

Current Advances in Forensic Dentistry-A Review Article

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Abstract

Forensic odontology is a branch of forensic science that deals with proper collection, handling, careful examination, appropriate interpretation and preservation of dental evidences for future references in the interest of ensuring justice. The methods of collection of data, interpretation and other additional techniques employed in the forensic odontology discipline have undergone significant revisions. With the developing contemporary science the forensic odontology is also molding to new

trends which made it possible to identify victims and also to produce solid evidence against the criminals to prove their indulgence in crime scene. This article is aimed to provide a review of developing trends in conventional methods, and the current conceptualizations used in forensic odontology. Various emerging trends in forensic odontology, holds a promising scope for the field in future. Most of the tools rely on records maintained by the dentists, so it is necessary for the dentists to know about the updates on current trends in forensic odontology.

Keywords: forensic odontology, mass disasters, recent trends, identification, uniqueness, softwares.

Introduction

Teeth are the hardest tissues in human body, which are resistant to decay, even in adverse environment like exposure to high temperature, burial etc [1]. The dental patterns are unique for each individual and therefore serve as a readily available record for the identification of individuals, especially when the conventional soft tissue records are not sufficient [2].

Forensic odontology has three key areas namely

- 1) Diagnostic and therapeutic investigation and assessment of injuries to oral soft tissues, jaws and teeth.
- 2) Identification of individuals, especially in criminal investigations as well as mass disasters.
- 3) Identification, examination, evaluation of bite marks that happens with some frequency in molestation, child abuse, and in personal defense situations [3].

The routinely used methods for identification of individuals are visual identification, personal details (like height, build, age, presence or absence of hair), medical details (like scars, tattoos, birthmarks, implants, amputations, prosthesis), footprint records from a chiropodist/podiatrist, clothing, personal effects, fingerprints, DNA profiling and dental identification[3]. Evolving trends are being observed in the conventional methods such as dental record maintenance, dental imaging techniques, bite-mark analysis, DNA analysis using oral tissues, cheiloscopy, and rugoscopy[1].

Added to this, the current concepts such as facial reconstruction, denture identification, comparison microscopes, tongue prints, vitropsy and various related softwares are being instigated in the province of forensic odontology. This article is aimed to provide a review of the evolving trends in conventional methods, and the

recent concepts employed in discipline of forensic odontology.

Materials and Methods

The recent articles from PubMed library, willey online library and google scholar were searched for extraction of data from published literature using keywords forensic odontology, mass disasters, identification, uniqueness, recent trends. The related articles in reference list of the articles found were also gathered. In the due course, 30 articles were selected. After excluding the articles without clear background, inadequacy in data and non English literature, 20 articles were selected for review purpose.

Conventional Methods and Their Refinements

In forensic odontology, the identification of individuals in most instances relies on the accessibility, sufficiency, and precision of ante mortem dental records. Maintenance of such dental records by dentists may serve for the medico-legal, administrative and forensic purposes[1]. Computer-aided dental records are procuring more significance, because it can be readily networked and fetched for regular professional consultation or forensic cases which are in need of dental records for identification [3].

Dental Imaging

The dental radiograph parameters taken into account for identification includes crown and root shape, number of teeth present, number of teeth missing , residual roots, supernumerary teeth, noncarious lesions such as attrition, abrasion, fractures, bone resorption attributable to periodontal disease, bone pathology, diastemas, dental caries, endodontic treatment, intraradicular posts, intracoronal posts, and dental prostheses[1]. With antemortem CT images it is possible to construct postmortem mimeographic image, by considering craniometrical points which could be accurately located and computed.

The frontal sinus geography utilizes parameters like size, shape, symmetry, margin and presence of septa. Precise spatial relations of teeth roots and adjacent supporting structures present in ante- and post-mortem images are precisely captured using the digital imaging techniques like radiovisiography (RVG) [1].

Other dental records such as facial photographs, video recordings, or smile photographs, extra- and intra-oral photographs can also be applied in forensic discipline [4].

Bite Mark Analysis

In human tissue, bite marks are observed in crime scenario like sexual assault, child abuse, physical assault, murders [4]. The assailant's age can be related by examining the biting surfaces which may display individual characteristics like fractures, rotations, missing teeth, width of dental arches [3]. Ultraviolet light illumination technique can be utilized to demonstrate bite marks which are not discernible to naked eye. From the bite suspect, particulars such as consent, detailed history, photographs should be collected. Added to this, the details of extra- and intra-oral examination along with high-quality maxillary and mandibular arch impression should be collected [5].

The bite marks comparison is usually done by analyzing and measuring the size, shape as well as position of individual teeth. The most commonly used method for such comparison is fabrication of overlays. The methods for fabrication of overlays are hand tracing from study casts, wax impressions, xerographic images, radio opaque wax impression, and computer-based methods like image perception software [6]. The bacterial genotyping and DNA recovery from saliva in bite surface are the most contemporary ones evolving as backbone for forensic world [5].

DNA Analysis

DNA analysis is a novel tool in the discipline of forensic odontology. It procures significance, when conventional

identification procedures fail due to extreme temperature, autolytic processes and distortions. Biological materials like blood, bone, tooth, hair, semen and saliva can be utilized to accomplish DNA typing. With the emergence of polymerase chain reaction it is made possible for enzymatic amplification of specific DNA sequence even with negligible amount of biological material [7].

The recent approaches in DNA profiling are Polymorphism Typing, Restriction Fragment Length, Y-Chromosome Analysis, Short Tandem Repeat (STR) Analysis, X-Chromosome STR, mtDNA Analysis, Single Nucleotide Polymorphism Analysis, DNA methylation analysis and Gender Typing [8].

Cheiloscopy

Cheiloscopy deals with identification of a person based on lips traces. Similar to the prints that exist in finger, palm and foot, the lip prints are also idiosyncratic and does not alter during the life time of an individual. Lips have furrows and grooves thereby, giving adequate details for forensic investigations. Lip prints can be retrieved either from the lips of the deceased directly or from the clothing, cups, cigarettes, window glasses or doors at the crime scene.

Lip prints should be extracted within the time period of 24 hours after death in order to prevent postmortem alterations of lip which may result in incorrect details. Lip print pattern may get altered based on whether mouth is opened or closed. When mouth is in closed position, lips may show well-defined grooves; whereas when the mouth is in open position, the grooves are ill defined and difficult to interpret [9].

The factors that affect lip prints includes mucocele, postsurgical alterations, thick layer of lipstick, presence of debris or fluid over the lip surface, or over stretching of cellophane tapes during lip print retrieval [3]. Lip prints

can be extracted with cellophane tape or a scotch tape which are pressure sensitive [9].

Palatal Rugoscopy

In the event of loss of teeth because of trauma, the palatal rugae pattern will provide alternative method for identification because of its uniqueness. As rugae are present inside the oral cavity and being safely protected by tongue and buccal pad, they remain undisturbed from factors such as heat and other assaults. Rugae patterns may alter with age and other oral environmental factors such as orthodontic movements of tooth, surgery of cleft palate, tooth extraction, eruption of impacted canine and periodontal surgery [3].

Various materials and methods utilized to analyze the rugae patterns are photographs and maxillary arch impression, calcor rugoscopy or overlay print, computer software programs (for example RUGFP-ID), stereoscopy (through which 3D image of palatal rugae is made), stereophotogrammetry (it is comparatively accurate)[10].

Recent Advances In Forensic Dentistry

Facial Reconstruction: Faces are unique to each and every individual born in this world. The fact that the face remains unchanged in deceased person made it as one of the important tool in forensic discipline. The identity of the person is made easily without any requirement for forensic professionals. Forensic dentistry operates only in the instance where the face is destroyed by some reasons. Forensic professionals play a vital role in identifying the recovered human remains, whole or fragmented bodies. In major disasters and accidents, the dead person's body may be skeletonized or decomposed. In such condition, the only remnant will be the skull and the other bones. Skulls can remain the same without any changes even for millions of years and therefore can provide a distinctive means of identification. The cranial appearances are useful in sexual dimorphism. Computerized facial reconstruction

is done using laser video camera interfaced with CT scanning or with a computer. Then the skull data will be imaged as a completely shaded 3D surface [11].

The computer software like Vitrea 2.3 version volumetric visualization is very useful in drawing the face. When compared to imaging done directly on CT slices and 2D-CT image, the reconstruction method with 3D-CT imaging has been found to be more accurate [12].

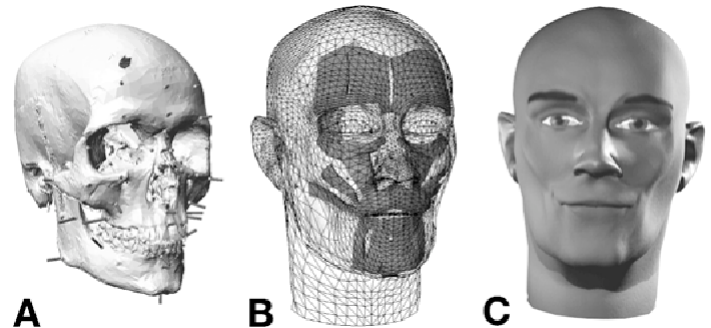


Figure 1: Facial reconstruction using computer modeling. (A) Skull model with tissue depth markers. (B) The Muscle models. (C) The Finished face.

Images courtesy of Kolja Kaehler, MPI Informatik Saarbruecken, Germany.

Denture Identification Methods

Labeling of the denture is found to be one of the reliable and easiest methods of identification. The methods of denture labeling are categorized into two, namely surface marking method and inclusion method. In the surface marking method, scribbling or engraving of the denture and marking it with embossed letters will be done. Whereas the Inclusion methods involve metal identification bands, micro-labeling system, computer-printed denture, embedding the patient photograph, lead paper labeling, denture bar coding, laser etching, T-bar, lenticular card system, radiofrequency identification tags and electronic microchips [13, 14]. Between these two categories, surface methods are quite easy to use and relatively inexpensive. But only disadvantage is they will wear off easily and replication is needed. Whereas,

inclusion methods are quite permanent but they can weaken the denture structure and also they can create porosity [15].

Virtual Comparison Microscope

The use of microscopes in discipline of forensic sciences will improve the accuracy [3]. The phase contrast microscope is beneficial in analyzing cemental annulations that helps in age estimation. For comparing the samples, the conventional microscope will take more time for readjusting the focus and for achieving different views. Also, the observer has to depend on his/her memory while comparing two objects. To avoid these difficulties, a prototype Virtual Comparison Microscope (VCM) is used now a days. The comparison microscope helps in analyzing the various specimens simultaneously. VCM has two microscopes connected through an optical bridge, with a split view window. VCM employs images of bullet fragments, deformed bullets, and different types of rifling arising out of company's BulletTrax-3D system. VCM makes it simple to find important markings in any direction simultaneously maintaining a consistent appearance [16].



Figure 2: Comparison microscope

Image courtesy of www.forensicmicroscopes.com

Tongue Prints

Tongue prints are as unique as finger print. Even identical twins cannot have same tongue print. The color, shape, and surface of tongue are characteristic of each and every individual and emerging as a potential biometric tool in the field of forensic dentistry [17]. The tongue biometric template is feasible with three views such as right lateral view, left lateral view, and profile view. The efficient template for shape of the tongue can be obtained by extraction of tongue algorithm of collecting points. The normalized histogram with Scale Invariant Feature Transform is utilized for texture analysis. By combining both the extraction techniques templates, the matching can be done [18]. These databases can be collected and stowed by dentist during routine dental procedure which can serve as forensic tool in future.

Vitropsy

Vitropsy is a no touch autopsy procedure. It is a trans-disciplinary technology that interlinks different branches like forensic radiology, medicine, image processing, physics, pathology, and biomechanics. Vitropsy consist of Photography and 3-Dimensional Optical Scanner, 3D body surface credentials using photogrammetry, Biochemical, Toxicology and Molecular Studies, Dentistry and fingerprinting, Multi-slice Computed Tomography and Magnetic Resonance Imaging for body volume documentation and survey, Computed Tomography Angiography and Heart lung machine, Cytology and Histology, Robotic Image guided biopsy, Image-guided Dissections [19].

Various softwares in forensic discipline

Various softwares such as Disaster and Victim Identification (DAVID), Windows Identification, automated dental identification system (ADIS), Auto computer-aided design (2D and 3D CAD), Computer-assisted postmortem identification (CAPMI), Unified

victim identification system (UVIS/ UDIM), GNU image manipulation program are available which makes the identification procedure much simple and easier. With the development of different software like Adobe Photoshop and Dentascan, it is made possible to scan the dentition of a deceased victim even within minutes. The post processing software such as Adobe Photoshop allows visualization of data adapted to each and every possible ante mortem X-ray for identification [20].

SOFTWARES	USES
DAVID	Number of matchable dental characteristics like primary dentition and prosthodontic work were recorded and stored. This helps in rapid identification of victims.
ADIS	dental record preprocessing ↓ search and retrieval ↓ image comparison
AUTO CAD	Pulp tooth ratio analysis, ante mortem and post mortem image comparison, odontometric analysis.
CAPMI	Ante mortem and post mortem records of extracted dental codes were compared ↓ List of candidates will be prepared by the program on the basis of number of matching dental features.
UVIS/UDIM	Coordinates and manages every function concerned with identification of missing individuals and victims. Comprises of self-correcting coding interface, partial jaw highlights twains explainable and unexplainable discrepancies, unique color coded odontogram to search and compare quickly.
GNU	execute functions like image composition, photo retouching and image authoring

Table 1: Various software in forensic science and their uses.

Conclusion

Forensic odontology is a looming branch that holds a promising scope in forensic discipline. How much ever less the available remnant is, the forensic dentistry will try to resolve it. Forensic dentistry is constantly trying to update the available forensic tool and simultaneously developing novel tools for identification. Sometimes it plays adjunct role in identification procedure whereas sometimes plays main role in identification procedure. With the constantly developing novel tools and with the further research in the field of forensic odontology it is evident that soon this discipline will cherish an unconquerable position in the world of forensic science. Dentists should update their knowledge in this field since

their contribution is undeniable for making the base of this discipline even stronger.

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