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Forensic Odontology in Dentistry: The Science Behind Identifying the Unidentified

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ABSTRACT:

Society is faced with various challenges in every step. Despite leaps in modern technology, medical breakthroughs and the geographical changes that the last century has brought, there has not been substantial literature dedicated towards the upcoming branch in medical sciences viz., forensic medicine. This article highlights the importance of Forensic Odontology and reviews the role of the periodontist in the same. Through the specialty of Forensic Odontology, dentistry plays a small but significant role in this process. By identifying the victims of crime and disaster through dental records, dentists assist those involved in criminal investigations. The most common role of the forensic dentist is the identification of deceased individuals. They can aid in identifying the person by using previous dental records and present dental findings. Even if the individual's previous records are not available, dentists can identify the sex and age by using the current postmortem findings. Recently, periodontists have identified the features of ante mortem and post-mortem changes in gingival tissues. Thus, in future, periodontists could also play an important role in forensic odontology.

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Introduction

Forensic Odontology a branch of Forensic sciences uses the skill of the dentist in personal identification during mass calamities, sexual assault and child abuse to name a few. This branch not stranger to many has been growing tenfold in its potential and its ability to bring the forlorn to justice where a dental remains is the only available evidence. It's role and importance in the judiciary is fast growing and hence in depth knowledge in this field seems more than justified.[1]

Forensic odontology is an evolving science and has a greater scope of development.It has established as an indispensable science in medico-legal matters and in the identification of the dead person. The dental tissues are often preserved even if the deceased person is skeletonized, decomposed, burnt, or dismembered. Various methods have been developed to determine age, sex, and ethnicity of the person, using dental tissues. Data collection methods and supplementary technologies used in forensic dental identification have undergone significant transformation. This article provides an overview of the evolving trends in conventional methods, and the recent concepts used in forensic odontology.[2]

Dentistry deals with diseases of the oral cavity. Forensic dentistry is used for identification of individuals through morphology and pathology of oral tissues and is also utilized for age estimation studies. The dental human identification is an essential procedure in the routine of medicolegal investigations. It is often performed through the comparison between the available antemortem (AM) dental data of the missing person and the postmortem (PM) data collected from dead person.[3]

History

- 66 AD: Well-documented evidence to the use of teeth for identification began AD with Agrippina and Lollia Pauline case. It was the first use of dental identification where there is a record.
- 1193: The first forensic identification in India started in were Jai Chand, a great Indian monarchy was destroyed by Muhammad's army and Jai Chand, Raja of Kanauji was murdered and he was identified by his false teeth.
- 1758: Peter Halket was killed in during French and Indian wars in a battle near Fort Duquesne. Halket son identified his father's skeleton by an artificial tooth.
- 1776: At the battle for Breed's Hill in Boston, Dr. Joseph Waren was killed in the year His face was not able to identify as he suffered from a fatal head wound. A dentist, Paul Revere, identified Dr. Warren, dead body by a small denture that he had fabricated for him. [1]
- In 1977, the body of Hitler and his wife Eva Brauma were identified using dental records with radiographs and prostheses.
- Sansare K and Dayal PK in their review in 1995 have mentioned that according to Elphinstine, M. Raja Jayachandra Rathore of Canouj, died on the battle field in 1191. His body was identified by his false anterior teeth. This was probably the first case of identification using dentition from India. [4]
- Thousands of people lost their lives in the world trade center disaster in the U.S.A on September 11, 2001. Deoxyribo Nucleic Acid (DNA) extracts from tooth brushes of the victims were used in identification of some victims. [4]

Scope of Forensic Odontology

1. Dental identification:
2. Multiple fatality incident management
3. Bitemark evidence collection and analysis
4. Abuse
5. Age estimation
6. Expert testimony in criminal and civil litigation

Role of Forensic Odontology in Dentistry

The techniques used to estimate age by means of teeth include Gustafson's technique, incremental lines of Retzius, perikymata, prenatal and postnatal line formation, racemization of collagen in dentin, cemental incremental lines and translucency of dentin. Gustafson used six dental changes connected with aging namely, attrition, apical migration of periodontal ligament, deposition of secondary dentin, cemental opposition, root resorption and transparency of the root dentin. Incremental lines of Retzius are caused by variation in the rhythmic mineralization of enamel prisms. These rhythmic patterns may be altered by various external

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factors such as metabolic disturbances so that the lines may appear closer or the rest periods may be prolonged. The number and spacing of incremental markings at the enamel surface, known as perikymata, are considered important indicators of dental growth patterns, as they provide information on crown formation times and the underlying develop mental processes. [5]

Other Methods for Age Estimation Includes

Age Assessment: Use of Chartier Digital Colorimeter

Age assessment is a crucial stage in dental forensic examination. It is often required by magistrates and investigators at the time of victim identification. Many assessment methods are based on dental measures (Lamendin, Solheim), others lean on different databases (Ubelaker, Nolla, Demirjian). The method we are going to address in this report requires a dental shade capture. In 1957, Brudevold correlated the change in dental shade with the age. In 1972, Ten Cate, who observed dental roots of persons of differing ages, noticed that an age assessment should be possible using dental root shade. In the 1980s, Bequain selected teeth of known ages in order to create an assessment of dental root coloration, going from lighter to darker. In 1988, Solhein introduced the shade assessment score of the radicular dentin in some of his age assessment formulae. In 1995, Collet created a natural "shade chart" of dental roots based on a selection of teeth extracted from 45 individuals, aged from 8 to 93 years. Age assessment is carried out by comparing a tooth with the shade chart. This process seems simple but the major problem resides in the fact that there is only one shade chart and therefore cannot be easily used by other forensic odontologists. Recognizing the availability of IT systems Laurent Chartier designed MAORI software which allowed automated age assessment of dental root colorimetrics in the HSB (hue, saturation, brightness) space. MAORI software provides a simple user interface for assessing root color. The system is simple; first, the user takes a digital photograph of the dental root with a graded test card. The image is taken in artificial (white light) or natural light. Secondly, the user loads the image into the software. The algorithm decodes the exact shade of the dental root color by comparison with the graded test card. As such, any differences in illumination are controlled. This comparison carried out in relation to a preprogrammed standard. Of course, this standard must be evolving. In increasing the quantity of samples, the standard equation increases in accuracy. Unlike the shade chart, it offers a better repeatability. The accuracy, which is totally independent of expert subjectivity and visual acuity, is in the order of +/ 5 years. Given the modularity and the possible evolutions, this first version should rapidly lead to a more stable version able to be deployed more widely in the future. [6]

Readability of Oral Radiographic Age (Bone and Dental Age) to Determine Chronologic Age: Preliminary Results on an Italian Population

A study done to evaluate if Oro-Cervical Radiographic Score (ORS), obtained by the combination of cervical vertebral maturation method and dental age, correlates with chronological age (CA) in an Italian sample showed that ORS correlates with CA and can be a useful tool for forensic medicine. Maturation stage of left lower third molar is mandatory when determining the age of subjects older than 14 years, but this evaluation can be influenced by several individual variations (i.e., agenesia, malformations, impaction). The introduction of CVM can add more information especially for those individuals with the third molar missing. Further studies must be carried out to enlarge the sample and to determine the influence of many possible confounding factors (i.e., race, socio-economical status, nutrition). [6]

Radiological Methods of Age Estimation in Children and Adolescents

There are four established methods of age estimation as mentioned below : [4]

1. Schoulr and Masslers method: In 1941 Shoulr and Massler have analyzed development of deciduous dentition and have evolved 21 chronological steps from 4 months to 21 years. They have published the data in the form of charts which have been updated from time to time by the American Dental Association.

2. Moorer, Fanning and Hunt method: In this technique 14 stages of mineralisation for developing single and multirooted teeth are used for age estimation.

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3. Demirijian, Goldstein and Tanners method: rated seven mandibular permanent teeth in an orderly manner ie second molar (M2), first molar(M1), Second premolar (PM2), first premolar (PM1), Canine(C), Lateral incisor(I2), Central incisor (I1) . They determined 8 stages of mineralisation from A-M using the above data and correlating the two, they determined the age of the individual.

4. Nollas technique: This technique evaluated the mineralization of permanent teeth in ten stages and can be used to assess development of each tooth in the maxilla and mandible.

Radiologic Methods of age Estimation in Adults

The accepted methods of age estimation using radiographs are as follows:

1. Volume assessment of teeth: this method is based on the reduction of the size of pulp cavity due to second ary dentin deposition which is directly proportional to age. A method by Kvaal et al used pulp to tooth ratio with volume values to calculate age.

2. Third molar development: Technique by Harris MPJ and Nortje CJ gives five stages of third molar devel opment. Based on the root formation of third molar one can estimate the individual's age.

Based on the above mentioned radiological methods of age estimation we can conclude that age measurement from X rays is simple and easy. Also with more advancement in the field of investigative and diagnostic radiology we can expect newer methods of age estimation from radiographs. [4]

Carbon Isotope Analysis of Dental Enamel Provides Precise Birth Dating and Clues to Geographical Origin

Determining the age of an individual is an important step in identification and a common challenge in forensic medicine. Age determination can be performed with high precision up to adolescence by analysis of dentition, but establishing the age of adults has remained difficult. The enamel of individual permanent teeth is formed at distinct, well-characterized time points during childhood. After formation there is no turnover of enamel, and its 14C concentration reflects the level in the food at the time of enamel formation. Atmospheric testing of nuclear weapons doubled the global 14CO2 level between 1950 and 1963. After cessation of atmospheric tests in 1963, the level of atmospheric 14CO2 started to decrease exponentially with a mean life of about 16 years due to transport into large carbon reservoirs such as the oceans. The enhanced level of 14C worked its way up the food chain from CO2 so that all living things are labeled with the pulse. The concentration of 14C in tooth enamel was measured of 95 teeth from 84 individuals from around the globe and related it to the known concentration in the atmosphere from 1955 to present to establish the time of tooth formation.

The use of the stable isotope 13C was investigated and used as an indicator of geographical origin of the individual. Using established ages of tooth formation, the dates were then used to estimate the year of birth of the person. The crown of the tooth was cut away from the root at the level of the cervical line. The crown was then immersed in 10N NaOH, and placed in a water-bath sonicator. The enamel was then washed with DDH2O and re-submersed in 10N NaOH every 24 hrs for 3-5 days until only enamel remains. Samples were rinsed with DDH2O and shipped overnight for isotope analysis. Upon arrival enamel samples were pretreated in 1.0N HCl for 1 h, rinsed 3 times with DDH2O and placed on a heating block at 95°C to dry overnight. Enamel splits were hydrolyzed to CO2 in individual reaction chambers, evacuated, heated and acidified with orthophosphoric acid at 90°C. The evolved CO2 was purified, trapped, and reduced to graphite in the presence of iron catalyst in individual reactors. Graphite targets were measured for 14C content by accelerator mass spectrometry (AMS). The technique of analysis of 14C content in enamel matched known age during the rising part of the pulse (1955-1963, N=12) and after the peak (post 1963, N=66) with average absolute errors of 1.9 ± 1.4 and 1.3 ± 1.0 years, respectively. Geographical location had no effect on the precision of 14C enamel birth dating. Much of the variability can be attributed to inter-individual differences in tooth formation and possible variations in carbon food sources at the time of enamel formation. Enamel formed prior to 1955 contained no 14C elevation above atmosphere at the time in 16 of 17 cases. Analyzing

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multiple teeth with different formation ages from a single individual can place date of birth on the ascending or descending side of the anthropogenic 14C spike and improve the temporal precision. In 46 teeth, measurement of 13C was also performed. Scandinavian teeth showed a substantially greater depression in average δ13C (-14.8) than teeth from subjects raised in Japan (-13.5), Middle East and North Africa (-12.7) and South America (-10.9). The differences in δ13C are due to differences in plants and diets in the different regions and thus can provide important information about the geographical origin of an individual. Isotopic carbon analysis of enamel offers a precise age determination with geographic information that can be applied in forensic casework, particularly to assist in investigations of unidentified human cadavers. [6]

Demonstration of the Fishman Method of Evaluating Hand-Wrist Radiographs and its Forensic Application

The hand-wrist film is an important diagnostic tool for predicting skeletal maturation. There are a number of methods used to assess skeletal maturation from these images. In the 1930s, Professor T. Wingate Todd published an atlas of skeletal development with hand wrist radiographs. Following in 1959, Greulich and Pile revised the hand wrist atlas. This atlas is still in use today. During the 1970s and 1980s, several papers were written with the goal of synthesizing the data to a uniform and easily managed assessment. The Fishman analysis was first published in 1982. This method has since been utilized by orthodontists to predict peak pubertal growth. The Fishman approach is easy to utilize. It reviews six anatomical sites. From these sites, four developmental categories are evaluated. The result is eleven stages of skeletal maturation. Assigned to each stage of skeletal maturation is an age range with standard deviation as seen in both males and females. The process of determining sites, assigning developmental categories and staging the image will be demonstrated. Applying this method to hand wrist radiographs for forensic age estimation not only provides an average age for adolescents for the particular stage but will provide an age interval and confidence interval. [6]

Recent Advances in Age Estimation

Amino Acid Racemization

Organisms utilize proteins which are the building block of their biologic composition. All amino acids (except glycine) have two asymmetrical geometric forms that are mirror images of one another and are known as stereoisomer designated as “L” and “D” forms of the molecule. At birth, only the L form of the amino acid exists systemically. Racemization is the gradual and spontaneous process of converting to a mixture of equal amounts of the L and D stereoisomers. Racemization will begin immediately at birth. Age can be estimated by measuring the degree of racemization that has occurred in a metabolically inactive tissue. Tooth dentin is rich in aspartic acid and assaying the degree of aspartic acid racemization within the tooth dentin has resulted in chronologic age assessment with error rates as low as ±3 years. [7]

DNA Analysis in Forensic Dentistry (Article2)

The sample for DNA analysis is isolated from the biological material such as blood, semen, hair roots, tissue, teeth, bone and saliva.

Specimen Selection

In the decomposed post-mortem tissue, Although DNA undergoes progressive fragmentation through autolytic and bacterial enzymes; the sequence of information is still present in the DNA fragment. Therefore information is not completely lost even though the body has undergone decomposition. In the fresh cadaver, unclotted blood can be source of DNA. [1]

Storage

The specimen should be stored in cold place or frozen. Desiccation, simple air-drying can be used to store bone and bloodstains. Tissue in formalin is often used for PCR ased DNA testing.[1]

Collection

One should be very careful about contaminating the specimens so should wear gloves and use pristine instruments. The collection of fresh specimen is done by incisional biopsy.[1]

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Reference sample

When there is no much information about ante-mortem of the individual, the specimens can be selected from spouse and children as reference sample for DNA testing. Forensic odontology has an important role because teeth and saliva is excellent source of DNA. Since 1992, the isolation of DNA from saliva and salivary stained material is done.[1]

Saliva

It is major source of DNA because; it contains sloughed epithelial cells from oral mucosa and inner surface of lip. The enzymes such as Streptococcus Salivarius and Streptococcus Mutans are present on teeth and in the saliva. In Polymerase chain reaction (PCR) technology, the Streptococcal DNA sequence provides a means with which to identify the bacterial composition from bite marks and can be matched exclusively to those from the teeth responsible.[1]

Cheiloscopy

Cheiloscopy is a forensic investigation technique which deals with identification of humans based on their lip traces. While using teeth as antemortem record, sometimes, we find loss of teeth and destruction of restorations may lead to difficulty in comparing the antemortem records and postmortem records. To overcome these difficulties, an immutable parameter should be used. Similar to the prints present in the finger, palm and foot, and lip prints are also unique and do not change during the life of a person. Lip prints provide sufficient information for forensic investigations as the lips also possess furrows and grooves.[2]

Rugoscopy

In case of teeth loss, due to reasons such as trauma, palatal rugae pattern serves as an alternative method for identification because of its uniqueness. As rugae is internally placed in the oral cavity and is protected by tongue and buccal pad of fat, it remains undisturbed from heat and other assaults. Rugae patterns change with age and other environmental influences such as orthodontic movements, tooth extraction, cleft palate surgery, periodontal surgery, and impacted canine eruption. Materials and methods used to analyze the rugae patterns includes, photographs and impression of maxillary arch, computer software programs (for e.g., RUGFP-ID), calcorrugoscopy or overlay print, stereoscopy (through which three-dimensional [3D] image of palatal rugae can be made), stereophotogrammetry (which is comparatively accurate). [2]

Recent Concepts

Tongue Prints

Tongue is unique to each person in its shape and surface textures and is the only internal organ that can be protruded from the body and easily exposed for inspection. Use of tongue prints for forensic identification is at budding stage now. For this technique to be successful, the antemortem photograph or impression of the tongue should be available. The lingual morphological aspects can be preserved using the alginate molding technique for duplicating the minute details which are unique for each and every individual. The lingual impression, together with its photographic image, may constitute secure methods for forensic dentistry identification.[26] The tongue prints present in the human tongue recently becomes a new member of the biometrics family. Tongue biometric template can be made using three views such as left lateral view, right lateral view, and profile view. Extraction of tongue algorithm of collecting points gives efficient template for shape of the tongue whereas for texture analysis, normalized histogram with Scale Invariant Feature Transform is used. Matching is done by combining both the extraction techniques templates. [2]

Ethics in Forensic Dentistry

Ethics is the process of determining right and wrong conduct. Three common approaches to decision making in bioethics are: (1) Principalism, (2) Moral Rules, and (3) Casuistry. Not only can a disciplined ethics analysis help to distinguish right action from wrong action in difficult cases, but it also provides a basis to understand why one action is morally preferable to another. Ethical issues usually arise when one's own interests come into conflict with the interests of others. In forensic dentistry there are instances where ethics and law may conflict.

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One has a prima facie ethical obligation to obey the law, but arguably a greater obligation to do the morally correct thing. A legal resolution is not necessarily ethically justified, nor is an ethical resolution necessarily legally permissible. Ethics considers obeying the law a prima facie obligation, while law attempts to achieve ethical harmony. [6]

Limitations of Research in Forensic Odontology

- Ethical issues in sample collection in crime investigation.
- The application of molecular and biochemical techniques in Forensic Odontology are expensive.
- False positive results , when Records are not stored properly.
- Technique sensitive methods require bigger team of investigators.
- Time consuming

Challenges in the Indian Scenario

In our country awareness about the importance of record maintainence among Dental Professionals is not satisfactory which poses a great challenge for person identification both in crime investigation and mass disasters. Most of the dental professionals in our country do not pursue research or career in this field due to social and cultural reasons.

Conclusion

Forensic odontology in dentistry can a boon in present as well as future. Identification of sex and age of person is the important part of forensic medicine in dentistry using dental tissues, hence experienced dental specialists should link together and provide guidance for the research studies in forensic odontology. So Maintaining all the records of patients visiting for dental treatment should be mandatory for future , which can be used in any kind of critical situations. It is important to know the knowledge about forensic science and dental role in it .

References

1. K. P. Divakar. Forensic Odontology: The New Dimension in Dental Analysis. Int J Biomed Sci 2017; 13 (1): 1-5.
2. Jeddy N, Ravi S, Radhika T. Current trends in forensic odontology. J Forensic Dent Sci 2017;9:115-9.
3. Harshni TS, Umayal M, Selvan NM, Nivetha R. Evidence of perio in forensic. J Indian Acad Dent Spec Res 2017;4:68-70.
4. Saranya V, Malathi. N. FORENSIC ODONTOLOGY: A BRIEF REVIEW; Sri Ramachandra Journal of Medicine, July-Dec 2014, Vol.7, Issue 2.
5. Thorakkal Shamim. Forensic Odontology. Journal of the College of Physicians and Surgeons Pakistan 2012, Vol. 22 (4): 240-245.
6. https://www.dentalage.co.uk/wp-content/uploads/2014/09/aafs_odontology_ebook2011-2012.pdf
7. Harshni TS, Umayal M, Selvan NM, Nivetha R. Evidence of perio in forensic. J Indian Acad Dent Spec Res 2017;4:68-70.