Review Article

Tools for Expert Witnesses in Dentistry: An Overview

P Gayathri, N Thilagavathy, K Karthikeyan

From the Department of Oral Medicine and Radiology, Adhiparasakthi Dental College and Hospital, Melmaruvathur, Tamil Nadu, India

Received: July, 2016.
Accepted: August, 2016.

Abstract

The Inter disciplinary knowledge of forensic dentistry and the modern Day investigation plays a small but important role in enforcing justice in civil and criminal cases. Forensic odontologists are the expertise who help to identify the unrecognizable human remains following a mass disaster with the preserved structures of the oral environment. Thus this article describes the various aspects of forensic odontology in the current scenario.

Key Words: *Ameloglyphics, chelioscopy, denture ID tag, dermatoglyphics, virtual autopsy*

Introduction

The word "*Forensis*" is a Latin word which means "forum." In Rome, forum is a meeting place where civil and legal matters are discussed before the public. Forensic science refers to the pursuit of truth and is a fact finding mission, which is accepted by the scientific community and the judicial system. Forensic medicine includes forensic pathology, forensic clinical medicine, toxicology, thanatology, forensic medical ethics, etiquette, jurisprudence, psychiatry, forensic odontology, anthropology, entomology, and serology.

Forensic dentistry is defined as that "branch of dentistry which, in the interest of justice, deals with the proper handling, and examination of dental evidence and with the proper evaluation and presentation of dental findings" (Paul Revere - first forensic dentist).

Forum –"court of law;" Odontology- "study of teeth."

Dr. Oscar Amoedo is considered as "the father of Forensic Odontology."

Forensic odontology is the application of dental and the associated knowledge used to identify the victims of any civil or criminal issues that are decomposed, mutilated and are visually unrecognizable of the human remains following the natural or accidental or intentional mass massacres and disasters.

Theory behind forensic dentistry is that, each individual is unique and no two mouths are alike and they leave recognizable marks. This concept plays an important role in the dental identification, age estimation, gender determination, blood group determination, cheiloscopy, rugoscopy, dermatoglyphics, bite mark analysis, denture labeling, and DNA typing.

Access this article online

Quick Response Code:

Website: www.ijofo.org

DOI: 10.4103/2542-5013.195058

Dental Identification

It is the establishment of recognition of an individual with the morphology and arrangement of the teeth among the races. Teeth are the hardest and chemically stable structure, which are highly resistant to various kinds of insults like high temperature and acids. It is mostly kept safe even after death.

Dental identification procedure is done during mass disasters when skeletal remains are charred and decomposed. This includes comparative identification and reconstructive profiling.[1]

Comparative identification is done when the ante-mortem records are available and are used to compare with oral autopsy and postmortem remains. The various kinds of dental restorations present in the victims oral cavity suggests the socio economic and racial background of the victim. The wear pattern and staining of teeth suggests occupational and the habits of the victim.-

Profiling is done when the ante-mortem records are not available and when attempts are made to identify the age and sex to a probable identification.

Advancement in Dental Identification

The selfie photographs

The selfie photographs are more common among men with advancement in electronic, telecommunication, and social network. Hence, this can also be considered one of the tool for human identification. The smile line and superimposition of the images can be used as an ante mortem record when

Address for correspondence:
Dr. P Gayathri, E-mail: gayathrisuren19@gmail.com

How to cite this article: Gayathri P, Thilagavathy N, Karthikeyan K. Tools for expert witnesses in dentistry: An overview. Int J Forensic Odontol 2016;1:44-7.

the other basic tools are unavailable for comparison with the postmortem findings.

Tattooing

As a fashioned state, tattooing is done in the hard and soft tissues of the oral cavity. Gold tattoos on the labial surface of the maxillary teeth, tattooing on the restorations, and prosthesis are highly resistant to decomposition and destructions caused by various disasters. Hence, they are equally accepted as a tool for forensic odontology.

Comparison of Ante-mortem and Postmortem Radiographs

The ante-mortem radiographs and postmortem radiographs are compared by superimposition and subtraction methods. The dental radiographs maintained along with the dental record that contains both the subjective and objective information about the patient is a legal document and can act as a source for victim identification.

Virtual Autopsy

It is a medical imaging modality, in which the cadaver is examined with advanced imaging modalities, such as computed tomography, magnetic resonance imaging, and surface scanning. It is done for permanent observation of all body parts.

For dental identification, clinically and radiologically observed ante-mortem records are compared by virtual reconstructions of full body computed tomography using oral identifiers. The axial slices provides information on position of the teeth, the sagittal and coronal slices provides information about the shape of the teeth and the depth of dental restorations. Three dimensional image reconstructions also help in better evaluation.[2]

Ameloglyphics

(Amelo-enamel; glyphics-carvings). The study of the enamel rod and its end patterns is called Ameloglyphics. Enamel is the hardest substance in our human body and is always subjected to wearing with our daily activities.[3] Enamel rods are usually perpendicular to dentin. In deciduous teeth, rods are horizontally arranged at cervical third and in permanent teeth, the rods incline toward the root. It plays a major role in identifying the victims during the fire accident cases.

Age Estimation

Age estimation is applied in living individuals whose chronologic age is under dispute and is an important step in constructing a biological profile from human skeletal remains. Age assessment using teeth was first published by Edwin Saunders in 1837. The stages of tooth development are considered one of the most important tools in determining the age of the victim during the first and second decades of life.[3]

Dental age estimation can be assessed with change in tooth color, eruption, and tooth calcification. Evaluation of eruption and calcification is also better done using radiographs, incremental lines of cementum, dentin translucency, the physical and chemical analysis of dental hard tissues, and amino acid racemization.

Craniofacial estimators of age are also done by examining the closure of cranial sutures and the development of mandible (body, ramus, mental foramen, and condyle).

The appearance of tooth germs, mineralization, formation of enamel and neonatal line, degree of the unerupted tooth, clinical eruption, and degree of resorption of deciduous teeth, degree of completion of roots of erupted teeth, formation of physiologic secondary dentin, cementum, and changes in the chemical composition of teeth are the various factors in age estimation.[4,5]

Gender Determination

Various features of teeth such as morphology, crown size, and root length are the characteristics for male and female sexes. Sex determination using barr bodies and polymerase chain reaction aids in amplification of very high degraded DNA. There are also differences in skull patterns and skull traits of two sexes. AMEL gene, a major matrix protein, is secreted by the ameloblasts of enamel and is located on X and Y chromosome. Females have identical AMEL genes and males have nonidentical AMEL genes.[1]

Advancement in age and gender determination

Etching of the enamel surface with 37% orthophosphoric acid for 15 s and analyzing with scanning electron microscope showed different enamel pattern types. This can be used in situations like fire accidents.

Bite Marks

"Mark made by the teeth either alone or in combination with other mouth parts"

- Mc Donald.

Bite marks are featured in the most violent, heinous crimes, and child abuse cases as it is the injury to skin caused due to the teeth. Bite marks provide information such as distance between the teeth, angulations between the teeth, structural alterations, edentulousness, restorations, and other dental treatment done. These evidences can be seen in the skin of the victim and other miscellaneous items.

Mc Donald classified bite marks into tooth pressure marks, tongue pressure marks, tooth scrape marks and complex marks. Bite mark analysis is usually done with the help of test bites with pattern association and odontometric triangle method. In children, when ecchymosis, lacerations, and abrasions are noted in either elliptical or ovoid pattern, bite marks in child abuse must be suspected and must be well documented as a record in the dental office.[6]

Cheiloscopy

Lips are the most expressive part of the face and it reflects the emotions of the individual. R. Fisher was the first anthropologist who described this in 1902 and Edmond Locard recommended to use the prints for the identification of the individual.[7]

In 1970, Suzuki and Tsuchihashi named the grooves as "Figura linearum labiorum rubrorum." The outer surface of the lip has numerous vertical, horizontal, and transverse lines that form a characteristic pattern. Lip impressions can be taken from cups, glasses, cigarettes, windows, and doors, and they are unique and different for every individual such as fingerprints.

In 1967, Santos was the first person to divide grooves into four types namely:

- Straight line
- Curved line
- Angled line
- Sine-shaped line.

Suzuki and Tsuchihashi (1970) classified into:

- Type I: Vertical grooves
- Type II: High length groove of type 1
- Type III: Branched grooves
- Type IV: Intersecting grooves
- Type V: Reticular grooves
- Type VI: Other patterns.

The major disadvantage is smudging or loss of impression details of lip due to unidentifiable marks, scratches, and prominent facial hair among men.

Dermatoglyphics

Study of fine patterned dermal ridges on volar surfaces of soles, palms and ridges. Cummins and Midlo (1926) coined the term dermatoglyphics.

There are various methods of recording the fingerprints such as ink method, inkless method, transparent adhesive tape method, and photographic method. The various patterns of fingerprints such as plain loop, double loop, arch with loop, plain whorl, double whorl, arch with whorl, plain arch, tented arch, and central pocket loop. The different palmar patterns are thenar area, hypothenar area, interdigital areas, palmar creases, and atd angle.[8]

Fingerprints developed at birth, are unique, remains unchanged during lifetime, and not the same for even identical twins, as the ridge formation develops around 13th week of prenatal life. During the 7th week of pregnancy, vertical thumb creases (thenar contours) begins to appear on the palm of the embryo. Two weeks later, remote and proximal horizontal creases (hypothenar contours) begin to form.[9]

Various patterns of fingerprints have been studied in various pathologies and hence the victim identification success rate is fairly high due to very high degree of accuracy.

Rugoscopy

The study of palatine rugae patterns help in person identification with different races, and also aid in gender determination. Rugae in the palatal aspect are called as "plicae palatinae." Rugae are the transverse ridges in the mucous membrane behind the incisive papilla in the anterior portion of the palate. The palatal rugae serve as an important aid even when the other forensic remains are destroyed and decomposed as it is placed deep inside the oral cavity in a secure environment. It can be used as an adjunct in the gender determination as they do not change, remains stable after the growth stops at puberty. The pattern might change with orthodontic tooth movement, trauma, or any other pernicious habits.

The various types of rugae patterns are curve, wavy, straight, circular, convergent, and divergent. Palatal rugae are classified into primary rugae, secondary rugae, and fragmentary rugae.[10]

Denture labelling

Denture marking helps in identification of either a living or deceased denture wearer in a mass disaster. Dentures with surface inscription and inclusion markers are used as markings and they consist of accurate identity marks such as gender, phone numbers, address, job, national identity number. This also facilitates to identify the person in case of a fire accident, putrefaction, and dementia, state of unconsciousness, and missing individuals with their denture.[11]

In surface method, scribbling, engraving, marking with embossed letters, and writing on the surface of the denture are done. In the inclusion method, the marks are enclosed within the denture. Denture labeling is considered an essential tool by most international dental associations to identify the lost dentures.[12]

Denture Bar Coding System

Denture bar coding is a method by which the data are transferred to the computer. The bar code contains the personal details of the individual that is scanned by a device and the data is transferred to the computer. Bar coding is done during acrylization of the denture. With the advancements in technology, tracking becomes easier and more reliable in cases of mass disasters.[11,13]

Electronic microchips

In this method, the patient's details are encoded on a chip and are bonded with an acrylic resin and it plays the role of a labelled denture.

Radio-frequency Identification System

Radio-frequency identification-tags are embedded within the dentures. It consists of a tag and an electronic reader. The tag acts as data collector and the reader energizes the transponder by electromagnetic field that is given by the reader's antenna. It then receives the coded signal returned by the transponder and converts it into a readable data.

DNA Analysis

DNA analysis from oral source is simple, noninvasive, and highly accurate. Soft and hard tissues of the jaws, saliva, and mucosal swabs are the oral sources. It is a precise method, but is very time-consuming and is an expensive process.

Genomic DNA represents the paternal and the maternal inheritance and mitochondrial DNA represents maternal inheritance. In the teeth, dentin powder is a good source of mitochondrial DNA.[14]

In mass calamities, the sources in teeth such as the pulp, dentin, cementum, periodontal fibers, and attached bone fragments are used. Sampling of the pulp tissue is attained by crushing, splitting, and by endodontic access opening of the tooth.

In homicide and physical/sexual assault, the most common method used to identify the suspect is with buccal swabbing. The exfoliated mucosal cells can be collected by Dacron-coated tips, foam-coated tips, or tongue depressors and analyzed. Saliva is also used as a source. Whole saliva or stimulated saliva is collected by chewing on paraffin or citric acid substitutes and is used for analysis. It is a simple, noninvasive, and is a quick method, but is highly sensitive to contamination.

Conclusion

Whenever dental experts are needed to provide information, adequate knowledge of various methods, techniques, and analysis procedure are needed as they would greatly improve in efficiency of the investigation in crime cases. The dental experts need to know about the dental ethics, any relevant medico-legal investigations, consistent need to maintain the dental records, and must work within the permit of law to deliver justice.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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