Sweet, 2001; Stavrianos, 2009). Whether a possible identity has been determined or not, the services of a forensic odontologist should be employed at this time. The dental examination is conducted under the authority and direction of the coroner/medical examiner and generally is carried out in a morgue, funeral home or private consultant facility as designated by each jurisdiction. A forensic odontologist should be retained to perform the examination and necessary record-taking so that all recorded information is accurate and preserved in such a way in the report as to facilitate potential comparisons.

**Severely fragmented body:** The area should be carefully checked for any remaining and not readily apparent hard and soft tissue fragments. Any recovered body parts or evidence should be placed in a body bag or other appropriate evidence container for transportation.

**Decomposed body:** The decomposition process in many cases will cause the fibres which hold the teeth to the

bone in the dental arches to break down. With this breakdown of the periodontal fibres, the teeth especially those with straight roots (like the front teeth) can be easily dislodged and potentially lost prior to examination. Before moving the body, note the absence of any front teeth by separating the lips gently (Blakaj *et al*., 2010).

**Severely burned body:** Extreme caution must be taken in transporting the body, not because whole teeth will dislodge but because the heat may have so desiccated and charred the crowns of the teeth that merely touching them may cause them to shatter. All surrounding debris which might contain dental evidence should be recovered as well, so that it can be inspected for dental fragments.

**Skeletonized body:** The teeth are readily visible but as in the decomposed cases, the soft tissue attachment between the teeth and the bone is no longer holding the teeth in the skeleton. Therefore, straight rooted teeth are easily and often lost. If the body has been buried or animal activity has caused the skeleton to be moved, it may be advisable to sift the surrounding ground for small bones, teeth or other evidence. These fragments can be tagged and brought to the facility for examination (Herschaft *et al*., 2006; Stavrianos *et al*., 2008a, b).

**Dental charting**

**Dental radiographs:** Every postmortem dental examination should include the taking of dental radiographs (X-ray films) because:

- A completely accurate dental charting without radiographs is not possible since, there are many conditions that are only detectable by this method i.e., root canals, retained roots, impacted teeth, etc.
- Dental films are the hard evidence that will be needed to substantiate any conclusions in the case. Anyone can make recording errors on a chart

The radiographs are solid objective recordings of the actual dental characteristics (Fischman, 1985; Goldstein *et al*., 1998; Wood *et al*., 1999; Cordner and McKelvie, 2002; Herschaft *et al*., 2006).

**Bitewing radiographs:** It is likely to turn up as part of the antemortem dental record. These films do not show the areas around the ends of the roots and therefore may not disclose some very useful information.

**Periapical radiographs:** A full set of these films should be taken along with any bitewing films. They show the bony structure at and around the end of the root as well as the entire tooth itself.

**Panoramic radiographs:** They should be used for comparison to antemortem dental films cautiously if the antemortem films are of a different type. This is because the film is so large that individual teeth and supporting structures are often overlapped and/or distorted making comparison to other film types difficult and the sheer logistics of positioning a decedent's head, jaw or jaw fragments, onto the machine may prevent the production of a quality image (Schwartz and Woolridge, 1977).

**Medical radiographs:** Radiographs commonly taken for orthodontic purposes or for diagnosis of head injuries, sinus problems and the like. These films usually show the entire skull from a particular view or exposure. However, the visualization of the teeth is difficult due to overlapping of teeth, superimposition of the right and left sides of the arches and other types of distortion (Fischman, 1985).

**Photographs:** Dental photographs are very helpful in preserving the evidence, especially when there is some unique dental feature which would be difficult to describe otherwise. Photography can also provide a double check for possible recording errors. In addition, photographs, particularly those of the front teeth may be useful for comparisons to antemortem photographs which show unusual features of these teeth (Wright and Golden, 1997).

**Study models:** Seldom used to preserve evidence in identification cases. Due to fragility of the teeth in some situations and the breakdown of the soft tissue in others, taking impressions can under certain circumstances, alter the existing evidence (Herschaft *et al*., 2006; Campobasso *et al*., 2007).

## RESULTS

**Comparison of antemortem and postmortem data:** Dental identifications are usually based on restorations, caries, missing teeth and prosthetic devices existing in the records (Appendix). Nonetheless, the significant decrease in caries incidence in recent years will necessitate greater reliance on other dental findings in the future. As long as records are sufficient, an infinite number of objective factors can contribute to identification. Thus, objective data, especially those which are unique to the individual, facilitate the decision for concordance or exclusion.

Simultaneously, obvious differences between the antemortem and post-mortem evidence (errors in recording, dental treatment subsequent to the available antemortem record) must be unravelled. The following

subsections constitute examples of objective findings in the teeth, periodontium and jaws which may be present in both antemortem and post-mortem records. Whereas the factors below are incomprehensive, they may be used for checking and demonstrating the range of objective findings that may be applied in difficult identification cases ABFO (American Board of Forensic Odontology) (1994), Herschaft *et al*. (2006).

**How can dental works help forensic identification?** The field of Prosthetics plays a crucial role on the identification procedure and it is a very useful tool for the forensic odontologist as it constitutesavery large part of dental work performed. Dental prostheses very useful to the forensic dentist are usually dentures, fixed partial dentures, crowns, bridges and also dental implants that tend to be more widespread every day.

**Removable prosthodontics:** Dentures are those mainly used in individual identification and that is the reason why the necessity for denture marking is so emphasized. Consequently, several methods for denture marking and identification have been invented and reported (Berry *et al*., 1995; Coss and Wolfaardt, 1995; Ibrahim, 1996; Milward *et al*., 1997; Ling, 1998; Todo and Lukens, 1977; Rajan and Julian, 2002; Millet and Jeannin, 2004; Kamath and Kamath, 2005; Richmond and Pretty, 2007; Stavrianos *et al*., 2008a, b). These can be devided into surface marking and inclusion methods. Inclusion methods involve the incorporation of metallic or non metallic labels, barcodes and microchips (Nuzzolese *et al*., 2010). Lenticular card for example (Colvenkar, 2010) is a technology in which a lenticular lens is used to produced images with an illusion of depth, morph or the ability to change or move as the image is viewed from different angles. It is a polyethylene terephthalate Lenticular card, 13 mm long by 10 mm wide of 0.5 mm thickness having the patient's details (first flip: name, sex, age and second flip image: adress, driving license number when viewed from a different angle) incorporated in the external posterior buccal surface of the maxillary denture.

The major advantages include its durability (up to 4 months in water showed no signs of fading or deteriorating), the storage of large amounts of information and also its ease of use as no glasses or special devices are required to read the data. The only disadvantage is that the information can never be changed. However, it is considered to be a simple and cost effective means of denture identification and it can also be used for removable partial dentures. Another recommended method is the insertion of a Radio Frequency Identification (RFId) tag into dentures (Nuzzolese *et al*., 2010). A serial number that identifies a person is stored in a microchip with an attached antenna. The chip and the antenna together are called an RFId tag or transponder. The antenna enables the chip to transmit the serial number or other information to a reader who converts the radio waves reflected back from the RFId tag into digital information that are then passed to a computer with applications to interpret it.

A general dentist without any special training or assistance from a laboratory technician can easily perform the incorporation of a microchip transponder in a denture and because of the tag's size (12×3 mm in depth) there is no real weakening of the denture and the procedure is really economical. However, further investigation is needed to evaluate RFId tags' technical performance under a range of post mortem circumstances and environmental impacts.

Denture marking is not something utopian but a real innovation in human identification as it has been proved in real life and cases. An example in which forensic odontologists used dentures in body identification is the multishooting incident at Port Arthur, Tasmania (Toolson and Taylor, 1989; Taylor *et al*., 2002) where 32 victims were shot dead, 19 severely injured in a short time and 3 were incinerated in a cottage where a married couple lived and was on fire after the gunman used it as his shelter taking a hostage. Forensic odontologists were called to identify the three victims of the fire. At the first body a full upper denture was well fitting and in its position. No denture identification marking was present but the characteristics of the denture were well studied and recorded. Dental records were obtained from a dentist and a dental laboratory and the denture was taken to a dental technician who was positive that the denture was made by him as he remembered doing the gold inlays on the denture teeth.

At the second body, the posterior part of a partially burnt upper denture was found but there were no distinguishing features were noted and the dental technician was unable to confirm whether he had constructed this denture or not. By elimination the identity of remains were suspected to be those of the wife of the man who identified as body 1 from the full upper denture. Therefore, even though without denture marking, removable prosthetics are a crucial assistance in human identification and this is why so much research is being done to invent new methods for denture marking.

**Fixed prosthodontics:** Dental implants have become a regular choice of treatment in replacing lost teeth or entire dentitions. Since, dental implants remain intact following most physical assaults thanks to their high resistance

properties (Berketa *et al*., 2010), their contribution in human identification can be determinant. The Strauman ™Company has recently released information that within the camber of their implants they have laser etched batch numbers. The same company studies to ascertain if the batch number was still identifiable following intense heat exposure (incineration). The results indicated that implants with an abutment attached maintained an intact identifiable batch number. If individual serial numbers rather than batch numbers could be placed then there will be a new approach for the identification of the deceased. More tests were released to certificate the durability of dental implants following incineration (Berketa *et al*., 2010). The results were unanimous to other studies performed and showed that dental implants are still recognizable following incineration.

The placement of crowns and bridges is an everyday dental procedure and as with dentures, their marking with a patient's name, zip code or serial number makes them unique amongst the crowd. If a complete code is too long (the social security number for example), first five numbers can be placed on the lingual surface and will shorten the research time needed. When more than 1 crown available the whole number may be marked in its entirety (Ferrari, 1993). Apart from dental prostheses, the materials used in everyday dentistry being resistant in most circumstances can be determinant in comparison of postmortem and antemortem clues and radiographs. An amalgam profile still intact in form during high temperatures even though the tooth enamel has popped off (Purves, 1975).

As it concerns dental prostheses' materials these are most acrylics, gold or chrome street alloys and the teeth can be of porcelain or acrylic. Acrylic melts at 20-250°C in comparison to the metals enduring temperatures up to 1100°C. For identification purposes, prostheses indicate both missing and clasped teeth. Moreover, experiments have shown that porcelain denture teeth were not damaged when placed into a crematorium furnace at 900°C for 1.5 h. Polymethacrylate denture bases and teeth depolymerise to monomer at 450°C (Bose *et al*., 2005; Herschaft *et al*., 2006).

**Endodontic imaging:** It is also useful in the comparison process for personal forensic identification. Radiographs are images that capture the unique morphological features of teeth, surrounding structures and physical detail of past dental treatment resulting in changes to a dentition. As for root canal treatments, they provide a wealth of morphological detail, providing rich data for the comparison of radiographs from a known missing person and an unknown deceased person to answer the question of whether the two images are derived from the same person. The obturation of root canals and hence post-preparation anatomy will be demonstrated by the radio-opacity of the materials (e.g., gutta-percha) used for root filling in a post-treatment radiograph (Fig. 2). Moreover, endodontically treated tooth often require complex restorations of their coronal structure. The complexity of the coronal restorations and variability in post and

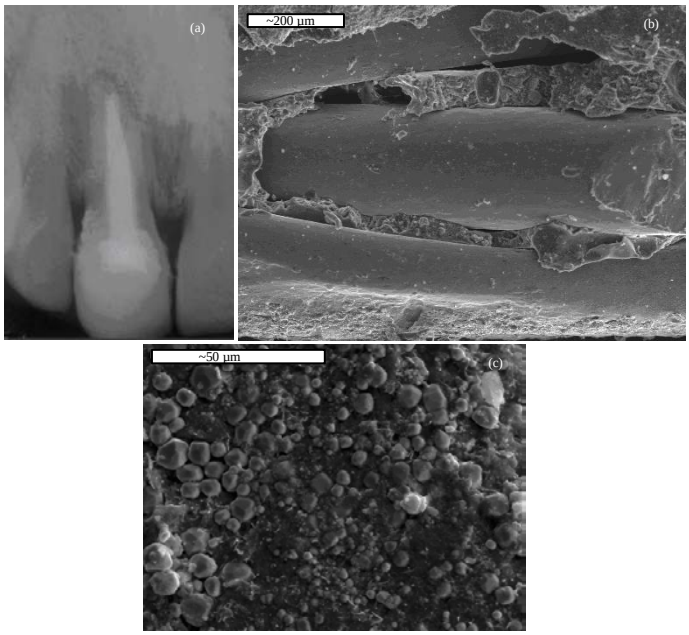


Fig. 2: a) Endodontically treated tooth; b) SEM image shows the dentin tubule contents gutta-percha (200 µm); c) Radiopaque material (wolfram) of the AH26 sealer

core material, design and placement provide further information features to each such treated tooth. Thus, taking post-mortem radiographs in such a way as to duplicate as closely as possible the conditions under which the ante-mortem radiographs were produced, permits demonstrably rigorous methods of comparison, raising the probative value of the outcome (Forrest and Wu, 2010). In addition, the proof of brands and classes of materials can be determined by the use of a SEM procedure (Scanning Electron Microscopy). Burnt and non-burnt specimens can be used in such procedures of microscopy. This method is a quite powerful type of approach for a forensic odontologist to acquire evidence. The uniqueness of its case concludes on the type of method for identification. Since, SEM facilities are accessible, the use of this method to identify dental structures and restorative materials is highly needed when the traditional methods are inconclusive (Herschaft *et al*., 2006).

**Role of DNA in dental identifications:** The resistant nature of dental tissues to environmental assaults including incineration, immersion, trauma and decomposition, enables them to represent an excellent source of DNA material. PCR consists a valuable technique allowing to amplify DNA at pre-selected and specific sites.

Comparison of DNA preserved in and extracted from the teeth of an unidentified individual can be made to a known antemortem sample (stored blood, hairbrush, clothing, cervical smear and biopsy) or to a parent or sibling (Sweet and di Zinno, 1996; Pretty and Sweet, 2001; Herschaft *et al*., 2006; Stavrianos *et al*., 2010a, b).

## DISCUSSION

Dental procedures cause non-reversible changes to the teeth compared to bone fractures and surgical procedures. These changes are often maintained during trauma and decomposition. That is the reason why dental records are crucial to human identification, procedure called dental identification (Komar and Lathrop, 2006).

Dental records very useful in dental identification are common X-rays made during treatment or as an aid in better diagnosis and pre-treatment planning. Simirarly, study casts for the analysis of the articulation or a more or less complex prosthetic treatment plan. Both provide information that can be compared to the body or the dental records of a missing person (Pretty and Sweet, 2001). During this procedure, the features that are compared are: presence or absence of teeth, the shape, size and bone peculiarities (Campobasso *et al*., 2007). According to the aforementioned, dental identification depends on the condition of the victim and the availability of antemortem dental records. Consequently, the accuracy of an identification process depends on many factors which effect not only the quality of dental records but also the post-mortem elements. Such factors are the circumstances of the accident, the nationality, the country of origin, the antemortem dental treatment, the presence of antemortem dental records and the degree of dental injury (Valenzuela *et al*., 2002). In order to minimize the factors affecting the accuracy and rapidness of the identification process the establishment of a commonly accepted organization of a system for the registration of the odontological status of individuals that will be part of the health system of every country. This will provide well registered, detailed dental records available to the competent authorities for dental comparison and identification (Blau *et al*., 2006).

Acknowledging the importance of forensic dentistry in human identification, this field is becoming more and more popular with new approaches based on molecular biology and DNA. DNA typing of genomic or mitochondrial DNA for the detection of gene polymorphisms and of a specific repetitive sequence of the DNA in order to match these results with putative antemortem findings are some of the most innovative means used in identification process now a days (Herschaft *et al*., 2006).

## CONCLUSION

A specific procedure for the record of the dental status of individuals is necessary so as to help the process of human identification following an accident or a mass disaster. Furthermore, it is crucial in forensic medicine to ensure the training of specific groups, the organization of multidisciplinary groups as well as the international cooperation.

## APPENDIX

Dental and oral features useful in identification ABFO (American Board of Forensic Odontology) (1994)

**Teeth:**

- Teeth present
- Erupted
- Unerupted/impacted
- Missing teeth
- Congenitally missing
- Lost antemortem
- Lost perimortem/postmortem

**Crown pathology**
- Caries
- Attrition/abrasion/erosion
- Atypical variations: e.g., peg laterals, fusion/ gemination, enamel pearl and multiple cusps
- Dens in dente
- Dentigerous cyst

**Tooth type**
- Permanent
- Mixed dentition
- Retained primary teeth
- Supernumerary teeth

**Root morphology**
- Size, shape, number, dilaceration and divergence of roots
- Root pathology
- Root fracture
- Hypercementosis
- External root resorption
- Root hemisections

**Tooth position**

Malpositions: facial/linguoversion, rotations, supra/infra positions, diastemas and other occlusal discrepancies

**Dental restorations**
- Metallic restorations: amalgams, gold or nonprecious metal crowns/inlays, endo-posts, pins, fixed prostheses and implants
- Nonmetallic restorations: acrylics, silicates, composites, porcelain, etc.
- Partial and full removal prostheses

**Crown morphology**
- Size and shape of crowns
- Enamel thickness
- Location of contact points, cemento-enamel junction
- Racial variations: e.g., shovel-shaped incisors, carabelli cusp, etc.

**Pulp chamber and root canal morphology**
- Size, shape and number
- Secondary dentin
- Pulp stones, dystrophic calcification
- Root canal therapy: e.g., gutta percha, silver points, endo paste and retrofill procedures
- Internal resorption
- Periapical pathology
- Periapical abscess/granuloma/cyst
- Cementoma
- Condensing osteitis

**Crown morphology**
- Size and shape of crowns
- Enamel thickness
- Location of contact points, cemento-enamel junction
- Racial variations: e.g., shovel-shaped incisors, Carabelli cusp, etc.

**Periodontium**
- Gingiva: Morphology/Pathology
- Contour: gingival recession, focal/ diffuse enlargements and interproximal craters
- Color: inflammatory changes, physiologic or pathologic pigmentations
- Plaque and concretions oral hygiene status, stains and calculus

**Periodontal ligament: morphology/pathology**
- Thickness
- Widening (e.g., scleroderma)
- Lateral periodontal cyst
- Alveolar process and lamina dura
- Height/contour/density of crestal bone
- Thickness of inter-radicular alveolar bone
- Exostoses and tori
- Pattern of lamina dura (loss, increased density)
- Periodontal bone loss
- Trabecular bone pattern osteoporosis, radio-densities
- Residual root fragments, metallic fragments

**Maxilla and mandible**
- Maxillary sinuses: size, shape, retention cyst, antrolith, foreign bodies, oral-antral fistula, relation ship to adjacent teeth
- Anterior nasal spine, incisive canal, median palatal suture, incisive canal: size, shape and cyst
- Pterygoid hamulus: size, shape and fracture
- Mandibular canal/mental foramen: diameter, anomalous (bifurcated), canal, relation ship to adjacent teeth
- Coronoid and condylar process: size and shape
- Temporomandibular joint: size, shape, hypertrophy/ atrophy, ankylosis, fracture and arthritic changes
- Other pathologic processes/jaw bones: developmental/fissural cysts, hemorrhagic (traumatic) bone cyst, salivary gland depression, reactive/neoplastic lesions, metabolic bone disease, other disorders inducing focal or diffuse radiolucencies or radiopacities, evidence of orthognathic surgery or prior evidence of trauma (e.g., wire sutures, surgical pins, etc.)

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