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REVIEW ARTICLE

CURRENT TRENDS IN FORENSIC ODONTOLOGY: REVIEW

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Abstract

Background: Forensic odontology is a subfield of dental science that includes the relationship between dentistry and law. Forensic odontology has played a key role in famous criminal cases. Forensic odontology plays a critical role in the identification of human remains of victims (mutilated, burned and decomposed), when fingerprinting and visual recognition, cannot be fulfilled.

This review article was conducted to show the implications of forensic dentistry in criminal investigations.

Aim: The purpose of this article provides an overview of the evolving trends in traditional methods and the latest concepts used in forensic dentistry.

Methodology: The systematic review included articles from Google Scholar, Medline, Scopus, Web Of Sciences, PubMed was conducted. For Search the following keywords: Forensic odontology, dental records, identification of human remains Estimate Age, Sex assessment, Identification following mass fatalities, assessing bite mark injuries, civil cases involving malpractice, analyze bite marks.

Results: Conducted a preliminary search and reviewed 82 titles and abstracts in this review and 27 full-text articles were selected of high methodological quality. Teeth are often resistant to decay even in major accidents, crimes, burials, or other severe exposures to the elements. Therefore, a person's dentition is useful for individual identification and comparison if records exist for this purpose. Various methods have been developed forensic dentistry to determine the age, gender, and ethnicity of an individual using dental tissue. The need for documented procedures and protocols is important for the dentist to In the case of victim identification disaster identification indicators (DVI), allowing for process auditing, they also serve to ensure identification reliability. Dental professionals play a major role in keeping accurate dental records and providing all necessary information so that legal authorities may recognize malpractices, negligence, fraud child abuse and also, identify an individual.

In order to serve the forensic operation and the legal authorities, dentists should be familiar with the basics of forensic dentistry, which will create awareness for the preservation of dental data.

Conclusion: Forensic dentistry (odontology) plays an important role in resolving dental malpractice or negligence issues, including evaluation, report writing, and/or testifying in court. Every dentist has a responsibility to understand the forensic activities related to their dental practice and should be aware of the available technologies and their use in forensic dentistry. The data collection methods and additional technologies used in forensic dental identification have undergone significant transformation. Artificial intelligence is a technology that is still evolving in forensic dentistry, and its usefulness depends on the specific use case and implementation. New research in forensic dentistry should be encouraged.

***Key-words:** Forensic odontology; dental records; identification of human remains estimate age; sex assessment; civil cases involving malpractice; analyze bite marks*

Introduction

Forensic odontology is one of the branches of odontology and involves the processing, examination, and evaluation of dental evidence in the context of criminal justice.

Role forensic odontology help criminal and civil law investigators identify human remains, particularly in cases where identifying information is otherwise scant or lacking, by reviewing the victim's dental records.[1,2]

In various situations a forensic odontologist assists law enforcement agencies by examining dental evidence.

Currently, there are three main areas of activity in forensic odontology, namely:

- The examination and evaluation of injuries to teeth, jaws, and oral tissues caused by various causes (abuse, assault, mass disasters, and crime-related injuries)
- The examination of trace evidence for the purpose of subsequent elimination or possible identification of a suspect as a criminal.
- The examination of dental remains (fragmentary or complete, including all types of dental restorations) of unknown persons or bodies for the purpose of possible identification of the latter.

Forensic dentists can also assist in determining age, race, occupation, and socioeconomic status of unidentified people using X-rays, antemortem and postmortem photographs, and DNA analysis.[3]

Responsibilities of forensic odontologist include:[4]

- Identify human Remains
- Estimate Age
- Sex assessment
- Identification following mass fatalities
- Assessing bite mark injuries
- Assessment abuse cases (child, spousal, elder)
- Civil cases involving malpractice
- Analyze Bite Marks

Why teeth are important in forensics

- **Durability:** Teeth are highly durable and remain intact even when other body parts may not, making them crucial for post-mortem identification.
- **Uniqueness:** Individual dental structures and records (x-rays, dental work) provide a unique identifier akin to fingerprints.
- **DNA Source:** Teeth can preserve DNA within their pulp, aiding in genetic identification when other sources are compromised.
- **Age Estimation**: Developmental stages and wear patterns in teeth help estimate the age of deceased individuals.
- **Bite Mark Analysis:** Comparison of bite marks to dental impressions can link suspects to a crime or exclude them.

The objects of study in forensic dentistry are parts of the facial skeleton, teeth, dentures, organs and tissues of the oral cavity, medical documentation reflecting the state of the dentoalveolar apparatus, etc.[5,6]

Teeth are of particular value as objects of study due to their significant resistance to various unfavorable physical and chemical factors, temperature, putrefactive transformation, etc., as well as the fact that they have unique features in their totality that individualize the personality.[7,8]

The evidentiary value of forensic dental studies in identifying a person largely depends on the correct choice of methods, their consistent and rational combination and knowledge of the basics of forensic identification, taking into account the degree of variability of the properties of objects and their features.[9] It should be remembered that when identifying, specific details of the identified object are of particular importance, which may prove decisive.

To identify a person by dental status, methods of photo alignment, comparative study of the front teeth from a lifetime photograph of the face and skull, methods of comparing lifetime and postmortem radiographs of the maxillofacial region, studying traces and impressions of teeth, anatomical and morphological features of the dentoalveolar system, relief of the back of the tongue, hard palate, etc. can be used.

When studying the anatomical and morphological features of teeth and dentition, the following identification features are taken into account: anatomical and morphological parameters of teeth,

anomalies of teeth and jaws, as well as those acquired during life (caries and its complications, extracted teeth, orthopedic and orthodontic structures and their traces).[10]

The study of the anatomical and morphological features of teeth and jaws includes:

- clinical examination of the patient (questioning, inspection), corpse (inspection);
- inspection and morphometric study of plaster models of teeth and jaws;
- x-ray examination;
- statistical method.

DNA analysis is a new tool used in the field of forensic dentistry.[11] With the advent of the polymerase chain reaction, DNA even in minute amounts of source material, is becoming increasingly popular when traditional identification methods fail due to heat, trauma or autolytic processes, distortion and difficulties in analysis. DNA from the teeth can be obtained by crushing, but it destroys the morphology of teeth.[11-13]

Courts and legal institutions during proceedings require that all conclusions and findings be substantiated based on the actual data obtained, therefore, in addition to legal knowledge, a dentist must be well acquainted with the anatomy of the facial skeleton in terms of the structure and mechanisms of formation of possible traumatic injuries.[14]

Understanding the mechanisms of formation of bite marks during violence, infliction of injuries in cases of sexual abuse, as well as injuries of a specific nature during child abuse are extremely necessary in the practice of a forensic dentist. No less important are the skills of determining a person's age using various methods.[15]

Finally, knowledge of methods for identifying individuals, as well as the principles, protocols and procedures for their implementation in cases of mass disasters, taking into account ethical standards, is a key aspect in the work of a forensic dentist.[16]

Age estimation

One of the most important aspects of criminalistics age estimation of a person is crucial in various forensic contexts such as crime scenes, accidents, mass disasters and potential identification of an unknown person. The most reliable analysis regarding age estimation is the clinical or imaging approach. It involves non-invasive examination of the rate of tooth eruption as well as degenerative changes on the teeth. The age of a human specimen can also be narrowed by the cementum tolshine, which lines the surface of the roots of the teeth, showing annual deposition patterns.[16,17]

Radiographic methods can further elaborate about the various stages of mineralization and further help in a more accurate estimation of age.[18]

Sex assessment

Sex determination is important in the identification of unknown individuals in forensic medicine. Polymerase chain reaction (PCR) DNA amplification yields 100% success in determining sex.[19,20]

The preferred anatomical methods for sex determination are based on pelvic and craniofacial morphology. Teeth are potentially useful for sex determination because their hardness makes them highly resistant to taphonomic processes because tooth enamel is the hardest biological substance in the human body; this makes them extremely resistant analytical evidence in a forensic context. Studies of sexual dimorphism in human teeth have found that there are significant differences in the average crown sizes of males and females.[21,22]

On average, male teeth are slightly larger than female teeth, with the greatest difference being in the canines.[23]

Microtomographic scanning to study the internal tissues of teeth has also shown that male teeth contain significantly more dentin than female teeth, resulting in female teeth having thicker enamel on average.[24,25]

Dental-based gender assessment remains experimental and has not yet gained widespread acceptance, but it does offer useful complementary techniques that can be used alongside more established methods.

Identification of Human Remains

Dental identification of a person occurs in the case of death as a result of violent crimes, road accidents - transport accidents, accidents at work, fires and, who were found immersed in water can be significantly disfigured, also difficult to identify visually, etc.[26]

Confirmation of identity using dental structures has long been of key importance in natural and man-made disasters, particularly mass casualty incidents,

usually associated with air crashes.[27,28]

Dental identification remains vital due to the lack of a comprehensive fingerprint database.

Bite Mark Analysis

Bite mark analysis is important in criminal cases in which a suspect or a victim has left his or her teeth marks on another person or on a nonliving object such as a candy bar, an apple, cheese or even a beer can seem to occur more frequently.[29,30] It has been indicated that teeth once used as weapons, they can be due to the person inflicting the wound. However, bite marks can be encountered in various cases including murder or rape with sexual motives.[31]

Suspect identification by teeth

- For abuse cases, impressions are taken with:
  - Alginate for reliability
  - Polyvinyl Siloxane (PVS) for detailed replication.
- Cast in stone to create a detailed model of dentition
- Special clay is used to simulate human skin texture
- Pressure is then applied to replicate bite marks, to compare with injuries on victim for identification.

Figures 1, 2. *Displays images of the same young patient, one with dentures and one without. Suspect claims they had no teeth to bite with. After locating their dentures, they were a perfect match to the bite marks on the victim.*

Computer study of the tongue dorsum pattern using an intraoral video camera makes it possible not only to record the image in digital mode on an electronic map, but also to measure the parameters of the object being studied with a high degree of accuracy, which allows obtaining reliable results.[32,33]

The mucous membrane of the hard palate is tightly fused with the periosteum. In the area of the median suture and directly at the teeth, there is no submucous layer, and the proper layer of the mucous membrane in these areas is directly fused with the periosteum of the palatine bones, due to which the mucous membrane is tightly fixed.[34]

Thus, anatomical data on the structure of the hard palate allow us to identify elements that can be used for forensic dental identification of a person: the median (palatine) suture, the incisive papilla, the folds of the mucous membrane of the hard palate, running perpendicular to the median suture in a certain sequence at different levels on the right and left.

Digital Facial Reconstruction

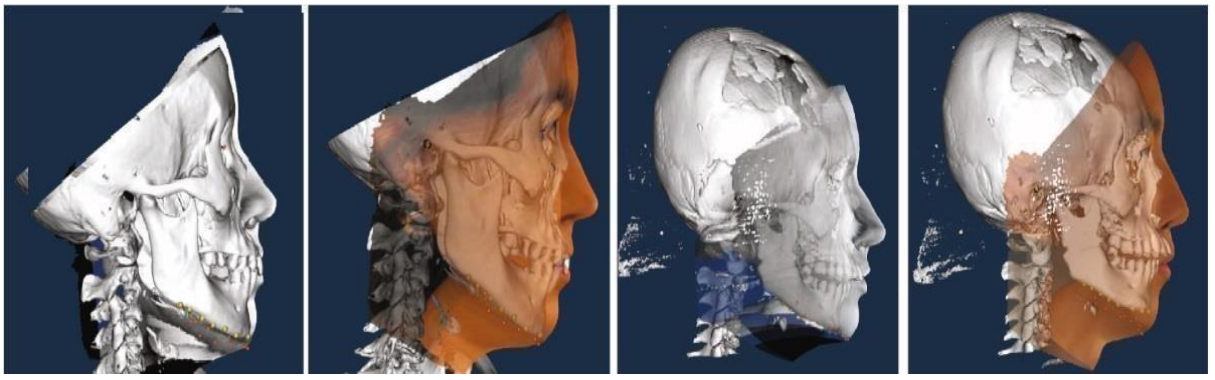
Faces are characteristic of each person, and play an important role in forensic medicine. In major disasters, skulls may remain intact and may serve as a female identity. The computer reconstruction data of the skull is visualized as a fully shaded three-dimensional surface.[35,36]

The face can be drawn using computer software (e.g., Vitrea volume rendering software version 2.3). This method helps to reconstruct the picture of a person who is important in identifying a person.

FaciLe Chair team was investigating an innovative field of research: the combination of scientific computing techniques and 3D visualization to digitally reconstruct the face of an individual from his skull.

Fully automated, applications range from forensics, where facial reconstruction assists the identification of deceased persons, to paleontology and archeology.

Figures 3-6. *Digital Facial Reconstruction from Underlying Skulls*
https://iscd.sorbonne-universite.fr/research/incentive-actions/facile/



Figures 7-10. *Digital Facial Reconstruction*

The computer reconstruction data of the skull is visualized as a fully shaded three-dimensional surface.

Forensic odontology is a complex branch of forensic medicine that involves the application of dental sciences to identify deceased persons by comparing.

Forensic Odontology has great potential for development. Forensic odontologists play an important role in the examination and interpretation of dental evidence.[37]

In recent years, the number of court cases related to cases of criminal medical negligence has increased significantly. A doctor may be subject to criminal, civil or disciplinary liability for his or her work.

In order to initiate criminal liability for the fact of medical error, it is necessary to present a forensic medical examination report on the infliction of significant harm to the patient's health or the occurrence of a fatal outcome.

This may occur for a wide range of reasons, from direct failure to fulfill obligations established by legislation and regulatory legal acts governing the performance of professional duties of a doctor to a violation of professional obligations that fall under the definition of a criminal offense.

Another feature of judicial practice in dental cases is that patients who have received dental care are increasingly seeking compensation for moral damages and costs of correcting treatment deficiencies.[38]

Although dental malpractice is relatively rare, it does happen. Negligence during dental treatment can lead to serious complications, sometimes life-threatening. Often, these health problems are related to routine procedures and mistakes that could have been avoided.[39]

Dental malpractice cases and investigations into dental insurance fraud schemes are attracting increasing attention, both due to increased public awareness of the dentist's duties and responsibilities to patients and the contentious nature of today's rapidly evolving society. To analyze such aspects, the dentist needs a thorough knowledge of the various laws pertaining to dental practice, professional codes of

conduct, and must be up-to-date with the conditions of treatment. In addition, dentists require continuous improvement in the recording of medical and legal criteria for dental treatment. In civil cases, forensic dentists may be called upon to provide expert testimony regarding medical malpractice.

Today, forensic dentistry is considered a specialized and reliable method of identifying a person in disaster situations

The unique nature of dental anatomy and individual restoration ensure accuracy when the techniques are applied correctly. Each dentist is responsible for understanding the forensic activities associated with their dental practice. Efforts must be made to maintain dental records which will serve as an important tool in forensic medicine.[40]

Therefore, the success of forensic dentistry can only be achieved if the dentist and dental institutions keep lifetime records of their patients with information such as name, age, gender, number of teeth present, filled teeth, dentures and other restorations, morphological changes of teeth and a pull-out case with photographs and radiographs. This lifetime record helps the forensic scientist in many situations where ordinary things do not provide complete information

The application of artificial intelligence in forensic medicine and forensic dentistry is still in its early stages.[41] Artificial intelligence can be integrated into existing testing and analysis processes to make the whole procedure rapid and more accurate.

Artificial intelligence can be used to improve forensic dentistry, including:

- Dental identification: Analyzing dental images, such as radiographs, to identify and match individuals based on their teeth and jaws.
- Age and gender estimation: Artificial intelligence can help forensic dentists estimate the age and gender of individuals.
- Creating 3D models of teeth and jaws for use in facial reconstruction of unidentified remains.[42]
- Analyzing and matching bite marks, which can be used as evidence in criminal cases.
- Searching and matching dental data in databases, which can help identify individuals.

Implementation artificial intelligence systems will be raised accuracy and efficiency in forensic dentistry however, should be used as an auxiliary tool, not as a replacement for forensic experts.

This review article was conducted to show the implications of forensic dentistry in criminal investigations.

The scope of forensic dentistry is significantly expanded beyond the practical segment of identification, including a number of activities where dental practice and theory intersect with the letter of the law. To be a competent specialist in this field, it is necessary not only to have a complete understanding of the theoretical provisions and methods of odontology, but also a certain amount of knowledge and experience in the field of forensic medicine, law, pathological anatomy, molecular biology and anthropology. In their practice, a forensic odontologist encounters the need to use knowledge of the above-mentioned disciplines in various scenarios of criminal cases. In addition, in order for the dentist to understand how he can best contribute to the investigation, he should take into account all the possibilities and limitations of the methods of the above-mentioned branches of science.

Declarations

Conflicts of interest and financial disclosures

The author declares that he has no conflict percent and there was no external source of funding for the research in question.

Ethical approval

The study was approved by the University ethics committee and was conducted in accordance with the Declaration of the World Medical Association.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Source of funding

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