Review Article

Commonly used Different Dental Age Estimation Methods in Children and Adolescents

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ABSTRACT

Age is an important factor for all the human beings whether it is living or dead. It is useful for day-to-day life works such as educational purpose, governmental purpose, job purpose, medical purpose, crime investigation, court of law, clinical practices, research, and reconstructive identification purpose in case of dead individuals. Of many procedures for age estimation such as chronological age, bone age, mental age, and others, dental age estimation is considered to be an important procedure as tooth development shows less inconstancy than other developmental features or in relation to chronological age and also teeth are most tough and resilient part of the skeleton. High survivability of teeth exposed to severe physical factors, such as fire and water immersion, make assessment of developing teeth the method of choice in forensic age estimation. Age estimation using teeth can be divided into three categories of age groups: prenatal, neonatal, and early postnatal period; children and adolescents; and adults. Children are defined as the human beings from birth to puberty and adolescents as from puberty to approximately age of 20 years. Hence, the motive is to overview for dental age estimation in children and adolescents from different techniques.

KEY WORDS: *Adolescents, calcification, children, dental age estimation, eruption, root development*

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INTRODUCTION

Age estimation in children and adolescents is important for variety of legal procedures such as child labor, employment, status of majority, rape, adoption, eligibility for marriage, and when the birth certificate is not available.[1] Although there are many techniques to be considered, dental age estimation techniques involving tooth maturation are considered as the most accurate indicators of chronological age in subadults because of genetic factors playing predominant role, and environmental factors tend to have minimal effects on tooth maturation which is specially true between birth and age of 10 years. Few age-dependent features remain, at the end of skeletal development and which can be used for estimating age by progressive morphological methods.[2] The third molar is the only remaining tooth undergoing growth and formation by the age of 14 years which is most developmentally variable tooth. Eruption of tooth is more applicable for deciduous dentition whose eruption is under genetic control but not for permanent dentition.[3] Whereas, calcification of tooth is applicable for both deciduous and permanent dentition for dental age estimation. Current dental age estimation techniques are based on the age-related changes in teeth such as formation and growth of teeth, post-formation changes in teeth, and biochemical changes in teeth.

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DISCUSSION

Choosing the right age assessment method relies heavily on the individual in question, according to the presence or absence of teeth in the oral cavity, and whether the individual is alive. Dental age assessment can be done in an invasive or noninvasive way.

Noninvasive methods are sequential tooth eruption and/or emergence, development by means of calcification and/or root maturation, root development stages, morphological tooth parameters, and tooth measurements.

Invasive methods are biomarkers, root dentine translucency, and incremental lines,

There are four different categories for dental age estimation.

1. Clinical or visual methods
2. Radiographic methods
3. Histological methods
4. Physical and chemical methods.

Hence, this article overviews the different techniques used for dental age estimation in children and adolescents [Figures 1 and 2].

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Classification of Dental Age Estimation in Children and Adolescents

Different methods of dental age estimation in children and adolescents

Depending on the presence or absence of mamelons

Mamelons are the prominent enamel extensions present on the incisal edge of the permanent incisor teeth. The presence or absence of mamelons helps in differentiating primary or permanent dentition.

A study conducted having sample size of 213 with the age group from birth to >50 years which correlates the prevalence of the mamelons with age, sex, and occlusal relationship.[4] They found that more mamelons present in the first decade of life and decrease with increasing age. They are more prominent in permanent maxillary central incisor and persist more in females than males.

Depending on the presence of teeth

Schour and Masslermodified Kronfeld's table which gives a long history of development and chronology of the growth of human teeth.[5]

Singh *et al*. conducted the study having 126 children up to the age of 33 months on eruption of temporary teeth, concluding that teeth appear earlier in the females and in the mandible.[6] He has given a table which shows mean age of eruption and the range of ages of eruption that can be used for dental age estimation method visually.

Schour and Massler method

Schour and Masslerstudied 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.[5] These charts do not have separate surveys for males and females. The chart is based on histological sections which takes into account three characteristics:

a. Teeth that have erupted
b. Amount of resorption of roots of primary teeth
c. Amount of development of permanent teeth.

Nolla's method

Nollaconducted a serial radiographic study of 25 boys and 25 girls starting from the average age of 4.6 years ending to the average age of 16.6 years for boys and starting from the average age of 5.7 years ending to the average age of 16.8 years for girls, illustrating the ten developmental stages starting from crypt formation to apex closure (i.e., 1–10) for both maxillary and mandibular teeth.[7] Staging is done on the evaluation of calcification of permanent teeth, and each tooth is assigned a reading and total sum of the staging of maxillary and mandibular teeth are done which is compared with the predetermined values in the table to determine age. 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 separately.

Moorrees, Fanning, and Hunt method

Moorrees *et al*., conducted a longitudinal study on children having age group from birth to 20 years.[8] This method provides chronological age assessment information of the permanent mandibular posterior teeth (C-M3) and the developmental stages of the permanent maxillary and mandibular incisors (I1 and I2). It consists of two separate development schemes, one for single-rooted teeth illustrating 13 stages and the other for the mandibular molars having 14 stages of development. This technique requires the odontologist to correctly identify the tooth, to assess its proper stage of morphological development, and then to read the associated mean age and standard deviation from the gender-specific graph. This method is totally radiographic study.

Demirjian's method

Demirjian *et al*., This method was first proposed in 1973 and it is one of the widely accepted methods for dental age estimation

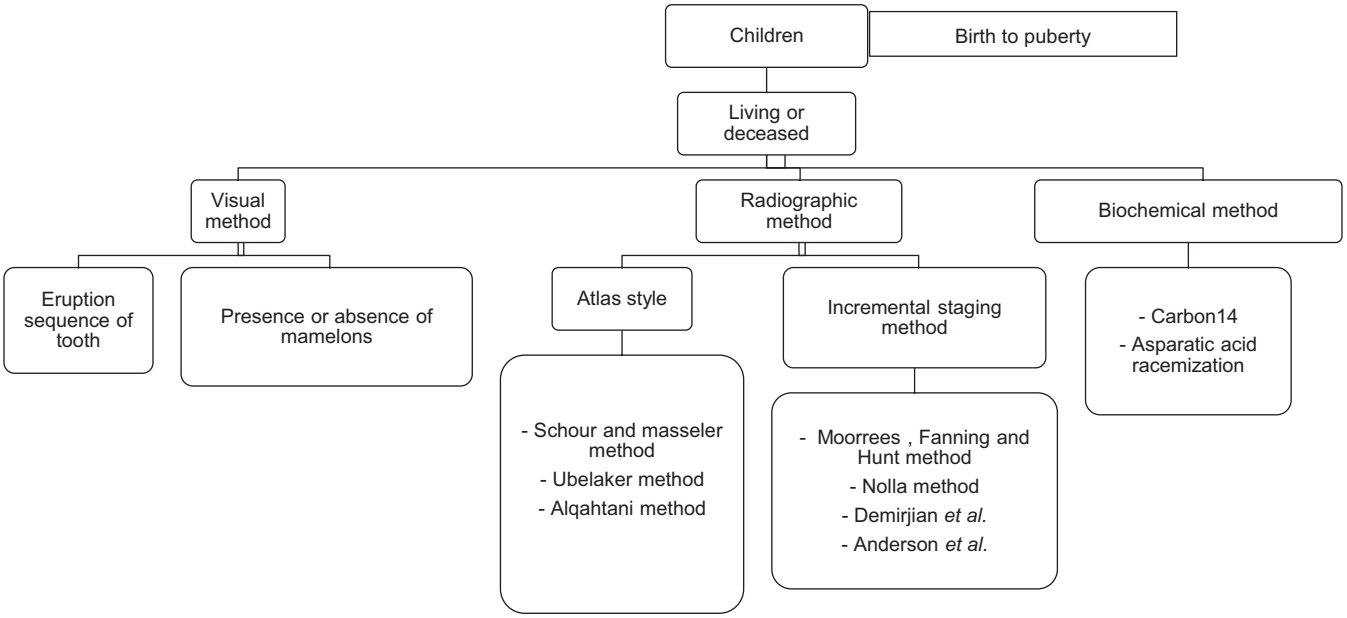

Figure 1: Child dental age estimation procedure flowchart

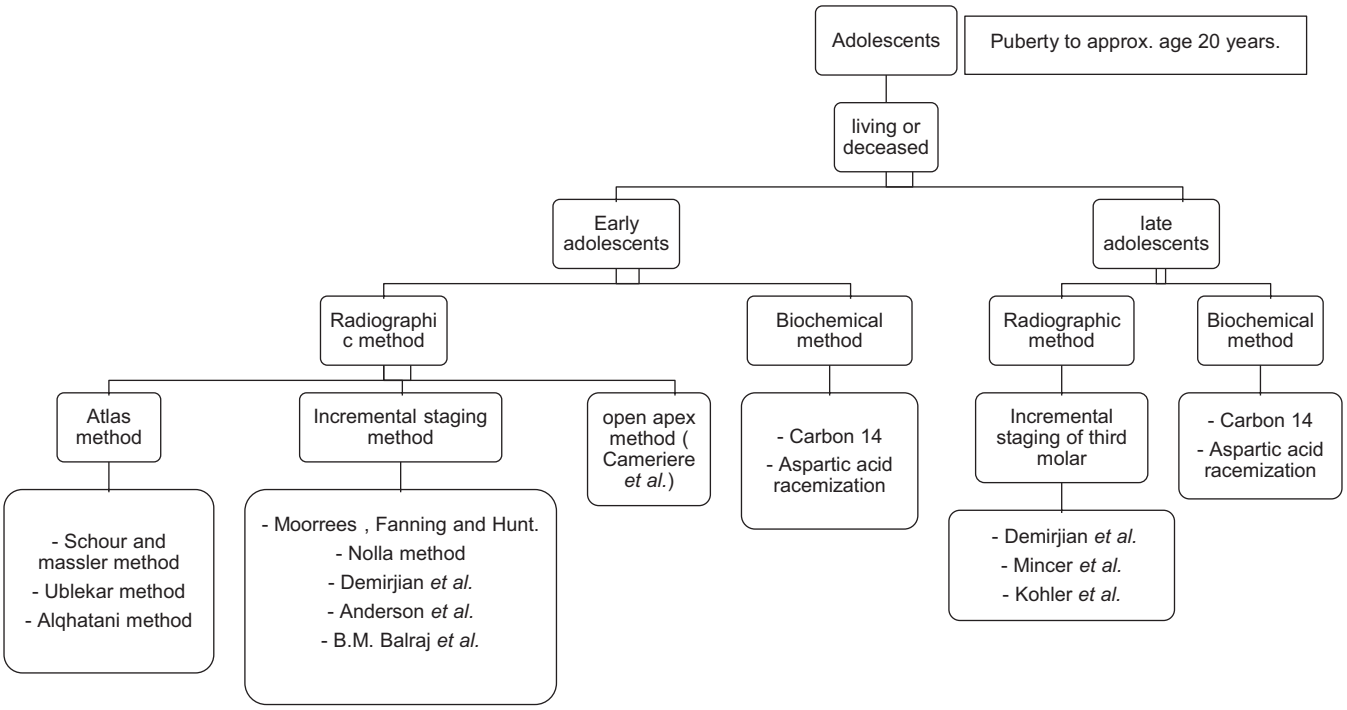

Figure 2: Adolescent dental age estimation procedure flowchart

in children and adolescents of the age group of 2–20 years.[9] Originally, it is seven teeth method done in mandibular left side teeth from central incisor to second molar consisting eight developmental staging from A through H, that defines the mineralization of tooth development beginning at the first radiographic appearance of mineralization to complete closure of root apex. This was later modified by Demirjian *et al.* in 1973.[9] In 2004, Chaillet and Demirjian did some modification including the third molar with a view to extend its application to a wider age group. Hence, all the eight mandibular left side permanent teeth are assessed on the radiograph, especially on orthopantomogram, and tooth development is compared to a developmental chart. It consists of ten developmental staging from 0 to 9, and each staging has its own maturity score for boys and girls separately. The final score or average sum should be 100 for all the teeth. The standard error rate in the Indian population of Demirjian method is ±1.17 for male and ±1.6 for female. The mandibular arch was selected due to the better quality of image as it is not superimposed by dental and cranial anatomy. It is permissible to utilize dentition on mandibular right side if the tooth is missing, malformed, rotated, or difficult to stage for any reason on the mandibular left side.

Open apex method

This is one of the methods that have been given by Cameriere *et al.,* which consists of the age group between 5 and 15 years study done on 455 Italian children.[10] The dental age is calculated based on the relationship between the age and measurement of open apices in teeth. The seven left permanent mandibular teeth excluding third molars are used to calculate the dental age. The height of the calcifying teeth and the width of the "open" apex are measured and their ratio is calculated. Such a ratio is calculated to compensate for magnification and angulation errors that may have been induced during radiography. The number of teeth with complete root development and closed apical ends is noted as N0. In the teeth with incomplete root development, the distance between inner sides of the open apex is measured. For the teeth with two roots, the sum of the distances between inner sides of two open apices is taken. The dental maturity is calculated as the sum of normalized open apices (s) and the numbers of teeth with root development complete (N0). The values are substituted in the following regression formula for age estimation.

$$\text{Age} = 8.971 + 0.375\ g + 1.631 \times 5 + 0.674\ N0 - 1.034\ s - 0.176\ s.\ N0,$$

where g is a dummy variable equal to 1 for boys and 0 for girls. Hence, this is also an age estimation method for children and adolescents. The median of residual errors between the actual and estimated ages was 0.035 years (interquartile range = 1.18 years).

Mincer's method

Mincer *et al.* studied third molar development radiographically to use it as an estimator of chronological age in children and adolescents (age range 14–24 years).[11] Mean and median ages for the formation of third molar are given using Demirjian's eight-grade classification. Development of maxillary third molar was found to be more foremost than mandibular third molars and also root formation was earlier than females. It can be used for predicting whether an individual is 18 years using regression formulas.

Kohler's method

Köhler *et al.*, This method is based on the evaluation of development and maturation of all permanent third molars.[12] It has modified the Gleiser and Hunt (1955) method of grading first molar. It consists of ten stages of grading, i.e., three stages

of crown formation and seven stages of root formation. It has given more priority to the development of root compared to other methods as the root is completed at the age of about 23 years. This method enables good accuracy in predicting whether an individual is juvenile or adult (</>18 years) using logistic regression formulas. It can also be used for the age estimation in 14–22-year-old individuals.[12]

Anderson's method

Anderson *et al*.evaluated the mineralization of each tooth of maxilla and mandible including all third molars which make use of the Moorrees *et al*.'s staging system, but changed the labeling nomenclature to stages 1 through 14, with stage 1 being the earliest stage of tooth development.[13,8] It consists of four charts that include age assessment data on all permanent teeth, both maxillary and mandibular arches for both sexes. The order of variability in specific tooth development for both sexes was important turn up of this study. According to Anderson, variability decreases as follows:

- Males: 1st bicuspid and 3rd molars > 2nd bicuspid and 2nd molars > cuspid > incisors >1st molar
- Females: 3rd molars > 2nd molars > cuspid and bicuspids > incisors > 1st molar.

Hence, it can be noted that first molar is reliable to provide the most accurate results. The data from Anderson's study start later in life than the data in the Moorrees *et al*.'s study, so it is considered an alternative study to Moorrees *et al*.[8] and can be used in later childhood and early adolescence.

AlQahtani's method

AlQahtani *et al*., It is one of the most recent and widely accepted atlases of dental development and alveolar eruption for age estimation in children and adolescents.[14] The chart does not differentiate between the sexes. The chart consists of 31 diagrams depicting the median dental development observed starting at 30 weeks *in utero* and ending at 23.5 years of age. Eight of diagrams only describe 3rd molar development beginning at the age of 16.5 years. Ubelaker's chart defines tooth eruption as the point in time that the tooth emerges through the gingival tissue, whereas AlQahtani's chart defines it as emergence through the alveolar bone. This method concluded that tooth formation is least variable in childhood and most variable after the age of 16 years for the development of the third molar. This technique is available online in numerous languages.[14]

Balaraj's method

Balaraj and Nithin conducted a radiological study of the closure of apical foramen of both permanent mandibular second molars for the determination of adolescents aged 14–16 years.[15] Their study makes the use of Demirjian's method utilizing the description of dental formation stages of complete root formation and apical closure. The study concluded with the facts that:

- At 15 years, 5 months of age, 94% of boys had closed apical foramen
- At 14 years, 9 months of age, 95% of girls had closed apical foramen
- If the apical foramen is closed, the boys' age will be >15 years and the girls' age will be >14 years
- If the apical foramen is opened, the boys' age will be <17 years and the girls' age will be <16 years.

Hence, using the single parameter (i.e., radiographic view of closure of apical foramen of the roots), the odontologist can determine the medicolegally important ages of 14 and 16 years.

Conclusion

Although there are so many different dental age estimation techniques for children and adolescents, forensic dentist must have to judge each age estimation case carefully and in addition to their visual age assessment, must choose one or more methods that would best serve the particular case, keeping in mind that perfection and exactness are the main requirements. Hence, the investigator should use more number of different methods and should perform repetitive measurements and calculations to improve the accuracy of age estimation. Although there are different methods for age estimation for children and adolescents of different population given by different foreign authors, it is mandatory for population-specific study to apply any methods in a certain population group. Of different methods for age estimation, Demirjian's method and AlQahtani's method are widely and commonly accepted methods for children and adolescents.

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Conflicts of interest

There are no conflicts of interest.

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