What are the Most Important Teeth in the Field of Forensic Odontology? *

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Abstract

The society has been aided by Forensic Odontology for centuries. The aim of this review article is to briefly present the role of the human teeth in the different aspects of forensic odontology and highlight the most important teeth, if any. Recent increase in vanity culture and drastic improvements in the field of aesthetic dentistry and orthodontics resulted in a decrease of dental treatment and an increase of standard well-aligned teeth, causing reduction on dental distinctiveness of individuals. As reflection, a transitional phase of the history of Forensic Odontology will make the forensic dentist less dependent on an intermediate dentist's work in order to carry out a comparative dental analysis. Other factors such as dental anatomy and surrounding areas will be more explored. Forensic dentists of this century are more likely to carry out more demanding comparative dental analysis. In summary, the assessment of all teeth is important combined with further information from the oral cavity.

Keywords: forensic odontology; dental profiling; dental identification; bite mark; age estimation

** Author is responsible for language correctness and content.*

Introduction

In the 70s, Forensic Odontology was considered as …"that branch of dentistry which – in the interests of justice – deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of dental findings" (1). Needless to argue that teeth are the main evidence to be investigated, but "What are the most important teeth in the field of Forensic Odontology"? Comparative dental analysis is one of the three primary human identifiers by the INTERPOL (2) and it is usually established through a reconciliation process between ante-mortem (AM) and post-mortem (PM) data. However, AM records can be insufficient, inconsistent or nonexistent which makes the comparative analysis impossible; yet, forensic dentists can performer a reconstructive analysis in order to create a profile for the body by estimating age, determining ancestry and sex through dental characteristics (morphology and metrics), habits and nutritional deficiencies.
Teeth have a pivotal role in age estimation because they are highly resistant to mechanical, chemical impacts and time (3) and less effected by diet. Human bitemark can be analysed through dental characteristics, particularly the arrangement of the front teeth (4). DNA is extracted from the hard structures, but the risk of contamination is lower in teeth than in bone due to the reduced porosity of teeth (5). Moreover, enamel has a highly resistant nature to environmental assaults (6) and the location of teeth in the jaws provides additional protection to DNA (7). In this article, the authors aimed to briefly present the role of the human teeth in the mentioned aspects of forensic odontology and highlight the most important teeth, if any.

Sex

Pelvis and skull are the most important tools in sex determination (8) and teeth would play a minor role (9). Regardless of the extreme variability of the sexual dimorphism in human dentition, dental sex assessment is explored in several studies. The maxillary teeth are more dimorphic than the mandibular ones (8) but the mandibular canines have the highest degree of sexual dimorphism (10). Whereas, the lower incisors are the teeth with the lowest degree of sexual dimorphism (8). The presence of canine distal accessory ridge can also be used for sex discrimination (11). Crown diameters have been assessed such as the mesiodistal and buccolingual cervical and diagonal diameters of incisors, canines, premolars and molars (12) along with cusp dimensions of the upper molars and root length (13). The conclusion of most studies is that a combination of those measurements give more accurate results in dental sex assessment (14).
In the 20th century, the incisor and canine index were created by Aitchison and Rao et. Al respectively. The incisor index [MD12/MD11] x 100, is higher in males than females (15) because the lateral incisor is more likely to be smaller than the central incisor in females (16). On the other hand, canine index used dimensions of the mandibular canines and the results showed an accuracy of 84.3% in the male and 87.5% in the female of that sample (17).
It should also be emphasized that the pulp tissue could be used for sex determination. The Y-chromosome-specific repeat sequences could be tested once the DNA from the pulp tissue is extracted (18). In addition, the major protein amelogin (AMEL) in the human enamel differs between males and females, having two different AMEL genes and two identical AMEL genes, respectively (19). There is also a difference in the dental tissue proportions between males and females. The Y chromosome is largely responsible for size of teeth by controlling the thickness of dentine and, generally, males have larger teeth than females. (20)
Sex determination can also be carried out based on the dental development and eruption because females might be more advanced than male by 1-4 months (21).

Ancestry

Based on the genetic heritage, the homo sapiens have been subdivided into three major geographic races named Caucasoids, Negroids and Mongoloids (22). In today's world, determining one's race can become a challenge when evaluating intermixing populations. Racial variations can be seen in the hard palate shapes. For instance, the palate is triangular in Caucasians and parabolic or horseshoe shaped in mongoloids; in negroids the palate shape may be rectangular, or narrow and pointed. Arch size can also be used for profiling; for instance, Negroids have alveolar prognathism, whereas it is usually absent in Caucasians (23). It is important to assess the overall skeleton for determination of race and not only dental characteristics (24).
Some dental traits can be assessed for race determination but environmental factors such as calculus, attrition or wear, decay and filling may destroy those. Moreover, not all of them are

exclusive to a single population. According to some studies, Asians and native Americans show shovel-shaped upper incisors (25). In Mongoloids, the upper third molars are congenitally missing, premolars have enamel pearls and especially the maxillary molars show taurodontism (26). The Cusp of Carabelli, a small additional cusp at the mesiopalatal line angle of maxillary first molars, is commonly found in the Caucasoids (22) as seen in figure 1. Moreover, it is more common to find shorter and less spread roots and enamel extensions in Caucasoids (27). Tooth size can be used as a dental determinant of race but one should be careful about its limitations (18). The races can be large toothed or small toothed. The former involves the Australians, Melanesians and American Indians. Whereas the latter involves the Lapps and the Bushmen (26).
Also, Flower has created a dental index which is the relation of the dental length to the basinasal length (d x 100/BN). The results classified the Caucasian or white races (microdont; below 42), the Mongolian or yellow races (mesodont; between 42 and 44) and the black races, including the Australians (megadont; above 44) (28).

Figure 1 Dental cast showing a Cusp of Carabelli (Centre for Forensic and Legal Medicine and Dentistry private archive).Figure 1 Dental cast showing a Cusp of Carabelli (Centre for Forensic and Legal Medicine and Dentistry private archive).

Age estimation

Assessment of dental age can be performed either by non-invasive methods including the assessment of tooth eruption and dental development or by invasive methods such as the assessment of the root dentine transparency and the incremental line analysis (25) as seen in figure 2. However, the application of these methods varies according to the categories such as fetus (prenatal and neonatal), children, adolescents and adults (29).

The methods of age assessment can further be divided into (1) techniques which rely on a diagrammatic representation of stages of development and eruption of teeth or (2) techniques that require incremental staging of developing teeth (29, 30). These methods do not rely on a single tooth but on a set of specific teeth. For instance, the diagrammatic representations evaluate either the right or the left side of the jaw, whereas methodologies such as Moorrees and Demirjian score a set of permanent teeth (10 and 7 teeth respectively) according to the developmental stage of each tooth (29, 31) as seen in figure 3. However, the overall assessment of tooth development is effective till ages 14-16 years (average of 13) (31, 32). After that age range, only third molars can be assessed till the age of 21 to 23 years (32, 33).
After the completion of third molar development, only regressive changes can be assessed, for instance: secondary dentine formation, periodontal recession, attrition, apical translucency, cementum apposition and external root resorption (34). Techniques created by Gustafson, Lamendin, Maples and Johanson are based on these changes (29, 33, 34) but are invasive. Radiographic non-invasive methods such as Kvaal and Camererie's are more popular currently (33). Kvaal's tested linear measurements of pulp, tooth and root of different single-rooted teeth producing acceptable results. Camererie's explored the measurements of the pulp and tooth area and most studies have been conducted on canines (33). A recent study investigated the relationship between canine pulp volumes and chronological age by assessing Cone Beam Computed Tomography (CBCT) images (35). Canines have a large pulp/tooth area ratio and they survive for longer duration than other teeth. Also, they have lesser chances of wear and have a large pulp chamber. Notably, numerous studies have been conducted on the upper canines (33).

Bite mark

The science behind the bite mark analysis is rooted in the association of the polemic individuality of human dentition, the belief that no two humans have identical dentition regarding the shape, size, position and the alignment of teeth (4). Usually only the six anterior teeth in the upper and the lower arch (canine to canine) are commonly seen in a bite mark injury. Occasionally the involvement of premolar is seen and very rarely the molars are present. (36) A maxillary central incisor would cause a

Figure 2 Analysis of tooth layers (Centre for Forensic and Legal Medicine and Dentistry private archive).

rectangular imprint with rounded edges, a maxillary lateral incisor would produce a similar imprint of a smaller size. On the other hand, mandibular central and lateral incisors would produce a smaller rectangular imprint. Maxillary and mandibular canines would produce a triangular or a pinpoint impression. The intercanine distance can also be appraised as an important element of analysis (37) All of which could vary under circumstances of distortion caused by the movement of victim or suspect or both. Classical features of a human bite mark comprise two opposing U-shaped arches separated by open spaces as seen in figure 4.
Mention should be made that the admissibility of bite mark evidence is at risk because innocent people were wrongly convicted and imprisoned due to failures in bite marks analysis poorly supported by the science (38).

DNA
Teeth are source of DNA for the purpose of identification. The pulp, due to its high cellularity, is the richest source followed by dentin and cementum (6). On the one hand, dentine is densely perforated by parallel tubules which consist of odontoblastic cell processes and nerve fibres, both of which have mitochondrial DNA (mtDNA). On the other hand, cementocytes within the extracellular matrix of cellular cementum, vessels crossing in accessory canals, adherent periodontal tissues and fragments of bone trapped between the roots of molar teeth, can also be another valuable source of DNA (7).
Sound teeth with the largest pulp volume will therefore be the best source of DNA (39). Multi-rooted teeth have the largest pulp volumes (more pulp cells) and a larger root surface area, providing more cementum (7). The INTERPOL protocols for Disaster Victim Identification (DVI) Guide 2009 (2) and the DNA Commission of the International Society of Forensic Genetics (ISFG) (40) prefer the molars as a selection of sample for DNA extraction. When molars are absent, premolars should be used. Canines have also been suggested to be optimal for DNA extraction due to their wide and long pulp canals (41). However, the anterior teeth are not preferred as they can compromise superimposition of photos for human identification.

Teeth that last longer
Specific methodologies require specific teeth, but tooth loss would prevent their applications. Pattern of tooth loss can be caused by periodontal problems, caries (42), presence of abutments and single crowns (43). Prevalence of tooth loss have been explored in different countries and the most common ones are as follows: incisor teeth in Nigerians (44), first molars in Greeks (42), molars in elderly Japanese and Israelis (43, 45) and maxillary teeth in South Africans (46). Findings of different

Figure 3 Radiographic image of lower left mandible and respective teeth in development (Centre for Forensic and Legal Medicine and Dentistry private archive).

studies also pointed out to a definite persistence of canines, mainly the lower ones, in the mouth (42, 45). Would lower canines be the long-lasting dental evidence? Even though, tooth loss is declining in some European countries (47), findings from ‘The Global Burden of Disease

2015 study' proved that oral diseases are highly prevalent in the globe (48).

Figure 4 Possible human bite mark with insufficient forensic value for comparison (Centre for Forensic and Legal Medicine and Dentistry private archive).

Identification beyond teeth

Studies claim that a reduction in caries, and consequent dental treatment, along with the increase in orthodontic treatment will make dental identification more challenging. (49) Consequently, the process of comparison of dental treatment patterns would eventually be substituted to the process of dental features comparison, including surrounding areas. A recent study suggested an elaborated oral charting system to document oral jewellery and tooth modifications (50). The analysis of dental anatomy including crown or root and specific features such as shape, size, dilacerations and bifurcations will demand a sharp knowledge in basic/supporting sciences. A recent radiographic study proved that examiners compared the root morphology of the first molars and the shape of the maxillary sinus in radiographs of individuals with unrestored teeth (51). This transitional phase will make the forensic dentist less dependent on an intermediate dentist's work to establish a dental identity.

Moreover, a minimum number of concordant points was required to achieve a positive identification in the past. Those points would be a combination of restorative procedures, developmental or acquired defects, or abnormalities of teeth; however, a single feature may be so extraordinary or unique that it alone can be sufficient to make a positive identification (52).

Teeth may be dislodged during death and/or recovery or manipulation of skeletal remains. Thus, the remaining sockets and surrounding bone can be assessed (53) by using the dental radiography and computed tomography (CT) (53). Furthermore, the trabecular pattern of the bone, including the mandible, is an excellent radiographic marker since its presence on a radiograph doesn't depend on a previous pathology or traumatic event (54).

The palatal rugae patterns which are unique to every individual and remain unchanged throughout life, can be a resourceful AM record when dental casts are available. Similarly, if lip prints are left at crime scenes, then they can be compared to link the suspect and can also be used for gender differentiation. The patterns and grooves of the labial mucosa are stable and unique to each individual and their study is known as "cheiloscopy" (39).

Anatomic variations of the frontal sinus are unique to each individual, permanent and immutable and can be accurately used for human identification as well as juvenile age estimation (55). It can be helpful sex determination because studies show that its volume and dimensions are significantly higher in males than in females except in children until six years of age (56).

Saliva, which consists of several nucleated epithelial cells and a substantial amount of amylase, can be found in the bitemark and should be carefully collected handled and stored. Further laboratory analysis would provide DNA profile which could be used for comparison (57).

Conclusion

Recent increase in vanity culture and drastic improvements in the field of aesthetic dentistry and orthodontics has diminished the dental distinctiveness of individuals. There is a decrease of dental treatment and an increase of standard well-aligned teeth. As reflection, a transitional phase of the history of Forensic Odontology will make the forensic dentist less dependent on an intermediate dentist's work in order to establish an identification by dental means. Other factors such as dental anatomy and surrounding areas will be more explored. Forensic dentists of this century are more likely to carry out more demanding comparative dental analysis. In summary, the assessment of all teeth is important combined with further information from the oral cavity.

Conflicts of interest

The authors declare no conflict of interest.

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