Forensic Odontology: A Hybrid System

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Forensic odontology involves the use of teeth to determine the identification of a deceased individual. Like a fingerprint, teeth are morphologically unique to an individual. With modern dentistry, additional structures such as caps and crowns can add to one's unique dental formation (Whittaker, 1994). Teeth are also the most indestructible part of a human body, allowing them to survive through more and for longer periods of time in comparison to flesh (Whittaker, 1994). Therefore, this identification process is typically used in times where a body cannot be visually identified such as in explosions and fires. Although time consuming, by comparing the ante mortem dental radiographs to the postmortem radiographs, forensic odontologist can effectively match a specific individual to their dental remains (Luntz, 1977). By combining the biology of teeth with the restorative technology of dentistry, the hybrid system of forensic odontology has been developed and incorporated into the process of human identification.

Dentistry is a science that involves the study of the oral cavity and the structures it contains, such as teeth and gums; this field of study also covers the diagnoses and prevention of diseases associated with the oral cavity (Wynbrant, 1998). Professionals within this field of study, or dentists, are typically capable of fixing and/or replacing teeth that are in poor condition or improperly located inside the mouth. People are able to get artificial dental implants for a variety of reasons. Fillings are used to prevent further expansion of tooth decay; these are meant to be permanent structures within one's mouth (Wynbrant, 1998). Caps and crowns are structures placed over an individual tooth that is damaged in order to protect it and allow it to heal and become healthy again; these can be removed once the tooth has reached a healthy condition (Wynbrant, 1998). Dental bridges, or tooth replacements, are fairly common in modern restorative dentistry as well. These artificial teeth are mounted to both the gums and adjacent teeth for support (Wynbrant, 1998).

With records dating back to the ancient Egyptians, the dental profession was first seen to be present in societies around 2600 BC. In the past, teeth were considered to be symbolic of immortality and contain incredible healing powers (Wynbrant, 1998). Although restorative dentistry was not present in these times, neither was food containing high sugar contents. While cavities are incredibly common nowadays, teeth degradation over time was the biggest morphological issue in these early time periods (Wynbrant, 1998). Toothaches were also of common concern in the past. Dental therapy in the distant past involved prayers, magic amulets, spells, and sacrifices to deities. The only dental procedure that occurred during these times was full extraction of a tooth (Wynbrant, 1998). In order to cope with teeth degradation, the use of dental bridges and crowns were starting to be used around 400 AD during the Roman Empire (Wynbrant, 1998). As described previously, with modern restorative dentistry becoming incredibly individualized and documented, teeth morphology is now becoming even more unique to each individual (Whittaker, 1994).

Forensic science is considered to be a merging of science and law; within this large field of study, forensic odontology serves as a major field involved with identification of deceased individuals who cannot be identified through other means, such as visual identification or possession of an identification card or passport (Whittaker, 1994). Due to one's unique dental morphology and often the incorporation of individualized dental structures such as caps, crowns, and dental bridges, an individual can be identified strictly through the comparison of postmortem and ante mortem radiographs, or X-rays, of their teeth (Luntz, 1977). An example of a postmortem and ante mortem radiograph comparison is shown in Figure 1. This procedure is most useful in identifying people who have died in mass disasters, such as plane crashes, fires, and explosions, as well as natural disasters like tsunamis (Nomir & Abdel-Mottaleb, 2005). The bodies involved in such events are typically destroyed or decayed, therefore preventing visual identification of the individuals. It is also easier to use this procedure in these types of disasters because there is a more limited pool of records to be analyzed and compared to the victims (Nomir & Abdel-Mottaleb, 2005). Some of the first cases that used forensic odontology for human identification were the Bazar de la Charité disaster in France as well as confirmation of John Wilkes Booth's death (Luntz, 1977).

In cases where the pool of victims is not known in a disaster, different qualities of the postmortem teeth can help narrow down the pool of potential victims. Excess erosion can show signs of alcoholism while stains can show signs of heavy smoking (Pretty & Sweet, 2001). The average age of the deceased person can also be predicted. If the postmortem teeth belong to a child, development charts of teeth morphology can be used to indicate the age of the child to approximately ± 1.5 years (Pretty & Sweet, 2001). The sex of the individual can also be determined due to the preserved DNA within teeth (Pretty & Sweet, 2001). By observing both the presence and absence of teeth along with their quality, the relative socioeconomic status of the individual can be somewhat determined (Pretty & Sweet, 2001). Forensic odontology is capable of helping generating the characteristics of a victim, allowing it to go above and beyond what fingerprint identification processes can do. However, the process of narrowing down the pool of ante mortem radiographs of potential matches is still incredibly time-consuming. Therefore, individual deaths and murders are much more difficult to identify through radiograph comparison due to the time consumption and difficulty of locating and narrowing down the pool of potential matches (Pretty & Sweet, 2001).

The process of identifying an individual through the comparison of postmortem and ante mortem dental radiographs is currently carried out manually. As shown in Figure 2, there is a very long list of factors that must be taken into account each time a set of teeth are being analyzed. Characteristics involved in root morphology, teeth morphology, and dental restoration

features are measured and documented (Nomir & Abdel-Mottaleb, 2005). Having to compare postmortem radiographs to a large pool of ante mortem radiographs one-by-one is time consuming and provides a lot of opportunity for mistakes (Nomir & Adbel-Mottaleb, 2005). This is the primary reason that forensic odontology is used much less extensively in comparison to identification by fingerprint, which has become an automated process carried out exclusively by computer programming and that is incredibly accurate (Nomir & Abdel-Mottaleb, 2005). When matching dental radiographs, an odontologist must document and describe all dental structures being shown in each x-ray and also measure the distance between adjacent structures. Although matches can be made solely based on teeth shape and location, dental enhancements such as fillings and caps make it much easier to identify individuals by adding to their unique dental morphology (Pretty & Sweet, 2001).

Research is currently being conducted in order to try and automate this procedure, which would allow forensic odontologists to run the radiographs of a deceased individual through an electronic system that would then match it to a few select radiographs within its database of ante mortem radiographs (Nomir & Abel-Mottaleb, 2007). These selections would be listed in order of highest morphological similarity to the lowest in comparison to the postmortem radiograph. An odontologist would then only have to manually match the postmortem radiograph to the small collection of radiographs selected by the system (Nomir & Abel-Mottaleb, 2007). An automated system that is currently being tested was shown to not only make this process more efficient in terms of time consumption, but also in terms of precision (Nomir & Abdel-Mottaleb, 2007). Using bite-wing images, the most frequently documented radiographs taken by dentists, this system was found to match images from postmortem and ante mortem databases to a very high accuracy; the quality of the radiograph was found to be the significant cause of unsuccessful matching (Nomir & Abdel-Mottaleb, 2007).

Considering the success of this newly tested system, forensic odontology could become an increasingly important field involved with identification of deceased individuals (Nomir & Abdel-Mottaleb, 2007). With an automated system in the works, I predict that forensic odontology will become an increasingly important field used for human identification. It not only is capable of telling the odontologist different characteristics about the victim, but by combining dental technology with teeth biology, the teeth of a victim are just as unique as their fingerprint (Pretty & Sweet, 2001). With tragic accidents and crime consistently occurring around the globe, and no sign of an end to dental restoration, forensic odontology will likely be an irreversible hybrid system that we can utilize in the process of human identification.

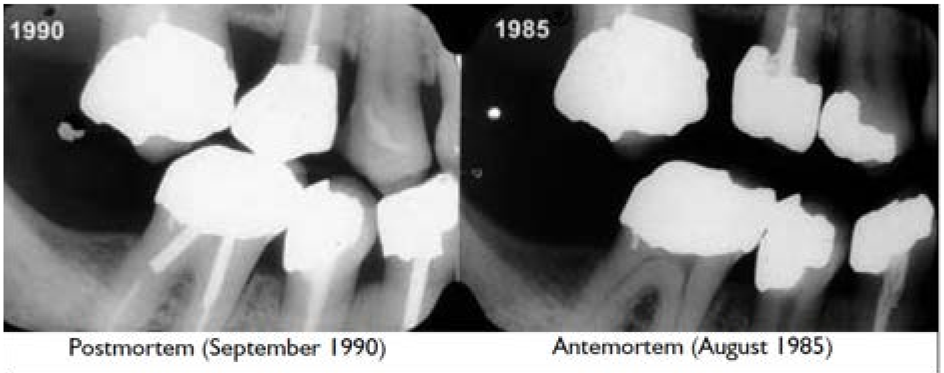

Figure 1: This shows a comparison of postmortem and ante mortem radiographs that were used to determine the identity of a deceased individual. After careful measurement and analysis, these two radiographs were found to be from the same person, and therefore successfully identified the victim. Note the difference between the top most right teeth of each radiograph; this can be accounted for by dental work that occurred within the time span between these two radiographs, most likely being a crown that was removed during this period. . Adapted from: Pretty, I. A., & Sweet, D. (2001). A look at forensic dentistry – part 1: the role of teeth in the determination of human identity.

Teeth

Teeth present
a. Erupted
b. Unerupted
c. Impacted

Missing teeth
a. Congenitally
b. Lost antemortem
c. Lost postmortem

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

Tooth position
a. Malposition

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 and 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 and 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 and 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 interradicular bone
c. Exostoses, tori
d. Pattern of lamina dura
e. Bone loss (horizontal/vertical)
f. Trabecular bone pattern and bone 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 and condylar processes
a. Size and shape
b. Pathology

Temperomandibular 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 radiopacities
f. Evidence of surgery
g. Trauma – wires, surgical pins etc.

Figure 2: The complex range of features that are examined during the dental identification process. Adapted from: Pretty, I. A., & Sweet, D. (2001). A look at forensic dentistry – part 1: the role of teeth in the determination of human identity.

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