Review Article

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Radiographic Methods of Age Estimation in Forensic Dentistry

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Abstract

Age estimation by radiographs is one of the most commonly used methods these days due to ease of handling, minimal instrumentation and universal acceptance. Age plays an important role in establishing the identity of the person. The radiographic method is a simple, quick, economic, non-mutilating and non-invasive method of age identification. It can be used for determining the age in dead as well as living persons in all communities without any religious or scientific issue. This article describes various methods of age determination on the basis of radiographic features in ante-mortem and post-mortem cases.

Keywords: Age Estimation; Forensic Odontology; Dental Age; Chronological Age**.**

Introduction

Age plays an important role in establishing the identity of the person. Age estimation of an individual is a procedure adopted by anthropologists, archaeologists and forensic scientists. With the passage of time different methods and techniques have been adopted for age estimation but none of these have proved useful for age estimation in adults above 25 years. The teeth are most durable and resilient part of the human skeleton [1]. However in modern global socio-political scenario, there is an increasing demand for determination of age in living persons such as immigrants, refugees and to clarify criminal and civil liability and social issues [2].

In older days teeth are the only means of identification when the dead bodies have under gone extensive postmortem changes and external characteristics provide little or no information [3]**.** The genetic control of tooth development is comparatively quite resistant to mutations i.e., conditions inhibiting growth and development have only a minimal affect on dental maturation [4]. Many studies have demonstrated that dental age relates more closely to chronological age than skeletal, somatic or sexual maturity indicators. For assessment of dental maturation, Tooth formation has been more widely used than tooth eruption as it is a continuous and progressive process that can be followed radiographically. Other advantage of this technique is that most teeth can be evaluated at each examination.

However when all information about the formation stages of several teeth is combined, the dental age of an individual can be easily estimated [6]. Radiographic age estimation is performed in 2 stages. First at puberty stage which is done by radiographic evaluation of tooth development by using intraoral periapical radiographs, bitewing radiographs, orthopantomographs alone or in combination with radiographic evaluation of third molar development and hand wrist and cervical vertebrae radiographs [8]. The second dental age estimation is done at adult sage after third molar development however after 3rd molar development, age estimation is done only on the basis of aging

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process and regressive changes of teeth [7]. In dental age estimation, the method based on the stages of tooth formation is more authentic and appropriate than those based on skeletal development. The dental development and calcification is controlled more by genes than by environmental factors. Teeth are less susceptible to nutritional, hormonal and pathological changes particularly in children [8].

In due course of time several methods have been developed for age estimation based on morphologic, radiographic, histological and biochemical methods. In ante mortem age determination morphological and radiographic methods (Schour and Massler's method, Demirjian's method and Kvaal's method) are very useful at adolescent and adult age whereas histological and biochemical methods (Gustafson's and Johanson's method, Bang and Ramm method, aspartic acid racemization and cemental annulation technique) are useful in postmortem analysis and age estimation in dead victims [9].

The radiological methods have several advantages over histological and biochemical methods for age determination. The radiographic method is a simple, quick, economic, non-mutilating and non-invasive method of age identification. It can be used for identifying the age in dead as well as living persons and in all communities without any religious or scientific issue.

However histological and biochemical methods for age determination require either extraction or preparation of microscopic sections of tooth from each individual along with expensive and sophisticated laboratory procedures. These are major drawback with either histological or biochemical methods. Therefore these methods cannot be used in ante mortem or postmortem cases as it is not feasible to extract teeth for religious or scientific reasons.

The radiological age determination is based on assessment of a number of features like jaw bones prenatally, appearance of tooth germs, earliest detectable trace of mineralization or beginning of mineralization, early mineralization in various deciduous teeth during intrauterine life, degree of crown completion, eruption of the crown into the oral cavity, degree of root completion of erupted or un-erupted teeth, degree of resorption of deciduous teeth, measurement of open apices in teeth, volume of pulp chamber and root canals / formation of physiological secondary dentine, tooth-to-pulp ratio, third molar development and topography [11].

Radiographic Methods of Age Determination in Adolescents and Children

Schour and Massler method

It was first introduced by Schour and Massler in 1941. They studied the development of deciduous and permanent teeth and described 21 chronological steps from 4 months to 21 years of age and published the numerical development charts. They compared the calcification stages of teeth on radiographs with the standards [12]. They compared the development of crowns and roots and state of eruption in the specimens which are matched against the diagrams in the chart to assign a dental age.

Star H et al Method

Star et al dsecribed a method of age prediction on the basis of calculation of pulp-tooth volume ratios. The secondary dentine apposition is a significant morphological dental age predictor. It is defined as the formation of dentine after the completion of the primary dentine and starts at the moment the related tooth formation is completed. The formation of secondary dentine reduces the area and the volume of the pulp chamber. Therefore the changes of area of the pulp chamber in intact teeth are considered as dental age predictor [13].

Robert Cameriere et al Method

In a study conducted by Robert Cameriere et al, the dental age estimation were done by using pulp tooth area ratios in 100 individuals aged between 18 to 72 years in right maxillary canines using orthopantomography. They have found significant results with an error of 3.7 years [14].

Demirjian, Goldstein and Tanner method

In this method dental age was determined on the basis of the degree of maturation of the seven mandibular teeth excluding the third molar. Every tooth was assigned a rating from "A" to "H". The eight developmental stages are described. Stages were subsequently converted to scores by using conversion table specific to gender. The scores for each tooth were then added resulting in a total maturity score which was then transformed into dental age using standard tables given for each gender separately.

The tooth formation stages according to Demirjian are as follows [15]:

Stage A: In both uniradicular and multiradicular teeth a beginning of calcification is seen at the superior level of the crypt in the form of an inverted cone or cones. No fusion of these calcification points is observed.

Stage B: Fusion of calcified points forms one or several cusps which unite to give a regularly outlined occlusal surface.

Stage C: Enamel formation is complete at the occlusal surface, dentine deposition has started and the pulp chamber has a curved shape at the occlusal border

Stage D: Crown formation is complete, extending down to the cemento-enamel junction. Beginning of root formation is seen in the form of a spicule.

Stage E: The walls of the pulp chamber form straight lines. The root length is less than the crown height. In molars the formation of the radicular bifurcation is seen like a calcified point or a semi-lunar shape.

Stage F: The walls of the pulp chamber form a triangle. The apex ends in a funnel shape. The root length is equal to or greater than the crown height.

Stage G: The walls of the root canal are parallel and the apical end is still partially open.

Stage H: The apical end of the root is completely closed and the periodontal membrane has a uniform width around the tooth apex.

Chronological age for each patient was calculated by subtracting the date of birth from the date when the radiograph was taken.

Nolla Method

Nolla described the mineralization of permanent dentition in ten stages .The method can be used to assess the development of each tooth of the maxillary and mandibular arch. The radiograph of the patient is matched with the comparative figure. After every tooth is assigned a reading, a total is made of the maxillary and mandibular teeth and then the total is compared with the table given by Nolla[16].

Moorees, Fanning and Hunt Method

In this method, the dental development was studied in the 14 stages of mineralization for developing single and multi-rooted permanent teeth and the mean age for the corresponding stage was determined [17].

Radiographic Methods of Age Determination in Adults

The radiographic age estimation after 17 years of age is quite difficult as eruption of permanent dentition is completed by this time with the eruption of the third molar. However development of the third molar may be taken as a guide to determine the age of the individual.

Kvaal et al Method

Kvaal reported a method in 1995 that allows age estimation based on morphological measurements of two-dimensional radiographic features of individual teeth. The measurements include comparisons of pulp and root length, pulp and tooth length, tooth and root length and pulp and root widths at three defined levels. This method is less discriminatory than other methods but has the important advantage of being non-invasive, not requiring extraction of teeth, being useful for examination and regression analysis of all data performed with age as the dependent variable [18].

Harris and Nortje method

They have given five stages of third molar root development with corresponding mean ages and mean length [19]**.**

Stage 1: Cleft rapidly enlarging–one-third root formed (15.8 ± 1.4 years, 5.3 ± 2.1mm)

Stage 2: Half root formed (17.2 ± 1.2 years, 8.6 ± 1.5mm)

Stage 3: Two-third root formed (17.8 ± 1.2 years, 12.9 ± 1.2mm)

Stage 4: Diverging root canal walls (18.5 ± 1.1 years, 15.4 ± 1.9mm)

Stage 5: (Converging root canal walls, 19.2 ± 1.2 years, 16.1 ± 2.1mm)

Van Heerden system

The development of the mesial root of the third molar was assessed to determine the age using panoramic radiograph. In this system he considered five stages in the course of development [20].

Advantages of Radiographic Methods

- Radiographic methods of age determination are simple methods which can be universally applied without any sophisticated instrumentation.

- They are non invasive and does not require tooth substance or any surgical intervention.
- One of most important reason for popularity of these methods is easy numerical value which can easily be used in epidemiological study also.

Disadvantages

- These methods cannot be used in case of congenital abnormalities, agenesis, retardation and systemic abnormalities affecting dentition.
- They cannot be used in young children and adolescents in which there is technical difficulty or any concerned ethical issues.

Conclusion

Age estimation using radiographs is one of the most commonly used methods these days due to ease of use with minimal instrumentation and universal acceptance. However due to some technical and ethical issues, there is a dire need for new innovations and advancements in modern technologies to predict the age of individuals more accurately and specifically. The age determination on the basis of radiograph can be a landmark step in forensic odontology in ante-mortem and postmortem cases.

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