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Review Article

Recent advances in forensic odontology made easy in identification

Satish BNVS¹, Poonam¹, Prashant Kumar^{1,*}

¹Dept. of Oral Pathology, HKE Society's S.Nijalingappa Institute of Dental Sciences & Research, Kalaburagi, Karnataka, India



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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 the recent concepts used in forensic odontology.

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1. Introduction

Forensic means legal: A word that comes from Latin, meaning "to the forum". The forum was the basis of Roman law and was a place of public discussion and debate pertinent to the law. Keiser-Neilson in 1970 defined Forensic odontology (FO), or forensic dentistry, as "that branch of forensic medicine which in the interest of justice, deals with the proper handling and examination of dental evidence and also with proper evaluation and presentation of the dental findings".¹ Forensic science refers to areas of endeavor that can be used in a judicial setting and accepted by the court and the general scientific committee to separate truth from untruth.²

Forensic odontology has three major areas of utilization:

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.³

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.⁴

Data collection methods and supplementary technologies used in forensic dental identification have undergone significant transformation. Conventional methods used in the forensic odontology includes dental record maintenance, dental imaging techniques, bite-mark analysis, DNA

* Corresponding author.

E-mail address: munna.pmk@gmail.com (P. Kumar).

analysis using oral tissues, cheiloscopy, and rugoscopy.

The recent concepts includes

1. DNA analysis
2. Facial reconstruction
3. Denture identification
4. Tongue prints and
5. Comparison microscopes, have been introduced in the field of forensic odontology⁵

This article provides an insight into the recent concepts used in this field.

Recent concepts in forensic odontology

1.1. DNA analysis

Analysis of DNA in forensic dentistry offers a new tool, where as traditional identification methods has demerit due to heat traumatism, or autolytic process. DNA analysis/profiling or DNA fingerprinting reveals the genetic makeup of a person. For DNA analysis, Both genomic and mitochondrial DNA can be used. The biological materials used for DNA typing are blood, bones, teeth, semen, hair and saliva. Teeth are the excellent source of genomic DNA.⁶ sex of an individual is determined from DNA fingerprint

Various ways of running a DNA fingerprint are as follows:

1. Polymerase chain reaction
2. Fragment length polymorphism method
3. Short tandem repeat typing
4. Single-nucleotide polymorphism
5. Analysis of mitochondrial DNA
6. Analysis of Y chromosome⁷

The use of techniques based on polymerase chain reaction (PCR) has acquired greater importance in DNA postmortem analysis in forensic cases⁶ (Figure 1)⁷

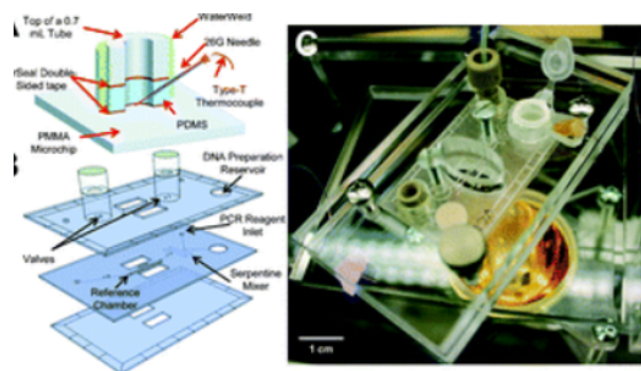


Fig. 1: Schematic photograph showing replication of DNA by polymerase chain reaction

1.2. Teeth as a source of DNA

Teeth are the most durable organs in the bodies of vertebrates. Their morphology is well preserved and persist for the long because they are resistance against extreme circumstances.⁸ Sex of the individual is determined from the very minute quantities of DNA (as little as 20 pg). The hydroxyapatite crystals, component of enamel binds to the DNA and stabilizes it, therefore an abundance of DNA can be obtained from the teeth.⁹ Amelogenin (AMEL) is one of the major matrix proteins secreted by the ameloblasts of the enamel. Modern DNA extraction methods can isolate genomic DNA from dental cells and the gene amelogenin, which is a sex-linked gene. In addition, microscopic examination of the cells from the pulp can also reveal the presence of Barr bodies in females.¹⁰

DNA from the teeth can be obtained by

1. Crushing
2. Conventional endodontic access
3. Vertical splitting
4. Horizontal section
5. Cryogenic grinding
6. Crushing gives better results than sectioning as more DNA can be obtained¹⁰

Facial reconstruction and facial superimposition

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.¹¹ (Figure 2)¹²

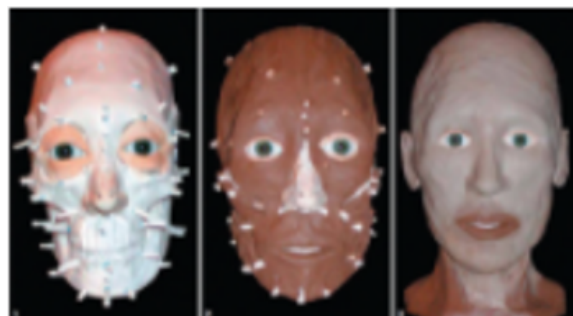


Fig. 2: Steps of manual method of forensic facial reconstruction: (a) replicated skull with landmarks and already constructed eye socket and nose structure (b) advanced reconstruction of the soft facial parts, (c) crude model of the face

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. 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. Although exact picture of the face may not be made, this method splendidly helps in identifying the individual.¹³

1.3. Methods of facial reconstruction

Forensic facial reconstruction can be achieved by two basic techniques. These are 2D and 3D facial reconstructions. 3D computed tomography (CT) imaging has been found to be more accurate than imaging performed directly on CT slices and two-dimensional (2D) CT image reconstruction.¹³ Each of them is again divided into manual and automated/computer-aided methods.

1.4. Manual method

These methods were 2D and 3D employing impressions and clay modeling techniques. In this technique, the impressions of skull were made, and casts were fabricated over which different landmarks pins were applied. These methods were relatively simple but had a few limitations. They were time-consuming, technique sensitive, and expensive.

1.5. Computer-aided reconstruction

This method is based on the application of mean tissue thickness for the given anatomical landmarks. Advantages of computerized facial reconstruction are:

1. Provides 3D images of 2D objects using soft-tissue depth markers
2. Completely noninvasive procedure as it allows virtual manipulation and preservation of original object
3. Provides high quality and resolution along with better visualization of anatomical and pathological state

2. Limitations

1. Technique sensitive
2. Requires highly trained specialists for the interpretation of obtained images¹³

2.1. Denture identification method

Victims missing with all of their teeth lack the important informations, 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.¹⁴(Figure 3)¹⁵

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 — include scribbling or engraving the denture and marking with embossed letters.

Advantage: Easy to apply



Fig. 3: Finished dentures with labels

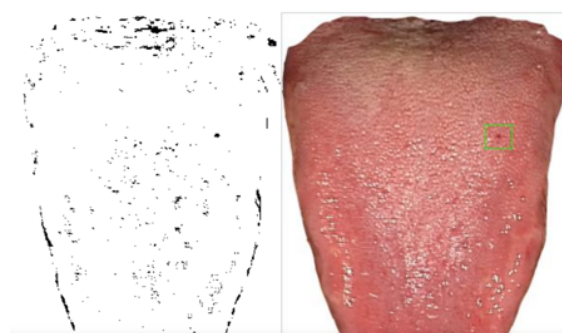


Fig. 4: Impression of the dorsal surface of the tongue was made and a positive replica is made using Type II dental stone

2.2. Relatively inexpensive

Disadvantage: worn off easily and needed to be reapplied
The inclusion method. — 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.¹⁴



Fig. 5: Virtual comparison microscope which can be used to compare two specimens simultaneously²⁰

2.3. Advantage: more permanent

Disadvantage It can weaken the denture structure and create porosity.

Both the methods of denture marking can be incorporated in full and partial dentures, mouth guards and removable orthodontic appliances.¹⁶

2.4. Tongue prints

Tongue morphology is unique for each and every individual. For this technique to be successful, the antemortem photograph or impression of the tongue should be available. The lingual impression together with its photographic image may constitute secure methods for forensic dentistry identification, in addition to rugoscopy and cheiloscopy.¹⁷ (Figure 4)⁶

2.5. Methods of recording tongue prints

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

1. Simple visualization
2. Alginate impression followed by cast preparation can be used
3. Obtaining digital images of the tongue using digital software
4. Sublingual vein analysis
5. Histological examination¹⁸

The tongue prints of humans is considered in 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.¹⁹

2.6. Comparison microscope

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 Bullet Trax-3D system. With the VCM, it is easy to find significant markings in any direction while maintaining a consistent appearance.²¹

3. Conclusion

Forensic odontology is an upcoming branch of dentistry with a lot of scope for development. Scope of forensic odontology make unique contributions in the administration of law and justice, which plays a major role in investing and interpreting the dental evidence. 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.

4. Source of Funding

None.

5. Conflict of Interest

None.

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Author biography

Satish BNVS, Professor

Poonam, P G Student

Prashant Kumar, Reader

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