Review Article

Indian Journal of Forensic Odontology
Volume 15 Number 2, July-December 2022
DOI: http://dx.doi.org/10.21088/ijfo.0974.505X.15222.4

Current Trends in Forensic Odontology: A Literature Review

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How to cite this article:
Ayappali Kalluvalappil Nabeel, P Nasma, Febin Shalu/Current Trends in Forensic Odontology: A Literature Review/Indian Journal of Forensic Odontology. 2022;15(2):83–88.

Abstract

Aim & Objectives: To Our society is facing new challenges, from an increase in crime to a rise in natural disasters. Despite advances in technology, it is still difficult to identify criminals using medical techniques. Dental tissues are frequently still present in corpses that have been burned, decomposed, skeletonized, or dismembered. So, forensic odontology has proven to be a crucial science in medical legal cases and in the process of identifying the deceased. This article gives a broad overview of contemporary forensic odontology concepts and the changing trends in traditional methods.

Keywords: Forensic Odontology; Dental Identification; Bite marks; Cheiloscopy; Rugoscopy.

INTRODUCTION

Despite advances in technology, it is still difficult to identify criminals using medical techniques. For a variety of reasons, including legal, criminal, humanitarian, and social ones, it is crucial to identify human remains.[1] Dental remains are frequently resistant to decay even in difficult situations like accidents, crimes, burials, or other severe exposure to the elements, so they can be used for identification.[2]

Forensic Odontology or forensic dentistry was defined by Keiser Neilson in 1970 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".[3]

Traditional techniques used in forensic odontology include maintaining dental records, dental imaging, analysing bite marks, cheiloscopy, and rugoscopy.[4] In addition, the field of forensic odontology has recently been introduced to new ideas like facial reconstruction, denture identification, DNA fingerprinting, and tongue prints.[5] This article gives a broad overview of contemporary forensic odontology concepts and the changing trends in traditional methods.

History of Forensic Odontology

The Agrippina and the Lollia Paulina case, which occurred in 49 AD, marked the beginning of ancient dental identification. Lollia's teeth were found to have some distinguishing characteristics that were used to identify her after she passed away.[6] A Walrus tusk used as a pontic for Joseph Warren's missing maxillary canine helped Paul

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Received on: 20.09.2022

Accepted on: 26.10.2022

Revere identify the body in 1775.[7] This was the first case of identification by a dentist. In 1977, Hitler and his wife Eva Brauma's bodies were identified using dental records, radiographs, and prosthetics.[8]

Dentition was used to identify General Zia-ul-Haq, the late president of Pakistan who perished in a plane crash in 1988.[6] On September 11, 2001, the world trade centre disaster in the United States claimed the lives of thousands of people. Some victims' toothbrushes were used to extract Deoxyribonucleic Acid (DNA) for use in DNA identification.[2] Southeast Asia's tsunami victims were successfully identified in 2004 by forensic dentistry.[9] The late Prime Minister of India, who was killed in a terrorist attack, was also identified by his dental records.[10] There is ample historical evidence demonstrating the importance of odontology as an identification technique.[11]

Conventional Forensic Odontology Techniques: Changing Trends

Maintenance of dental records

Antemortem dental records must be readily available, adequate, and accurate for forensic dental identification to be successful. It is the dentist's responsibility to maintain dental records, which are crucial since they are a source of information for both dentists and patients for medico-legal, administrative, and forensic purposes. There are many different types of dental records, including dental notes, dental charts, radiographs, photographs, and models.[5]

Comparative dental identification is a process where dental evidence from human remains, such as dental fluorosis, dental caries, missing or restored teeth, prosthetics, taurodontism, talons cusp, and developmental defects like amelogenesis imperfecta and dentinogenesis imperfecta, is compared to previous records to determine the identity of the deceased. This highlights how crucial it is for every dentist to keep records of their patients.[2] It is agreed that whenever there are enough characteristic features between the pre and post-mortem data available and are identical with explainable differences if any, then it is considered a positive identification.[12]

Computer-generated dental records are becoming more and more important because they may be readily networked and transferred for routine professional consultation or forensic investigations needing dental records for identification.[13] High-quality dental records are a crucial component of patient care, a medico-legal case, and a prerequisite for dental identification. The speed and effectiveness of identification can be greatly impacted by their availability and precision.[13]

Dental imaging

The antemortem radiographic image of the suspected person can be compared to the radiographic images of the deceased. For revealing "hidden dental information" and tooth coloured restorations that are readily missed in less than optimum funerary settings, good quality radiographs (whether film or digital) are helpful.[14] To identify the presence of lead bullets inside a victim's brain, radiographs were first used in forensic sciences in 1896, barely one year after Roentgen discovered X-rays.

The parameters used in dental radiographs are the shape of the teeth and roots, teeth present, missing teeth, residual roots, supernumerary teeth, non-carious lesions such as attrition, abrasion, fractures, bone resorption due to periodontal disease, bone pathology, diastemas, dental caries, endodontic treatment, intra-radicular posts, intra-coronal posts, and dental prostheses.[5]

Antemortem CT images offer information that can be used to create a postmortem facsimile image, given that measurements can be made accurately and craniometrical points can be located precisely.[15] An accurate analysis of the spatial relations of tooth roots and supporting structures on ante and post-mortem images is possible by using digital imaging techniques like radiovisiography.[16] Numerous software programmes that aid in image rotation, translation, and scaling have been created. These tools make it easier to align ante and post-mortem radiographs precisely, obviating the need for additional exposures.[17]

Bite mark analysis

Bites on human tissue may be seen in violent situations where the victim or attacker bites the other during a defensive reaction. A person may bite themselves or an in animate object left at the scene, such as an apple core or children, in more passive incidents. In situations other than domestic violence or physical or sexual abuse, biting can serve as a form of expression when verbal communication is ineffective.[18] The most frequent bite sites on male victims are the arms and shoulders, while the most frequent bite sites on female victims are the breasts, arms, and legs. Each group of teeth has a different bite surface that relates to its function. Individual characteristics, such as rotations, fractures, or extra or missing teeth, are also visible. The width of the dental arches, which describes the size relationships

of the bitemark, can indicate either an adult or child's bite.[19]

Non human animal bite wounds are occasionally discovered on victims. By differences in arch alignments and particular tooth morphology, animal bite injuries can typically be distinguished from bite wounds in humans.[20] Dog bites, which are arguably the most frequent nonhuman bites, are distinguished by a narrow anterior dental arch and involve numerous deep tooth wounds in a condensed area.[13]

An ultraviolet light illumination technique can be used to demonstrate bites that are not visible to the naked eye. Evidence from the bite suspect must be collected with the proper consent, a thorough medical history, photographs, the findings of an extra and intra-oral examination, and accurate impressions of the upper and lower arches.[19]

Overlays are made, which is the most popular comparison technique. The processes used to create overlays include radiopaque wax impressions, hand tracing from study casts, hand tracing from wax impressions, hand tracing from xerographic images, and computer based processes like using image perception software.[21] In addition to all these techniques, salivary DNA recovery and bacterial genotyping from the bite marks are the most recent ones and have become the backbone of forensic investigation.[19]

Cheiloscopy (Examination of lip prints)

Like fingerprints, lip prints are a crucial component of forensic evidence at the crime scene.[2] Cheiloscopy is a forensic investigation technique that deals with the identification of humans based on lips traces.[22] To prevent erroneous data from being obtained because of post-mortem lip alterations, lip prints must be taken within 24 hours of the time of death.[23] Lip prints are distinctive and remain constant throughout a person's lifetime, much like the prints on the finger, palm, and foot.

Six different types of groove patterns in the lip have been proposed by ***Tsuchihashi*** et al., which may be helpful in criminal investigations.[24] They are

Type I - with clear cut vertical grooves that runacross the entire lip.

Type I'- like type I but not coveringthe entire lip.

Type II - with branched grooves.

Type III – with intersected grooves.

Type IV with reticular grooves.

Type V with grooves that are not morphologically differentiated.

Rachna V Prabhu et al. in 2012 found that the type V pattern occurs most frequently and has for the first time noted trifurcation, Bridge or H pattern, horizontal lines, cartwheel, pineapple skin, and multiple branching appearances.[25] At the scene of the crime, lip prints can be collected from the deceased's lips directly or from clothing, cups, glasses, cigarettes, windows, or doors. The lip print pattern depends on whether the mouth is opened or closed. Lip grooves are well defined when the mouth is closed; however, in an open mouth position, the grooves ill defined and more difficult to interpret.[26]

Recent research has shown that lip prints are a more accurate method for determining gender than fingerprints and the mandibular canine index.[27] Lip prints can be obtained using cellophane tape or scotch tape which are pressure sensitive. Biometric methods have recently attracted a lot of attention because they only require the patterns that are already present in the human body and do not require anything to be remembered or carried around.[26]

Rugoscopy (Study of palatal rugae)

The use of human palatal rugae has been suggested as an alternative method for identification when teeth are lost due to any reason, the most common of which is trauma. The palatine rugae possess unique characteristics that can be used in circumstances when it is difficult to identify a dead person through fingerprints or dental records.[13] Rugae is not damaged by heat or other attacks because it is internalised in the oral cavity and shielded by the tongue and buccal fat pad. Age and other environmental factors, such as orthodontic adjustments, tooth extraction, cleft palate surgery, periodontal surgery, and impacted canine eruption, can alter rugae patterns.

To analyse the rugae patterns, researchers have used a variety of tools and techniques, such as photographs and impressions of the maxillary arch, computer software programmes (such as RUGFP-ID), calcorrugoscopy or overlay prints, stereoscopy (which allows for the creation of three-dimensional [3D] images of the palatal rugae), and stereophotogrammetry (which is comparatively accurate).[28]

Recent Advances in Forensic Odontology

DNA analysis

DNA analysis is a new tool used in the field of forensic odontology, gaining importance when conventional identification methods fail because of heat, traumatism or autolytic processes, distortions, and difficulties in analysis.[29] Comparison of DNA preserved in and extracted from the teeth of an unidentified individual can be made to a known antemortem sample (stored blood, hairbrush, clothing, cervical smear, biopsy, etc) or to a parent or sibling.[30]

The use of DNA analysis for forensic identification is growing in popularity among detectives thanks to the development of polymerase chain reaction, which enables enzymatic amplification of a specific DNA sequence even from a small amount of source material. In the field of forensic sciences, genomic and mitochondrial DNA (mtDNA) is used.[31] DNA analysis/profiling or DNA finger printing reveals the genetic makeup of a person.

Various ways of running a DNA fingerprint are as follows:

a. Restriction fragment length polymorphism method
b. Polymerase chain reaction
c. Short tandem repeat typing
d. Analysis of mitochondrial DNA
e. Analysis of Y chromosome
f. Single nucleotide polymorphism.[32]

DNA analysis is a complex process that takes a lot of time and is not available in the town's rural and outlying areas. Even though it is accurate, there are times when it cannot be quickly and easily examined. Therefore, traditional methods must be used.

Facial reconstruction and facial superimposition

Faces are peculiar to every human being born in this world from the past. The face is a gift to human kind and essential for maintaining individual identity. It is necessary to reconstruct the individual's appearance during life if the post-mortem profile does not match the tentative identity of the deceased. Forensic artists utilize the dental profile to help the facial reconstruction.[33]

Forensic facial reconstruction can be achieved by two basic techniques. These are 2D and 3D facial reconstructions. Each of them is again divided into manual and automated/computer aided methods.[33]

A laser video camera connected to a computer or to a CT scan is used in the computerised facial reconstruction technique. Then, the imaged skull data is rendered as a fully shaded 3D surface.[34] Computer software can be used to draw the face. Compared to imaging carried out on CT slices directly and 2D-CT image reconstruction, 3D-CT imaging has been found to be more accurate.[35] Although a precise image of the face may not be possible, this method greatly aids in identifying the person.

Denture identification methods

As denture prosthesis is quite resistant to high temperatures, they can be used as aids in the identification process. A denture as such without any markings is of less or no use in forensic dentistry. Only if it is marked, a person's denture can positively identify them.Two methods of marking have been proposed: the surfacemarking method and the inclusion method.

Inclusion methods include

a. Metal identification bands
b. Computer printed denture micro-labelling system
c. Lead paper labelling
d. Embedding the patient photograph
e. Denture barcoding
f. T-bar
g. Laser etching
h. Lenticular card system
i. Radiofrequency identification tags
j. Electronic microchips[36,37]

The surface marking methods include scribbling or engraving the denture and marking it with embossed letters. Among these two categories, the surface methods are easy to apply and relatively inexpensive. The only disadvantage was that they needed to be reapplied because they wore off so quickly. Whereas the inclusion methods are more permanent; however, it can weaken the denture structure and create porosity.[38]

Comparison Microscope

The use of a microscope plays a major role in forensicscience. Examination of teeth under the microscope can confirm sex by the presence or absence of Y-chromatin.[13] The conventional

microscope takes longer to focus and obtain different views when comparing samples. Forensic technology has developed a prototype Virtual Comparison Microscope (VCM). The comparison microscope is a device which helps in analysing thespecimens simultaneously. It consists of two microscopes. Two microscopes are joined together by an optical bridge with a split view window. With the VCM, it is simple to locate significant markings while maintaining a uniform appearance in any direction.[39]

Tongue prints

The tongue is the only internal organ that can protrude from the body and be easily exposed for inspection. Its shape and surface textures are distinctive to everyone. The application of tongue prints to forensic identification is currently in its infancy. The antemortem image or impression of the tongue must be accessible for this method to be effective.[40]

Basic features of the tongue such as colour, surface texture, mobility, and any other special characteristics can be inspected by:

1. Simple visualization
2. Alginate impression followed by cast preparation canbe used
3. Obtaining digital images of the tongue using digital software
4. Sublingual vein analysis
5. Histological examination[41]

Ameloglyphics: A Recent advance in person identification

The term ameloglyphics is used to describe the study of enamel patterns. Enamel rod patterns of teeth have been found to be unique for every individual and hence could be used as an aid in person identification. Manjunath et al. in a study compared the efficacyof cellulose acetate film, cellophane tape, and light body impression material to record enamel rod patterns in thirty extracted teeth and observed that the cellulose acetate film technique gave more accurate results in comparison with the other two techniques.[42]

CONCLUSION

Forensic Odontology is a relatively new science that utilizes the dentist's expertise to serve the legal system. Dental tissues are distinctive in that they produce accurate results. It is crucial in identifying people who cannot be recognised visually or through other ways. However, standardisation is necessary for the application of biochemical methods for estimating age and ameloglyphics and molecular procedures for personal identification. To make space for the use of more modern technology in establishing a person's identification, it is necessary to promote new research in the field of forensic dentistry.

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