

Current trends in forensic odontology

Nadeem Jeddy,
Shivani Ravi, T. Radhika
*Department of Oral
Pathology and Microbiology,
Thaimoogambigai Dental
College and Hospital, Chennai,
Tamil Nadu, India*

Address for correspondence:
Dr. Shivani Ravi,
13/274-A, Dhanalakshmi
Nagar, Periakolathuvanchery,
Iyyapanthangal,
Chennai - 600 122,
Tamil Nadu, India.
E-mail: drshivanirmds@gmail.
com

Abstract

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.

Key words: Evolution, forensic odontology, recent concepts

Introduction

Teeth are the most hardest and robust tissues of the human body. They are often resistant to decomposition even in major accidents, crime, burial, or other severe exposure to the elements. The dental patterns are unique for every individual. This uniqueness is also due to variety of treatments given by the dentist. Therefore, dentition of a person is useful for individual identification and comparison, if records exist for the purpose.^[1] Forensic dental identification plays a primary role in the identification of remains when postmortem changes, traumatic tissue injury, or lack of fingerprint record invalidate the use of visual or fingerprint method.^[2] The history of forensic odontology goes long back. In courts, the dental evidence has been used for the past many years. The techniques used in forensic odontology has evolved through the evolution of humankind.^[3]

Forensic odontology has three major areas of utilization as follows: (1) diagnostic and therapeutic examination

and evaluation of injuries to jaws, teeth, and oral soft tissues. (2) The identification of individuals, especially casualties in criminal investigations and/or mass disasters. (3) Identification, examination, and evaluation of bite marks which occur with some frequency in sexual assaults, child abuse cases, and in personal defense situations.^[4]


The common methods used for individual identification are using visual identification, personal information (such as height, build, age, presence or absence of hair), medical information (such as scars, tattoos, birthmarks, implants, amputations, prosthesis), footprint records from a chiropodist/podiatrist, clothing, personal effects, fingerprints, DNA profiling and dental identification.^[4] Identification by dental means gains more importance because the dental tissues are often preserved even if the deceased person is skeletonized, decomposed, burnt or dismembered. Dental tissues are often used to determine age, sex, and ethnicity of the person who can either be a victim or a suspect.

Data collection methods and supplementary technologies used in forensic dental identification have undergone

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Jeddy N, Ravi S, Radhika T. Current trends in forensic odontology. J Forensic Dent Sci 2017;9:115-9.

Access this article online	
Website: www.jfds.org	Quick Response Code 
DOI: 10.4103/jfo.jfds_85_16	

significant transformation. Evolving trends have been observed in the conventional methods used such as dental record maintenance, dental imaging techniques, bite-mark analysis, DNA analysis using oral tissues, cheiloscropy, and rugoscopy. In addition, the recent concepts such as facial reconstruction, denture identification, comparison microscopes, and tongue prints have been introduced in the field of forensic odontology. This article provides an overview of the recent trends in conventional forensic methods and also provides an insight into the recent concepts used in this field.

Evolving Trends in Conventional Methods used in Forensic Odontology

Dental record maintenance

Forensic dental identification most of the times are dependent on the availability, adequacy, and accuracy of antemortem dental records. Maintenance of dental records is the duty of a dentist and is an essential component, serving as an information source for the dentists and the patients, in medico-legal, administrative, and for forensic purposes. Identification by comparative dental analysis plays an important role similar to fingerprints and DNA analysis. The dental records were successfully utilized in many disasters such as world trade center disaster, Indian Ocean tsunami disaster in December 2004, etc. Dental records are available in various forms such as dental notes, dental charts, radiographs, photographs, and models. Maintenance of these records is mandatory in the Western countries. Different countries have different guidelines regarding the retention of dental records.^[5]

Computer-generated dental records gain more importance due to the fact that it can be easily networked and transferred for routine professional consultation or forensic cases requiring dental records for identification.^[4] It is accepted that whenever sufficient characteristic features between the pre- and post-mortem data are available and are identical with explainable differences if any, then it is considered as a positive identification.^[6]

Dental imaging

In cases where previous records are not available for comparison, an alternative aid used for individual identification is radiograph. The radiographic images of the deceased can be obtained and compared with the available antemortem radiographic image of the suspected person. Historically, the use of radiographs in forensic sciences was introduced in 1896, just a year after the discovery of X-ray by Roentgen, to reveal the presence of lead bullets inside the head of a victim. Dental radiographs are easily available and serve as a vital clue for forensic identification. The parameters used in dental radiographs are shape of the teeth and roots, teeth present, missing teeth, residual roots, supernumerary teeth,

noncarious lesions such as attrition, abrasion, fractures, bone resorption due to periodontal disease, bone pathology, diastemas, dental caries, endodontic treatment, intraradicular posts, intracoronal posts, and dental prostheses. Conventional radiography allows observation of coronal shape and size, pulp anatomy, crestal bone, etc.^[7] Computed tomography (CT) images reveal the cross-section of the areas exposed and produce multiple images. Antemortem CT images provide information which can be used in the construction of a postmortem facsimile image, considering that craniometrical points can be precisely located and measurements can be accurately performed.^[8] The frontal sinus configuration is peculiar to each individual which can be used as a parameter for individual identification. The parameters used for comparison of frontal sinus images are variations in its size, shape, symmetry, border outline, and number and presence of septa and cells.^[7]

The digital imaging techniques such as radiovisiography allow accurate analysis of the spatial relations of teeth roots and supporting structures on ante- and post-mortem images.^[9] Many soft wares have been developed which helps in rotation of the images, translation, and scaling, facilitating the exact alignment between ante- and post-mortem radiographs which eliminate the necessity of new exposures.^[10] Thus, the use of radiographic techniques provides the hidden dental information for the use in forensic odontology.

Facial photographs, video recordings, or smile photographs that show specific characteristics of each individual also serve as a valuable aid in forensic identification. In this manner, orthodontics serves as a source of extensive clinical documentation of the dental tissues that determine the smile of individuals. The increased use of extra- and intra-oral photographs for the planning and execution of treatments, along with the popularization of digital cameras, is providing more data for forensic human identification.^[11]

Bite mark analysis

Bite marks on human tissues can be observed in violent incidents such as sex-related crimes, child abuse cases, and offenses involving physical altercations, such as homicide. It can occur in instances where the attacker bites the victim or the victim bite the attacker as an act of defense, but it should be remembered that the bite victim could be the suspect in the cases. Male victims are most often bitten on the arms and shoulders, while female victims are most commonly bitten on the breasts, arms, and legs.^[12] The biting surfaces of the individual groups of teeth are unique and related to the function. And also, it shows individual characteristics such as fractures, rotations, missing, or extra teeth. In addition, the width of the dental arches could be related to the age of the attacker.^[4]

The anatomical location, severity, and quality of the bite marks have significance in the identification of the individual. The information such as demographics (name, age, sex, date, etc.), location, size, shape, color, type of injury, and swabs should be collected from the bite victim. In case of bites which are not visible to the naked eye, demonstration using ultraviolet light illumination technique can be performed. The collection of evidence from the bite suspect must have a proper consent, detailed history, photographs, the details of extra- and intra-oral examination along with high-quality impressions of the upper and lower arches.^[13] The process of comparing bite marks includes analysis and measurement of size, shape, and position of the individual teeth. The fabrication of overlays is the most common comparison method used. The methods used to fabricate overlays are hand tracing from study casts, hand tracing from wax impressions, hand tracing from xerographic images, the radiopaque wax impression method, and the computer-based methods such as using the image perception software.^[14] In addition to all these methods, salivary DNA recovery and bacterial genotyping from the bite marks are the most recent ones and have become the backbone of forensic investigation.^[13]

DNA analysis

DNA analysis is a new tool used in the field of forensic odontology, gains importance when conventional identification methods fail due to the effects of heat, traumatism or autolytic processes, distortions, and difficulties in analysis. There are many biological materials such as blood, semen, bones, teeth, hair, and saliva that can be used to accomplish DNA typing. With the advent of polymerase chain reaction which allows enzymatic amplification of a specific DNA sequence even in a negligible amount of source material, forensic identification using DNA analysis becomes increasingly popular with investigators.^[15]

In the field of forensic sciences, the genomic and mitochondrial DNA (mtDNA) are used. The genomic DNA is found in the nucleus of each cell in the human body. The teeth are an excellent source of genomic DNA. mtDNA can be used when the extracted DNA samples are too small or degraded, such as those obtained from skeletonized tissues.^[16] The amplified DNA is then compared with the antemortem samples such as stored blood, hairbrush, clothing, cervical smear, and biopsy specimens.^[17]

The currently performed DNA profile tests are reliable and provide information about the physical characteristics, ethnicity, place of origin, and sex of the person. In courts, these tests are accepted as legal proofs such as for investigation of paternity and human identification.^[16] Some of the advanced techniques in DNA profiling are Restriction Fragment Length Polymorphism Typing, Short Tandem Repeat (STR) Analysis, Y-Chromosome Analysis, X-Chromosome STR, Single Nucleotide Polymorphism

Analysis, mtDNA Analysis, Gender Typing and DNA methylation analysis.^[17]

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.^[4] 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. Lip prints can be obtained at the crime scene either directly from the lips of the deceased or from the clothing, cups, glasses, cigarettes, windows, or doors. Lip prints have to be obtained within 24 h of death to prevent erroneous data that would result from postmortem alterations of lip. Lip print pattern depends on whether mouth is opened or closed. In closed mouth position, lip shows well-defined grooves; whereas in open mouth position, the grooves are relatively ill defined and hard to interpret.^[18] Pathology of the lip such as mucocele, postsurgical alterations, loss of support due to loss of anterior teeth, presence of debris or fluid on the lip surface, application of a thick layer of lipstick, or over stretching of cellophane tape can alter lip print recording.^[4]

Recent studies have proven lip prints as a superior tool compared to fingerprints and mandibular canine index in gender determination.^[19] Lip prints can be obtained using cellophane tape or a scotch tape which are pressure sensitive. Biometrical methods gained much attention recently due to the fact that it only requires the patterns which are naturally present in the human body and does not need something to be remembered or carried along.^[18]

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.^[4]

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).^[20]

Recent Concepts in Forensic Dental Identification

Facial reconstruction

Faces are peculiar to every human being born in this world from the past. Face is crucial for human identity and is a boon to the humankind. It plays a major role in forensic sciences because of the fact that if the face of the deceased person remains unchanged, the identity of the person can be easily made without any need for forensic professionals. Forensic dentistry functions only in cases where the face of the person is destroyed by some means. Forensic professionals work for identifying the recovered human remains (identification of whole or fragmented bodies). Most often in major disasters and in accidents, the body of the dead person may be decomposed or skeletonized. In such cases, the only part retained may be the skull and the other bones. Skulls can remain unaltered even for millions of years and can provide an inimitable means of identification. The cranial appearance is very much helpful in determining the sex of the individual. Computerized facial reconstruction method uses a laser video camera interfaced with a computer or with CT scanning. Skull data are then imaged as a fully shaded 3D surface.^[21] The face can be drawn with the help of computer software (for e.g., Vitrea 2.3 version volumetric visualization software). 3D-CT imaging has been found to be more accurate than imaging performed directly on CT slices and 2D-CT image reconstruction.^[8] Although exact picture of the face may not be made, this method splendidly helps in identifying the individual.

Denture identification methods

Victims possessing all or most of their dentition can be identified using their teeth through various methods, whereas those missing all of their teeth lack such information. In such circumstances, the only identifiable remains are the victim's dentures. A denture as such without any markings is of less or no use in forensic dentistry. The dentures can reveal the positive identity of a person, only if it is marked. Labeling the denture is one of the easiest and reliable methods of identification. Methods of denture labeling falls under two categories: the surface marking method and the inclusion method. The surface marking methods include scribbling or engraving the denture and marking with embossed letters. Inclusion methods include metal identification bands, computer-printed denture micro-labeling system, lead paper labeling, embedding the patient photograph, denture bar coding, T-bar, laser etching, lenticular card system (using a polyethylene terephthalate, in which the first flip shows patient's name, sex, and age, and the second flip shows address and driving license number, when viewed from a different angle), radiofrequency identification tags, electronic microchips.^[22,23] Both the methods of denture marking can be incorporated in full and partial dentures,

mouth guards and removable orthodontic appliances. Among these two categories, the surface methods are easy to apply and relatively inexpensive. The only disadvantage is they worn off easily and needed to be reapplied. Whereas, the inclusion methods are more permanent; however, it can weaken the denture structure and create porosity.^[24]

Comparison microscopes

The use of microscopes in forensic sciences has an impact on the accuracy. Examination of teeth under microscope can confirm sex by the presence or absence of Y-chromatin.^[4] The phase contrast microscope is useful in analyzing the cemental annulations for age estimation. In case of comparison of the samples, the conventional microscope consumes more time in readjusting the focus and in achieving different views. Moreover, the observer has to rely on memory when comparing two objects. To avoid these problems, the forensic technology has developed a prototype Virtual Comparison Microscope (VCM). The comparison microscope is a device which helps in analyzing the specimens simultaneously. It consists of two microscopes connected by an optical bridge, which has a split view window. VCM utilizes images of deformed bullets, bullet fragments, and various types of rifling from the company's BulletTrax-3D system. With the VCM, it is easy to find significant markings in any direction while maintaining a consistent appearance.^[25]

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.^[27]

Conclusion

Forensic odontology is an upcoming branch of dentistry with a lot of scope for development. At the crime scene, the forensic odontologists play a major role in investigating and interpreting the dental evidence. The unique nature

of the dental anatomy and the custom restorations ensure accuracy when the techniques are appropriately employed. A consistent effort has to be made to computerize all the data available to facilitate comparison. Efforts have to be made to maintain the dental records which will serve as antemortem data. Each dental professional has a responsibility to understand the forensic involvements associated with their dental practice. The practicing dentists and the dental students should be made aware of the available technologies and its use in forensic dentistry. New researches have to be encouraged in the field of forensic dentistry which will pave way for incorporating newer technologies in establishing the human identity.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

- Auerkari E. Recent trends in dental forensics. *Indones J Leg Forensic Sci* 2008;1:5-12.
- Singh NN, Gowhar O, Ain TS, Sultan S. Exploring trends in forensic odontology. *J Clin Diagn Res* 2014;8:ZC28-30.
- Balachander N, Babu NA, Jimson S, Priyadharsini C, Masthan KM. Evolution of forensic odontology: An overview. *J Pharm Bioallied Sci* 2015;7 Suppl 1:S176-80.
- Zakirulla M, Meer A. Modern tools in forensic dentistry. *J Contemp Dent* 2011;2:28-32.
- Balla SB. Forensic dental identification: Practice in Indian context compared to western countries. *J Forensic Sci Med* 2016;2:44-7.
- Hegde P, Shetty S, Gupta L. Role and Importance of forensic odontology in identification. *Int Interdiscip J Sci Res* 2014;1:64-9.
- Carvalho SP, Silva RH, Lopes C Jr., Sales-Peres A. Use of images for human identification in forensic dentistry. *Radiol Bras* 2009;42:125-30.
- Rocha Sdos S, Ramos DL, Cavalcanti Mde G. Applicability of 3D-CT facial reconstruction for forensic individual identification. *Pesqui Odontol Bras* 2003;17:24-8.
- Wood RE, Kirk NJ, Sweet DJ. Digital dental radiographic identification in the pediatric, mixed and permanent dentitions. *J Forensic Sci* 1999;44:910-6.
- Hubar JS, Carr RF. Computed dental radiography used to reproduce antemortem film position. *J Forensic Sci* 1999;44:401-4.
- Silva RF, Pereira SD, Prado FB, Daruge E 2nd, Daruge E. Forensic odontology identification using smile photograph analysis – Case reports. *J Forensic Odontostomatol* 2008;26:12-7.
- Giannelli PC. Bite Mark Analysis. Paper 153. Faculty Publications; 2007. Available from: http://scholarlycommons.law.case.edu/faculty_publications/153. [Last accessed on 2016 Oct 02].
- Bhargava K, Bhargava D, Rastogi P, Paul M, Paul R, Jagadeesh HG, et al. An overview of bite mark analysis. *J Indian Acad Forensic Med* 2012;34:61-6.
- van der Velden A, Spiessens M, Willems G. Bite mark analysis and comparison using image perception technology. *J Forensic Odontostomatol* 2006;24:14-7.
- Silva RH, Musse JD, Melani RF, Oliveira RN. Human bite mark identification and DNA technology in forensic dentistry. *Braz J Oral Sci* 2006;5:1193-7.
- Datta P, Sood S, Rastogi P, Bhargava K, Bhargava D, Yadav M. DNA profiling in forensic dentistry. *J Indian Acad Forensic Med* 2012;34:156-9.
- Mayall SS, Agarwal P, Vashisth P. Dental DNA finger-printing in identification of human remains. *Ann Dent Spec* 2013;1:16-9.
- Reddy LV. Lip prints: An overview in forensic dentistry. *J Adv Dent Res* 2011;2:17-20.
- Krishnan RP, Thangavelu R, Rathnavelu V, Narasimhan M. Gender determination: Role of lip prints, finger prints and mandibular canine index. *Exp Ther Med* 2016;11:2329-32.
- Krishnappa S, Srinath S, Bhardwaj P, Mallaya CH. Palatal rugoscopy: Implementation in forensic odontology – A review. *J Adv Med Dent Sci* 2013;1:53-9.
- Verzé L. History of facial reconstruction. *Acta Biomed* 2009;80:5-12.
- Thomas T, Muruppel AM, Dinesh N, Gladstone S, George N. Dentures in forensic identification – A review of methods benefits. *J Adv Med Dent Sci* 2014;2:85-94.
- Rathee M, Yadav K. Denture identification methods: A review. *IOSR J Dent Med Sci* 2014;13:58-61.
- Bali SK, Naqash TA, Abdullah S, Mir S, Nazir S, Yaqoob A. Denture identification methods: A review. *Int J Health Sci Res* 2013;3:100-4.
- Sumalatha S, Padmaja S, Thumati P. “Every contact leaves its trace” – Insight into recent advances of forensic odontology. *J Cancer Treat Res* 2015;3:1-7.
- Stefanescu CL, Popa MF, Candea LS. Preliminary study on the tongue-based forensic identification. *Rom J Leg Med* 2014;22:263-6.
- Diwakar M, Maharshi M. An extraction and recognition of tongue-print images for biometrics authentication system. *Int J Comput Appl* 2013;61:36-42.