IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Newer Advances In Forensic Odontology – A Review Article

[1]Dr. Srri Ranjani P, [2]Dr. Keerthana G, [3]Dr. Mathumala Subramanian , [4]Dr.Arunachalam M , [5]Dr.Sathish Kumar M

[1]Under Graduate, [2,3]Post Graduate, [4]Reader, [5]Head of the Department

Department of Oral and Maxillofacial Pathology

Karpaga Vinayaga Institute of Dental Sciences Chengalpattu, India

ABSTRACT

Forensic odontology plays a vital role in criminal investigations, disaster victim identification, and human rights abuse cases. Recent advances in forensic odontology have enhanced its capabilities in identification, analysis, and investigation. This review highlights the newer advances in forensic odontology, including DNA analysis, digital radiography, facial reconstruction, saliva analysis, and dental record management. The role of forensic odontology in crime scene investigation, mass disasters, and human identification is also discussed. The review emphasizes the importance of standardized procedures, accurate dental record-keeping, and collaboration between forensic odontologists and law enforcement agencies.

The integration of newer technologies and techniques has improved the accuracy and efficiency of forensic odontology, making it a crucial tool in modern forensic science. Furthermore, the review explores the application of emerging technologies, such as 3D printing and artificial intelligence, in forensic odontology. The importance of maintaining accurate and comprehensive dental records, adhering to standardized procedures, and staying updated on the latest techniques and technologies is also stressed. Overall, this review aims to provide a comprehensive overview of the newer advances in forensic odontology and their implications for the field.

KEY WORDS : Forensic Odontology , Dental Identification , DNA Analysis , Digital Radiography , Facial Reconstruction , Artificial Intelligence.

INTRODUCTION

Forensic odontology is a vital branch of dentistry that applies dental science to the legal system. It involves the examination, analysis, and interpretation of dental evidence in criminal investigations. Forensic odontology plays a crucial role in identifying human remains, particularly in cases of mass disasters or crimes. Dental records, bite marks, and other oral evidence are used to aid in identification. This field requires expertise in both dentistry and forensic science. Forensic odontologists work closely with law enforcement agencies and medical examiners. Their expertise helps solve crimes, identify victims, and bring perpetrators to justice. The field of forensic odontology is constantly evolving, with new techniques and technologies emerging. Despite its importance, forensic odontology remains a relatively new and developing field . Research and education are essential for advancing this field and improving its applications. Forensic odontology has become an essential tool in modern forensic science. Its contributions to justice and public safety are undeniable. As the field continues to grow, its impact on forensic investigations will only increase. The importance of forensic odontology cannot be overstated. Dental characteristics are a unique and efficient method for identification due to their distinctiveness and resilience. Teeth offer an ideal means for post-mortem identification, given their durability and resistance to environmental factors. Successful dental identification relies on ante-mortem data, which is obtained through meticulous dental examination, documentation, and preservation of dental records, radiographs, and clinical images. When dental records are unavailable, forensic dentistry can still aid in establishing identity by creating a profile of the individual's oral characteristics, habits, diet, socioeconomic status, and age at the time of death. Dental aging estimates an individual's age based on tooth formation and eruption patterns, providing accurate age assessments up to 15 years old. Beyond this age, dental aging is determined by modifications in tooth structure and surrounding tissues.

ROLE OF DENTIST

Identifying victims in mass disasters is extremely challenging. Forensic odontologists (specialized dentists) play a crucial role in identifying victims through dental records. In normal situations, identification is straightforward. However, during disasters, infrastructure damage hinders recovery efforts. To address this, a hierarchical system involving ante-mortem (before death), post-mortem (after death), and reconciliation teams is established. Forensic odontologists have successfully identified victims in several mass disasters, including the 2004 Indian Ocean tsunami. Accurate dental records are vital for identification. These records include Medical history , Clinical examination, Dental records, Radiographs (x-rays) , Study casts, Clinical photos . Despite their importance, many Indian dentists do not maintain proper dental records. In disaster situations, specialized procedures like the Disaster Victim Registry

(DVR) and software tools like DVI System International and Dental Cross aid in victim identification. These tools help analyze and compare dental records, facilitating accurate identification.

BITE MARK ANALYSIS

Bite marks, or patterned injuries left by teeth on objects like skin, are valuable evidence in criminal investigations, helping to indicate violent interactions, reveal criminal intentions, and potentially identify perpetrators. Recent studies have explored 3D digital comparisons of teeth and bite marks to overcome perspective distortion limitations. Notable cases, such as the 1692 Salem Witch Trials, the Theodore (Ted) Bundy case, and the 2012 Delhi gang rape case, demonstrate the significance of bite mark analysis in securing convictions. This complex process involves recognizing and analyzing bite marks, considering variables like tissue flexibility, bite mark position, biting force, and victim's age, and using metric analysis to compare tooth size with bite marks.

LIP PRINTS

Cheiloscopy, the study of lip prints, is a valuable forensic tool for human identification. Like fingerprints, lip prints are unique and unchanging, providing sufficient information for investigations. Lip prints can be collected from crime scenes, clothing, or objects, but must be done within 24 hours of death to ensure accuracy. The study of lip prints can reveal personal identification, race, and sex, with certain patterns more common in males or females . Both cheiloscopy and palatoscopy have been used to solve crimes, including a 1966 burglary case in Poland and a 1988 grocery store burglary case.

RUGOSCOPY

Rugoscopy, also known as palatal rugoscopy, is the study of the patterns of the palatal rugae, which are the ridges and grooves found on the palate. The palatal rugae start developing in the third month of fetal life and remain stable until death, making them a valuable tool for identification. Rugae patterns can be classified into different types, such as "branches and unification," based on their length and origin. The study of palatal rugae can be used to identify individuals, especially when other methods such as fingerprints and dental records are not available. Additionally, rugoscopy can provide information on the age, sex, and ethnicity of an individual. However, rugae patterns can change due to various environmental factors, such as orthodontic movements, tooth extraction, and surgery. Despite these limitations, rugoscopy remains a valuable tool in forensic science, particularly in cases where other identification methods are not feasible.

DNA ANALYSIS

Dental tissues are a valuable source of DNA due to their resistance to environmental factors such as incineration, immersion, trauma, and decomposition. This biological material can provide a crucial link in identifying individuals when conventional methods fail. With advancements in polymerase chain reaction (PCR) techniques, DNA analysis has become increasingly popular in forensic dentistry. By comparing antemortem DNA samples from sources like toothbrushes, hairbrushes, or blood samples with postmortem DNA extracted from human remains, investigators can establish identity. DNA techniques offer a new tool when traditional identification methods are unsuccessful due to heat, trauma, or autolytic processes. Various biological materials, including teeth, can be used for DNA typing, and techniques like PCR, short tandem repeat typing, and mitochondrial DNA analysis can reveal an individual's genetic makeup, providing a unique identifier.

TEETH AS AN EVIDENT SOURCE OF DNA

Teeth are a reliable source of DNA due to their resistant nature. Various methods can be used to extract DNA from teeth, including:

- Conventional endodontic access
- Vertical splitting
- Horizontal sectioning
- Cryogenic grinding,

which involves freezing the tooth with liquid nitrogen and grinding it into a fine powder using magnetic fields.Crushing the tooth yields better results than sectioning, as it releases more DNA. Cryogenic grinding is a particularly effective and efficient method, even for endodontically treated teeth, as DNA is present in the hard tissues.

AGE DETERMINATION

Age determination in forensic odontology involves analyzing the development and degeneration of teeth. Two main techniques are used

1. Developmental alterations: These changes occur during tooth development and eruption, including:
   - Formation of hard tissue
   - Dental expansion
   - Third molar emergence (typically between 17-19 years old)
   - Measuring tooth length
2. Degenerative changes: These changes occur after teeth have erupted and start to wear down. By analyzing these changes, forensic odontologists can estimate an individual's age, which is crucial

in forensic investigations. Additionally, comprehensive dental records and unique features like decay, malposition, and restorations can aid in identification.

DIGITAL RADIOGRAPHIC RESEARCH

Accurate and comprehensive dental records are crucial in forensic odontology, particularly in identifying individuals. These records should include the patient's medical history, clinical examination, dental records, therapy, and follow-up information. Any errors in charting can invalidate the record. Dental records may also contain radiographs, study casts, impressions, and clinical pictures. In many European countries, registering dental data is mandatory, and erasing a patient's record requires state legislation permission. Despite the importance of dental records, many Indian dentists do not maintain them or keep low-quality records. Research has shown that only 38% of dentists in Rajasthan and 21% of dentists in Chennai keep dental records. In cases of major disasters, the "Disaster Victim Registry (DVR)" procedure is required, which involves filling out separate forms for antemortem (AM) and postmortem (PM) data.

Various software tools, such as "DVI System International" and WinID3, aid in analyzing and comparing AM and PM dental record data. Digital imaging technologies, like Dental Cross, can also positively identify individuals. Teeth are often identified using two techniques: comparing previous dental records with PM dental characteristics or creating a PM dental profile to guide the search for AM materials. Dental identification is critical, as teeth are more resistant to deterioration than other bodily tissues. When other identification methods are not possible, dental structures and restorations may be the only remaining elements of the body. Forensic odontology involves the administration, inspection, appraisal, and presentation of dental evidence in civil and criminal procedures, as well as research.

FACIAL RECONSTRUCTION

Facial reconstruction is a technique used to create a likeness of a deceased person's face. This can be achieved through two basic techniques: 2D and 3D facial reconstructions, which can be further divided into manual and automated/computer-aided methods. Manual methods involve creating impressions and clay modeling techniques, which can be time-consuming, technique-sensitive, and expensive.

Computer-aided reconstruction, on the other hand, uses mean tissue thickness for given anatomical landmarks. This method provides high-quality and resolution images, better visualization of anatomical and pathological states, and 3D images of 2D objects using soft-tissue depth markers. Additionally, it is a non-invasive procedure that allows virtual manipulation and preservation of the original object .

However, computer-aided reconstruction also has some limitations. It requires highly trained specialists for image interpretation and can be technique-sensitive. Recent advancements in 3D computed tomography (CT) imaging have shown to be more accurate than traditional methods.

Overall, facial reconstruction is a valuable tool in forensic odontology, helping to identify deceased individuals and provide closure for families.

TONGUE PRINTS

The unique morphological features of the tongue's dorsal surface make it a valuable tool for identification in forensic dentistry. For this technique to be effective, an antemortem photograph or impression of the tongue is necessary. Combining lingual impressions with photographic images can provide a secure method of identification, complementing rugoscopy and cheiloscopy. Several methods can be used to record tongue prints, including visualization of basic features, alginate impression and cast preparation, digital imaging, sublingual vein analysis, and histological examination.

Oral autopsy involves a thorough examination of the oral cavity, which is crucial for identification purposes due to the resistance of teeth to decomposition. However, the time elapsed between death and forensic examination is critical, as the body undergoes decomposition, compromising the examination. To overcome rigor mortis, specific dissection techniques are employed, including extraoral incisions and inframandibular incision, to access the oral cavity and examine the tongue and other structures.

DENTURE LABELLING

Denture labelling is a crucial aspect of forensic odontology, serving as a means of identifying the owner of the denture. This is particularly important in forensic investigations, where labelled dentures can provide valuable evidence in court. When labeling dentures, it is essential to include specific information, such as the patient's name, date of birth, address, dentist's name, and date of fabrication. There are various methods of labeling dentures, including engraving, inking, and labeling with a permanent marker. To ensure consistency and prevent loss of information, it is recommended to use a standardized format and label multiple locations on the denture. Furthermore, permanent methods of labeling should be used to prevent the information from fading or being removed.

SALIVA ANALYSIS

Saliva analysis providing valuable information for identification and investigation purposes. Saliva contains DNA, enzymes, hormones, and other biomarkers that can be analyzed to identify individuals, detect diseases, and determine the presence of drugs or toxins. In forensic odontology, saliva analysis can be used to analyze saliva stains on bite marks, clothing, or other objects found at crime scenes. This can help investigators link suspects to crime scenes, identify victims, and reconstruct events. Additionally, saliva analysis can also be used to detect saliva on dental evidence, such as dentures or orthodontic appliances, aiding in the identification of human remains.

CONCLUSION

Forensic odontology has evolved significantly, offering a range of techniques for identification, investigation, and analysis. Advances in DNA analysis, digital radiography, facial reconstruction, and saliva analysis have enhanced the field's capabilities. Furthermore, specialized procedures like denture labeling, rugoscopy, cheiloscopy, and tongue print analysis provide valuable tools for forensic experts. As technology continues to advance, the role of forensic odontology in solving crimes, identifying victims, and bringing perpetrators to justice will only grow. It is essential for dental professionals to maintain accurate and comprehensive dental records, adhere to standardized procedures, and stay updated on the latest techniques and technologies to support the field's continued development and effectiveness.

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