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Mini Review

Age Estimation.

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Abstract

Forensic odontology is a much sought after and unique specialty within the broader discipline of Forensic Sciences. Dental age estimation is specialized under forensic odontology focusing on determining an individual's age. This process relies on analyzing parameters such as tooth development, biochemical changes, and alterations that occur after tooth formation. Determining age is crucial for identifying humans, relevant for both living individuals and those who have passed away. For the living, various reasons, including determining criminal responsibility, establishing asylum status, and assessing criminality in cases involving paedophilia or sex with a minor require confirmation. Estimation of age using various techniques are reviewed in detail in this paper.

Keywords: age estimation, forensic odontology, forensic sciences, disaster victim identification.

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INTRODUCTION

Forensic odontology, a specialized field within dentistry, focuses on the meticulous handling, examination, and interpretation of dental evidence to support legal investigations. Nowadays, it is recognized as a distinct specialty within the broader discipline of Forensic Sciences. This field is essential to prominent international forensic organizations like International Association of Identification (IAI) and the American Academy of Forensic Sciences (AAFS).The main application of forensic odontology lies in identifying human remains by analyzing the unique features of an individual's teeth.[1]

Dental age estimation is a specialized area of forensic odontology focused on determining an individual's age. This process relies on analyzing parameters such as tooth development, biochemical changes, and alterations that occur after tooth formation[2]. Age estimation is essential for both living and deceased individuals for various legal procedures, identifying victims in mass disasters, and conducting anthropological studies.[3] Growth is a multifaceted and dynamic process that engages various physiological systems, such as the skeletal system and dentition, both of which experience a progression of changes leading up to maturity.[4] Dental age assessment in children and adolescents can be performed by examining the development and eruption patterns of both deciduous and permanent teeth, typically up to the age of 14 years.[5] Age assessment is often necessary for administering justice in both civil and criminal litigation involving individuals.[6] Determining age is critical for identifying humans, relevant for both living individuals and those who have passed away. For the living, it is undertaken for various reasons, including determining criminal responsibility, establishing asylum status, and assessing criminality in cases involving paedophilia or sex with a minor.[7] Determining adult age is more complex and typically involves assessing factors such as bony remodeling in the pelvis, the sternal end of the fourth rib, the symphyseal surface of the pubis, suture closure, and dental wear or structural changes in the teeth, among other methods.[8]

METHODS

Age estimation methods in adults are categorized into three main categories:

1. Morphohistological methods,
2. Radiological methods, and
3. Biochemical methods.

1. Morphohistological methods

Morphologic criteria are over looked in unsectioned or sectioned teeth**.**

Gustafson's method (1950)

The initial method for estimating age by evaluating specific regressive changes in teeth was developed by Gosta Gustafson in 1947 and 1950.[4] This method is classified under morphohistological techniques and is specifically suited for single-rooted teeth. These are the age-related changes identified in this method:

- Enamel attrition (A)
- Deposition of secondary dentin (S)
- Changes or recession of the periodontal ligament (P)
- Apposition of cementum (C)
- Root resorption (R)
- Dentin transparency or translucency (T)

In Gustafson's method, each criterion was assigned a score (n) ranging from 0 to 3. The total score (Y) was calculated by summing the scores for each criterion: $An + Pn + Sn + Cn + Rn + Tn = Y$, where 'n' represents the score given to each criterion(Figure – 1).

Gustafson determined that the method had an age estimation error of approximately ±3.6 years (Gustafson, 1947). Importantly, there was a linear relationship between an increase in the total score (Y) and an increase in age

Drawback of Gustafson's method

- It is not applicable to living individuals due to its subjective scoring based on the interpretation of regressive changes.
- The method is labor-intensive because it involves multiple assessments.
- Assessing the periodontal ligament in decomposed bodies poses challenges.
- A single regression line is applied to all teeth, regardless of their eruption time and morphological variations.
- Proficiency in dental histological techniques is necessary for accurate application.
- In the Indian population, Gustafson's method showed an age estimation error rate of approximately ±8.13 years.
- Each of the six criteria is given equal weight, without considering potential interactions between them.

Dalitz modified Gustafson's method by implementing a 5-point scoring system from 0 to 4, This adaptation omits criteria such as root resorption and secondary cementum. This revised approach focused on four criteria applicable to the 12 anterior teeth, which correlated effectively with age. However, this method does not include the use of posterior teeth. Dalitz suggested using up to four of the 12 anterior teeth per individual for age estimation. The standard deviation for age estimates using this method is roughly ±6 years.

A drawback of the method given by Dalitz is, it excludes molars and premolars, which tend to remain intact during mass severe trauma or disasters.

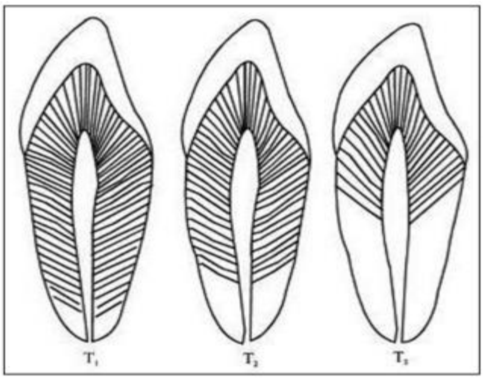

Figure 1- Gustafson's method (1950)

Root transparency scoring T1: Noticeable root transparency, **T2**: Extension of root transparency over the apical third of the root, **T3**: Transparency of root extending over the apical two-thirds of the root.[4]

Li and Ji introduced a novel clinical method for age estimation utilizing permanent first and second molars. This method entails documenting attrition values for each molar cusp using the Average Stage of Attrition (ASA) chart, which categorizes wear from stage 0 to 9. Subsequently, an average is calculated from these values. The method employs respective formulas tailored for the first molar, second molar, and both molars combined.

Stage	**Inference**
Stage 0	The cusp remains sharp, with distinct gullies and ridges, and shows no signs of attrition
Stage 1	There is slight attrition observed on the top and ridges of the cusp
Stage 2	The cusp either looks obtuse or shows a small oblique facet
Stage 3	The majority of the cusp is worn down. The worn facet is slightly or noticeably depressed and may connect with one or more additional facets.
Stage 4	Dentin appears as a spot with an average diameter that does not exceed 1 mm.
Stage 5	Dentin is observed as a spot where the average diameter exceeds 1 mm, and the attrition plane is either level or deeply sunken.
Stage 6	One exposed spot of dentine merges with another, and/or the cusp is nearly completely worn away.
Stage 7	One exposed spot of dentin merges with two others, and/or the cusp is completely worn away.
Stage 8	Exposed dentin presents as a circular area with small enamel islands within, and it may also expose secondary dentin.
Stage 9	The entire occlusal surface exhibits exposed dentin, with secondary dentin now visible.[4]

Morphological techniques remain the most advanced and statistically reliable methods for calculating dental age to date[5]

2. Radiological method

These non-destructive methods have grown in popularity because they are applicable to both living and deceased individuals, as well as in archaeological research and legal contexts where tissue collection from human remains is restricted. They rely on dental radiographs, eliminating the need for tooth extraction or sectioning. [4]

This method is highly effective in determining whether an individual is under or over 18 years of age. Despite its specificity to individuals with all six specified teeth (mandibular lateral incisors, mandibular canines, mandibular premolars, maxillary central and lateral incisors, maxillary second premolars), Furthermore, it cannot be used if the teeth are rotated, worn down, decayed, or have any periapical diseases.

Radiographic evaluation of developing third molars can serve as an age assessment method for individuals over 17 years old. Harris and Nortje proposed five stages of root development in third molars, each associated with corresponding mean ages and length of the root.

Yang et al. developed a groundbreaking technique that utilizes cone-beam computed tomography (CT) scans to create 3D images of teeth in living individuals.

These 3D images allow for the calculation of the pulp/tooth area ratio, yielding encouraging results for age estimation.

Kazmi et al. studied cone-beam CT (CBCT) images of mandibular and maxillary canines in a homogeneous sample from the Pakistani population, characterized by an even distribution of ages.

Their findings indicated that the pulp volumes of mandibular canines are a reliable predictor for chronological age estimation.

The automatic software program Dental Age Estimation® incorporates the most precise and referenced morphological and radiological techniques. This software provides rapid age estimation results and offers the advantage of automatically selecting the borders of the pulp and tooth, thereby reducing processing time and minimizing subjective errors. It also enables the application of various methods in a given case, leading to more dependable results. Hard tissues like bones and teeth change as they grow. Tooth formation is well-suited for age estimation because it is a continuous and progressive process, observable from the early stages of calcification through to apex closure.

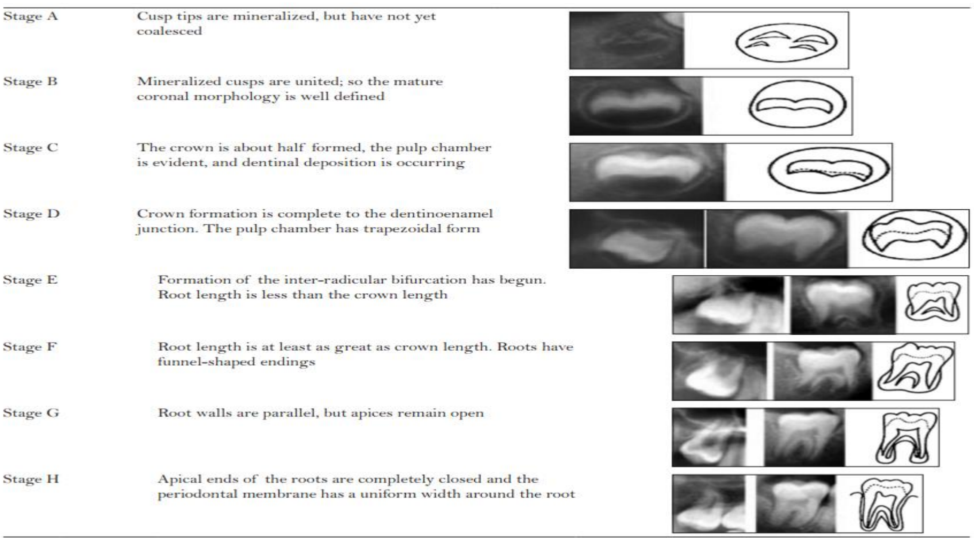

Figure 2 - The eruption status of third molars in Southern India

3. Biochemical methods

These methods depend on the racemization process of amino acids, which occurs swiftly in metabolically stable proteins such as enamel, dentin, and cementum. Specifically, L-aspartic acid converts into D-aspartic acid over time, accumulating in increasing amounts with age. Helfman and Bada proposed that analyzing the ratio of D/L enantiomers in aspartic acid from enamel and coronal dentin could estimate the age of long-lived mammals and thereby determine the organism's age. Ohtani et al. observed a linear increase of aspartic acid in dentin with age. [4]

Ritz et al. employed the racemization method on dentinal biopsy specimens (1 mm × 1 mm) obtained from the molars of living individuals. Their findings revealed a significant correlation between the extent of aspartic acid racemization in these samples and the chronological age of the subjects.[4]

Aspartic acid in age estimation – biochemical method

The technique of using aspartic acid racemization for age assessment was initially introduced by Helfman and Bada in 1975 and has subsequently been extensively applied in forensic age estimation.[9] As individuals age, L-amino acids gradually convert to D-amino acids through the process of racemization. At a temperature of 25°C, this complete transformation of all L-amino acids in living tissues to their D-form would take approximately 100,000 year.[8] Therefore, the degree of amino acid racemization can be utilized to estimate the age of different tissues. Among stable amino acids, aspartic acid exhibits one of the quickest racemization rates, making it the most frequently employed amino acid for age estimation purposes.[9]

The rates at which L-form amino acids convert to D-forms are affected by factors like temperature, humidity, and pH levels. Due to the ongoing formation and degradation of amino acids, tissues with low metabolic rates offer more accurate age estimates compared to those with high metabolic rates. Considering this, teeth are the preferred tissue for analysis age estimation.[9]

VARIOUS TECHNIQUES FOR AGE ESTIMATION

1. Age estimation using tooth cementum
2. Technique using pulp/tooth ratios calculated from tooth sections
3. Estimation of age using development and eruption of teeth
4. Method for estimating age by assessing occlusal tooth wear in molars
5. Estimating age based on dental maturity

1. Age estimation using tooth cementum

Examining tooth cementum annulation (TCA) is a histological method commonly used in non-human mammals, which has also shown significant applications in humans. This technique relies on the continuous growth of dental root cementum, which forms annual incremental lines throughout life. These lines appear as pairs of dark and light layers under a microscope, with each pair representing 1 year of growth. By counting these lines and adding them to the age of tooth eruption, an estimate of the individual's age can be determined.

TCA analysis holds potential for aiding identification even in poorly preserved deceased individuals, provided that protocols are well-defined, validated, relatively simple, and utilize tools commonly found in forensic histology laboratories.[10]

2.Technique using pulp/tooth ratios calculated from tooth sections

Age-at-death estimates for adult skeletons are typically derived from a macroscopic analysis of various skeletal components, including the pubic symphysis, the auricular surface of the ilium, sternal rib ends, and cranial sutures.[7,11]

Methods for estimating age at death based on skeletal analysis often yield results that are overly narrow (for example, ages 18–19 as reported by Todd, 1920), excessively broad (such as ages 25–83 in phase 5 according to Brooks & Suchey, 1990), or imprecise (for instance, ages 50+ as indicated by Milner & Boldsen, 2012). After the age of 35, systematic growth of the human skeleton halts, leading to more random changes in the skeletal structure.[11]

Bodecker (1925) initially discovered that the formation of secondary dentin is inversely related to chronological age. Building on this, Gustafson (1950) conducted a pioneering study on secondary dentin deposition, revealing that dentin transparency and secondary dentin measurements had the highest correlation with age. Secondary dentin starts to form after both the tooth crown and root have fully developed. The continuous formation of dentin by odontoblasts results in a continuous decrease in the size of the pulp chamber. Dentin, consisting mainly of odontoblasts, is a living tissue within the tooth structure. As a person ages, these odontoblasts deposit concentric layers of secondary dentin, gradually filling in the pulp chamber (Bodecker, 1925; Vasiliadis, Darling, & Levers, 1983).The process of forming secondary dentin is similar in both permanent teeth with multiple roots and those with a single root. This secondary dentin is slowly deposited, and its metabolism is sustained by the pulp tissues.

The thickness of dentin increases on average by approximately 10 µm/year for the root and 6.5 µm /year for the crown (De Luca et al., 2010). As secondary dentin forms at the boundary between primary dentin and the pulp, the pulp cavity reduces in size as individuals age (Gustafson, 1950; Hillson, 2002; Morse, 1991; Solheim, 1992). Studies have investigated the dimensions of the pulp chamber—length, area, and width—to monitor its contraction with age (e.g., Cameriere et al., 2007a, 2007b; Solheim, 1992). Solheim (1992) established a notable link between age and secondary dentin formation by evaluating the ratio of tooth width to pulp width in sectioned teeth. This underscores the importance of analyzing tooth sections, as secondary dentin is continuously deposited without remodeling; once deposited, it serves as a permanent age indicates.[11]

3. Estimation of age using development and eruption of teeth

The practice of using teeth to determine age dates back 170 years, originating with the use of tooth eruption for estimating the age of children involved in labor during the industrial revolution. This method was crucial for determining the eligibility of factory children, who were not permitted to work under the age of nine and had restricted working hours between nine and twelve years old.[12]

In ancient times, the estimation of age in adolescents was also significant. Historical records from Ancient Rome indicate that adolescents were considered fit for military service as soon as their second molars had fully erupted. Dentists were primarily responsible for conducting these age assessments (Figure- 2).

Age estimation using development of third molars

The most commonly used methods rely on dental development observed through orthopantomograms or cephalometric radiographs. The presence, timing, eruption, and orientation of third molars, also known as wisdom teeth, are particularly significant across all branches of dentistry, especially in forensic contexts.[7,13]

Multiple studies have underscored that the development of third molars is the sole quantitative biological marker for estimating the age of individuals in their early twenties. The timing of calcification, development, and eruption of third molars varies significantly: development can start as early as five years or as late as six years, with peak formation usually occurring around eight or nine years. Some individuals may begin calcification as early as seven years, while others may not start until they are sixteen.

Enamel formation generally completes between ages 12 and 18, while root formation typically finishes between ages 18 and 25. The emergence of third molars spans from 12 to 22 years of age. Radiographic examination of third molar development extends the ability to estimate age from 9 to 23 years, as it allows for separate assessment of crown and root development irrespective of eruption.[7]

Estimation using eruption status of third molars clinically

- Third molars that have erupted to the level of the occlusal plane and are fully visible
- Third molars that have partially erupted and are partially visible clinically
- Third molars that are clinically invisible and have not yet perforated the oral mucosa(7)

Figure 3a - Lower right third molar absent upon clinical examination

Figure 3b - Lower right third molar visibly erupted during clinical examination

Teeth serve as important indicators for age estimation. The study revealed that the average age for the complete clinical eruption of maxillary third molars was 22.41 years for males and 23.81 years for females. In contrast, mandibular third molars erupted at an average age of 21.49 years for men and 23.34 years for women. Clinically, it was observed that mandibular third molars were more commonly absent in females than in males.(Figure- 3a, 3b)

Mandibular third molars typically emerge earlier than maxillary third molars into the oral cavity. Factors such as bone and soft tissue covering can hinder their eruption, but these were not addressed in the current study. Future research should account for these factors. Using third molars as developmental indicators is beneficial, especially when comparing their variability with other skeletal age calculation methods based on hand/wrist or long bones.[7]

4. Method for estimating age by assessing occlusal tooth wear in molars

Age estimation based solely on occlusal wear is not highly accurate due to multiple factors influencing tooth wear, including mastication patterns, malocclusion, dietary habits, the presence of restorations or prosthetic teeth, geographic and environmental factors and parafunctional habits like bruxism (Lu et al., 2017).[14,15]

Various systems and indices exist for assessing occlusal wear, but there is no universally accepted method. Murphy (1959) pioneered the study of different occlusal wear patterns and dentin exposure based on individual tooth morphology, using human skeletons for analysis.

In 1962, Miles proposed a method for age estimation based on evaluating the relative wear of only 3 permanent molars.[15] He categorized tooth wear into specific symbols, including:

(i) Unworn or polished enamel,
(ii) Severely worn enamel surface,
(iii) Progressive dentin exposure, and
(iv) Presence of secondary dentin or visible pulp cavity.

Miles developed a grading system with eight levels, from a to h, where grade a indicated the least wear and grade h indicated the most severe wear.[15]

Tooth wear is influenced not only by age but also by factors such as sex, enamel composition, habits, and cultural practices, leading to varying attrition scores across different populations.[14]

It's important to acknowledge that age estimation is more of an art than an exact science. Therefore, there may be a degree of subjectivity in age determination due to variations in biological processes involved

Age estimation is most reliable when multiple methods are used together. Attrition has shown moderate correlation with age, estimating age within ± 5 years of age in 44.2% of females and 50.0% of males. However, due to the challenges in estimating age accurately among older adults, broad age categorization can be beneficial.

Attrition serves as a valuable non-invasive tool for age estimation when invasive procedures are not feasible. There is a insufficiency of studies focusing solely on attrition as an age indicator, particularly in India. Research on dental attrition in contemporary populations is crucial to better understand its interaction with factors like modern diet, habits, ancestry, and stress.[14]

5. Estimating age based on dental maturity

Dental maturity is widely acknowledged as the most dependable method for estimating the chronological age of children. The commonly used techniques rely on assessing dental maturity from radiographs, particularly panoramic radiographs, which offer the advantages of being noninvasive and user-friendly.[16]

Currently, the most widely used method is Demirjian's method, which relies on eight stages of calcification representing crown and root development up to apex closure. Each tooth stage is assigned a score, and these scores are summed to generate a dental maturity score. This score can then be converted into an estimated dental age using existing tables and percentile curves. Demirjian's method, particularly when used with percentile charts, is effective for determining whether a subject's dental maturity is advanced or delayed compared to their known age, rather than predicting an unknown age. It has been determined to be highly reliable and reproducible. Additionally, combining Demirjian's stages with multiple linear regression analysis via the method of least squares enhances the accessibility and accuracy of age estimation in childres.[16]

ESTIMATION OF AGE IN DEATH

Estimating age-at-death from human skeletal remains is a crucial yet complex component of bioarchaeology and forensic investigations. Techniques for assessing adult age typically emphasize bone remodeling, maturation indicators, and degenerative changes.[17]

While cementum age-at-death estimation holds promise, it remains less mature in human studies compared to its routine use in nonhuman mammals. Consequently, many anthropologists prefer classical techniques that are more standardized and well-defined. (Figure – 4)

Anthropologists frequently encounter challenges in estimating age-at-death using biological traits and recognize that variability is inherent in biology. Therefore, they advocate for using broad age ranges as a standard practice (Cunha et al., 2009).

Embracing the notion of flawless regularity in the development of biological tissue while asserting a high level of accuracy in cementum age-at-death estimation would go against the core principle of biological variability.[17]

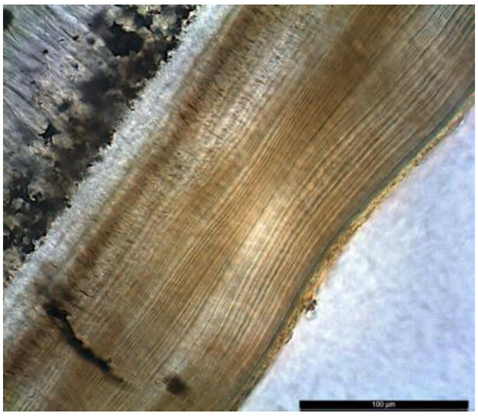

Figure 4 - Transverse sections of a canine tooth extracted from St-Amé 510 (16th-18th centuries) display well-preserved acellular cementum, with a scale bar measuring 100 µm.

Cementum is the mineralized connective tissue that covers the root surfaces of teeth , primarily anchoring collagen fibers of the periodontal ligament to the root surface.

Like bone, cementum is composed of both organic and mineral matrices. However, unlike bone, this avascular and non-innervated tissue experiences minimal to no remodeling throughout an individual's lifetime (Saygin, Giannobile, & Somerman, 2000).

Different types of cementum exhibit specific structures and developmental patterns tailored to their distinct functions.

Cellular cementum's adaptive role and its variability prompt cementochronological studies to focus exclusively on acellular extrinsic fiber cementum (AEFC), characterized by a consistent growth rate (Sequeira, Bosshardt, & Schroeder, 1992).

Cementochronology relies on the presumed annual deposition of cementum from its initial formation until the individual's death. The cumulative layers of cementum, distinguished by alternating light and dark bands observed under photonic microscopy, in conjunction with the age of root completion or tooth eruption, enable estimation of the individual's age-at-death

This straightforward principle, however, relies on a complex biological tissue and mechanisms that are not yet fully understood, which remains a primary criticism of cementochronology. Nevertheless, our current understanding of cementogenesis should not hinder further cementochronological investigations.

In fact, studies focusing on the periodic formation of enamel and dentin preceded the comprehension of the biological rhythms involved in these tissues' development.

Cementum growth is not governed by a singular mechanism, but rather operates on a rhythm distinct from that of dentin and enamel formation. Despite the slow and continuous pace of cementogenesis throughout life and the unclear mechanisms influencing its deposition, there are legitimate concerns regarding the consistency of tissue formation and its accuracy in age estimation in humans.

Age estimation based on cementum is typically derived from multiple measurements, taking into account the variability in counts between teeth and even within different cross-sections of the same tooth, which helps establish error ranges. It is widely acknowledged that alterations can affect the reliability of age estimation techniques (Ubelaker, 2010).

Cementum, being the least mineralized of the three dental tissues, forms a bridge between the external environment and the dentin, with tubules connecting to the vascular system despite its lack of vascularity and low porosity (Hillson, 2005).[17]

ROLE OF DENTAL EXPERT IN FORENSIC ODONTOLOGY

Identifying a missing individual can greatly assist in the grieving process for their family and friends. Forensic dentists play a crucial role globally in human identification, bite mark analysis, assessing maxillofacial trauma, and identifying malpractice cases.[18]

Dental identification becomes paramount when post-mortem changes, traumatic tissue injuries, or the lack of fingerprint records preclude the use of visual or fingerprint identification methods. Dental remains are crucial in cases involving skeletonized, decomposed, burned, or dismembered individuals.

One of the principal advantages of dental evidence is its resilience. Teeth, like other hard tissues, tend to remain well-preserved after death. Even though the condition of a person's teeth changes throughout life, the pattern of decayed, missing, and filled teeth provides a measurable and comparable reference point. Teeth are among the most durable parts of the body and can withstand temperatures up to 1600°C without significant loss of their microstructures.[18]

SIGNIFICANCE OF AGE ESTIMATION

Forensic odontology focuses on using teeth and oral structures for identification purposes in legal contexts. Forensic odontology of various techniques includes instrumental in identifying human Corpses in scenarios such as airplane, road and train accidents, terrorist attacks, mass murders, fires and natural disasters like earthquakes, floods and tsunamis.[1]

The number and sequence of erupted teeth can reasonably determine an individual's age[1] Age estimation is crucial for legal proceedings, identifying victims in mass disasters, and conducting anthropological studies, regardless the individual is live or dead.[3]

Estimating age is one of the foremost aspects of analysis in forensic anthropology. Among the various variables within the biological profile of missing persons as evidenced by recovered skeletal remains, age at death is a pivotal feature crucial for identification.

Methods for estimating adult age are diverse and include assessing various anatomical features such as the extent of cranial suture closure, parietal thinning, metamorphosis of the pubic symphysis, development of sternal rib ends, osteoarthritis indicators like osteophytosis, Methodological advancements have occurred in techniques for age assessment in both skeletal remains and living individuals, particularly in evaluating overall degenerative changes, alterations in the acetabulum of the pelvis and auricular area, as well as histological features of dental and bone.[19]

Age estimation in children is crucial in forensic medicine, pediatric endocrinology, and orthodontic treatment. Key anatomical areas for age estimation include dental development and assessment of the hand-wrist region. Throughout growth, a combination of skeletal, dental, anthropological, and psychological methods provides an approximate assessment of age. The Demirjian method, widely employed in dental maturity studies, is particularly valuable for estimating age in individuals of unknown age.[20]

Statistical analyses revealed significant Pearson's correlation coefficients between age and various ratios such as pulp/root length, pulp/tooth length, tooth/root length, and pulp/root width at three different levels for each type of tooth.[21]

THE APPLICATION OF ARTIFICIAL INTELLIGENCE IN DENTAL AGE ESTIMATION

The effectiveness of using artificial intelligence (AI) to assist in dental age assessment for identifying growth delays in children was studied. Panoramic films meeting the inclusion criteria were collected for training the AI model, establishing a population-based dental age standard. Following this, the dental ages of a validation dataset consisting of healthy children and children with growth delays were evaluated using both traditional methods and AI-assisted standards

AI-assisted standards offer significantly more accurate chronological age predictions, with mean errors under 0.05 years, whereas traditional methods tend to overestimate for both genders. Parents and practitioners are always concerned about children’s growth conditions. The most frequent approach to assessing growth rate is by recording height measurements over time. In annual evaluations, a growth delay is generally identified when a child's height falls below the third percentile. Children experiencing growth delays often have shorter stature can be attributed to familial, nutritional, endocrinological, and genetic factors. Additionally, delayed physical development can sometimes indicate underlying diseases, and children with growth delays often face increased psychosocial stress due to their shorter stature

While recent studies have demonstrated the promise of AI-assisted dental age assessments in identifying growth delays in children, several limitations persist. Firstly, the intricate mechanisms governing somatic and craniofacial growth necessitate further investigation into the influence of environmental, socioeconomic, and nutritional factors to enhance the accuracy of dental age evaluations. Moreover, the research focused exclusively on a younger demographic, excluding adults from consideration. It is crucial to determine whether various dental treatments, including prosthetic procedures, root canals, and tooth extractions, impact AI performance. Lastly, as this was a descriptive study, additional clinical observations and prospective research are essential to provide reliable long-term predictions.

It was observed that the AI-assisted standard effectively identified dental age delays in children with growth delays of both sexes. The convolutional neural network (CNN) model was uniquely capable of detecting dental age delays in both male and female children with growth delays. Unlike other methods, the CNN model used the entire panoramic image as input during model training. Panoramic film images were analyzed to identify and extract features, with chronological age as the reference standard for output.[22]

CONCLUSION

The precision of forensic age estimation is greatly enhanced by integrating data from clavicular and wisdom teeth analyses. In Germany, for instance, better nutritional conditions compared to some poorer countries can affect both clavicle development and tooth mineralization. These variations in the timing of dental and skeletal development across different populations can influence the accuracy of age estimation.[23]

Forensic age estimation allows courts and government agencies to ascertain the official age of individuals whose actual age is uncertain, particularly unaccompanied refugee minors. This process ensures that legal procedures based on age are correctly followed, upholding the rule of law. The minimum-age concept is implemented to avoid the misclassification of minors as adults.[24]

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There are no conflicts of interest

REFERENCES

1. Krishan, Kewal, Tanuj Kanchan, and Arun K. Garg. "Dental evidence in forensic identification–An overview, methodology and present status." The open dentistry journal 9 (2015): 250.
2. Kurniawan A, Chusida AN, Atika N, Gianosa TK, Solikhin MD, Margaretha MS, Utomo H, Marini MI, Rizky BN, Prakoeswa BF, Alias A. The applicable dental age estimation methods for children and adolescents in Indonesia. International Journal of Dentistry. 2022;2022(1):6761476.
3. Mathew, Deepu George, et al. "Adult forensic age estimation using mandibular first molar radiographs: A novel technique." Journal of forensic dental sciences 5.1 (2013): 56.

4. Verma, Meenal, et al. "Dental age estimation methods in adult dentitions: An overview." Journal of forensic dental sciences 11.2 (2019): 57.
5. Bosmans, Nathalie, et al. "The application of Kvaal's dental age calculation technique on panoramic dental radiographs." Forensic science international 153.2-3 (2005): 208-212.
6. Priyadharshini, K. Indra, et al. "Age estimation using development of third molars in South Indian population: A radiological study." Journal of International Society of Preventive & Community Dentistry 5.Suppl 1 (2015): S32.
7. Khorate, Manisha M., A. D. Dinkar, and Junaid Ahmed. "Accuracy of age estimation methods from orthopantomograph in forensic odontology: a comparative study." Forensic science international 234 (2014): 184-e1.
8. Sharma, Sneha, et al. "Age Estimation Using the Tooth Coronal Index on Mandibular First Premolars on Digital Panoramic Radiographs in an Indian Population." Frontiers in Dentistry 20 (2023).
9. Alkass, Kanar, et al. "Age estimation in forensic sciences: application of combined aspartic acid racemization and radiocarbon analysis." Molecular & cellular proteomics 9.5 (2010): 1022-1030.
10. Gualdi-Russo, Emanuela, et al. "Age estimation using tooth cementum annulations: Bias and sources of inaccuracy." Frontiers in Bioscience-Landmark 27.5 (2022): 141.
11. D'Ortenzio, Lori, et al. "Age estimation in older adults: use of pulp/tooth ratios calculated from tooth sections." American Journal of Physical Anthropology 165.3 (2018): 594-603.
12. Manjunatha, B. S., and Nishit K. Soni. "Estimation of age from development and eruption of teeth." Journal of forensic dental sciences 6.2 (2014): 73.
13. Demirjian, Arto, and Herbert Goldstein. "New systems for dental maturity based on seven and four teeth." Annals of human biology 3.5 (1976): 411-421.
14. Lewis, Amitha J., et al. "Estimation of age by evaluating the occlusal tooth wear in molars: a study on Dakshina Kannada population." Clinical, Cosmetic and Investigational Dentistry (2021): 429-440.
15. Phulari, Rashmi GS, and Esha J. Dave. "Evolution of dental age estimation methods in adults over the years from occlusal wear to more sophisticated recent techniques." Egyptian Journal of Forensic Sciences 11 (2021): 1-14.
16. Lee, Sang Eon, et al. "Age estimation of Korean children based on dental maturity." Forensic science international 178.2-3 (2008): 125-131.
17. Bertrand, Benoit, et al. "Age at death estimation by cementochronology: Too precise to be true or too precise to be accurate?." American journal of physical anthropology 169.3 (2019): 464-481.
18. Verma, Anoop K., et al. "Role of dental expert in forensic odontology." National journal of maxillofacial surgery 5.1 (2014): 2.
19. Ubelaker, Douglas H., and Haley Khosrowshahi. "Estimation of age in forensic anthropology: historical perspective and recent methodological advances." Forensic sciences research 4.1 (2019): 1-9.
20. Cameriere, Roberto, Luigi Ferrante, and Mariano Cingolani. "Age estimation in children by measurement of open apices in teeth." International journal of legal medicine 120 (2006): 49-52.
21. Kvaal, S. I., Kolltveit, K. M., Thomsen, I. O., & Solheim, T. (1995). Age estimation of adults from dental radiographs. Forensic science international, 74(3), 175-185.
22. Wu, Te-Ju, et al. "The application of artificial-intelligence-assisted dental age assessment in children with growth delay." Journal of Personalized Medicine 12.7 (2022): 1158.
23. Bjelopavlovic, Monika, et al. "Forensic Age Estimation: A Multifactorial Approach in a Retrospective Population Study." Diagnostics 13.12 (2023):2029
24. Schmeling, Andreas, et al. "Forensic age estimation: methods, certainty, and the law." Deutsches Ärzteblatt International 113.4 (2016): 44.

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