The Role of Periodontics in Forensic Odontology: A Literature Review

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Abstract

Forensic Odontology is an important part of forensic science and is indispensable in dealing with medicolegal issues and useful in the identification of deceased individuals. Various methods have been developed to determine a person's identity using the teeth and surrounding tissues. This paper aims to inform the role of periodontal in forensic odontology.

This review was obtained from various literature from 2004 to 2020. Various studies have shown that periodontal tissue can be used to identify a person's identity. Clinical parameters of the gingiva, periodontal ligament, alveolar bone, and cementum, as well as comparison of ante-mortem and post-mortem radiographic records for alveolar bone height, crestal bone, interradicular bone thickness, lamina dura pattern, bone loss (vertical or horizontal), trabecular bone pattern and islet bone, have helped in establishing the individual identity.

Periodontology has a role in certain forensic autopsy conditions and this requires the support of the multidisciplinary team. Periodontists can also actively take part in the identification of individuals before and after death. Its role is through the identification of the periodontal tissue and is expected to assist the process of enforcing human rights and science-based law enforcement.

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Introduction

Forensic odontology is an important part of forensic medicine. Forensic dentistry has an essential role in enforcing the law by detecting and finding solutions to crimes or civil proceedings. This science has been established to be indispensable in dealing with medicolegal issues and is useful in identifying deceased individuals. Even when the body is skeletonized, decomposed, burned, or dismembered, tooth tissue frequently survives. In forensic odontology, a number of techniques have been developed to use dental tissues, bite marks, dental impressions, radiography, photographic investigations, and molecular techniques to establish the person's age, sex, and ethnicity.[1-5]

The role of teeth in forensics plays an essential role in identifying the conditions left behind during post-mortem changes because teeth are the most durable part of the body and can be heated to temperatures of 16000°C without significant loss of microstructure. Teeth can last longer than soft tissue and other skeletal tissues destroyed by possible trauma.[2,6] Traumatic tissue injury or lack of fingerprint records makes them invalid when used for viewing or using fingerprinting methods. According to its requirements, forensic dentistry falls into three primary categories: (1) A diagnosis and treatment plan for injuries to the jaw, teeth, and soft tissues are examined and evaluated. (2) The identification of people, particularly victims, in homicide investigations and/or major catastrophes. (3) Recognize, investigate, and assess bite marks that appear repeatedly during sexual assault, child abuse, and self-defense.[7]

The stages of work in forensic dentistry are developed based on how they relate to different dental specializations that have been studied in scientometric research.[8] The central dogma of dental identification involves comparing post-mortem with antemortem dental remains, including records, impression models, and radiographs, to explain the subject's identity. Individuals with specialized restorations and complex dental care can ensure accuracy when

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the technique is used correctly compared to individuals with little or no restoration. The forensic dentist will take excellent and careful post-mortem records of the tooth structure and its radiographic features. Identifying a person's gender and age using various methods such as through teeth, periodontal tissues, and all forms of dental treatment to help interpret trace evidence for authorities' justice. [9]

The branch of dentistry known as periodontics deals specifically with conditions affecting the gums and other supporting structures around teeth. Studies on periodontitis (gum recession), root transparency, and root length can all be utilized to estimate age. Periodontists can actively assist in the pre- and post-death identification of both known and unidentified individuals.[9,10]

In order to determine a person's identification, periodontal ligament clinical factors including thickness, widening, and diseases such lateral periodontal cyst and periodontal abscess have been taken into account. The identification of individuals has been aided by the comparison of ante- and post-mortem radiographic recordings for alveolar bone height, crestal bone contour, density, inter-radicular bone thickness, lamina dura pattern, bone loss (horizontal or vertical), trabecular bone pattern, and bone islets.[2] The purpose of this paper is to inform the role of periodontics in assisting forensic odontology.

The role of periodontics in supporting forensic odontology

A forensic expert's ability to estimate the passing of time is crucial. Early in the post-mortem, before many environmental factors can affect it, is when the most precise time of death estimate can be made. Changes in cellular degeneration, which typically come before cytoplasmic degeneration after death, may be seen by observing the victim's state.[11]

The victim's condition in an autopsy activity can be found in various situations and conditions that are complex and incomplete.[12,13] The field of periodontology can assist forensic odontology through individual identification by looking at the gingival epithelium, periodontal ligament, alveolar bone condition, root condition and length, and exposed tooth roots.[13] Studying the post-mortem periodontal structures can help with identification, cause of death, sex analysis, and age estimation.[2,9]

Clinical characteristics related to the gums can be used to identify people. To establish individual identification, antemortem records can be compared to recession contours, enlargements, interproximal craters, and color (inflammatory alterations, racial physiology, or pathological pigmentation).[2,14]

Gingival

The location and size of the proximal contact area, the shape of the teeth and how they fit into the arch, and the dimensions of the facial and lingual gingival embrasures all affect the contour or shape of the gingiva.[15] Certain gingival conditions, such as gingival enlargement, gingival recession, gingival cracking, and gingival pigmentation that is typical of certain individuals, if well documented, can support the process of identifying victims.[13]

Biomolecular approaches have been widely developed in research and application in dental age estimation.[16] The use of oral epithelial cells obtained by applying toothbrush pressure to assess the quality of individual DNA was found to be very small, followed by gender identification by amplifying the Y-gender sex-determination region. SRY was performed using a real-time polymerase chain reaction. A functioning amount of DNA and examination with a valuable and sensitive tool are sufficient for determining a person's gender. In order to evaluate the age- and sex-related changes in the cell nucleus area, cytoplasmic area, and cell nucleus, quantitative cytomorphometric analysis of exfoliated healthy gingival cells was performed by scraping the connected gingiva. Premalignant and oral lesions' pathological smears' cytoplasm ratio values have shown that the connected gingiva can be examined for human identity.[17]

In many forensic situations, an estimation of the passing of time since death is crucial. Physical, physicochemical, biochemical, microbiological, entomological, and botanical processes are a few different ways to determine the time of death. To ascertain alterations after death, histological changes in post-mortem gingival tissue can be examined. Decomposition starts within 15 minutes and continues over time.[2,18]

Only the topmost layer had autolytic modifications. The basal layer did not, however, exhibit autolytic alterations, and over time, basal layer modifications were visible in the examined sections at four-hour intervals. Compared to

other superficial epithelial layers, the basal cell layer has more nuclei. Chromatin clumping was the histological change that was seen in the gingival tissue over time (chromatin fragmented to form visible clumps within).[2,9,18]

Cementum

When there is minimal information on the deceased, the estimated age is a crucial factor in the identification process. The connective tissue that surrounds the teeth and is stored throughout life is called cementum, and it is a component of the periodontium. Concentric incremental lines of precipitation form, with each line representing a year of life. Recent studies have demonstrated that tooth cementum annulation (TCA) can be used to estimate age in humans by comparing it to other morphological or histological markers.[17,19]

The cementum apposition feature of cement assists in addition to the assessment of biological age, which can be a useful tool in forensic investigations, if the contributing conditions can be avoided for a suitable amount of time. The age of the deceased can be inferred from dental cementum annulation. Under a light microscope, polarized microscope, or phase contrast microscope, this is determined on a pictomicrograph.[2,9]

Number of incremental rows (n) = X/Y

Where:

X = Total cementum width from the junction of the cement and dentin to the surface

Y = Cementum width between two subsequent incremental lines[2,17]

We can determine a person's age by multiplying the tooth's eruption age by the quantity of lines. The diagnosis of TCA should be based on multiple teeth from a single individual, if possible, and need to be supported by different techniques in forensic cases in order to ensure the high reliability of the method.[17]

The microscopic examination of the cementum layer known as cementochronology involves counting the incremental line of dental cementum (IL). Results from cementochronology were encouraging and suggested that charred teeth could benefit from this histological approach. Black originally reported on this association between cementum apposition and its layer according to age, and Gustafson later validated it. This was subsequently further elucidated in several research, leading to a method known as cementochronology or TCA.[20,21]

It has been thoroughly explored since Stott et al. employed it for the first time on human teeth, however the findings are conflicting. Others warn against it or claim that it has little promise, while some see it as a viable strategy. As a result, there is currently no agreement, which may be brought on by the use of various samples, microscopic conditions, and variances among observers.[20,22]

Burned tooth cementochronology analysis presents a number of extra difficulties. The chronological approach may be constrained by the heat-induced alterations that teeth are prone to. For instance, a dimension modification may result in further line shrinking, which eventually causes agglomeration. Since many lines become interconnected and therefore impossible to count, this process may impede the use of incremental line counting. This strategy was influenced by Gupta et al research's which examined the total IL count in unburned teeth in a comparable manner. Such extrapolation would benefit from avoiding the issue of heat-induced dimensional changes impacting the incremental line if it were to be successful.[21,23]

Using ImageJ (1.48v), an image processing program, the incremental lines were calculated, and their thickness and cement thickness were measured. Each pair of bands in an IL, one dark and one light, is thought to represent a single year. To measure differences in the number of lines, ILC was carried out in the mesial, distal, buccal, and lingual regions. From the dentin/cement boundary to the cement outer boundary, the thickness of the cement is precisely determined for ILE. The thickness of two visible, neighboring IL (L) was then measured. Since there are two incremental lines, this thickness pertains to them. Each slide underwent this process three times, with the median value being chosen for study.[21,24] It has been extensively studied since it was initially used to human teeth, albeit the findings have been conflicting. Others warn against it or claim that it has little promise, while some see it as a viable strategy. As a result, there is currently no agreement, which may be brought on by the use of various samples, microscopic conditions, and variances among observers.[25]

Periodontal ligament

The legal significance of the age of 18 is due to the legal definition of adulthood in China and the majority of European nations. The stage

of tooth mineralization serves as the primary indicator of chronological age when determining age from teeth. The only teeth that have not fully developed by the time a person is 18 are their third molars. Lower third molars with complete root mineralization had varying degrees of periodontal ligament visible. The lower third molar root's exposure of the outer periodontal ligament determines the stages (i.e., on the mesial portion of the mesial root and distal portion of the distal root). 26 The following is the justification:[26] (1) Stage 0: The root's full length can be seen the periodontal ligament. (2) Stage 1: From the apex to more than half of a root, the periodontal ligament is not discernible. (3) Stage 2: The periodontal ligament is mostly hidden along one root's length or along a portion of two roots. (4) Stage 3: Nearly the full length of the two roots are devoid of the periodontal ligament.

Stage zero is first attained around ages 17.05 for men and 17.46 for women, according to Guo et al, Stage one first manifests in males and girls at ages 17.47 and 17.86, respectively. Men and women begin to show signs of stage two at 21.43 and 21.96 years old, respectively. At the ages of 25.83 years for men and 23.14 years for women, stage three was found to begin.[26]

Alveolar bone

According to Lamendin, measuring the alveolar bone level revealed that as people age, the process of alveolar resorption on the labial aspect of the anterior monoradicular teeth accelerated. Alveolar bone alterations, beginning at approximately 30 years and becoming significant at about 50 years, assist in estimating a person's age. The aging process and behavioral changes (tobacco use, hormonal impregnation, and cleanliness) in the periodontal tissues are inextricably linked to the relationship of alveolar bone loss with age. Labial alveolar resorption increased with age, according to a regression analysis. The respective maxillary teeth also demonstrated increased labial alveolar resorption against the older age group, but with greater variability than the former. Labial alveolar resorption was expressed as the alveolar resorption factor in mandibular monoradicular anterior teeth, and it increased in the older age group.[2.18]

Limitations of forensic periodontology

Soft tissue decomposition

Through apoptosis, necrosis, or autolysis, cells can die. After death, the release of tissue fluids causes cell autolysis, which results in breakdown and alterations, particularly in soft tissues like those in the oral cavity. Understanding post-mortem changes in medicolegal practice is essential. The decomposition process started 10 hours after death, and other cellular changes followed, according to a histological analysis of gingival tissue taken from post-mortem and antemortem samples at various time intervals.[17,27] In cases involving fire decomposition and severe trauma, the epidermal ridge may change post-mortem or may not exist. Preserving clinical photographs is another important piece of evidence because soft tissue death happens after a person dies clinically within 48 hours of their death.[13]

Dependence on tool availability

Cementochronology, pictographs, light microscopy, and deoxyribonucleic acid (DNA) laboratories are just a few of the sophisticated tools and calculations used in the examination of periodontal tissues that are crucial to the identification process.[13,20,24]

Discussion

One of the responsibilities of a forensic expert is the process of identifying and calculating the period after death. The body experiences significant changes in both its chemical and physical makeup after death, which are helpful in determining the post-mortem period. Early in the post-mortem period, before numerous environmental factors can influence the results, is when the time of death estimate can be determined with the greatest accuracy. The foundation of practice in the past has been macroscopic observation, but histological and even cellular microscopic techniques are proving to be an increasingly useful tool in forensic investigation.[11]

Diseases of the periodontium are the focus of the clinical science of periodontics. The identity, timing of death, sex determination, and age estimation of the deceased can all be assisted by the post-mortem examination of the periodontal structures. Microscopical, histological, and even molecular analysis of periodontal tissues can be useful in the field of forensic odontology as a result of advancements in science and society.[2,3]

Multidisciplinary teams must work together to advance and support criminal

investigations. Intensive interactions with law enforcement (police) and the judiciary (judges) in various forums, such as workshops and hands-on conferences, as well as continuing education programs have increased understanding, awareness, and importance of DNA profiling providing information on the traits of physical, ethnic, and gender determination. Forensic odontology and forensic dentistry must work together. This article's major objective is to show how a periodontist can advance the study of forensic odontology by using the boundaries of his specialty to shed light on a crime.[17, 28]

Alveolar bone, cementum, gingiva, and clinical characteristics of the periodontal ligament can all be used to identify. It has been possible to identify an individual by comparing ante- and post-mortem radiographic recordings for alveolar bone height, crestal bone shape, density, interradicular bone thickness, lamina dura pattern, bone loss (horizontal or vertical), and trabecular bone pattern.[2]

To ascertain the changes after death, the histological alterations in the post-mortem gingival tissues can be examined. Decomposition starts within 15 minutes and continues over time. The basal layer did not exhibit any autolytic changes, but as time goes on, the changes affect the basal layer, which is apparent in the sections examined at the four-hour mark of the time interval. The autolytic changes only affect the superficial layers. Chromatin clumping (where the chromatin is fragmented and forms visible clumps within the nucleus), nuclear vacuolation, karyopyknosis (where the nucleus shrinks and basophilia increases), a prominent and widened intercellular junction, eosinophilia (where the cytoplasm is stained bright pink), homogenization (where cellular outlines merge to give cells a glossy, homogenous appearance),[2,8,11]

Individuals' DNA characteristics have been evaluated using oral epithelium cells harvested by applying pressure with a toothbrush, and then their gender has been determined by sex-determining region-Y (SRY) gene amplification using real-time polymerase chain reaction. In addition, age- and sex-related changes in the nuclear area, cytoplasmic area, and nucleus can be evaluated using quantitative cytomorphometric analysis of exfoliated healthy gingival cells that were obtained by scraping attached gingiva.[17]

When compared to other human morphological or histological traits, tooth cementum annihilation (TCA) is a trustworthy tool for age estimation. Concentric incremental lines of precipitation form, with each line representing a year of life. Under a light microscope, polarized microscope, or phase contrast microscope, this is determined on a pictomicrograph. Results from cementochronology were encouraging and suggested that charred teeth could benefit from this histological approach. This was subsequently further elucidated in several research, leading to a method known as cementochronology or TCA.[2,9,17,19-21]

Dental databases should be improved, and existing databases should offer a crucial tool for effective identification attempts. In emergency scenarios, keeping dental records is crucial. Data accessibility is essential to forensic dentistry's effectiveness. Dental professionals are encouraged to keep dental records, label prostheses with distinctive markings, and maintain databases due to the use and recording of comprehensive medical records that can be used in a variety of contexts, particularly in the identification process.[9]

Cementum is a useful tool in forensic investigations and can help determine biological age. It can be advised to use a new staging system to people in China based on the observation of the periodontal ligament in the lower third tooth. It is feasible to demonstrate that a person is at least 21 years old if they are discovered in stage two or three.[26]

Periodontal tissue examination has limitations when applied to forensic cases that have decomposed over time, resulting in soft tissue damage13, as well as when applied to situations of mass disaster, particularly in third-world countries where more practical infrastructure and equipment are less readily available.[12]

Conclusions

Particularly under specific forensic autopsy circumstances, periodontology can facilitate the identification of people. Together with the forensic team, periodontists can help identify known and unidentified people both before and after death, particularly when it comes to their periodontal health. It is anticipated that its unique role in the identification of periodontal

tissue conditions based on the comparison of ante-mortem with post-mortem records will aid in the process of enforcing human rights and scientifically-based law enforcement.

Declaration of Interest

The authors report no conflict of interest.

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