Review Article

Dental Radiograph: Tool for Age Estimation

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Abstract

Background: Age estimation is essential for various reasons including legal, criminal, humanitarian, and social grounds. It can be either based on the dental (tooth) identification or by ante mortem records. With the help of forensic odontology now it has become easier to estimate the age in a very less time. Although age can be estimated by various methods, each method has an error rate which suggests its accuracy. In this article, we will discuss different radiographic methods of age estimation from teeth.

Keywords: Dental age estimation, Forensic odontology, Radiographic methods.

Introduction

Age is the one of the important factors to establish the identity of a human being. It becomes a challenging job to estimate age in adults when compared to adolescent age group. Ritz *et al*. stated that adult growth completion and tooth eruption are also effected by many other factors such as nutrition and environmental factors but tooth maturity is comparatively least effected by any exogenous factors as compared to its eruption. Although age estimation is an archaic exercise but it has been in practice since past decades by forensic anthropologists. However, nowadays, a new emerging branch known as "Forensic Odontology" is used to estimate age using tooth/teeth because teeth are resistance to high temperature, any mass disaster. Although there are various methods of age estimation, in the present article we will only discuss about radiographic methods of age estimation.[1,2]

Need for Age Estimation

As already mentioned every person whether dead or alive has right to be identified for several reasons:-

I. Living person requires age estimation for
   (a) Birth certificate is not available or records are doubtful
   (b) To determine the age of a young or adult for criminal liability
   c) In case of illegal marriages.
II. Dead person requires age estimation for
   (a) During disaster victim identification
   (b) Aborted fetal age estimation

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Significance of Radiographic Methods

Age estimation can also be done by clinical methods such as eruption sequence; histologic features such as neonatal line, incremental lines of cementum, dentin translucency, dentin predentin interface using scanning electron microscopy and biochemical characteristics such as C14 levels and racemization of dentin. Clinical methods are subjective in nature and predict a wider range of age. Biochemical and histological methods are destructive methods as these methods require teeth to be extracted that cannot be possible for every case especially in living persons.[3] This makes usage of dental radiographs, a more practical and relevant approach for age estimation in living individuals as it is a non-destructive and simple technique used daily in dental practice.[4]

Types of Dental Radiographs

Various types of radiographs can be used for age assessment such as intraoral periapical radiographs commonly known as IOPA, lateral cephalometric radiographs, and panoramic radiographs, digital imaging technologies such as Orthopantomogram, Radiovisiographs, and cone beam computed tomography (CBCT).[5]

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The radiological age determination is based on assessment of various features as follows.[6,7]

- Jaw bones pre-natally
- 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 unerupted 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
- Digitization of the available radiographs for analysis of images to obtain the dental information.

Dentition is used to estimate age in three groups, namely[8]

1. Prenatal, natal, and post-natal period
2. Children and adolescents and\Adults.

Prenatal, natal, and post-natal period

Radiographically, the mineralization of deciduous incisors starts at the 16th week of intrauterine life. Before the mineralization, the tooth germs may be visible as radiolucent areas on the radiograph. At the 26th week of intrauterine life advanced mineralization starts in mandibular anterior teeth. The mineralized outline for the two cusps of the deciduous first molar, the one cusp outline for the deciduous second molar and the crypt of permanent first molar are seen at the 30th weeks of intrauterine life 3/5 crown completion for anterior teeth. The deciduous first molar cusps show fusion. The deciduous second molar with five cusps is seen, while there is no evidence of mineralization in the permanent first molar. While the radiograph of the newly born fetus shows completely fused cusps for the deciduous first and second molar, for the deciduous second molar there is no continuity across the occlusal surface. Within the crypt of the permanent first molar, there is evidence of a tip of one of the mesial cusps.[9,10]

Stages by Kraus and Jordan

Kraus and Jordan studied the early mineralization in various deciduous teeth as well as in the permanent first molar. The development is described in ten stages, denoted by Roman numerals from I to X; the IXth stage includes three stages; and the Xth stage includes five stages.[11]

Age estimation in children and adolescents

Dental age estimation in children and adolescents is based on the time of emergence of the tooth in the oral cavity and the tooth calcification. The radiographic analysis of developing dentition, especially when there is no clinical evidence available (2.5–6 years) as well as the clinical tooth emergence in various phases will help in age determination.

Methods applied for age determination in children and adolescents:

- Schour and Masseler method in 1941, Schour and Masseler studied the development of deciduous and permanent teeth, describing 21 chronological steps from 4 months to 21 years of age and published the numerical development charts for them. These charts do not have separate surveys for males and females[12,13]
- Moorees, Fanning and Hunt method in this method, the dental development was studied in the 14 stages of mineralization for developing single and multirooted permanent teeth and the mean age for the corresponding stage was determined. Moorees *et al*. used panoramic radiographs or lateral oblique radiographs for their study. The earliest age in the survey was 6 months and the data also include the development of the third mandibular molar[14]
- Demirjian, Goldstein and Tanner method Demirjian, Goldstein and Tanner rated seven mandibular permanent teeth in the order of second molar (M2), first molar (M1), second premolar (PM2), first premolar (PM1), canine (C), lateral incisors (I2), and central incisor (I1) and determined eight stages (A to H) of tooth mineralization together with stage zero for nonappearance[15]
- Nolla's method: Nolla evaluated the mineralization of permanent dentition in ten stages. The advantages of this method are that it can be applied to an individual with or without the third molar and that girls and boys are dealt with separately[16]
- Age estimation using open apices: Various studies assessed the relationship between the age and measurement of open apices in teeth.[17]

Age estimation in adults

Clinically, the development of permanent dentition completes with the eruption of the third molar at the age of 17–21 years, after which the radiographic age estimation becomes difficult. The two methods commonly followed are the assessment of volume of teeth and the development of the third molar.[18]

a. Volume assessment of teeth
   - Pulp-to-tooth ratio method by Kvaal
   - Coronal pulp cavity index

b. Development of third molar
   - Harris and Nortje method
   - Van Heerden system

Volume assessment of teeth

Method by Kvaal *et al*.: In this method, pulp-tooth ratio was calculated for six mandibular and maxillary teeth, such as maxillary central and lateral incisors; maxillary second premolars; mandibular lateral incisor; mandibular canine; and the first premolar. The age is derived using these pulpto-tooth ratios in the formula for age determination given by Kvaal *et al*. Using intraoral periapical radiographs, pulp-root length (R), pulp-tooth length (P), tooth-root length (T), pulp-root width at cemento-enamel junction (A), pulp-root width at

mid-root level (C), and pulp-root width at midpoint between levels C and A (B) for all six teeth were measured. Finally, mean value of all ratios excluding T (M), mean value of width ratio B and C (W), and mean value of length ratio P and R (L) were substituted in the given formula.[19]

$$Age = 129.8 - (316.4 \times M)\ (6.8 \times (W-L)).$$

The coronal pulp cavity index

The correlation between the reduction of the coronal pulp cavity and the chronological age was examined using panoramic X-ray photographs. For each radiograph, only mandibular premolars and molars were considered, panoramic radiography was used to measure the length (mm) of the tooth crown (CL, coronal length), and the length (mm) of the coronal pulp cavity (CPCH, coronal pulp cavity height or length). The tooth-coronal index (TCI) was computed for each tooth and regressed on the real age of the sample.[20]

$$TCI = CPCH \times 100/CL$$

Development of third molar

Harris and Nortje method

Harris and Nortje have given five stages of third molar root development with corresponding mean ages and mean length.[21]

Stage 1 – cleft rapidly enlarging — one-third root formed, 15.8 ± 1.4 years, 5.3±2.1 mm.

Stage 2 – half root formed, 17.2 ± 1.2 years, 8.6 ±1.5 mm.

Stage 3 – two-third root formed, 17.8 ±1.2 years, 12.9 ± 1.2 mm.

Stage 4 – diverging root canal walls, 18.5± 1.1 years, 15.4±1.9 mm.

Stage 5 – converging root canal walls, 19.2±1.2 years, 16.1±2.1 mm.

Third molar development by Van Heerden system

Van Heerden assessed the development of the mesial root of the third molar to determine the age. He described the development of the mesial root in five stages using panoramic radiographs the males and females were surveyed separately and no significant differences were found between them.[22]

Stage 1 Crown complete, radiographic evidence of root formation 3.5–5.3 mm, 16.8–16.9 years.

Stage 2 Root length ›1/3 ‹1/2, 7–8.6 mm, 17.5 years.

Stage 3 Root length ›2/3 but not complete, 10–12.9mm, 17.8–17.9 years

Stage 4 Root fully formed with open apex, 12–15.4mm, 18.4–18.5 years

Stage 5 Apex closed.

Advanced radiographic techniques

CBCT is a newly effective and noninvasive three-dimensional diagnostic imaging modality in dental practice, resulting in a highly accurate image with a low radiation dose and affordable costs. In addition, CBCT has a several advantages over conventional radiographic methods, including easy accessibility, ease of handling, magnification, lack of superimposition, absence of geometric distortion, and ability to offer a data set of multiplanes cross-sectional and 3D reconstructions (in a single scan), therefore leading to improved structure visualization and diagnostic efficacy.[23]

Conclusion

As lot of research had been done in area of age estimation, numerous radiographic methods are available in the literature for assessing dental age. However, there is no study till now describing which digitized parameters are best suited for age determination in different age groups. More than one method of age estimation should be used to get a more effective and reproducible age range. To achieve more accurate age estimation, there is need for a corroborative population specific study with larger samples.

Conflicts of Interest

The authors declare they have no potential conflict of interests regarding this article.

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