

Evolving Trends in Forensic Odontology

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Abstract

Forensic odontologists have been playing an indispensable role in the sphere of forensics for over a hundred years. The various method used by them in identifying individuals from the human remains have been evolving over the years. Using dental remains is not just feasible but budget-friendly and time-saving as well. This article reviews the current trends in the branch of forensic dentistry while also highlighting the importance of antemortem records in comparison with post-mortem evidences.

Keywords: *Forensic odontology, identification, antemortem, postmortem, trends.*

Introduction

Forensic odontology is a subspecialty of dentistry that deals with the implementation of the art and science of dentistry within the criminal justice system. It mainly focuses on identifying deceased victims and unknown perpetrators. Forensic odontologists collect dental evidences from the crime scene, examine them and present them in the court of law.¹

Teeth are the hardest and the most resistant tissues in the human body. Teeth are capable of standing firm against various natural disasters, major accidents, burials, crimes, or other severe exposures like broiling temperatures, humidness, and pressure changes. They do not decay easily and the teeth pattern is unique to each individual which is why they are very useful in identifying a person. The techniques used in forensic odontology has evolved through the evolution of humankind. This article aims to provide an overview of the most recent trends.²

Evolving Trends in Conventional Method Used in Forensic Odontology:

DNA finger typing: DNA analysis is one of the most recent trends in forensic dentistry. Teeth being strong and resistant to trauma provides an excellent source for DNA finger-typing. The genome can be extracted from the pulpal tissue and crossmatched to identify the victim. Even an amount of DNA as negligible as 1 nanogram can be amplified to easily differentiate an individual with the help of the PCR (Polymerase chain reaction) technique. The amplified DNA is then compared to the post-mortem samples like blood, combs, clothes, bedsheets, etc. This method has gained popularity in forensics.³

Types of DNA:

- a) Genomic-DNA – Found within the nucleus
- b) Mitochondrial-DNA - Used when the retrieved DNA-sample is insufficient or degraded

Stages in DNA extraction:

- a) Cell membrane is ruptured
- b) Proteins are denatured using chelating agents and inactivated using proteinases
- c) DNA is extracted using organic phenol, Chelex or isopropyl alcohol

“Advanced techniques in DNA typing:

- Restriction Fragment Length Polymorphism Typing

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- Short Tandem Repeat (STR) Analysis
- Y-Chromosome Analysis
- X-Chromosome STR
- Single Nucleotide Polymorphism Analysis
- DNA methylation analysis”

Bite mark analysis: Bite marks are often found on the skin of victims in brutal events like sexual assaults, child molestation and abuse and other such crimes. Sometimes the victims while defending themselves, bite the perpetrator which leaves a mark on the attacker. The marks on males are found on the hands, forelimbs and shoulders whereas on women they're usually found on the bust and rear end. Unique characteristics like missing, broken, rotated teeth or supernumerary teeth along with the arch width can be determined. This helps in age determination as well. They have been categorized by Mac Donalds as “tooth pressure marks”, “tongue pressure marks” and “tooth scrape marks”.⁴

Method

Most of the bites are hardly discernible by the naked eyes and hence UV-illumination method is used to detect the bites.

1. The marks are analyzed by comparing a suspect's bite marks to those found at the crime scene with the help of transparent overlays. These overlays are usually hand traced using study-casts, wax-impressions, xenographs or other techniques like image-perception.
2. DNA can be retrieved from the saliva from the marks. This is one of the trends. salivary DNA recovery and bacterial genotyping from the bite marks are the most recent ones and have become the backbone of forensic investigation.
3. Another recent method is genotyping from bacteria from the marks.

The analysis of bite marks is not very accurate since the skin has many contortions and indentations. Therefore, they're usually used conjointly with other method of investigations to achieve a more accurate inference.⁵⁻⁷

Dental Record Maintenance: The dental records are legalized documents which contain the data of the patients. The dentist must maintain these records which are very useful in identifying the deceased victim or the

criminals in medicolegal cases and forensics. The records also help in following up on the patients. They have been of great use in many disasters such as the 11th September WTC attacks and the tsunami of the Indian Ocean. The antemortem records are compared with the post mortem affirmations or other pieces of evidence found at the crime scene. These records have an account of all the complaints, medical histories, clinical examinations, diagnoses, dental-treatments, prognoses of the patients. These are usually penned down in forms and stored in huge shelves inside a storeroom. However, with the advent of technology, storing data in computers makes it easier for transferring and networking documents without much hassle. In America and other states of Europe, maintaining teeth records is mandated by law. The case is not the same in a third world country like India where people including many dentists are not aware of this practice and its uses.^{8,9}

Dental imaging: The first application of radiology in forensics dates back to the year 1898, which is 3 years after the first radiograph was devised by C. Roentgen. Since then they have been playing a vital role in post mortem examinations. The post mortem radiographs are superimposed on the ante mortem images and then the comparison is made. Facial snapshots and videos show features of individuals in detail and hence are very useful in identification purposes. Orthodontists can help in determining the various oral tissues that form the smile of a person with the help of radiographs and photographs.

Identification of victims: Antemortem computed tomography pictures layout many details which help in reproducing a duplicate photograph of the deceased person, taking into consideration that points of craniometry can be accurately located and calculations can be made. Every person has a unique design of their frontal-sinus which can also be put in service in identifying the victims.¹⁰

Age estimation of adults from dental radiograph: With an increase in age, the proportions of the pulpal tooth cavity reduces as the consequence of secondary dentinal deposition. This takes place along with a reduction in the pulpal size. Hence, the pulp-tooth ratio can be determined to estimate the age of a person. The 3rd finger's middle-phalanx radiographs also indicate the skeletal maturity of a child.

To determine the cause of death: Radiographs may provide evidence of bullets or foreign bodies in the soft tissues following firearm incidence and explosion. After air crash accidents, the cause of the crash may be elucidated by the presence of radio-opaque objects in the soft tissues.¹¹⁻¹³

Dental profiling: Profiles of individuals before their deaths can be designed with the help of radiographs. The post mortem anterior teeth play a major role in profile designing as they can be remodeled to estimate their alignment and angulations. The triad of factors taken into account are age, gender and ethnicity.¹¹⁻¹³

Radiographs must be curated before the head and neck necropsy. Ideally, they should be taken at the crime scene. Proper labeling with IDs, location and date is mandatory and helps in the future.¹¹⁻¹³

Rugoscopy: Rugoscopy is the study of palatal rugae. It is an emerging tool used for personnel identification in forensics. They have three to seven folds of irregular connective tissue known as ‘plica palatine’ located on the anterior third of the palate. These are unique to each individual. They are quite reliable as they are safeguarded by tongue and buccal fat and remain unruffled by any trauma. This method is preferred when teeth are absent. Several impression materials such as alginate, impression compounds, etc are used to record the pattern. Then the casts are poured and the rugae are compared to those of the suspects.

Other method used to examine the rugae markings comprise of:

- Photographs
- Clorugoscopy (overlay print)
- Stereoscopy (creates a 3D image of the rugae)
- Stereophotogrammetry”
- Computer-software like RUGFP-ID

Studies have shown that there is no sexual dimorphism in the rugae patterns which is why they cannot be used to determine gender. Although the patterns are unique to each individual, some errors may be found as they can change with age, orthodontic treatments, and other surgeries.

Cheiloscopy: Cheiloscopy (*Cheilos* meaning lips and *scope* meaning examination) is a forensic

investigation technique dealing with the identification of humans based on their lip prints. Just like fingerprints, the grooves present on one’s lips (sulci labiorum) are unique to each individual. Lip prints should be obtained within 24 hours of death from the deceased person’s lips or from objects like cups, glasses, phones, clothing, etc. at the crime scene. The prints are clear-cut in closed mouth and when the mouth is open the prints are ill-defined and hard to decipher. The prints can be inaccurate if the lips wear a thick layer of lipstick or balm or in pathological conditions like mucocoeles, traumatic ulcerations, loss of support in absence of anterior teeth.

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

- Type I: “Prominent grooves running vertically across the lip
- Type I: Straight grooves which disappear half-way
- Type II: Fork grooves
- Type III: Intersecting grooves
- Type IV: Reticulate grooves
- Type V: Undermined”

Cheiloscopy plays a major role in age determination. They have been proven to be superior to fingerprinting in determining gender. According to the Vahanwala-Parekh study, a study conducted by Vahanwala-Parekh,

- Type I and Ia patterns were primarily found in females in the third and fourth quadrants
- Type II pattern was dominant in males in the second quadrant Individuals with different patterns in all quadrants were common in males, whereas having the same pattern in all quadrants were seen in females.

Lip prints can be procured by cellophane/scotch tapes which are sensitive to pressure. Of late, biometrics scanning of lips has gained traction.¹⁴

Recent concepts in forensic dental identification:

Denture identification method: If the injured/deceased person has been found to wear dentures, then the identification process becomes effortless, provided that the dentures are marked. Marking the dental prostheses is not practiced in India where people are not cognizant about the merits of marking dentures.¹⁵

Method

- **Superficial marking:** involves etching and embossing on the surface of the denture. The backdrop with this is that the markings fade with time and hence not permanent.
- **Inclusive marking:** This involves metal identification-bands, lead paper-labels, micro-labels, T bars, bar codes, etching by lasers, radiofrequency ID tags, polyethylene lenticular cards, photoelectric microchips.

Every country has its own special identification numbering system for its citizens. In America, the dentures are labeled with the social-security digits whereas in Australia citizens have their tax numbers which are labeled on dentures. In India, this practice is yet to be started and when it does, we can effectively use our unique Aadhar QR bar code to label on the dentures.

Comparison Microscopes: Comparison-microscopes, as the name suggests, help in comparing different specimens simultaneously. The device comprises of 2 microscopes attached by an optical-bridge. This bridge has a split-view window. This device allows easy comparability between a piece of evidence-specimen and the smear of a suspect.

Determination of both sex and age can be easily done using this device. Sex can be determined with the absence or presence of Y-chromosome and age can be found out by examining teeth for annuli of cementum. With age, cementum forms ring-like annuli in teeth just like the trees. This phenomenon called, cementum aging, can be examined under the microscope for estimating the age of an individual. The virtual comparison- microscopes have excellent accuracy and hence are an evolving trend in forensics. They can also identify bullets.

Facial reconstruction: When a person's face gets damaged beyond identification, this field of forensics comes into play in fabricating a facsimile of the person's premortem face. The skull does not decompose easily and hence it plays a crucial role along with the soft tissues over the bone. The method can be both 2D and 3D.¹²⁻¹⁶

Method

- **Manual:** Impressions of the skull are taken, casts poured, face is manually sculpted with modeling clay. The facial-features are chiseled on the model and

hair is added.

- **Computer-assisted:** Virtually sculpting a face on computerised software using various imaging techniques that give an idea about the soft-tissue depth. The various imaging method are cephalometry, CT, CBCT, MRI, lasers, digital stereophotogrammetry and fusion imaging.

Face being the most distinct feature of humans is of utmost importance when it comes to identification techniques. Although reconstruction may not produce the exact copy of faces but it has proven to be a splendid.¹²⁻¹⁶

Tongue Prints: Tongue prints just like finger and lip prints are unique to each individual. Not just prints, the differences in the texture, size, colour and shape can be visually inspected. This method of personnel identification is burgeoning now in forensics. It has been recently added to the family of biometrics.

These prints can be recorded with impression-materials like alginate, casts are poured and the model of the tongue is prepared for studying the details and comparisons are made. For this technique to be successful, the antemortem images of the tongue should be available in the form of digital databases. It was found in a study that males had septate tongues whereas females had sharper tips. Hence, approximate gender estimation is also possible using this method. The presence of pathologies on the tongue may cause errors.¹²⁻¹⁶

Conclusion

Forensic odontology is a budding field of dentistry which has evolved manifolds over the years and has a great scope for further development. The anatomy of the tooth is unique to each individual and its resistant nature even in harsh conditions has made it an excellent and reliable source for personnel identification. However, the various method devised for the same will have little or no use if there is an absence of premortem records of the person as without them the post mortem records cannot be compared and identified. In many western countries, dental record keeping has been mandated by the law. Therefore, in our country too, the government should encourage this practice and the researches related to it while paving the way for the implementation of several new technologies in the field of forensic dentistry.

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