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Forensic Dentistry: 1. Identification of Human Remains

Abstract: For many forensic dentists the identification of found human remains will comprise the majority of their case work. However, there is rarely a typical dental identification. The resilience of teeth and their supporting tissues to peri- and post-mortem assaults provides a wealth of information for those interested in the identity of the deceased. Chemical attack, burning, burial, submersion, and even severe head and neck trauma are all withstood by the dentition to an extent where identification is possible. The lack of a tentative identification or failure to locate dental or similar ante-mortem records is a more common reason for an odontological investigation to fail.

Clinical Relevance: The purpose of this review is to describe the techniques employed by forensic dentists to identify human remains and also to provide details of some of the novel developments within this area.

Dent Update 2007; 34: 621-634

Introduction

Reasons for identification

The living have responsibilities for the dead; and in particular, civilized societies recognize the need for identity both during life and at death. This right to Human Identity is enshrined within the UN Charter of 1948. Dental identification of humans may be required for a number of different reasons (Table 1) and in a number of different situations.[1] The 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.[2] Persons who have been deceased for some time prior to discovery and those found in water also present unpleasant and difficult visual identifications. Dental identifications have always played a key role in mass disaster situations (both natural and man-made) and in the mass casualties normally associated with aviation disasters.[3] Owing to the lack of a comprehensive fingerprint database, dental identification continues to be crucial within the EU. However, it should be noted that it is possible to recover ante-mortem fingerprint evidence from recently deceased individuals by visiting their homes, for example, and collecting evidence from objects that they will have handled.

Criminal	Identification of a murder victim is normally a prerequisite prior to any criminal investigation.
Marriage	It is usually necessary to confirm the death of a spouse before remarriage is permitted.
Monetary	Life insurance companies and similar will require a scientific confirmation of death, and scientific identification if necessary, prior to the commencement of payments.
Burial	In order to be buried in certain burial grounds, a positive identification and proof therefore of religion is required.
Social	Society's duty to preserve human rights and dignity beyond life begins with the basic premise of an identity.
Closure	Identification of loved ones is an essential step in the grieving process.

Table 1. Common reasons for identification of found human remains. (After Pretty and Sweet, 2001.)

Strength of dental evidence

Numerous methods exist for the identification of human remains and all have their advantages and disadvantages; these include:

- Visual identification;
- Fingerprints;
- The presence of medical prostheses;
- DNA; and, of course
- Odontological techniques.[4]

Dental identifications comprise a sizeable proportion of all identifications. In the north-west of England, 70% of individuals who require formal, scientific identification are identified by their dental records and this relates to approximately 45 cases per year.[5] In mass disasters, odontological identifications have comprised up to 90%

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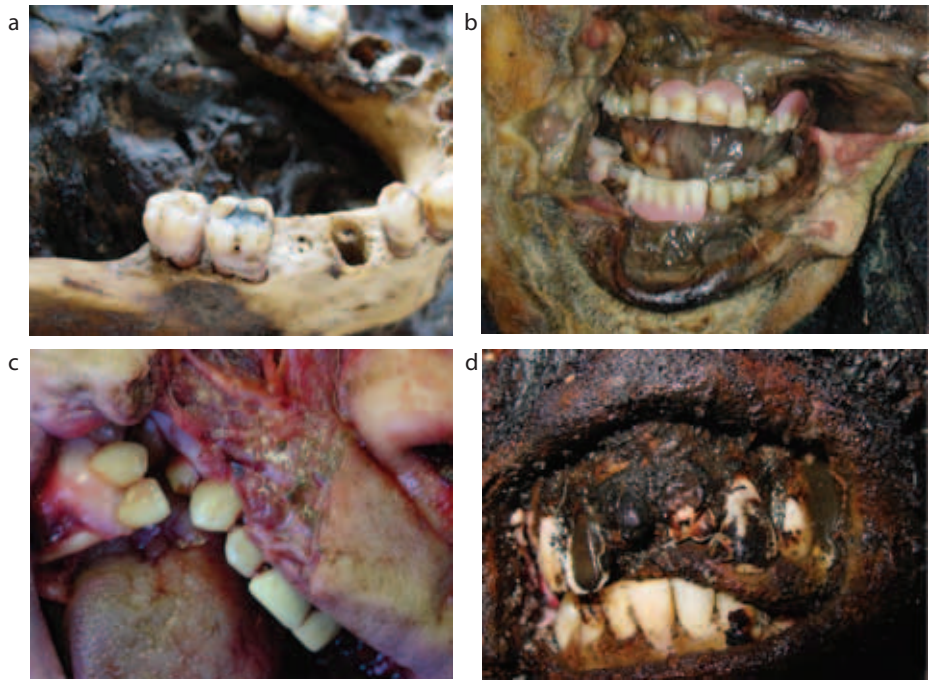

Figure 1. Resistance of dentition to decomposition, severe trauma and fire. **(a)** Skeletal remains discovered some 18 months after death. Despite post-mortem loss of some teeth, those remaining contain a wealth of information for identification. **(b)** Gross decomposition of the soft tissues, but the dental structures and prostheses remain in sound condition. **(c)** Initial presentation of road traffic accident victim, with extensive head and neck trauma. Despite maxillary and mandibular fractures, the teeth themselves are in good condition. **(d)** Anterior teeth; the lips have retracted and the anterior teeth have suffered damage to the enamel due to the differential expansion of the underlying dentine during exposure to heat. These brittle teeth should be photographed and radiographed as soon as possible. The use of transparent nail varnish may prevent further damage.

of all individuals identified. The remainder are usually either viewable for visual identifications or have ante-mortem fingerprint records.[6]

Why is dental evidence so useful? While very few of us will have, for example, a fingerprint record, almost everyone has teeth, and those who do not will commonly wear a dental prosthesis. The non-restored dentition is, itself, unique between individuals, but the processes of dental treatments render the dentition increasingly 'unique' through the placement of restorations, extractions, implants and prostheses.[7] The attendance of individuals to their dental practitioner and the methods of recording the restorations undertaken ensure that, in many cases, the presence of dental treatment will indicate that an ante-mortem record of such treatments exists. It should be noted that this is not always the case but, even in the absence of ante-mortem records, the teeth contain an invaluable source of information that can be employed to produce a post-mortem profile of the individual, including features such as age at death, racial origin and, occasionally, even occupation![8]

A further reason for the usefulness of dental evidence is the post-mortem survival of the human dentition.[9] As the hardest structure in the human body, enamel lends an 'armoured' coating to teeth. The effects of fire, chemical attack, trauma and burial are all minimal (Figure 1). In cases of severe incineration, it is possible to stabilize dental tissues by the use of transparent nail varnish or hair lacquer until they can be examined in the mortuary. Even attempts to remove the teeth will sometimes leave their roots, which can contain a wealth of information, that can be employed in the odontological identification of an individual.[10] The protection offered by the enamel and dentine also serve to protect the molecular information contained within the dentinal tubules, pulp and vasculature of the tooth, which can serve to be useful sources of DNA when bone and deep muscle are not available.[11]

There are four main methods of dental identification and each of these will be described in turn:

- Comparative;
- Profile;
- Ageing; and
- DNA.

Comparative dental identification

The central tenet of dental identification is that post-mortem dental remains can be compared to ante-mortem dental records (including written notes, study casts, radiographs, photographs) to confirm identity.[12] Clearly, individuals with numerous and complex dental treatments are often easier to identify than those individuals with little or no restorative work. The teeth not only represent a suitable repository for such unique and identifying features, they also survive most post-mortem events.

A forensic dental identification is initiated by a request from the appropriate authority. The requesting authority will vary from region to region and, in the UK, it is most often the Coroner or, in Scotland, the Procurator Fiscal. Often, a presumptive or tentative identification is available (ie a wallet or driving licence may be found on the body, or the body may have been found in a residence) and this will enable ante-mortem records to be located. The responsibility for obtaining the records usually rests in the hands of the Coroner's Officer (often a police officer) who will, usually, contact the Dental Practice Board to obtain the name of the last registered dentist. It is of concern that no record of private practitioners exists, and this may present problems in the future. In other instances, the geographical location in which the body is found, or other physical characteristics, may enable a putative identification to be made, frequently using data from the missing persons' database. Ante-mortem records are sourced from the dentist of record.[13] A Coroner's Officer will generally present to the dentist a letter of authority from the Coroner and

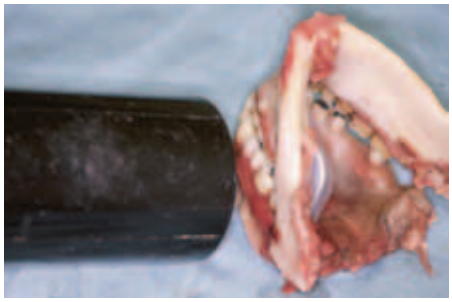

Figure 2. Replicating the orientation of a bitewing radiograph during a dental postmortem. Following removal of both the mandible and the maxilla, a postmortem bitewing radiograph can be taken for comparison to antemortem views.

practitioners are obliged to assist in the identification of one of their patients by the release of ante-mortem notes.

The forensic dentist produces the post-mortem record by careful charting and written descriptions of the dental structures and radiographs. If the ante-mortem records are available at this time, the post-mortem radiographs should be taken to replicate the type and angulation (Figure 2). Radiographs should be marked with a rubber dam punch to indicate ante-mortem and post-mortem to prevent confusion – one hole for ante-mortem and two holes for post-mortem.[13] Replication of DPT radiographs is particularly difficult, and while this can be done, it is more usual to take a full mouth series of radiographs to replicate the regions of interest. If the ante-mortem records contain study casts of any kind, an impression should be taken in the mortuary so that these may be compared.

Once the post-mortem record is complete, a comparison between the two records can be carried out. A methodical and systematic comparison is required, examining each tooth and surrounding structures in turn. While dental restorations figure significantly in the identification process, many other oral

TEETH

Teeth present
a. Erupted
b. Unerupted
c. Impacted

Missing teeth
a. Congenitally
b. Lost ante-mortem
c. Lost post-mortem

Tooth type
a. Permanent
b. Deciduous
c. Mixed
d. Retained primary
e. Supernumerary

Tooth position
a. Malpositions

Crown morphology
a. Size and shape
b. Enamel thickness
c. Contact points
d. Racial variations

Crown pathology
a. Caries
b. Attrition, abrasion, erosion
c. Atypical variations, enamel pearls, peg laterals, etc.
d. Dentigerous cyst

Root morphology
a. Size
b. Shape
c. Number
d. Divergence of roots

Root morphology
a. Dilaceration
b. Root fracture
c. Hypercementosis
d. Root resorption
e. Root hemisections

Pulp chamber/Root canal morphology
a. Size, shape & number
b. Secondary dentine

Pulp chamber/Root canal pathology
a. Pulp stones, dystrophic calcification
c. Root canal therapy
d. Retrofills
e. Apicectomy

Periapical pathology
a. Abscess, granuloma or cysts
b. Cementomas
c. Condensing osteitis

Dental restorations
1. Metallic
   a. Non-full coverage
   b. Full coverage
2. Non-Metallic
   a. Non-full coverage
   b. Laminates
   c. Full coverage
3. Dental implants
4. Bridges
5. Partial and full removable prosthesis

PERIODONTAL TISSUES

Gingival morphology & pathology
a. Contour, recession, focal/diffuse, enlargements, interproximal craters
b. Colour - inflammatory changes, physiological (racial) or pathological pigmentations
c. Plaque and calculus deposits

Periodontal ligament morphology & pathology
a. Thickness
b. Widening
c. Lateral periodontal cysts and similar

Alveolar process and Lamina dura
a. Height, contour, density of crestal bone
b. Thickness of inter-radicular bone
c. Exostoses, tori
d. Pattern of lamina dura
e. Bone loss (horizontal/vertical)
f. Trabecular bone pattern & bony islands
g. Residual root fragments

ANATOMICAL FEATURES

Maxillary sinus
a. Size, shape, cysts
b. Foreign bodies, fistula
c. Relationship to teeth

Anterior nasal spine
a. Incisive canal (size, shape, cyst)
b. Median palatal suture

Mandibular canal
a. Mental foramen
b. Diameter, anomalous
c. Relationship to adjacent structures

Coronoid & Condylar processes
a. Size and shape
b. Pathology

Temporomandibular joint
a. Size, shape
b. Hypertrophy/atrophy
c. Ankylosis, fracture
d. Arthritic changes

Other pathologies
a. Developmental cysts
b. Salivary gland pathology
c. Reactive/neoplastic
d. Metabolic bone disease
e. Focal or diffuse radio-opacities
f. Evidence of surgery
g. Trauma - wires, surgical pins, etc.

Table 2. Features examined during the comparative dental identification. This extensive list represents the complexity of these cases, particularly in those instances in which restorative treatment is absent or minimal. (After Pretty and Sweet, 2001.)

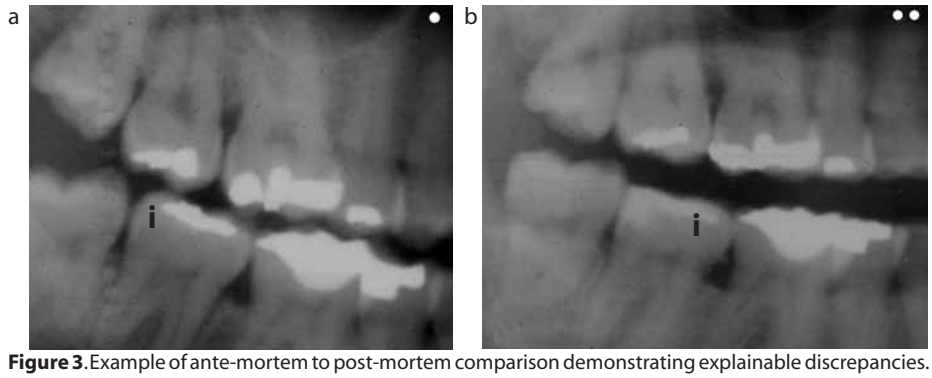

Figure 3. Example of ante-mortem to post-mortem comparison demonstrating explainable discrepancies. **(a)** Ante-mortem radiograph. **(b)** Post-mortem radiograph. There is only one discrepancy visible (labelled i). The restoration has been extended distally and also has been replaced by a composite (white) material rather than the original amalgam and this explains the decreased radio-density between the two materials.

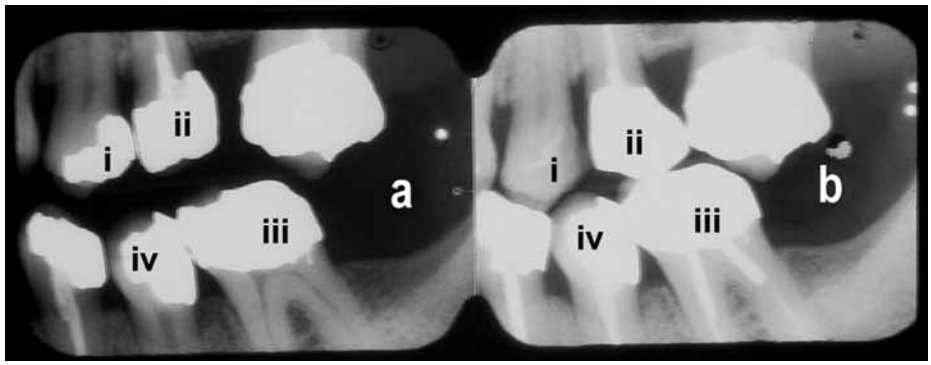

Figure 4. Example of a simple comparative identification. **(a)** This is the ante-mortem bitewing radiograph demonstrating the maxillary and mandibular left posterior teeth. **(b)** The post-mortem radiograph represents a positive identification with the ante-mortem but there are some differences between the radiographs that must be explained; there were some 8 years between the radiographs. **i)** The occlusal distal amalgam restoration is not present in the post-mortem film. Close examination reveals the evidence of a lining and examination of the body showed that this restoration had been lost. **ii)** The shape of the restoration has changed; in fact the amalgam in the ante-mortem film has been replaced with a cast restoration (crown). This is likely to have been done to close the gap between the teeth and prevent food packing. **iii)** This tooth has retained the small pin in the distal aspect but has been root-filled and also a post supported restoration has been placed – this is likely to be due to irreversible pulpitis. **iv)** Again this tooth has been root-filled but the very unique shape of the amalgam restoration can be seen.

features are assessed (Table 2), and these play an increasingly important role in those individuals with minimal restorations. With the progressive decrease in dental caries, so-called non-restorative cases are likely to become more common.[8]

Similarities and discrepancies should be noted during the comparative process. There are two types of discrepancy:

- Those that can be explained; and
- Those that cannot.

Explainable differences normally relate to the time elapsed between the ante-mortem and post-mortem records. Examples include teeth extracted or restorations placed or enlarged (ie a mesio-occlusal (MO) amalgam that is now a mesio-occlusal-distal (MOD)). If a discrepancy is unexplainable, for example a tooth is not present on the ante-mortem record but is present on the post-mortem record (or a MOD amalgam is now a MO), then an exclusion must be made.[14] When considering such 'unexplainable discrepancies' it is important to consider charting errors or incorrectly orientated radiographic films. Figure 3 illustrates explainable discrepancies. Fraud may be a factor in confounding an identification, for example the ante-mortem chart shows a full gold crown yet, in the mortuary, only a large pinned amalgam is seen.

A range of conclusions can be reached when reporting a dental identification. The American Board of Forensic Odontology[15] recommends that these be limited to the following four conclusions:

- Positive identification – the ante-mortem and post-mortem data match in sufficient detail to establish that they are from the same individual. In addition, there are no irreconcilable discrepancies.
- Possible identification – the ante-mortem and post-mortem data have consistent features but, owing to the quality of either the post-mortem remains or the ante-mortem evidence, it is not possible to establish dental identification positively.
- Insufficient evidence – the available information is insufficient to form the basis for a conclusion.
- Exclusion – the ante-mortem and post-mortem data are clearly inconsistent.

It is important to note that there is no minimum number of concordant points or features that are required for a positive identification[15] and, in this way, the process differs from fingerprint analysis. In some cases, a single tooth can be used for identification if it contains sufficient identifying or unique features. Equally, a full-mouth series of radiographs may not reveal sufficient detail to render a positive conclusion.[9] The certainty of identification conclusion lies with the odontologist, who must be prepared to justify his/her conclusions in court.[8] However, it should be pointed out that the decision to confer identity on any deceased individual lies, within England and Wales, solely with the Coroner, who may or may not accept the decision of the odontologist.

Figure 4 illustrates a simple case of a comparative identification using dental records.

Post-mortem dental profiling

When ante-mortem dental records are unavailable and other methods of identification are not possible, the forensic dentist can assist in limiting the population pool to which the deceased is likely to belong and thus increase the likelihood of locating ante-mortem

Abnormality	Description	Ethnicity?
Incisors: Chisel/Blade	Smooth palatal surfaces with little or no expansion of the proximal margins, small cingulum, rarely a cingulum pit.	Negroid and Caucasoid
Shovel-shaped incisors	Varying degrees of lingual edge thickening giving rise to 'shovel' appearance.	Mongoloid
Premolar: Occlusal enamel tubercle/pearl	A nodule of enamel on the occusal surface, often with a pulp horn extension; normally lost eary in life; can also be present at furcations.	Monogoloid
Maxillary molar Carabelli cusp	Of varying size, this additional cusp can be seen on the mesio-palatal aspect of the first maxillary molar.	Caucasoid
Mandibular molars: Supernumary distolingual root	Third root present on the distal aspect of lower molars.	Mongoloid, Inuit, Native American
Fourth molars	Additional molar distal to the third molar.	Negroid
Macrodonts	Typically of central incisors.	Caucasoid

Table 3. Dental ethnic indicators.

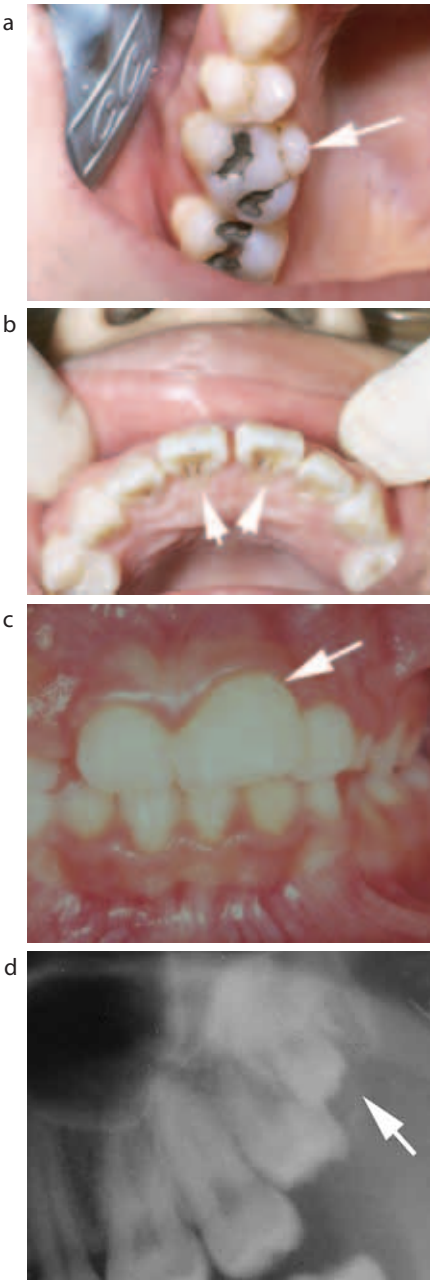

Figure 5. Dental ethnic indicators. **(a)** Cusp of Carabelli (arrowed) which is an indicator for Caucasoid individuals. **(b)** Incisal shovelling (arrowed) which is strongly associated with a Mongoloid ethnic origin. **(c)** The upper left central incisor is a macrodont – ie the mesio-distal width is increased relative to its contra-lateral equivalent. This is most common in Caucasoid individuals. **(d)** The presence of fourth molars; 9s, arrowed. These are most common in Negroid individuals.

dental records. This process is known as post-mortem profiling. The information from this process will enable a more focused search for identity. A post-mortem dental profile can provide information on the age, ancestry background, sex and socioeconomic status of the deceased. In rare instances, it is possible to provide additional information regarding occupation, dietary habits, habitual behaviour and, occasionally, on dental or systemic diseases.[16]

Forensic anthropologists most often provide details of osteological studies, but forensic dentists can assist in the process. The determination of sex and ancestry can be assessed from skull shape and form. Generally, from skull appearance, forensic dentists can determine race within the three major groups: Caucasoid, Mongoloid and Negroid. Additional characteristics, such as cusps of Carabelli, shovel-shaped incisors and multi-cusped premolars can also assist in racial determination (Table 3, Figure 5). Sex determination is usually based on cranial appearance, as no sex differences are apparent in the morphology of teeth that can be employed on an individual level, although population-based studies do exist.[16] Microscopic examination of teeth can confirm sex by the presence or absence of Y-chromatin and DNA analysis can also determine sex.[17]

Dental structures can provide useful indictors to the individual's chronological age. The age of children can

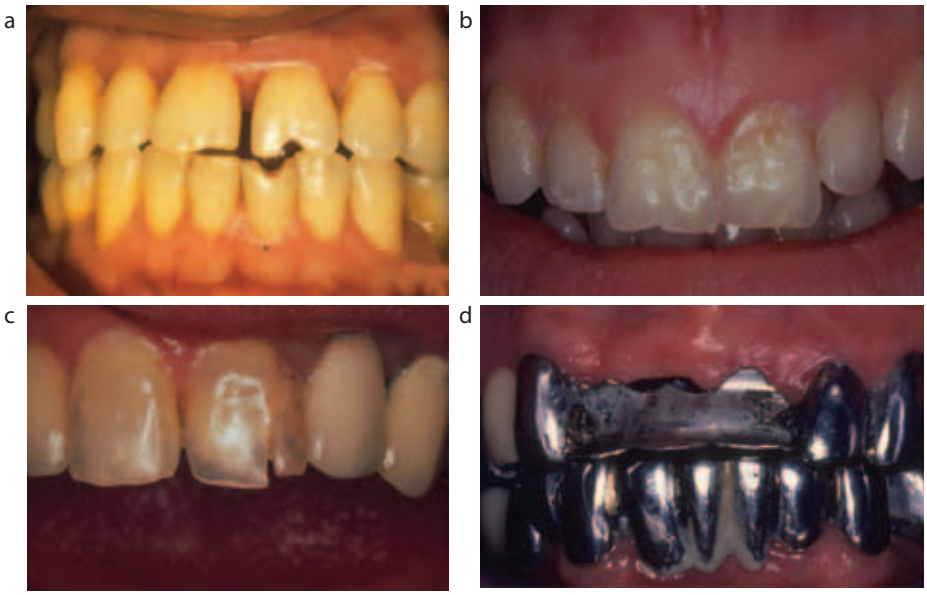

Figure 6. Additional findings from the human dentition. **(a)** This individual exhibits characteristic notching of the mandibular and maxillary left central incisors associated with electrical wire stripping. The individual has worked as an electrician for many years. **(b)** Labial erosion characteristic of the type seen among workers in acidic environments. **(c)** A notch caused by the holding of pins between the teeth; this individual was a seamstress. **(d)** Dental treatments typical of those provided in the former Soviet Republics; non-precious metal substructures with acrylic facings, many of which have been lost.

be determined by the analysis of tooth development and subsequent comparison to developmental charts, usually to an accuracy of approximately ± 1.5 years.[18] Third molar development is used by some forensic dentists to assign age to young adults, although doubts concerning the accuracy of this technique have been raised due to the variability of these teeth.[19]

Those who advocate third molar use claim an age accuracy of ± 4 years, but only within the 16–22 year-old range.[20] Middle-aged and older adults present difficulties. Periodontal disease progression, excessive wear, multiple restorations, extractions, bone pathosis and complex restorative work may indicate an older individual.[21] Accuracy using these highly-variable markers is in the range of ± 10–12 years. Additional methods include the use of SEM-EDXA that examines dentine in relation to age determination, while a study examined the use of root length in the determination of age in paediatric cases.[22] The use of dentine translucency has been shown to be a useful method and is described in more detail later in this paper.

The presence of erosion can suggest alcohol or substance abuse, an eating disorder or even hiatus hernia,[23] while stains can indicate smoking, tetracycline use or betel nut chewing.[24,25] Unusual wear patterns may result from pipe stems, cigarette holders, hairpins, carpet tacks or previous orthodontic treatment.[26] The quality, quantity and presence or absence of dental treatment may give an indication of socioeconomic status or likely country of residence.[16] See Figure 6 for examples of tooth conditions that can assist in post-mortem profiling. Figure 7 shows a case example of post-mortem profiling using dental tissues.

If the post-mortem profile does not elicit the tentative identity of the deceased, it may be necessary to reconstruct the individual's appearance during life. This is the responsibility of forensic artists who utilize the dental profile to help with the facial approximation.

Facial superimposition

The use of ante-mortem photographs to permit facial superimposition of skeletal or teeth fractures has been used in cases of identification. This technique requires the availability of suitable ante-mortem photographs, showing, if they are to be used, the teeth. Research has suggested that, in order to get a high rate of correct matches, two photographs – one full face and the other lateral – are required.[27] Other authors have warned that the placement of a photographic face over a skull will often result in an image that demonstrates 'consistency' based on the commonality of skeletal structures. It is essential that magnification and angulation difficulties are properly corrected for in order to reduce false positives.[28]

Ageing of the adult

There are a number of medico-legal reasons for determining the age of an individual. Immigration services across Europe are keen to establish the age of individuals seeking asylum and similar efforts are in place at the US/Mexico border. However, it is the determination of the age of deceased individuals where the odontologist can best assist. Within the author's jurisdiction there have been a number of cases where the age of the victim was required in order to determine identity. As mentioned previously, the use of attrition (wear) and the development of third molars have been suggested as means of ageing those individuals over 18, but both are unreliable.[29] Techniques, such as aspartic acid racemization, have been employed successfully but require expertise and expensive equipment not usually available to odontologists.[21] Further, recent studies have suggested that the technique is highly influenced by heat and this must be factored in when considering remains that may have been buried.[30] Translucent dentine is a stable, well-defined technique which was one of several aspects of ageing that were originally described by Gustafson.[31] Several studies have demonstrated that translucent dentine is the most influential variable in age determination.[32] Sclerotic, or translucent, dentine is the result of increased mineral content within the dentine resulting in transparency. It begins at the apex of the tooth and spreads coronally throughout life.[32] In order to measure this dentine, it is necessary to extract the tooth and then measure, either whole or in section, in mm, the length of dentine affected. A number of authors have produced regression formulae to use with these data, and Bang

Figure 7. Example of a reconstructive dental profile. **(a)** Body recovery scene. **(b)** Right lateral view of teeth. **(c)** Frontal view demonstrating skull features characteristic of a male Caucasoid. **(d)** Occlusal view of mandibular teeth: the smooth, round and deep sockets suggest that the missing teeth were lost post-mortem; only a minimum of good quality dentistry performed. **(e)** Occlusal view of maxillary teeth; note the cusp of Carabelli on the first molars, reinforcing the view that this individual is Caucasoid. **(f)** All of the recovered remains. **(g)** Anterior view of teeth; note the staining suggesting a cigarette smoker. **(h)** Left lateral view; note the untreated caries (decay) on the upper left second molar. **(i)** The artist's impression following the dental profile that stated that the individual was a white male smoker aged 24–30. The individual was finally identified as a white male aged 28.

Tooth Section	T1	T2	TM	Estimated Age	SD
	in millimetres			*in years*	
LL2 section 1	4	7	5.5	58.60	10.78
LL2 section 2	4.5	6.1	5.3	57.82	10.78
UL1 section 1	3	3.3	3.15	44.17	11.03
UL1 section 2	2.5	3.2	2.85	42.69	11.03
UL3 section 1	5.1	5.3	5.2	48.28	13.78
UL3 section 2	3.5	4.5	4	43.24	13.78
UR1 section 1	3.5	6	4.75	48.31	11.43
UR1 section 2	3	3.2	3.1	44.71	11.43
UR3 section 1	3.5	4.2	3.85	49.03	13.29
UR3 section 2	5.2	5	5.1	57.14	13.29
MEAN				**49.40**	**12.06**

Table 4. Results from the measurement of transparent dentine with estimated age.

and Ramm's studies have been shown to be effective.[33]

A case example using translucent dentine is shown in Figure 8 with the translucent dentine data in Table 4. When this individual was first examined, an assessment of the degree of toothwear by the pathologist placed the individual in his 70th year or older. The wear was excessive and, as shown in Figure 8, the enamel had worn to expose the underlying coronal dentine.[34] However, when the translucency of the dentine was assessed, an estimated age of 49 years was arrived at. Ultimately, the individual was identified as a 51-year-old.[34] This demonstrates the strength of the Bang and Ramm technique, as well as serving as a useful reminder that visual age assessment, based on aspects such as toothwear, can be misleading and should not be relied upon.[35]

However, it should be noted that there are some complexities associated with this technique. Determining the boundary between sclerotic and non-sclerotic dentine can be problematic, as can the differentiation between apical sclerosis and other forms of dentine sclerosis. Research has been undertaken

a

b

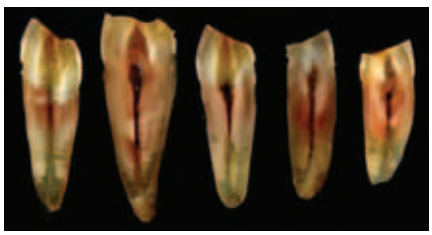

Figure 8. Example of a dental ageing case. **(a)** Presentation of a severely decomposed adult male with extensive wear of the anterior teeth on both maxillary and mandibular arches suggest that he was elderly. **(b)** Results of sectioned teeth demonstrating only minimal translucent dentine and suggesting that the individual was younger than that suggested by the degree of wear.

Figure 9. The process of cryogenic grinding. **(a)** Technique of sectioning tooth and scraping out pulpal contents. This can lead to missed material and would be of little use when examining root-filled teeth. **(b)** The tooth, in this case a molar, to be cryogenically ground. **(c)** Tooth is placed within a vial with an anvil at the base. **(d)** Vial is placed within the freezer mill. **(e)** Liquid nitrogen is added and the mill set to run for approximately 8 minutes. **(f)** The resultant powder from a single tooth which can now be used for DNA extraction.

that suggests that racial origin may also influence the accuracy of ageing techniques using root transparency and this should be considered when undertaking such procedures.[36] Despite these concerns, the assessment of apical translucency is an important technique in forensic dentistry, with researcher's reporting correlations of over 0.90 in large numbers of cases.[37]

DNA and dental identifications

The resilient nature of the dental hard tissues to environmental assaults, such as incineration, immersion, trauma, mutilation and decomposition ensure that teeth represent an excellent source of DNA material.[38] When conventional dental identification methods fail, this biological material can provide the necessary link to prove identity. 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. Comparison of DNA from the teeth of an unidentified individual can be made to a known ante-mortem sample (stored blood, hairbrush, clothing, cervical smear, etc) or to a parent or sibling.[38]

Genomic DNA

Genomic DNA represents the DNA source for most forensic applications. When body tissues have decomposed, the structures of the enamel, dentine and pulp complex persist. It is necessary to extract the DNA from the calcified tissues and a number of different techniques exist. The cryogenic grinding method is recommended as it ensures that all possible biological material is sourced.[38] Other techniques, such as sectioning and removing the pulpal tissues, are not only prone to missing valuable material but, in the case of root-filled teeth, not practical (Figure 9a).[13,39] Using the cryogenic method (Figure 9), authors have shown that even root-filled teeth can provide more than adequate amounts of DNA for use with PCR.[40] A recent study has also determined that mitochondrial DNA can be sourced from dentine powder obtained via cryogenic grinding.[41] Such is the protective nature of enamel, DNA has been sourced from incinerated teeth.[42]

Following analysis, a DNA profile is elicited that can be compared to known ante-mortem samples or parental (preferably maternal) DNA in the normal manner. The identification of individuals or determination of sex is not the only use for dental DNA. The technique has allowed criminal investigators to link victims to crime scenes once the body has been removed and incinerated and this potential source of DNA should always be considered when more traditional sources, such as deep muscle and bone, are unavailable.[43]

Summary

The role of the odontologist in the identification of human remains has been described. Conventional techniques, such as those employed in comparative identifications and post-mortem profiles, have been supplemented by the use of molecular biology and ageing methods. The vast majority of medico-legal services within Europe, North America and Australasia employ the services of odontologists regularly; they can provide an expeditious and economical solution to the identification of individuals who cannot be visually identified or, in circumstances such as homicide, where scientific corroboration of identity is required.[13] The recent spate of terrorist attacks and natural disasters in which there have been multiple fatalities has reinforced the need for trained, experienced odontologists who have undergone training in mock disasters in order to co-ordinate the response to such events properly.[44]

Acknowledgments

The author is grateful to Nature Publishing Group for permission to reproduce Figures 3, 5, 7 and 9; Tables 1 and 2 and to the *Journal of Forensic Sciences* for permission to reproduce Figure 8.

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BookReview

Pocket Atlas of Dental Radiology. By F A Pasler and H Visser. Stuttgart, New York: Thieme Publishing Group, 2007 (342pp., £34.95). ISBN 978-3-13-139801-7.

This book is written by two experienced radiologists. It first appeared as a German language edition in 2003 but has now been translated into English. It is just about pocket size, measuring 13 x 19 mm. Whilst smaller in size than a textbook, it is comprehensive in its content. It covers almost all aspects of dental radiography and dental radiology, being liberally illustrated with dental, facial and cross-sectional images, including CT, MRI and cone beam CT.

It has two sections, one on radiography and the other on diseases of the jaws and their interpretation. The book as such does not contain chapters but each of these two sections is subdivided into aspects of radiography or radiology, these being classified by a colour coding system.

The radiography sections include imaging techniques from dental radiography to CT and MRI, radiographic anatomy, image processing and digital radiography, but does not cover radiation physics or radiation biology. The text contains a number of colour illustrations which help not only because of their clarity, but they make the pages brighter and thus more reader friendly in an otherwise monochrome book. In the anatomy sections, identification of anatomical structures is through the use of numbers on the radiograph. Whilst this is by and large clear, some of the images have too many numbers, making the images look cluttered, figure 124 being a notable example.

The pathology section contains a comprehensive range of disorders affecting the jaws and facial bones. The text is succinct, but detailed, providing the relevant information of the conditions described.

There is a large number of reproduced radiographs, the quality of which is surprisingly good, despite the small size of the book. The line diagrams which accompany the radiographs are in colour and well drawn. Again, some radiographs use arrows to identify abnormalities, which is generally helpful, with one exception being figure 468, which has so many arrows that it resembles 'Custer's last stand'!

As with almost all first editions, there are some examples where the image has been inappropriately cropped or recorded, nevertheless it is difficult to find fault with the book. However, there is one bit of text which I feel requires revision should this book go to a second edition. The authors mention that the dose from a panoramic radiograph is so low that routine examination can easily be justified. This perhaps sends out the wrong message as, for any radiograph in the UK, it is the clinical examination which is the prime determinant for radiographic justification.

Pocketbooks tend to be used as easy references in the clinic. This one contains almost as much information as some textbooks and its small size will suit many. On balance, the authors have produced a good book which will be useful to dental students and general practitioners and I am happy to recommend it.

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