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ROLE OF FORENSIC ODONTOLOGY IN HUMAN IDENTIFICATION: CURRENT PERSPECTIVES

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ABSTRACT

Background: Despite significant advances in science and technology, natural disasters and criminal activities continue to pose major challenges to society. The identification of human remains is essential for legal, criminal, humanitarian, and social purposes. **Aim:** This review aims to highlight recent advancements in forensic odontology, emphasize the role of dental professionals in human identification, and critically evaluate the limitations of various forensic dental techniques. **Discussion:** Dental evidence plays a crucial role in personal identification due to its reliability, cost-effectiveness, and rapid applicability. Forensic odontology, a specialized branch of dentistry, involves the collection, examination, and interpretation of dental evidence, thereby bridging dentistry and legal investigations. In recent years, its application in forensic science has gained increasing recognition and is considered a reliable method for personal identification in appropriate cases. However, variability and inconsistencies in forensic dental techniques remain significant concerns that affect accuracy, reliability, and reproducibility. **Conclusion:** Although forensic odontology is a valuable tool in human identification and forensic investigations, its limitations must be critically addressed. Continued refinement of methodologies is essential to enhance its effectiveness and strengthen its role in forensic science.

KEYWORDS : Forensic odontology; bitemarks; cheiloscopy; rugoscopy; toothprints; photographs; radiographs; human identification; dental evidence; limitations.

INTRODUCTION

Forensic odontology is a specialized discipline of dentistry dedicated to the systematic recovery, analysis, interpretation, and presentation of dental evidence in the administration of justice. It serves as a critical tool in the identification of individuals in mass disaster scenarios such as aviation accidents, earthquakes, and tsunamis, as well as in criminal investigations and the examination of unidentified human remains. Its applications extend to the identification of severely decomposed or disfigured bodies, including victims of drowning, thermal injuries, and road traffic accidents, thereby reinforcing its significance in forensic casework. [1]

The methodologies employed in forensic odontology encompass rugoscopy, cheiloscopy, bite mark analysis, toothprint comparison, radiographic assessment, photographic documentation, and molecular approaches. Despite their established utility in forensic investigations, these techniques are associated with inherent limitations and methodological variability that may affect evidentiary interpretation. A critical appraisal of these discrepancies is essential to improve diagnostic accuracy, enhance reproducibility, and strengthen the scientific validity of forensic conclusions. This paper examines the limitations associated with key techniques in forensic odontology and underscores the need for standardization in practice. [1,2]

Rugoscopy

Palatal rugae are a series of approximately three to seven ridges that extend laterally from the incisive papilla. Based on their morphology, they are generally classified as straight, curved, wavy, or branched, and are regarded as unique to every individual. In forensic situations where dental identification cannot be carried out—such as in edentulous cases—palatal rugae may be used as a supportive identification feature. However, their application as a definitive forensic tool is limited by several factors. [2]

The foremost requirement is the availability of ante-mortem records; without these, comparison and identification cannot be established. In addition, irregular or complex rugae patterns that do not conform to a single classification may result in observer-related errors. Kapali et al. [1] observed that conditions such as denture use, malaligned teeth, and palatal diseases may influence or modify rugae patterns. Similarly, Thomas et al. [2] emphasized that these patterns are largely genetically determined, making them more appropriate for distinguishing populations rather than identifying individuals.

Furthermore, palatal rugae are highly susceptible to destruction in cases of fire. Their forensic utility is also reduced by postmortem changes, as decomposition and skeletonization can occur rapidly—within approximately six weeks in summer and up to four months in winter [3].

Cheiloscopy

Lip prints are the characteristic patterns formed by the elevations and grooves on the outer surface of the lips. These prints can be left on various objects at a crime scene, such as cups, glasses, cigarettes, clothing, windows, and doors, and are therefore useful in forensic identification. They are a recognized tool in Forensic Odontology and are accepted within the criminal justice system. Typically, the most reliable impressions are obtained from the central part of the lower lip, which is most commonly visible in traces.[3] Lip print patterns are generally classified into vertical, intersected, branched, reticular, and undetermined types. Important anatomical landmarks of the lips include the chelion (the corners of the mouth), the stomion (the point where the upper and lower lips meet in the midline), and the labrale superius and labrale inferius, which represent the highest and lowest points of the upper and lower lip margins respectively.

The quality and accuracy of lip print evidence can be influenced by several factors. It is ideal to collect prints within 24 hours of death to minimize postmortem changes that may distort results. Mouth position also plays a role, as closed lips produce clearer impressions compared to open-mouth positions, which tend to be less distinct. In addition, pathological conditions such as mucoceles or surgical alterations, as well as loss of anterior teeth, may affect lip support and alter the pattern. External factors like debris, fluids, heavy lipstick application, or improper handling of lifting materials can further compromise print quality. [3,4]

Although lip prints are generally considered unique to each

individual, their interpretation may be challenging when impressions are unclear, unless additional identifying features such as scars or clefts are present. [3]

Bite Marks Examination:

Bite mark identification is a relatively recent but potentially useful tool in forensic investigations. Bite marks may be present on food items, objects, or the skin of a victim and typically appear as circular or oval areas of abrasion or bruising, sometimes accompanied by indentations. [5] They often show two U-shaped dental arches separated by an open space and usually measure about 25–40 mm in diameter, with possible central bruising. Modern advancements in bite mark analysis include electron microscopy, computer-enhanced imaging, ABO blood group determination from saliva, and microbiological profiling that may link oral bacteria to a suspect's oral cavity [6,7].

Despite these developments, the recording and interpretation of bite marks remain challenging. Their appearance can change rapidly—often within 10–20 minutes in both living and deceased individuals—making prompt documentation essential. Even when photographed quickly, the three-dimensional nature of bite marks is reduced to a two-dimensional image, which can distort color, depth, and spatial relationships. Incomplete bite impressions are generally inconclusive, and reliable analysis typically requires the involvement of at least four to five teeth [8]. In addition, the curved and elastic nature of skin introduces further distortion, while factors such as the location of the bite, the impression method used, hemorrhage, and post-injury swelling can all alter the evidence. In some cases, different sets of teeth may produce very similar patterns. Further complications arise from changes in a person's dentition over time due to trauma, extractions, periodontal disease, decay, or prosthetic restorations.

Given these limitations, bite mark evidence is considered less reliable than many other forms of forensic identification. Its interpretation often depends heavily on expert testimony, which may be difficult for judges and juries to independently evaluate, leading to concerns about its potential prejudicial impact. As a result, forensic odontologists must exercise caution when analyzing bite marks and should rely on them only in conjunction with supporting evidence [9].

Ameloglyphics:

Ameloblasts lay down enamel rods in a complex undulating and interwoven pattern, which produces distinctive configurations on the outer enamel surface formed by the terminal ends of adjacent rods. The analysis of these enamel rod-end patterns, referred to as *ameloglyphics* by Manjunath et al[10], has been proposed as a potential identification method, particularly in cases involving decomposed or burned remains, since enamel is highly resistant to decomposition. However, the technique is dependent on the availability of ante-mortem dental records for comparison.

Although enamel is the most highly mineralized and hardest tissue in the human body, its surface is still susceptible to micro- and macrowear over time. Consequently, teeth that are fractured, decayed, attrited, abraded, or eroded are unsuitable for reliable analysis using this method. Ameloglyphics remains in its developmental stage, and further research is required to establish whether tooth print patterns remain stable across different enamel depths.

Radiographic Examination:

Dental radiographs can be useful in forensic identification, especially when other biometric methods (like fingerprints) are unavailable due to advanced decomposition. While dental features can change over time and are generally less stable, radiographs still provide valuable identifying information—often more reliably from root structures than crown features. [11] They can reveal details such as tooth decay, missing or restored teeth, fractures, stages of healing in extraction sites, root development, and even patterns in jaw bone structure. These characteristics can assist in building a biological profile for identification. [11]

However, dental identification has important limitations. Ante-mortem dental records are often missing, incomplete, of poor quality in many regions, and this problem is especially pronounced in children due to changing dentition. Differences caused by later dental treatment or trauma can also reduce match accuracy. Technical issues—such as differences in image angle, exposure, and magnification between ante- and post-mortem radiographs—further complicate comparisons. In some cases, the condition of remains may even prevent post-mortem radiographs from being taken at all. [11]

Photographs

Photographs are useful substitutes for written documentation and can also help bridge language barriers. However, their accuracy is limited and depends on strict standardization during capture. One major issue is that three-dimensional objects are recorded in a two-dimensional format, which can introduce distortion and alter perceived color. Parallax error is another common problem that may affect measurement accuracy. Proper photographic technique is essential, including correct lighting, stable positioning, appropriate camera orientation, and the ability to take close-up images when required. Ideally, the camera should be mounted on a tripod and positioned perpendicular to the long axis of the object to minimize distortion. [12]

Another important requirement is the inclusion of a scale or reference device in the image. Photographs taken without such a reference can be unreliable for measurement purposes. While small plastic rulers may provide limited accuracy, the ABFO Scale No. 2 is widely accepted as a standard tool in forensic photography. [12]

MOLECULAR METHODS:

Molecular techniques used in forensic science are highly accurate, reproducible, and capable of generating unique DNA profiles, making them extremely valuable for personal identification. Despite these advantages, the methods are not without limitations. Errors may occur at various stages, including sample collection, laboratory processing, and result interpretation. Contamination from external biological material, such as microorganisms or DNA from other individuals, can compromise the integrity of results. Furthermore, low DNA concentrations may produce weak signals or faint band patterns, increasing the likelihood of misinterpretation. In cases involving degraded biological samples, only fragmented or insufficient quantities of high-quality DNA may be recovered, which can further reduce the reliability and completeness of the analysis. [12]

CONCLUSION

Therefore, findings in forensic odontology must be interpreted with caution. Experts should clearly communicate the limitations and degree of uncertainty associated with the methods used. This ensures that the evidence is not overstated in legal proceedings. Careful presentation helps prevent misinterpretation and supports fair judicial outcomes.

Conflict Of Interest: No conflict of interest exists.

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