REVIEW ARTICLE

Role of Dental Hard Tissue in Human Identification

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Abstract

Ethnologic identification is one of the major demanding subjects to facilitate human has been encountered with. The forensic magnitude of the dental tissue has been well predictable since teeth are hardest of all human tissues and they can be conserved undamaged for an extensive episode of instance following fatality. They are constant chemically and they retain their characteristics, which becomes a consistent source for determination of human identification. The study of the dental hard and soft tissue for the rationale of establishing the individuality of a victim is called dental profiling. By using the dental profiling techniques, age, gender, and race of an individual can be determined, as well as the data about their socioeconomic status, personal habits, oral and systemic health, occupation, diet, familial relationship, and psychological characteristics. A dental profile is more detailed and reliable if more than one technique is applied. Each human being possesses a unique dental profile that helps them in identification. Education in the field of forensic odontology and techniques of dental profiling is essential since it contributes significantly to the status of the dental profession in additional associated disciplines as well as in public, and it encourages dentists to view their own achievements from a wider perspective. Through the ages, odontological examinations have been a critical determinant in the search of human identity. This piece of review writing gives an overview of the dental evidence and its use in forensic identification.

Keywords: Forensic, Forensic odontology, Gender.

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Introduction

Forensic science is defined as a discipline associated with the application of science and technology for detection and investigation of crime and administration of justice, requiring the coordinated efforts of a multidisciplinary team.[1] The word "forensic" has originated from the Latin word "forensis," which means a place, forum, or "relating to the law," where legal matters and circumstances are scrutinized. Forensic odontology or forensic dentistry was defined as "that branch of forensic medicine which in the interest of justice deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of the dental findings" by Keiser-Neilson in late 1970.[2] In the current state of affairs, forensic odontology has been included as a specialty in the broad arena of forensic sciences.[3]

Forensic dentistry is relatively a latest science, to aid the judicial system, that exploits the dentist's skill and knowledge. In cases of mass disasters like earth temblor, aviation, and tidal wave, it serves an important role in identification of individuals. It also plays an important role in racial studies, criminality studies, and in the detection of disfigured and decayed bodies such as rape victims, drowned individuals, flames or burn sufferers, and road accidents.[4] Forensic odontology also concerned with individual recognition depends on human dental accounts, bitemarks records, ameloglyphics, lip impression, and the palatal rugae pattern.[4] Nonscientific methods such as tattoos, piercings, scars, subdermal body modifications, and soft tissue abnormalities are helpful for visual identification, especially if the tissue is intact.[5] The dental silhouette establishes a collection of person uniqueness associated to the hard and soft tissue. It assists in the assessment of race, age, gender, personal habits, social class, physical condition, and profession and nutritional state of the individual.[7] However, teeth are a trusted source in identification as compared to the soft tissue as they can survive in the catastrophic environmental situations like fire or burn. Teeth are not effortlessly decayed like different remains, even subsequent to death.[8] They are hard stable distinctive structures with unique sizes and shapes.[8,9] Variations in shape, color, wear patterns, position, age, caries, temporary and permanent tooth filling, periodontitis, and crowns contribute to the dentition of humans similar to that of fingerprints.[6,10] Through the ages, dental scanning has been a significant epitope in the exploration of person identity.[11] This brief review presents an overview of the dental evidence and its use in forensic identification.

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Method of Identification in Forensic Medicine[12,13]

Primary Methods of Identification

- DNA profiling
- Fingerprint analysis
- Forensic odontology

Secondary Methods of Identification

- Medicine information (scar, evidence of disease)
- Piercings and tattoos

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- Articles/evidence/clothing (jewelry, clothing, and personal identification documents)
- Visual identification (facial features)

Methods of Forensic Odontology[12,13]

Using hard tissue: tooth prints, dentin translucency, radiographs, bite marks, DNA fingerprinting/profiling, and dental jewelry

Using soft tissue: visual identification, photographic study, rugoscopy, chelioscopy, tongue prints, lip/tongue piercing, and tattoos

According to the American Board of Forensic Odontology (FO), identification reports can be:[7,9]

- Positive identification—records that match with no discrepancies
- Possible identification—antemortem and postmortem records that have constant features but there is doubt in the value of confirmation
- Insufficient evidence—lacking adequate proof to arrive at a conclusion
- Exclusion—records that obviously do not match.

Comparing antemortem with postmortem data:[7,9]

- To scrutinize earlier tooth accounts of the individual assumed as deceased and glance for these tooth uniqueness in the deceased individual for resemblance and verification
- Postmortem tooth profiling is made if there is no earlier tooth records that will give clues to constrict the investigation essential for antemortem resources to recognize the deceased individual.

Dental Profiling

The individual dental patterns are unique due to the range of genetic and environmental changes as well as dental treatments. Hence, individual human dentition is marked as useful for personal detection and assessment, if records exist for the purpose.[5] Morphological variation in crown, root along with jaw bone, certain pathologies associated with them, and some restorative dental procedures may prove to be a hallmark for identification. Various identification methods have been used in forensic sciences; however, there are certain methods that are associated only with identification of the dental hard tissue[14] (Table 1).

Determination of individuals by means of the human dental tissue attains additional paramount because they are often preserved posthumously. The forensic dental detection plays a prime part in the recognition of remnants when there is soft and hard tissue damage, postmortem changes, or deficiency of fingerprint evidence. Hence, different methods using the dental hard tissue have been frequently used to determine the following:

- Sex determination
- Age estimation
- ABO blood group determination
- Ethnicity

Sex Determination

Sex determination can be done either by morphological or by molecular analysis. The visual method includes the morphological analysis, which can be done on hard tissues (odontometric and orthometric) and soft tissues of oral and paraoral regions (lip prints—cheiloscopy, palatal rugae pattern—rugoscopy). Other methods include microscopic methods, advanced methods, and miscellaneous methods[15–17] (Table 2).

Age Estimation

In forensic odontology, age estimation through human teeth is one of the interesting applications. The estimation of age using human teeth can be divided into three categories of age groups: (1) prenatal, neonatal, and early postnatal period; (2) children and adolescents; and (3) adults. Age can be chronological age, bone age, mental age, and dental age. The procedure of the dental age assessment can be performed by invasive or noninvasive methods[18–21] (Fig. 1).

Different techniques are used for estimation of age from human dentition. These may be described in four types, specifically, clinical or visual, radiographic, histological, physical, and chemical analysis (Table 3).

Table 1: Visual dental features useful in identification of human[5]

Role of dental teeth			
Morphological variation			
Crown	*Root*	*Pathology*	*Restorative*
• Size, shape, and number • Crown present—erupted/unerupted/impacted • Congenitally missing•Lost antemortem • Lost perimortem/postmortemPermanent mixed dentition • Retained primary teeth • Supernumerary teeth • Malpositions: facial/lingual version, rotations, supra/infra positions, diastemas, other occlusal discrepancies • Atypical variations (peg laterals, screw-shaped incisor, talon cusps)	• Size, shape, and number • Dilaceration • Divergence of root	• Caries • Attrition/abrasion/erosion • Fusion/gemination, enamel pearl, multiple cusps • Dens in dente • Periapical pathology, periapical abscess/granuloma/cyst, cementoma, condensing osteitis • Crown and root fracture • Hypercementosis • Internal and external root resorption • Exogenous and endogenous pigmentation (systemic disease, syndrome associated)	• Metallic restorations: amalgam, gold or nonprecious metal crowns/inlays, endo-posts, pins, removable and fixed prosthesis including cast partial, overdenture, implants • Nonmetallic restorations: acrylics, silicates, composites, glass ionomers, porcelain, zirconia, etc.

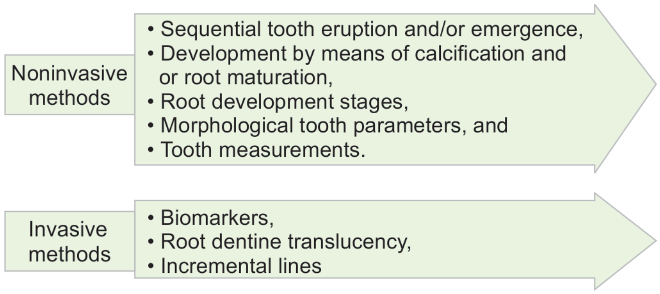

Fig. 1: Methods of age estimation

Table 2: Classification of methods used for sex determination

Methods of sex determination			
1. Visual method or clinical method	*2. Microscopic methods*	*3. Advanced methods*	*4. Miscellaneous methods*
Hard tissue analysis: odontometric methods	Sex determination using Barr bodies	Sex determination using PCR	Labeling of dental prostheses
• Tooth size	Sex determination using F bodies	Sex determination from enamel protein	
• Canine dimorphism	Sex-determining region "Y" gene		
• Dental index			
• Tooth shape			
Orthometric method			
• Morphology of skull and mandible			
• Frontal sinus dimensions			
Soft tissue analysis			
• Cheiloscopy			
• Rugoscopy			

ABO Blood Group Determination

ABO blood grouping and Rhesus factor determination for a biological evidence on the human teeth material such as the soft tissue pulp and the hard tissue dentin are of immense significance in forensic odontology. The blood group substances are utilized in medico legal assessment depends on blood group when recognized in a person, it remains unaffected all over life. The human blood group, like fingerprints, is an unalterable primary character. It can survive for a long time even after soft and skeletal tissues have been destroyed.

Various studies have been done on dental hard tissues for determination of ABO blood grouping and Rh factor in which the dentine was found to be the most reliable source. Determination of the blood group can be through the dental tissue by using methods like absorption elution, hemagglutination, and the histochemical

Table 3: Dental age estimation methods

Clinical or visual method	*Radiographic method*	*Histological method*	*Physical and chemical analysis*
Visual observation of the stage of eruption of the teeth and evidence of changes due to function such as attrition can give an approximate estimate of age.	Radiography can provide the gross stage of dental development of the dentition.	Histological stage of development of the dentition can be more appropriate for postmortem situations. It is also significant in estimation of age of early development of dentition.	Determination for alterations in ion levels with age has been proposed. Further, future developments might provide an adjunctive means of collecting evidence of value in the dental context.

Age estimation using the dentition can be grouped into three phases	
1. Age estimation in prenatal, neonatal, and early postnatal child	
Age assessment from the neonatal line	They are seen in the enamel and the dentin of human deciduous teeth and permanent first molars, which signify the development during the transitional period between intrauterine and extrauterine environments.
Age assessment based on thickness of the enamel and the dentin from the neonatal line	Miles (1958): By appropriate daily rate of formation.
Age assessment from the incremental lines	Teivens A., Mornstad H., Noren: Enamel Incremental lines of Retzius are caused by variation in the rhythmic mineralization of enamel prisms. This rhythmic pattern may be altered by various external factors such as metabolic disturbances so that the lines may appear closer or the rest periods may be prolonged. Dentin In the dentine, incremental lines of Von Ebner and contour lines of Owen are present. These lines are used to estimate age of the neonate or fetus at death.
Age assessment from the weight of the development dentition	Stack: By measuring the dry weight of the mineralized tooth cusps. Estimated weight of developing teeth at sixth month of intrauterine—60 mg, newborn—0.5 g, 6 months after the birth—1.8 g.
2. Age estimation in children and adolescents	
Age estimation of children and adolescents depends on the eruption of teeth and the tooth calcification. • Eruption: Convenient clinical method visual assessment of teeth and compared with radiographs and charts (Schour and Massler's in 1941).	

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• Calcification: Better alternative since calcification can be observed for a period of several years from radiographs, not altered by local factors and assess age at periods when no emergence take place (2.5–6 years and more than 12 years) (Demirjian method).	
3. Age estimation in adults	
Morphological method	• Gustafson's method (1950) • Dalitz method (1962) • Bang and Ramm method (1970)
Biochemical method	• Helfman and Bada: suggested a relationship between dentinal age and the extent of aspartic acid racemization in the dentin. This method accuracy is within ±3 years. • Rietz-Timme et al.: used the racemization method in dentinal biopsy specimens in order to estimate the age of living individuals without extraction of teeth.
Radiographic methods	• Volume assessment of the teeth: – Pulp to tooth ratio method (Kvaal et al.) – Coronal pulp cavity index (Yang et al.) • Development of third molar: – Harris and Nortje method – Van Heerden system – Prosthetic restorations, dental root fillings, and periodontal bone resorption as a forensic odontologic aid for determining the age(Friedrich et al.)

technique. Polymerase chain reaction (PCR) stands higher than all the allusion procedures because of elevated rate of sensitivity and specificity.[22]

Ethnicity

Humans, as a species, are physically diverse as a result of genetic influences and environmental factors such as climate and geographic location. Human diversity applies to dental morphology as well, and dental anthropologists have cataloged this diversity. Hence, it is possible to identify an individual's ethnic origin based on the dentition. The recommended method for this is to assess nonmetric dental traits, defined in terms of their presence or absence. A description of these traits is enlisted in Table 4.[23,24]

Conclusion

The dental tissue is the resistant tissue in the human body, which can sustain even after extensive injury. Although there are so many different methods for human identification in forensic science, teeth being considered as distinct and resistive to ecological changes and are a tremendous postmortem substance for recognition with adequate concordant points to compose an important evaluation due to the capability of the inert, calcified structures of teeth to resist postmortem degradation. They are well preserved for a long period even after death; hence, dental structures are the mainly constant biological data encountered in crime and capitulate helpful details in mass disasters and medicolegal cases. This current article may assist in creating awareness among the fraternity about the role of the dental tissue in personal identification so as to help in the development of a central database of medical and dental records, which may aid in comparison of antemortem and postmortem records.

Table 4: Hallmark for ethnicity from teeth

Identifying the ethnicity from teeth				
Shoveling	*Carabelli's trait*	*Three-cusped maxillary second molar*	*Winging*	*Four-cusped mandibular molars*
Shoveling refers to the presence of mesial and distal marginal ridges on the lingual surface of the maxillary and mandibular anterior teeth.	Carabelli's cusp, or tubercle of Carabelli, is a cingular derivative expressed on the mesiopalatal or palatal aspect of the mesiopalatal cusp of maxillary molars. The trait may be absent or expressed as minor depressions or well-developed tubercles with free apexes.	The distopalatal cusp of the maxillary molars is usually retained on the first molar, but tends to be of reduced size or absent on the second molar.	It is characterized by the bilateral labial rotation of the distal margins of maxillary central incisors. The incisal edge of the central incisors, taken together, appears "V" shaped from the occlusal aspect.	The first molar is considered to have five cusps while the second molar is regarded as having four. However, the distal cusp may be absent on the first molar and/ or expressed on the second molar. Therefore, both first and second mandibular molars are studied for the absence of the distal cusp
No shoveling was found in the preliminary heterogeneous Indian.	In Indians, it is reported to be present in 26% of the population.	Three-cusped maxillary second molar was observed in 34% of Indians.	Winging was observed in 16% of the Indian population.	The frequency of four cusps is 11% for first molars and 90% for second molars in the preliminary Indian sample.
Common in East Asian and native American.	Europeans (75–85%) and rarest in Pacific (35–45%)	–	American Indian	–

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