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Recent updates in Forensic Dentistry-A literature Review

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Abstract

Forensic Dentistry 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. Since teeth are among the body's most durable structures and can withstand the majority of environmental conditions, they are valuable instruments for post-mortem study. When determining the victim's gender, the size and general form of the jawbone are important pieces of evidence. The objective of this review is to present an overview of the conceptualizations that are currently employed in forensic odontology as well as emerging developments in traditional approaches.

Keywords: Analysis, Bite mark, Forensic dentistry, lip print

Full length Review article **Corresponding Author*, e-mail: m.awinashe@qu.edu.sa

1. Introduction

Forensic odontology has been defined as that branch of dentistry which, in the interest of justice, deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of dental findings. The identification of people involved in large-scale disasters (such as aeroplane crashes, earthquakes, and tsunamis), criminal investigations, ethnic studies, and the identification of decomposed and disfigured bodies such as those of drowning victims, fire victims, and auto accident victims have all benefited greatly from forensic odontology [1]. The human body's toughest tissues, teeth are resistant to deterioration even in harsh conditions such as exposure to high temperatures or burial. Because each person's dental pattern is distinct, it can be used as an easily accessible record to identify people, particularly in situations when traditional soft tissue records are insufficient [2, 3].Forensic odontology involves three important areas namely;1) Diagnostic and therapeutic investigation and assessment of injuries to oral soft tissues, jaws and teeth. 2) Person identification, particularly in criminal cases and large-scale disasters 3) The identification, inspection, and assessment of bite marks, which occur occasionally in cases of child abuse, molestation, and self-defense [4]. Visual identification, personal information such as height, build, age, hair type, and medical information such as scars, tattoos, birthmarks, implants, amputations, prosthetics, footprint records from a podiatrist or chiropodist, clothing, personal belongings, fingerprints, DNA profiling, and dental identification are among the commonly used techniques for identifying individuals[4]. Furthermore, the field of forensic odontology is introducing contemporary ideas like facial reconstruction, denture identification, comparative microscopes, tongue prints, vitropsy, and numerous related softwares [2].

The purpose of this article is to present an overview of the latest ideas used in the field of forensic odontology, as well as the ways that traditional procedures are changing.

1.1 History of forensic odontology

The first known instance of forensic dentistry concerns a woman who was a consort of Emperor Nero and was recognised after her death by the distinctive arrangement of her teeth. Paul Revere used dental work and teeth to identify Revolutionary War victims in 1775. Additionally, he was able to identify Joseph Warren's remains by recognising a Walrus tusk that had been used as a pontic for his missing maxillary canine. Hitler and Eva Brauma's bodies were identified in 1977 with the use of dental records, radiography, and prosthetics. The "fire of the Bazaar de la Charité tragedy" in May 1897 in Paris marked the introduction of mass forensic identification by dentition [5,6,7,8].

1.2 Applications of Forensic Odontology

• Age estimation; • Identification of people at crime scenes and/or mass disasters; • Identification and examination of bite marks, which are occasionally seen in cases involving sexual assault, child abuse, and self-defense***[9]***; • Assessment of damage to the jaws, teeth, and oral soft tissue. The various methods employed in forensic odontology include rugoscopy, cheiloscopy, tooth prints, bite marks, photographic study, radiographs, and molecular methods [1].

2. Conventional Methods of Dental Identification

2.1 Sex determination

A crucial step in the forensic procedure of person identification is sex estimation. An essential step in the dental profiling procedure for human identification is sex estimation. Metric, non-metric, and biochemical techniques are the main categories into which forensic instruments for dental sex determination can be divided [10].Dental structures are measured using metric methods of dental sex determination, either directly (by measuring the tooth) or indirectly (via dental radiography, imaging, or dental castings). Metric analysis can be performed on post-mortem remains that still have teeth in them without significantly damaging the remains. Because these techniques are easy to use, affordable, and non-invasive, they are frequently employed in research projects. The science and data supporting metric approaches indicate that variations in sex should result in quantifiable and statistically significant variations in the size of male and female teeth. Rugoscopy has also been proposed in certain research as a potential sex estimation technique, however its effectiveness has been limited because the evidence does not support a unifying conclusion [10].

2.2 Tooth as a tool for forensic evidence/ Odontometrics

Since teeth are among the body's most durable structures and can withstand the majority of environmental conditions, they are valuable instruments for post-mortem study. Odontometrics, the measuring and analysis of tooth size, is an important method for estimating dental sex [10].Every person has a different set of teeth and a different morphology. In order to determine the identity of the deceased, a process known as comparative dental identification involves comparing dental evidence—such as dental caries, missing teeth, restored teeth, prosthetics, changes in tooth shape like taurodontism or talons cusp, developmental defects like amelogenesis imperfecta and dentinogenesis imperfecta, and colour changes in teeth like dental flurosis—collected from human remains with prior records [5].The buccolingual and mesiodistal crown dimensions are typically measured in most research on sexual dimorphism. The Incisor and Mandibular Canine indices are two of the most often utilised metric analysis indicators for dental sex estimation. Additionally, several academics have looked into the possibilities of estimating dental sex using root lengths. These days, dental morphology—such as the predominance of the Carabelli's cusp in the Caucasoid race or shovel-shaped incisors in the Mongoloid race—plays a crucial part in forensic ancestry estimation rather than sex estimation. Dental abnormalities are rare and can help identify a person because of how different they are from one another. Nonetheless, it was discovered that a person's sex had no bearing on the likelihood of having dental abnormalities [10].

2.3 Examination of tooth prints (ameloglyphics)

Despite being the strongest mineralized substance in the human body, enamel typically experiences macro and microwearing. Since amethysticism is still in its infancy, more research is needed to determine whether teeth prints are the same at various enamel depths [1].

2.4 Age estimation

Dental stability is largely unaffected by environmental, social, nutritional, dietary, and even endocrine influences. When compared to other systems, these characteristics make the developing teeth the most accurate age indicator [8].

2.5 Dental Imaging

When identifying dental radiographs, factors such as the shape of the crown and roots, the number of teeth that are present or missing, residual roots, extra teeth, noncarious lesions like fractures, attrition, abrasion, and bone resorption from periodontal disease, bone pathology, diastemas, dental caries, endodontic treatment, intraradicular posts, intracoronal posts, and dental prostheses are taken into consideration. By taking into account craniometrical points that can be precisely found and computed, postmortem mimeographic images can be created using antemortem CT images [2,11].

2.6 Radiographs

Dental-based identification is thought to be less trustworthy than other biometric techniques, such as finger prints, because dental traits do change over time. But radiography might be the only biometric technique accessible for victims in total decomposition. From the radiographs, several morphological and pathological changes can be examined. In research based on morphology, root morphology identifies subjects more accurately than crown morphology [1].

2.7 Photographs

Pictures are a great replacement for textual documents because they are universally understood. The fundamental issue comes from trying to picture three-dimensional objects in two dimensions. When shooting pictures, stability, close-up ability, lighting, and camera position are all very important considerations. The camera should be supported by a tripod such that its long axis is perpendicular to the subject being photographed. Images that don't have a scale or any other circular reference point may be erroneous by nature [1]. When representing an object in its 2D form, forensic photography needs to produce correct results [8, 11].

2.8 Bite Mark Analysis

Bite marks are described by the ABFO as a pattern that an animal or human's teeth leave on an object or piece of tissue [9]. Bite mark identification is a relatively young field of study with potential applications in forensic investigations. Bite marks might appear on the victim's skin, in food, or on other objects, depending on the situation. Bite marks are ovoid or circular spots of contusion or abrasion, sometimes with corresponding indentations. It could consist of two U-shaped arches with a gap between them at the base. The damage usually has a diameter of 25–40 mm, and a bruise is frequently visible in the centre. The use of electron microscopy and computer enhancement techniques, the identification of ABO blood groups from the saliva on the bite mark, and the connection of bacteria and other microorganisms found in the bite mark to the oral environment of the perpetrator are some of the more recent methods that have improved bite mark identification [1].

Bite marks have been found in human tissue in cases of sexual assault, child abuse, physical assault, and murder [2,12]. By looking at the biting surfaces, which may show unique features like fractures, rotations, missing teeth, and breadth of dental arches, one can determine the age of the attacker. By using an ultraviolet light illumination approach, bite marks that are invisible to the human eye can be seen. The process of comparing bite marks often involves examining and quantifying each tooth's size, shape, and position. The creation of overlays through hand tracing from study casts, wax impressions, or xerographic photographs is the most widely used technique for this kind of comparison [2].

2.9 Steps involved in Bitemark recording

From victim- Consent, history, Documentation, Photography, Saliva swab, Impression and model, UV illumination, First aid [2].

2.10 Cheiloscopy / lip print analysis

In forensic dentistry, the examination of lip prints and patterns is known as cheiloscopy. Individual lip prints have been proven to be distinct, and forensic human identification may be aided by the investigation of lip prints and patterns. In forensic medicine, cheiloscopy entails taking the subject's lip print and comparing it to a recognised source. Since cheiloscopy may be collected and captured from surfaces, items, or cigarettes, it may be a more successful method of identifying criminals at crime scenes. In forensic odontology, using lip prints for human identification is a recognised technique used by criminal justice systems across the globe [1,10–15].

Disadvantages

- cheiloscopy heavily depends on the lips being intact at the time of post-mortem examination.
- Decomposition begins almost immediately after death, and mechanical trauma or thermal injury to the lips will cause greater distortion and disfiguration, rendering cheiloscopy ineffective [10]

At the crime scene, lips can be found on clothes, in glasses, cups, cigarettes, windows, and doors. The chelion, which is the lateralmost point in the mouth opening, the labrale superius and labrale inferius, which are the highest and lowest points of the upper and lower lip margins in the mid-sagittal plane, respectively, are the anatomical landmarks of the lip. The design of the lips varies on whether the mouth is closed or open. Lip grooves are clearly defined while the mouth is closed, but they are comparatively ill-defined and challenging to understand when the mouth is open[1]. Because lips feature ridges and grooves, they provide sufficient information for forensic examinations. In order to avoid postmortem lip modifications that could lead to inaccurate data, lip prints should be extracted within 24 hours of the death. Reference [2].

Mucocele, postsurgical changes, a thick layer of lipstick, and the presence of debris are among the variables that can impact lip prints [1,2].

2.11 Palatal Rugoscopy (Rugoscopy)

A branch of forensic dentistry called rugoscopy, oftenknown as palatoscopy, deals with the examination of palatal rugae. The keratinized ridges or mucosal elevations on the anterior surface of the palate mucosa are known as the palatal rugae. Once created, they are individualised and stable for life, making them useful for forensic human identification. Rugoscopy is superior to other traditional procedures for human identification, particularly when it comes to deceased victims who are edentulous or missing all of their teeth. In order to aid in identification, maxillary detachable prostheses that are currently available and adequately capture the palate rugae can also serve as ante-mortem records[10]. Photos and maxillary arch impressions, calcor rugoscopy, overlay prints, and other materials and techniques are used to analyse the rugae patterns [2].

The incisive papilla has three to seven ridges that radiate tangentially outward to form the palatal rugae. There are four different types of ridges: branching, wavy, straight, and curved. These rugae are thought to be exclusive to a single person. Palatal rugae are typically destroyed in fire situations [1].Because the palatal rugae are made of strong connective tissue that is more resistant to physical, temperature, and decomposing stresses than the skin or lips, rugoscopy is preferable to cheiloscopy. Rugoscopy has also been proposed in certain research as a potential sex estimation technique, however its effectiveness has been limited because the evidence does not support a unifying conclusion [10].Because of its distinctiveness, the palatal rugae pattern will offer an alternate form of identification in the event that teeth are lost due to trauma. Because rugae are found inside the oral cavity and are shielded from external threats like heat by the tongue and buccal pad, they are not affected. Age and other oral environmental factors, such as orthodontic tooth movements, cleft palate surgery, tooth removals, impacted canine eruption, and periodontal surgery, can change rugae patterns [2].

3. Non-Dental Structures

Many of the skull's anatomical components, which are close to the teeth, have also been shown to be sexually dimorphic and to be capable of precise and trustworthy sex determination. The maxillary sinus and the mandible are two of these features that the forensic odontologist may find interesting [10].

Mandible: Compared to female mandibles, male mandibles are typically bigger, stronger, and have more noticeable muscle attachment points. Gonial flare, a broad ascending ramus, high symphysis, and a modest mental eminence are further prominent male traits. The value of the mandible in sex estimation has been determined by both metric and non-metric investigations [10].

Maxillary Sinus - One of the four paranasal sinuses in the skull is the maxillary sinus. It is situated directly above the maxillary posterior teeth's roots. When estimating the gender of adult human subjects, panoramic radiographs can be utilised to record the height and width of the maxillary sinuses. The dimensions of the maxillary sinuses were shown to be statistically considerably higher in males, with the sinus height being the most reliable indicator of sex [10].

3.1 Biochemical Methods/ Molecular Methods

Natural catastrophes can result in the loss, shattering, or burning of human remains as well as significant damage to most soft tissues and occasionally even the teeth, rendering them unusable for metric or non-metric study. Because biochemical methods of sex assessment only require a tiny sample for analysis, they are helpful in situations when post-mortem remains are fragmentary or damaged. In terms of sex estimation, biochemical approaches are the most accurate and reliable; they began to emerge in the 1990s. The sex-determining region Y protein (SRY) analysis, the amelogenin protein analysis, and the presence of Barr bodies are examples of biochemical techniques for dental sex assessment. For confirmatory testing, only a tiny sample is needed thanks to PCR amplification [10].In forensic science, molecular techniques are incredibly dependable, distinct, and highly accurate. However, this relatively new methodology does have certain drawbacks. Mistakes might occur during the collecting, processing, and interpretation of samples. The interpretation can be changed by any bacterial contamination or DNA from another person. A small amount of DNA can result in fewer intense bands during processing, which could lead to incorrect findings interpretation. Furthermore, relatively little high molecular weight DNA can be produced from deteriorated materials [1].

i) ***DNA Analysis***

One new technology in the field of forensic odontology is DNA analysis. It becomes significant when autolytic processes, severe temperatures, or distortions cause traditional identification methods to fail. DNA typing can be carried out using biological materials such as blood, bone, tooth, hair, semen, and saliva [2, 15].

ii) Barr Bodies

Barr bodies are dormant X chromosomes that are discovered in cells that have multiple X chromosomes, which are typically found in females. A typical male cell nucleus contains no Barr bodies, whereas a typical female cell nucleus has one. In 1949, Barr and Bertram made the first discovery of Barr corpses. Because the dental pulp is highly protected within the tooth, barr bodies are typically derived from this source rather than other sources of soft tissues. The viability of the sample determines its effectiveness in determining sex [10].

iii) ***Amelogenins***

The main protein component present in the enamel matrix is called amelogenins. They belong to the class of extracellular matrix proteins and play a role in the formation of dental enamel. The X and Y chromosomes in humans include the amelogenin gene, and the variation in size between them serves as the foundation for the differentiation of males and females. A DNA sample is first taken from the tooth enamel in order to ascertain the sex of an unknown sample. The sample's sex can then be determined by either analysing it with a known primer or using mass spectrometry to measure the proportion of X to Y peptides [10].

3.2 Artificial Intelligence In Forensic Odontology

AI has played a key role in the transition of forensic analysis from manual to automated techniques. Large volumes of data could be transformed into information by artificial intelligence (AI), allowing for analysis and interpretation. This offers the ease of cloud accessibility while lowering human labour and hours. Artificial Intelligence (AI) is compared to the human brain by some experts because it mimics human intelligence. The potential for integrating AI technology in forensic orthopaedics has been impressive [16].

3.3 Recent Advances in Forensic Dentistry

a) Facial Reconstruction

Every person born into this world has a distinct face. One of the most vital tools in the forensic field is the face, as it never changes in a deceased individual. The person's identity can be ascertained without the need for forensic experts. Only in cases where the face is severely damaged by certain factors can forensic dentistry be used. When it comes to identifying the retrieved human remains—whether whole or in pieces—forensic experts are essential. The corpse of a deceased individual may be skeletonized or decomposing in large-scale accidents and calamities. The skull and the remaining bones will be all that remain in such a state [2].When creating a face, computer programmes such as Vitrea 2.3 version volumetric visualisation come in quite handy. Reconstruction using 3D-CT imaging has been found to be more accurate than imaging directly on CT slices and 2D-CT images [2].

b) Denture Identification Methods

One of the most dependable and simple ways to identify someone is to label their denture. Denture labelling techniques are divided into two groups: the inclusion method and the surface marking method. The denture will be marked with embossed lettering and scribbled or engraved using the surface marking method. Metal identification bands, a micro-labeling system, computer-printed dentures, patient photo embedding, lead paper labelling, denture bar coding, laser etching, T-bar, lenticular card systems, radiofrequency identification tags and electronic microchips are examples of exclusion techniques. Surface approaches are the more affordable and user-friendly of these two types [2].

c) Comparison Microscope

Accuracy in the field of forensic sciences will increase with the use of microscopes. Age estimation is aided by the analysis of cemental annulations, which is facilitated by the phase contrast microscope. The traditional microscope will require more time to focus and obtain diverse viewpoints when comparing the materials. Also, while comparing two items, the observer must rely on recollection. These days, a prototype Virtual Comparison Microscope (VCM) is used to get around these problems. The comparative microscope facilitates the simultaneous analysis of multiple specimens. VCM features a split view window and two microscopes linked by an optical bridge. VCM uses pictures of broken bullets, distorted bullets, and various rifling from the company's BulletTrax-3D technology [2].

d) Vitropsy

A non-touch autopsy method is called viteropsy. It is a cross-disciplinary technology that connects various fields, including pathology, physics, image processing, forensic radiology, medicine, and biomechanics. Among the techniques used in vitropsy are photography, 3-D optical scanning, photogrammetry, biochemistry, toxicology, molecular studies, dentistry, and fingerprinting [2].

e) Various softwares in forensic discipline

The identification process is made much simpler and easier by a variety of software programmes, including Unified Victim Identification System (UVIS/UDIM), Windows Identification, Automated Dental Identification System (ADIS), Auto computer-aided design (2D and 3D CAD), Computer-assisted postmortem identification (CAPMI), Disaster and Victim Identification (DAVID), and GNU image manipulation programme. The development of several software programmes, like as Adobe Photoshop and Dentascan, has made it feasible to scan a deceased victim's teeth in a matter of minutes [2].An optimal technique for estimating dental sex should be simple to use, consistent, non-invasive, and highly accurate and reliable. Forensic dentists continue to rely on the methods that are currently available to them, despite the fact that there is ongoing quest for a better solution. More crucially, the type and quality of the remains that are present, as well as the time, money, and resources available to carry out the necessary investigations, will all play a role in deciding which approach or methods of dental sex estimate to use.

4. Conclusions

A developing field within the forensic sciences with a bright future is forensic odontology. It is imperative that dentists stay up to speed on their knowledge in this area, since they have unquestionably contributed to strengthening the foundation of this specialty.

References

[1] J. Gupta, K. Gupta (2018). Forensic odontology- a review. Research Journal of Life Sciences, Bioinformatics, Pharmaceutical and Chemical Sciences (RJLBPCS). 4(3) :.420-425

[2] S.Renuga, N.S.Sahana, S.T.Yadav, H. Khatoon, M. Kulkarni, A.Chakraborty (2021). Current Advances in Forensic Dentistry-A Review Article. International Journal of Dental Science and Innovative Research (IJDSIR).4(4): 16 – 22.

[3] N.Jeddy, S.Ravi, T.Radhika (2017). Current trends in forensic odontology. Journal of forensic dental sciences. 9(3):115

[4] M.Zakirulla, A.Meer (2011). Modern tools in forensic dentistry. International Journal of Contemporary Dentistry. 2(3):1-6.

[5] V.Saranya, N.Malathi (2014). Forensic odontology: a brief review. Scientific Research Journal of Medicine (SRJM)7:22-28

[6] K.Sansare (1995). Forensic odontology, historical perspective. Indian J Dent Res. 6:55–7.

[7] B.S.Bagi (1977). Role of forensic odontology in medicine. J Indian Dent Assoc. 1977;49:359-63.

[8] B.Shiva Kumar, R. T. Ganesh (2016). Forensic Odontology: The Investigative Branch of Dentistry - A Review. International Journal of Oral Health Dentistry. 2(1):29-34

[9] L.B.Kumar, S.Shivakumar (2016). Forensic odontology: A historic review. Int J Forensic Odontol. 1:2-3.

[10] D.Heng, S.Manica, A. Franco (2022). Forensic Dentistry as an Analysis Tool for Sex Estimation: A Review of Current Techniques. Research and Reports in Forensic Medical Science. 12 25–39

[11] D.T.Devore (1977). Radiology and photography in forensic dentistry. Dent Clin North Am. 21:69-84

[12] C.Shebah, A.Sheethal, B.R.Harshita, P.Preethi, R.K.Prasanna (2022). A Review on Bite Marks in Forensic Dentistry. Austin J Dent. 9(1): 1167

[13] S. Samudhrasri, V. Vishnu Priya, A. Abirami, R. Gayathri, S. Kavitha, P. K. Reshma, Y. Dinesh (2022). Lip Prints Analysis: An Observational Study. Journal of Pharmaceutical Research International. 34(6A): 1-9.

[14] A.Franco, L. K.Gomes Lima, M. N. de Oliveira, W.de Andrade Vieira, C.Blumenberg, M.M. Costa, L. R. Paranhos (2021). The weak evidence of lip print analysis for sexual dimorphism in forensic dentistry: a systematic literature review and meta-analysis. Scientific Reports. 11:24192

[15] A.A. Javier, A.A.Fadi (2014). Forensic dentistry in human identification: A review of the literature. J Clin Exp Dent. 6(2): e162-7.

[16] O.Ahmed, S.A.Saleem, A.A.Khan, S.Daruwala, A.Pettiwala (2023). Artificial intelligence in forensic odontology – A review. International Dental Journal of Student's Research. 11(2):54-60.