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Forensic Odontology: The Recent Advances in Identification

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ABSTRACT:

The word forensic is derived from the Latin word *forensis* meaning public. The fundamental principle in any forensic investigation is based on the simple axiom "any contact leaves a trace. It is now clearly established that dental evidence can be invaluable in personal identification and criminalities. In the eyes of most law enforcement agencies and courts, it is a valid and reliable method. The scope of forensic dentistry is broad and ever challenging. Forensic odontology includes two distinct areas, identification and bite mark. It has three major areas of utilization: Diagnostic and therapeutic examination and evaluation of injuries to jaws, teeth and oral soft tissues, identification of individuals, especially causalities in criminal investigation/ mass disasters and identification, examination and evaluation of bite marks which occur with some frequency in sexual assaults, child abuse cases, and in personal defense situations. This article reviews the forensic odontology as science for identification of an individual.

Keywords: forensic, odontology, identification, dentistry, bite marks.

INTRODUCTION

The word forensic is derived from the Latin word *forensis* meaning public. It may also refer to public discussion or debate. It is now clearly established that dental evidence can be invaluable in personal identification and criminalities. Forensic odontology is defined as the branch of odontology, which deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of dental findings in the interest of justice. Forensic odontology is the best method to identify burned or decomposed bodies. The teeth are the hardest substances in the human body and may be the only method available to identify the decedent. Teeth potentially can survive most of the insults and consequences encountered at death and during decomposition [1,2].

It has three major areas of utilization that includes diagnostic and therapeutic examination and evaluation of injuries to jaws, teeth and oral soft tissues, identification of individuals, especially causalities in criminal investigation/ mass disasters and identification, examination and evaluation of bite marks which occur with some frequency in sexual assaults, child abuse cases, and in personal defense situations. There are 3 types of personal identification means 1) Comparative dental identification 2) Reconstructive post-mortem dental profiling and 3) DNA profiling methods

1. Comparative Dental Identification

It involves the comparison of ante-mortem (before death) and post-mortem (after death) dental records. Congenital (anatomic) and acquired (treatment) characteristics of the teeth are compared between the ante-mortem and post-mortem records. Records may be intraoral and extraoral radiographs. Clinical photographs, odontograms, study casts, orthodontic appliances, dental prostheses and sports mouth-guards [3].

2. Reconstructive post-mortem Dental Profiling

To determine the deceased person, often it is necessary to assess personal features, such as the age at death, sex, race and other associated findings. Each person actually has more than one age: ***Pathologic Age***: Dental experts can

estimate pathologic age by examining factors such as arthritic changes in the temporomandibular joints, attritional wear of the teeth, and root transparency [4]. ***Physiologic Age***: An estimate of age can be determined from an examination of the development of roots (apical closure) and comparison with tables that record the amount of development versus age [5]. ***Chronologic Age***: Chronologic age is the time from birth to death. Forensic dentist normally take into account estimates of a person's pathologic and physiologic age to arrive at an assessment of the most likely chronologic age at the time of death [6]. **Race-**Landmarks such as the shape of the cranium, lateral projection of the zygomatic arches, the shape and contour of the orbits and nasal aperture, and the shape of the dental arcades can provide information about racial differences. **Sex-** Sex determination is not possible through morphologic appearance of teeth. Microscopic examination of the cells from the pulp can reveal the presence of Barr bodies in females. Modern DNA extraction methods can isolate genomic DNA from dental cells and the gene *Amelogenin*, a sex linked gene, can be used to determine if a person has an XX or XY profile [7].

3. **Dental DNA Evidence**

DNA can be used to discriminate one individual from another. Except for identical twins, everyone's DNA is different. The DNA is the same in all the cells of the body, and it does not change from birth to death. Forensic DNA profiling methods using the PCR (Polymerase chain reaction) technique to amplify small amounts of recovered DNA at specific genetic loci are sensitive [8].

CRANIOFACIAL CHARACTERISTICS AS DETERMINANTS OF AGE, SEX AND RACE

Krogman [9] states "there are really no pure races". Yet certain populations present a combination of morphological traits that seem to distinguish them from other populations. The problems related to identifying population affinity, using the skull as the primary criterion, are enormous. The increased level of hybridization poses a severe problem.

Aging the Skull

During the periods of prenatal and postnatal growth, the skull exhibits age-related structural changes that can be utilized in cautious age estimation. For example, at birth the composite occipital bone consists of four ossified parts: an upper or squamous part, a basilar part and two lateral parts. The squamous unites with the lateral parts between the third and fifth years. The basilar part does not unite to the lateral parts until the fifth year. There are individual skull bones which fuse with each other. For example the sphenoid bone approximates the ethmoid bone at the cartilagenous sphenoethmoidal synchondrosis. Bony fusion and cartilage obliteration occur at about 8^{th} year. The cartilagenous spheno-occipital permits the initial fusion of the basioccipital and basi-sphenoidal bony surfaces at a variable age near puberty but is not obliterated until the 14^{th} to 18^{th} years.

Suture Closure in the skull is another trait once thought to be an excellent criterion for age estimation. Some ethnic and sexual differences in sutural closure are apparent, *i.e.* populations of African ancestry tend to exhibit earlier initial and final closure than populations of European ancestry. Sutural closure in females tend to initiate and terminate earlier than it does in their male counterparts [10].

Sexing the Skull

The determination of sex in the skull is not reliable until well after puberty when the secondary sexual characteristics emerge. Generally a large skull is male, a small skull female. Skull of female is usually more gracile (rounder or more infantile). The supraorbital ridges, mastoid processes, base of skull, occipital region and muscular markings are generally more pronounced or marked in male. The male orbits are more square, the nasal apertures higher and narrower with sharp margins, and the mandible more rugged and square chinned. By contrast, the female orbits are higher, larger and more rounded, and the forehead contour is higher, more rounded and smoother. Radiography is extremely useful in revealing additional characteristics of the skull bones. Lateral radiographs and postero-anterior radiographs can offer additional information, particularly where there is evidence that the individual may have received orthodontic or other dental therapy prior to death. The lateral cephalometric radiograph can reveal architectural details of the skull and the morphological details of the frontal, maxillary and sphenoidal sinuses.

How Teeth Helps in Age Estimation?

There are several methods which used in estimating age with the help of teeth. They are as follows: a) Estimation of the age of an individual based on times of eruption of teeth b)Age estimation of aspartic-acid racemization in dentin of teeth. c) Age estimation from teeth using Gustafson's method. d) Age estimation from teeth using modified Gustafson's method. e) Age estimation by tooth cementum annulation.

a) Estimation of the age of an individual based on times of eruption of teeth [11]

The times of eruption of teeth, for deciduous and permanent, are fairly constant. Assessment of age of the individual by dental examination is one of the accepted methods of age determination. Eruption of teeth is one of the changes observed easily among the various dynamic changes that occur from formation of teeth to the final shedding of the teeth.

b) Age estimation by aspartic acid racemization in dentin of teeth

This method can be used for both deciduous as well permanent teeth. This method focuses on aspartic acid. The amino acid that has the highest racemization rate of all amino acids, and takes advantage of the phenomenon that the D enantiomers of aspartic acid contained in the dentin increase almost regularly as age increases [12]. An HPLC method is described for simultaneously obtaining the enantiomeric ratio of three amino acids (aspartic acid, serine and glutamic acid) from dental collagen [13].

c) Age estimation from teeth using Gustafson's Method [14]

Gustafson used six types of retrogressive change: ***Attrition (A)***: Mastication resulting in wearing down of the incisal or occlusal surfaces of teeth. ***Periodontosis (P)***: Periodontal changes. ***Secondary dentine (S)***: This will develop in the pulp cavity as a result of the ageing process. ***Cementum apposition (C)***: in and around the root, associated with periodontosis. ***Root resorption (R)***: Involving both cementum and dentine. ***Transparency of root (T)***: in the apical parts of the root. Gustafson was the first worker to use root resorption and root transparency for age estimation in a systemic manner. These changes were ranked on an arbitrary scale, being allotted 0, 1, 2 and 3 points according to the degree of change. This is very relevant in India where a good number of unidentified human remains frequently pose medicolegal problems.

d) Age Estimation from teeth Using Modified Gustafson Method

Gustafson method has been critically tested and reviewed by several workers and the method has been questioned in relation to old individuals because of the problems of quantifying the extent of migration of the periodontal attachment and the degree of root translucency. A modification to the Gustafson method was given by V.K. Kashyap and N.R. Koteswara Rao [15].

Principles

The ***attrition index*** was calculated as the width of attrited area measured in relation to the width of the teeth at the cervical margin. The ***dentine index*** represented the extent of dentine deposition in the pulp cavity measured in relation to the entire length of the pulp cavity. The ***translucency index*** was the length of the translucent region of the root measured in relation to the entire length of the tooth. The ***cementum apposition index*** was the thickening of the cementum at the thickest point on either side of the tooth measured in relation to the width of the tooth at the point where cementum was thickest.

Measurement of Parameters

I- Attrition (A)

Incisor and canine attrition index values

$$(A) = \frac{a}{A} \times 100$$

premolar and molar attrition index values

$$(A) = \frac{a_1 + a_2}{A} \times 100$$

where a = width in mm of the attritted teeth

a_1 and a_2 = width in mm of the attrited tip of buccal and lingual sides

A = width of teeth in mm at the cervical margin.

II- Secondary Dentin (D)

$$(D) = \frac{d}{D} \times 100$$

where d = length in mm of the secondary dentine deposition in the pulp cavity

D = length of the entire pulp cavity of the tooth

III. Translucency of the root (T)

$$(T) = \frac{t}{T} \times 100$$; where t = length in mm of the region of the tooth

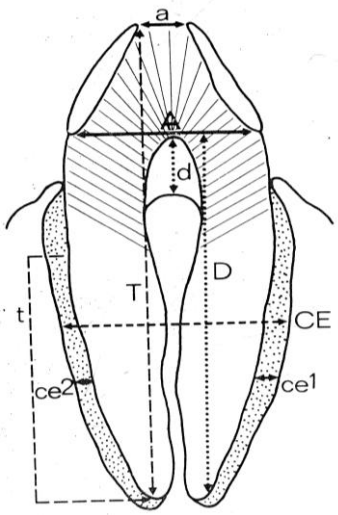
T = length in mm of entire tooth

IV. Cementum Application

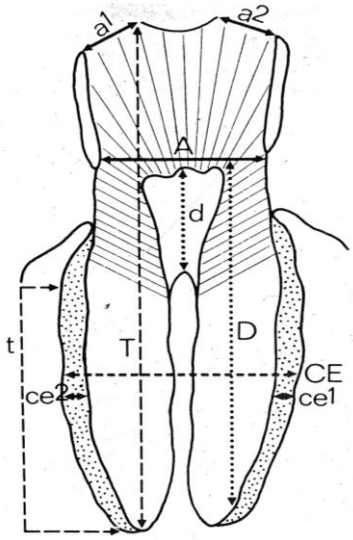
$$(C) = \frac{Ce_1 + Ce_2}{CE} \times 100$$

where Ce_1 and Ce_2 = thickening of cementum in mm at the thickest point on either side of the tooth

CE = width in mm of teeth with cementum at the thickest point



Parameters of incisor teeth for estimation of age



Parameters of molar teeth for estimation of age

(e) Age Estimation by tooth cementum annulation

Recent research indicated that tooth-cementum annulations (TCA) may be used more reliably than other morphological or histological traits of the adult skeleton to estimate age. Improved digital graphic procedures and enhancement strategies are used to produce digital images with a specially adapted software packages. Ursula Wittwer-Backofen *et al*. concluded by a study that TCA technique is a reliable method for estimating a subject's age from cementum [16].

CONCLUSION

There is no end of scope and utility of forensic dentistry. With the help of a single clue, you may find out the tale of whole crime. Dentist should always be aware of all those facts which can help in the procedure of investigation. He knows the value of records which should be kept for a long period as they may be further helpful in the investigation. Several computer programmes are available in market, according to which records can be maintained. It is amazing that so many cases had been solved on the basis of dental records and even a single tooth can be helpful in the investigation. By the passage of time this field has become more popular and everybody has accepted the role of dentistry in field of forensic science.

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