



Forensic Odontology-A Complete Insight

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Abstract

Forensic odontology has played a vital part in the branch of forensics from ancient ages, in modern world the forensic odontology has evolved a lot and remains as one of the most accurate methods in person identification. It uses remains of teeth, Oral and para oral structure to identify an individual. The article underscores how dental evidence remains a reliable and authentic means of identification offerings insights into age, gender, ethnicity and even lifestyle. This article also depicts about the history, various methods, present and recent advancements of forensic odontology.

Keywords: Bite mark, Chelioscopy, Dental profiling, Forensic odontology, Molecular methods, Viridentopsy

Introduction

Forensic refers to Latin word “forum” which pertains to court of law. Keiser-nielson (1980) defined forensic odontology as “ the branch of forensic medicine, which in the interest of justice, deals with proper handling and examination of dental evidence and with proper evaluation and presentation of dental findings”. [1]

Forensic dentistry plays a vital role in personal identification especially in crime and mass disaster. It also plays major role in identification of criminals in abuse and assault cases. It also elicits the lifestyle followed from the remains gathered from archaeological sites

In the recent ages the forensic dentistry has progressed to greater extent through DNA analysis and molecular methods .It uses genomic and mitochondrial DNA from various structures including cells from Pulp, dentin or cementum and desquamated cells that are present in saliva.[3]

In digital forensic the traditional methods are computerized in terms of analysing and reporting the evidences and are commonly used in mass disasters nowadays. Amidst covid-19, a new technique viridentopsy has been introduced which uses dental data from remains to get generic information about the unidentified persons. This article is intended to explain the Techniques and advancements in forensic odontology field

History

The earliest recorded case of forensic dentistry was of Emperor Nero’s wife , who was identified after her death through the unique arrangement of her teeth. She was killed by the soldiers sent by his mistress who demanded to see the head of the victim in a dish. She recognised the head by a black anterior tooth. Later in 1775, Paul Revere found victims of a revolutionary war by their teeth and dental work. He also identified the body of Joseph Warren by finding a Walrus tusk which was used as a pontic for his

missing maxillary canine. Late in 1977, the body of Hitler and his wife Eva Brauma were identified using dental records. In 2001, thousands of people lost their lives in the world trade centre disaster in the U.S.A when Deoxyribo Nucleic Acid (DNA) extracts from tooth brushes of the victims were used in identification of some victims.[5]

Forensic Anthropology

In forensic anthropology by examining the skeletal remains, one can determine the race, gender, stature and age of the deceased. It significantly narrows down the search for identity of the victim in case of cemetery or skeletal remains. The morphological features of tooth such as Cusp of Carabelli, hypocones, peg shaping of teeth and taurodontism gives us an idea about the dead.[1]

Dental Profiling

It is used for identifying the ethnicity from teeth. Post mortem dental profiling helps to limit the population pool of possible victims, thus directing the investigator to a presumptive identification of the individual and a potential identification. This profile may provide information on the decedent's age, ancestry, sex, location of origin or residence, occupation, habits, lifestyle behaviour, past or present systemic disease and socioeconomic status. The recommended approach for this is to evaluate non-metric dental traits, defined in terms of presence and absence of features such as Cusp of Carabelli, three cusped maxillary second molar, four cusped mandibular molars, shovelling, winging.

Age Estimation

Physical examinations such as skeletal maturation, dental age estimation, and a combination of dental development helps in the process of identification of human beings.

Dental maturity helps in assessing the chronological age of individuals. The teeth analysis can provide a pretty accurate estimation of age between infancy and childhood. However, beyond adulthood, changes are too unpredictable. If the third molars are fully erupted, then the person is above 17 years; if the root growth is incomplete, the person is probably under 25 years. Several factors used for age determination includes appearance of the tooth germs, the earliest trace of mineralization, the degree of completion of the unerupted tooth, the rate of enamel formation and

neonatal line formation, attrition of crown and transparency of the root dentin

Clinical methods for age Estimation includes eruption sequence, appearance of tooth germs in X ray, commencement of mineralization, Degree of crown and root completion, ration of pulp to tooth, Degree of root resorption in deciduous teeth, eruption of the third molar, translucency of dentin and racemisation of dentin. Eruption of third molar is of great use in distinguishing between juveniles and adults. Radiographs can reveal much information about the person's age. This method is simple as it is based on identification of stages of mineralization on the radiographs followed by comparison of it with the data. Features like

1. prenatal appearance of jaw bone
2. tooth germ appearance
3. crown eruption into oral cavity
4. third molar development and eruption
5. volume assessment of teeth
6. aid in radiological age Estimation.

Recent advances in age Estimation are done by analysing the biochemical changes in teeth. It uses racemisation of amino acids in the dentin and carbon 14 levels from enamel.[5]

Sex Determination

Molecular and morphological analysis is usually used for sex determination in cases of personal identification. Sex of the individual is determined from very minute quantities of DNA [1]. Teeth are the excellent source of genomic DNA and sex of an individual is determined from DNA fingerprint. They include Polymerase chain reaction, Fragment length polymorphism method,

Single-nucleotide polymorphism and Analysis of Y chromosome. Amelogenin is one of the major matrix proteins secreted by the ameloblasts of enamel. Modern DNA extraction

methods can isolate genomic DNA from the gene amelogenin, a sex-linked gene. Sex determination can also be accomplished with microscopic examination of the pulp tissue observing the nuclei of somatic cells. Females will exhibit Barr bodies in the nuclei while males do not.[17]

Bite Mark

Bite marks are mostly found on the victims of brutal events such as sexual assaults, child molestation and other abuse. Features like missing, broken, rotated or supernumerary teeth can be determined. As dentition of each person is unique, bite marks are of great importance for forensic odontology.[21] Bite marks can indicate the shape of the arch and other necessities like shape of nose and jaw for the occlusion. Computer odontology is a new advance that allows digital comparison of the teeth to the bite marks at a 3D level which includes automatic dental code matching, odontosearch and 3D bite mark analysis. The steps in bite mark investigation includes preliminary interrogation, evidence collection from the victim, case demo graphs, visual examination, photographs, saliva swab, impression making, evidence collection from the suspected, comparison and drawing a conclusion. The questions include what is the shape and size of the teeth seen in the mark and their demarcation and whether the injury fit the history provided, how and when inflicted.[23]

Rugoscopy:

The study of palatal rugae is known as Rugoscopy. It helps for personal identification. Rugae are irregular connective tissue folds in the palate that are unique to each individual. Thus it is the preferred method when teeth are absent. Impression materials like alginate, impression compounds, etc are used to record rugae patterns and then casts are poured after which the rugae is compared with the suspects. Other methods like

Photographs

Clcorrugoscopy (overlay print)

Stereoscopy

Stereophotogrammetry

Computer-software like RUGFP-ID

are used to examine rugae markings. Factors that affect palatal rugae pattern includes aging, Orthodontic tooth movement,

neighbouring tooth extractions, surgery of cleft palate, periodontal surgical procedures, and forced eruption of impacted canines. Rugae pattern are classified as diverge, converge, curve, wavy, straight and circular. Rugae patterns are helpful in gender differentiation and race differentiation.[21]

Cheiloscopy:

The study of lip prints is called as Philosophy. Like fingerprints, Lip prints are also unique to each individual. Lip prints must be obtained within 24 hours of death from the body or from objects like cups, glasses, spoons, clothing, etc. present in the crime scene. The well-defined grooves of lip are seen when the mouth is in a closed position, while the grooves in the open-mouth posture are not well defined and are difficult to understand. Cheiloscopy is also used for age determination.

Suzuki and Tsuchihashi's Classification of lip prints (1970):

1. Type I: Prominent grooves running vertically
2. across the lip
3. Type I': Straight grooves which disappear half-way
4. Type II: Fork grooves
5. Type III: Intersecting grooves
6. Type IV: Reticulate grooves
7. Type V: Undermined.[21]

Tongue Print:

Tongue prints are just like finger prints and lip prints. Tongue prints are unique to each other. It is recently added in the family of biometrics. Tongue biometric template has three views such as left lateral view, right lateral view, and profile. Tongue prints are recorded with alginate, and then cast are poured and the model is used for study purpose. For successful technique antemortem photograph should be taken. The tongue pathologies may cause errors. Gender estimation is also possible in this method. In this technique the changes in the texture, size, colour and shape of the tongue can be seen.[21]

Smile Analysis

The dental analysis of the smile constitutes of specialties that include aesthetic dentistry. A smile can reveal dental relationships of symmetry, dental axes, gum contours, incisal edges, teeth proportions and smile lines.[23]

Denture Identification

Dentures can be useful aids in identification. The chances of identification of an edentulous person wearing dentures are high. Thus labelled or marked dentures are more useful. The denture labelling should consist of name alone or along with other

details like contact number, address, city code and others which when used inside a denture provides great help by preventing misidentification or delay in identification. Cobalt—chromium made dentures resist melting even in some cases of incinerated remains. A new method for denture identification is The Lenticular card: which consists of the first flip image of the patient's name, sex, and age, and a second flip image of his/ her address and driving license number, they can be inserted into an existing denture. An all-acrylic resin denture could be marked with the patient's full name on a paper or metal and is sealed inconspicuously into the surface of the denture before delivery. Materials such as stainless steel orthodontic band, matrix band material, shim steel material, or aluminium can be used as metal inserts. In cases of air disaster, some denture materials, especially the posterior part of any type of dentures, outlast because of the tongue.[23] poi

Facial Reconstruction

When the examination and identification process toward establishing a presumptive Identity for the victim is unsuccessful an artist's facial reconstruction technique may be used. Facial reconstruction from a skull is a combination of both science and art. The anthropologist could provide information regarding the estimated Age, ancestry, sex, and stature from the remains. The forensic dentist obtains information regarding racial Characteristics seen in the teeth and any unusual dental traits or anomalies. The various Law enforcement agencies may provide information about items found at the Recovery scene such as hair color, eye glasses, facial hair, and unusual clothing or jewellery. There are two methods of facial reconstruction. The first is a 2-D method, it is a sketch Of the unidentified subject upon life size photographs of the skull. The second is the 3-D method, it is done by applying clay to the actual skull in an attempt to render a Sculpture of the unidentified subject. The known "tissue thickness stops" for each Anatomical location of the skull has been used for reconstruction. The 2-D technique is less time-consuming but it is a typical artist's composite sketch. The 3-D version generates much more realistic results yet it is more time-consuming and Expensive to produce and the skull must also be available in a stable condition In order to support the clay.

Amelogyphics

Amelogyphics is a study of Enamel rod pattern of tooth. Enamel rod patterns are obtained by using cellulose acetate peel technique and subjecting the photomicrographs to verifinger standard SDK V5.0 software. The enamel rod pattern is unique for every tooth and every individual and it is also shows gender variations. Hence it can be used in person identification. The branched wavy subaltern of enamel rod is the most commonly observed pattern. Cellulose acetate film, cellophane tape and light body impression materials can be used for recording enamel rod pattern. The cellulose acetate film is proven to give more accurate results among all others[5]

Role Of Saliva

Early collection of saliva from the bite marks are useful for group tests. This saliva sample can then be coupled with forensic DNA analysis to rule out the connection between an individual and the forensic evidence. Saliva tests can also reveal age related diseases, viral infections, and details about presence of drugs in the body.[23] Also the genomic and mitochondrial DNA from desquamated cells that are present in saliva can be used for unique identifying techniques in this advanced era of genomics and proteomics.[3]

Molecular Methods And Dna Analysis

DNA profile reflects a person's genetic makeup, so can be used as The person's identifier.[1] Teeth are the most durable structure in our body. The hydroxyapatite crystals of the enamel binds To the DNA and stabilizes it, therefore much DNA can be obtained from the teeth. In addition, Microscopic examination of the cells from the pulp can also show the presence of Barr bodies in females. The ample sources for genetic material from the pulp of tooth includes the fibroblasts, odontoblasts, nucleated blood cells and endothelial cells. The preferred method of extracting the DNA from The tooth is considered to be horizontal sectioning of the cervical portion of the tooth.[17] DNA analysis has become one of the most Recent trends in forensic dentistry. Teeth being the strong and resistant structure of our body to trauma, provides an excellent source for DNA finger-typing. The genome extracted from the pulpal tissue can be crossmatched to identify the victim. Even a very negligible amount of 1 nanogram of DNA can Be amplified easily to differentiate an

individual with the help of the PCR (Polymerase chain reaction) technique. The amplified DNA then could be compared with the post-mortem Samples like blood, combs, clothes, nails, etc. Some advanced techniques that has gained popularity in forensics by DNA typing include Restriction Fragment Length Polymorphism Typing, Short Tandem Repeat (STR) Analysis, Single Nucleotide Polymorphism Analysis and DNA methylation analysis(with saliva).[21] The most important observation on use of DNA From dead bodies is that the DNA Sample can be degraded by time, temperature, humidity And light but the teeth still represents as the best source For DNA as a molecular tool for forensic odontology.[5]

Computer Odontology

In recent days, the 3D printing plays major role in forensic odontology, incase of bite mark analysis, chelioscopy, rugoscopy, 3D facial reconstruction, age estimation from 3D model, sex determination and population identification. It can also be used to illustrate the pattern of bony injury. When more number of victims are involved, a computer programme can be used in the comparison of ante mortem and post mortem reports. The manipulation of data by the programme depends on the quality of both post mortem and ante mortem records. These programmes provide good quality and rapid results when good records are available

Viridentopsy

The term VIDENTOPSY is a combination of two terms “virtual” And “dental autopsy”. It provides a remote forensic odontological assessment of post-mortem dental data of Unidentified human remains. Viridentopsy allows for the systematic collection of post-mortem dental data Performed by forensic pathologists, dentists with no forensic background, dental hygienists With a forensic background, or other forensic operators authorized in the mortuary. These Operators perform dental and intraoral collection of post-mortem dental data following the Preliminary dental examination of human remains. These Data can be transmitted to the human identification laboratory, where One or more forensic odontology consultants could evaluate the data received and provides dental Charting and autopsy report. The viridentopsy screening reduces technical consultancy costs, speeds up the process of Human forensic identification and respect forensic human

identification protocols through The complete collection and evaluation of all dental evidences. this process is immediately applicable as the technology required is already available in latest smartphones and it is a revolutionary humanitarian forensic Odontology tool in all identification processes.[42]

Conclusion

Forensic odontology is an evolving branch of dentistry with lots of recent advancements. It plays a major role in investigating and interpreting the dental evidence which makes a huge contribution in the court of law. The dental evidences are considered authentic and reliable as the teeth is intact even after decomposition of body and can be recovered from disaster site.[1] The person identification in forensic odontology through various methods such as bite mark analysis, rugoscopy, chelioscopy, tongue prints and smile analysis provides the most reliable results. The genetic identification of an individual can be easily Performed in forensic odontology with recent advancements such as DNA recovery from saliva and dental samples, Amelogyphics and molecular methods. With the latest developments such as videntopsy, the forensic odontology would reach milestones in future.

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