Review Article

Role of Periodontal Tissues In Post-Mortem Interval Estimation : A Review

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Abstract :

Forensic odontology is among one of the growing branches of forensic medicine , which deals with handling of dental evidence and its evaluation of dental hard and soft tissue findings. The post – mortem interval (PMI) is a very crucial part of forensic investigation in most homicide and unwitnessed death, including hospital deaths. Most of the research has been focused on dental pulp for PMI investigation and lack of studies on periodontal tissues which can be a good source of DNA for PMI estimation.Periodontist are known to manage diseases associated with periodontal supporting tissues of teeth and implants, periodontal tissues are well recorded for its contribution in the field of forensic odontology in terms of sex determination, PMI estimation and age determination . This review article focuses on how a periodontist as a branch of dentistry can contribute to the field of forensic odontology in terms of PMI estimation.

Keywords : Forensic Odontology, Forensic medicine , post mortem interval , periodontal tissues

Introduction

Forensic odontology is one of the most emerging branches of forensic sciences for decades now. It is the branch of forensic medicine that deals with the examination and handling of dental evidence and its evaluation and presentation of dental hard and soft tissue findings. This specialization plays an important role in the identification of a person by bite mark analysis, DNA/RNA analysis, and sex determination by odontometric measures, rugoscopy, cheiloscopy, etc.[1]

The identification of a dead person through dental identification when the body is disfigured is amongst the most reliable methods of identification due to its precision . Dental identification has always played a key role in natural and manmade disaster situations.[2] The post – mortem interval (PMI) is an important element of forensic investigation and is a crucial step in most homicide and unwitnessed death, including hospital deaths. After death, many changes begin to take place in the human body due to physicochemical and biochemical processes.[3] Degenerative changes depend upon environmental conditions, which can be evaluated by morphological and histopathological changes.[4,5]

In the post – mortem interval (PMI) a variable number of changes based on duration and circumstance of demise occur in the body after death. Cells death occurs by enzymatic digestion. The dissolution of cells and tissues becomes apparent microscopically.[6] The importance of body tissue changes in the deceased person, such as eyes (fall in intraocular pressure, flaccid eyeball, etc.), skin (pallor mortis), muscles (rigor mortis), and liver (livor mortis) have been studied extensively.[7,8] Whereas periodontal tissues are not much studied ,evidence on post-mortem dental tissues shows outermost layer is the enamel that protects the cementum that lines the dentine beneath which the pulp is present, decomposition of the dead sets in, and soft tissues slowly degrades leaving behind skeletal remains and teeth which are good sources of DNA.[9] Periodontics and oral implantology is a specialty in dentistry that studies the supporting structures of teeth and dental implants, they focus on the diseases and conditions affecting the supporting structures of teeth and dental implants. In the literature available it is well reported that periodontal tissues and implants are used to estimate the age, post-mortem interval, and sex determination.

The major focus of this article is to foreground how a periodontist can contribute to the field of forensic medicine by associating the parameters of his specialty to unwind a crime scene and to outline the findings of studies that reported periodontal associations or potential associations that could play a role in dental forensic research in terms of post-mortem interval estimation .

History

The Agrippina and Lollia Pauline case (66 a.d.) it was the vey first time a teeth were used as evidence for identification of human . Agrippina, he planned to kill Lollia Paulina with the help of her soldier, who was directed to bring the head back. Lollia Paulina's death was confirmed by the discovery of specific dental alignment traits.[10]

The first ever recorded medico-legal identification of a body using dental means is that of Dr. Joseph Warren, who was killed during a battle of the American Revolution in 1775, by a musket ball through the skull. Initially, he was buried in a

mass grave and then[10] months later, identified by the dental work of Paul Revere, and given a hero's re-burial in 1776.

Dr. Oscar Amoedo wrote an article on the identification procedures used in the Paris disaster, his work "l'art dentaire en medicine légale", was published in 1898, by Dr. Oscar Amoedo is also known as the father of forensic odontology.[11]

Role of Periodontal Tissues In Forensic Dentistry

Individuals are identified for the post-mortem interval estimation, sex determination, and, age estimation using the anatomical landmarks on the periodontal tissues, the anatomic malformations and associated tissue pathologies, alveolar bone topography, mucogingival malformations, and implants.

Determination Of Post-mortem Interval Estimation By –

1. Gingival Tissues

Several histological and biochemical changes in the gingival tissues occur at various post-mortem intervals. Various studies have assessed the cellular changes in gingival tissue at specific time intervals since death, including: a) histological changes, b) ultrastructural changes, c) electrolyte changes, d) immunohistochemical distribution and mRNA expression of hypoxia-inducible factor (HIF-1alpha)[12] .

Fais p et al. (2018)[13] studied post-mortem gingival tissues for the mRNA expression and immunohistochemical distribution of hypoxia-inducible factor (HIF-1±) . Samples were obtained from 10 cadavers at different PMIs (1–3 days), (4–5 days), and (8–9 days). The results showed an increased HIF-1± protein signal that was mainly present in the stratum basale of the oral mucosa in samples collected at PMI (1–3 days). A gradual reduction in samples collected at PMI (4–5 days) was observed, but it was not observed in samples collected at PMI (8–9 days). This suggests that HIF-1± has remarkable potential to be used as a marker for PMI estimation.

Mazzotti mc et al. (2019)[14] combined morphological and immunohistochemical analysis of collagen fibers in post-mortem gingival tissues, post-mortem intervals (short post-mortem interval, 1–3 days , mid-post-mortem interval, 4–6 days , long post-mortem interval, 7–9 days were observed, the results showed progressive and potential changes, degradation of extracellular matrix in the connective tissue concerning the difference in time of death. Cellular morphology, ultrastructure, and immunohistochemical expression of collagen (type I and type III) allowed better estimation of PMI.

Srirangarajan s et al. (2021)[15] correlated both histological changes and enzymatic changes in gingival tissue samples at intervals of immediate, one hr, five hr, twenty-four hr, and forty-eight hr after death. It was found that there are potential enzymatic changes when correlated with histological reports help us to predict the time of death accurately. Two enzymes (acid phosphatase) and (ammonia) were evaluated using UV spectrometer.

2. Cementum

Cementum , it anchors teeth into their sockets through the periodontal ligament. Dental cementum in mammals, alternating opaque and translucent bands appear which represents winter and summer seasons. Each pair of opaque and translucent bands depicting 1 year of life.[16]

In a study by Wedel Vl (2007)[17] dental cementum incremental analysis was done to investigate the season of death , they found that cementum increment analysis has 99% accuracy in determining whether a tooth was extracted between winter and summer or summer and winter. They concluded from a single tooth, dental cementum increment analysis can help us identify the exact year and season in which an individual died.

In another study by Granrud Ma et al. (2012)[18] investigated coronal dentine, root dentine, and cementum analysing differential nuclear and mitochondrial DNA for PMI estimation. DNA was extraction was done from coronal dentine, root dentine, cementum, and pulp of 114 teeth using a silica column method and the remaining 36 teeth were examined on histological basis . They concluded that targeted sampling of cementum from teeth buried for up to 16 months can provide a definitive source of nuclear DNA for str-based genotyping using standard extraction methods, without any need of specialized equipment or large-volume demineralization steps.

Higgins d et al. (2015)[9] studied post-mortem teeth for differential nuclear and mitochondrial DNA preservation , one hundred and fifty-third molar teeth, which werefree from dental disease, were collected from a total of 85 donors, teeth were randomly alloted to one of six groups, six groups represented six PMIs (0 months, 1 month, 2 months, 4 months, 8 months and 16 months). From the results obtained , cementum was found to be having significantly higher predicted nuclear DNA yield than that from dentine . An increased PMI time and average temperature were found to harm the nuclear DNA yield.

3. Periodontal Ligament

The periodontal ligament is composed of mainly an unmineralized network of collagen fibers, which provides a flexible attachment of the tooth-alveolar bone. During degeneration The fiber meshwork structure is lost over the path in the following sequence: I) the pdl fibers are first disarranged and then thinned, II) then the number of fibers are reduced and III) reduction in attachment of the fiber to the bone is observed .[19]

In a study by Alaçam t et al . (1996)[20] estimated incisor exfoliation for post-mortem teeth changes . Accumulated degree days (celsius) was used in the quantification of decomposition rate of the periodontal ligament cells , represented by post-mortem exfoliation of the incisors. The average daily temperature was calculated using hourly temperature and the data was recorded using ds1921g thermochrons for the duration of the study (June –December). And these six teeth had an average of 1788.08 Celsius. They concluded that the rate of decomposition of the periodontal ligament can be used to determine a minimum length for the PMI .

Cho Mi (2000)[21] investigated the viability of periodontal ligament cells which were studied after an avulsion injury. Extracted teeth were used for evaluation of the breakdown and necrosis of periodontal ligament cells using lactate dehydrogenase (Ld) measurements on the root surfaces. Lactate dehydrogenase measurements were made at 2h, 6h, 24h, 72h, and 168 h after extraction. Results showed a significant increase in cell death to be statistically significant ($p < 0.001$) at each time interval studied . They concluded that lactate dehydrogenase can be a potential indicator of PMI.

4. Alveolar Bone

In periodontitum alveolar bone undergoes effective remodeling during growth with reduced elasticity and flexibility in adults. In addition, compared to young subjects, adult patients have reduced progenitor cells, decreased vascular supply, and fibroblast density, leading to reduced bone turnover rates; remodeling of the periodontal tissues occurred earlier and was more prominent in the young than older animals.[22]

Amler Mh (1969)[23] studied the sequence of tissue regeneration in human extraction wounds, they observed clot formation on the same day, replacement of clot by granulation tissue (7th day), replacement of granulation tissue by connective tissue (20th day), the appearance of osteoid at base of the socket (7th day), filling of at least two-thirds of the socket (38th day), fundus by trabeculae (4th day), the first evidence of epithelization fusion of epithelium (24-35 days and more). Findings from this article have the potential for future studies in the path of PMI estimation using alveolar bone remodeling.

In a case report by Viciano J (2017)[24] remodeling of alveolar bone socket post extraction allowed an estimation of the time that had elapsed from the day of tooth extraction of the tooth to the time of death. Macroscopic, radiographic, and histological examinations of the oral cavity showed the initial changes , a small reduction in the vertical height of the vestibular surface concerning the theoretical original position of the tooth , resorption of the intra-alveolar septum and lamina dura and , formation of new immature bone, which covered the entire inner surface of the socket. This case report demonstrated that the subject died 13–42 days after the extraction. Knowing the date of the surgical tooth extraction provided by the police investigation, provided an estimate of the date of death using remodelling changes in tooth socket.

Future Directions :

Dentine and cementum as source of nuclear DNA:

Differential DNA preservation in post-mortem teeth, post-mortem kinetics of DNA degradation helps targeted sampling of cementum which can provide a reliable source of nuclear DNA for short tandem repeats (STR) -based individualization using standard extraction methods, without the need for specialized equipment or large-volume demineralization steps, even from teeth, which have been buried for 16 months. The correlation between the rate of decomposition and predicted nuclear DNA can produce reliable and successful str profiling results for PMI time estimation.

Conclusion :

The post-mortem interval plays a vital role in forensic science for identification. Currently, a few studies have been conducted to demonstrate the importance of periodontal tissues in the estimation of PMI, in which most of the studies are related to gingival tissues. Further, more studies on periodontal ligament, cementum, and alveolar bone are required to validate the role of periodontal tissues to predict PMI at an early stage with a cost-effective and convenient technique. To improve accuracy and reliability of this topic of interest , it is advised to perform several in–vitro and human studies concurrently. This knowledge update inspires researchers to conduct further studies to widen the scope of periodontal tissues in the field of forensic odontology.

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