

Dental age estimation in children: a review

Abstract

Age plays an important role in every aspect of life. Teeth and the oral structures play an important role in identification of an individual. Chronological age, as recorded by registration of birth date, is referred throughout an individual's life. Age is an important factor in clinical practice; research and court of law. Forensic odontology is playing a very important role in the identification of an individual's age. Dental age is considered to be vital as tooth development shows less variability than other developmental features and also low variability in relation to chronological age. Hence, dental age is considered to be vital in establishing the age of an individual. Different morphological stages of mineralization correlate with the different developmental stages. Thus, this paper reviews the various methods to determine the dental age of children.

Age is the length of time that a person has lived or a thing has existed. The estimation of age is an important activity and is commonly carried in medico legal area. Assessment of age is often required while governing justice to an individual involved in civil and criminal litigation. Many anthropologists have studied the age systems, where age is often a major organizing principle. Individuals are generally classified as according to similar numerical age, age grades or developmental stages based on social and biological development, and relative ages of individuals. Body development is not completely associated with biological and chronological age. In many cases, chronological age and biological age may not be the same, due to the developmental variations. Hence, different parameters such as dental age, bone age, mental age etc. are considered as proxy indicator for biological age and body development.

Keywords: chronological age, dental age, bone age, mental age, visual, radiographic, chemical, histological

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Introduction

Teeth are extremely useful in the estimation of age and are preferable over other skeletal methods. As they are durable in archaeological contexts, have minimal remodeling, and the growth of permanent and deciduous teeth continues over the entire juvenile period.^{1,2} Formation of deciduous teeth begins in utero at about 4 months and permanent teeth complete formation at approximately 25 years of age.¹ Also, dental development, in particular dental formation, is less affected by environmental factors than skeletal growth and development used in the estimation of age including epiphyseal fusion and long bone growth.³ Rai⁴ and Smith⁵ found that the dental development is more reliable as an indicator of biological maturity in children that can be used from infancy to late adolescence. It is found that chronological age is synchronous with dental age in a normal child.

Need for dental age estimation

Since the emergence of child labour laws over one hundred years ago, chronological age has become increasingly significant for children as precise age took on a social value in relation to the law. It is also widely used to estimate the chronological age of children of unknown birth records for medico legal purposes. The treatment planning and the prognosis of certain orthodontic treatments greatly depend on the dental age. It can be used a crucial indicator to determine the abnormal eruption sequence so that preventive measures can be implemented.

Classification of dental age estimation methods

Dental age estimation methods can be broadly classified based on the technique used for the determination and on the age. Based on the methods used for age estimation⁶:

- I. Visual
- II. Radiographic
- III. Chemical
- IV. Histological

Visual method

It is based on of the sequence of eruption of the teeth and the changes that are caused due to function such as attrition, changes in color are indicators of ageing.

Radiographic method

Radiographs of the dentition can be used to determine the stage of dental development of the teeth. This method is the most commonly used method as it aids in age determination over a long span of time.

Histological method

Histological methods require the preparation of the tissues for detailed microscopic examination, which can determine more

accurately the stage of development of the dentition. This technique is more appropriate for post-mortem situations.

Physical and chemical analysis

The physical and chemical analysis of dental hard tissues determines alterations in ion levels with age. These techniques are not of great value to the forensic odontologist and future developments might provide an adjunctive means of collecting evidence of value in the dental context. Based on the age⁶:

- A. Age estimation in the prenatal period
- B. Age estimation in infants
- C. Age estimation in children and adolescents
- D. Age estimation in adults

Pre natal and infant age determination

Age estimation in this group can be done accurately. Mineralization of deciduous dentition commences from 2 - 4 months in-utero and the mineralization of the permanent molars is seen around 6 months in utero.⁷ The histological methods can detect mineralization before being detectable in the radiographs by around 12 weeks. The neonatal line is an optical phenomenon produced due to alteration in the dimension, degree and mineralization of enamel prisms caused due to sudden change from intra uterine to extra uterine environment.⁸ These lines are present in both enamel and dentin permanent teeth. This method can be used for assessing the amount of pre and postnatal enamel formation. Neonatal lines are independent of gestational age or size at birth.⁹ The estimation of period of survival of an infant in perinatal period using neonatal line as a line of reference can give the exact age of the baby in days.⁹ In primary enamel, rate of enamel formation is 2.5 - 4.5µ/ day.¹⁰ Cross striations are seen across enamel rods representing the daily incremental deposition of enamel¹¹ and this can be used to find the exact age of the baby in days by counting the cross striations from the neonatal line.⁹ Neonatal lines can be used to differentiate between live birth and still birth and is an important tool in forensic cases and for pre epidemiological studies. The main limitation of using neonatal line for estimation is that a couple of days of survival are necessary for the neonatal line to develop. The detection of neonatal line depends on various factors like axis of tooth section, thickness of the section and light source used. However, the absence of the neonatal line is not always an indicator of still birth.¹²

Kraus and Jordan method¹³

They studied the early mineralization in various deciduous teeth as well as the permanent first molar. The development is described in 10 stages, denoted by Roman numerals from I to X; the IXth stage includes three stages and the Xth stage includes five stages.¹³

Stack method¹⁴

This method measures the dry weight of the mineralized tooth cusps and gives an approximate age of the child. At 6 months intra uterine life, the weight is 60 mg, in the newborn child, the teeth weigh 0.5 gm which increase to 1.8 grams after 6 months.

Dental 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 method is used in a developing dentition when there is no evidence of tooth emergence between 2.5 - 6 years. Many studies have concluded that the tooth formation is a more reliable indicator of dental maturity than gingival emergence or eruption.¹⁵⁻¹⁷

Schour and Masseler method¹⁸

In 1941, Schour and Masseler¹⁸ 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. The chart is based on histological sections which takes into account 3 characteristics -

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

Nolla's method¹⁹

It was devised by C M Nolla¹⁹ in 1960. Nolla evaluated the mineralization of permanent dentition in 10 stages. Each tooth is assigned a reading and a total of the maxillary and mandibular teeth are made. The total is compared with the pre-determined values in the table to determine the age. This method is one of the most accurate methods in estimating dental age. It is reliable method as girls and boys are dealt separately.

Moore's, fanning and hunt method²⁰

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 were determined. This method mainly uses IOPA of mandibular canines.

Cameriere's method²¹

In this method, 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 are used to calculate the dental age. The number of teeth with complete root development and closed apical ends are noted as N0. In the teeth with incomplete root development the distance between inner sides of the open apex is measured (A). For the teeth with two roots, the sum of the distances between inner sides of two open apices is taken. To nullify the magnification, the measurement of open apex or apices is divided by the tooth length (L) for each tooth and these normalized measurements of seven teeth are used for age estimation. 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 variable equal to 1 for boys and 0 for girls. Many authors have found Cameriere's method with modifications to be the most accurate method of age estimation.^{22,23} However, a regression model for different populations is required for accurate estimation.²⁴

Haavikko method²⁵

This method was introduced by Haavikko²⁵ in 1974 and based on the cross-sectional data from radiographs of 1162 Finnish children

between the ages of 2 and 21 years. Twelve radiographic stages of 4 permanent teeth are used to assess the dental age. This method is useful when some of the permanent teeth may be missing congenitally. In this method, the formation of the teeth is assessed - six relating to crown formation and six relating to root formation. Then average is then taken to determine the dental age.

Demirjian, goldstein, and tanner method¹⁵

In 1973, Demirjian¹⁵ introduced a method which estimated chronological age based on developments of seven teeth from the left side of the mandible. This method was similar to that of Tanner, Whitehouse, and Healy, who estimated chronological age based on the maturity of hands and wrists. Demirjian, Goldstein, and Tanner used the stages have usually been marked by recognizable tooth shapes, from the beginning of calcification through to final mature form. This was later modified by Demirjian and Goldstein in 1976. In this method, the 7 left permanent mandibular teeth were analyzed and each tooth's development is divided into eight developmental stages. The system most widely accepted as being the most accurate is the one developed by Demirjian, which assesses the developing dentition of an individual child. The formation stages of the left mandibular teeth (excluding the third molars) are assessed, the individual scores for each of the seven stages are summed and this is converted to a single dental age which represents the average age for a child of that score. Koshy,²⁶ Prabhakar²⁷ found a poor correlation when Demirjian's method was used for different populations.

Williem's modification¹⁷

This was based on a study on Belgian Caucasian population and formed new tables for the dental maturity for boys and girls. The chronological age is obtained by adding the maturity score of different teeth. This method is simpler and retains the advantage of Demirjian's method and there was a reduction in the overestimation of dental age. According to Maber,²⁸ the estimated dental age to be more accurate than the Demirjian's method. Other modification of Demirjian's method was by calculating the chronological age based on the cumulative score of 4 teeth - 1st premolar, second premolar, first molar and second molar.

Kvall's method²⁹

In this method, the x-rays of the front teeth are taken in addition to a clinical examination of the oral cavity. The method is used to possibly remove doubt as to whether a person is under 18 years of age and to calculate the age above this level. In this method, pulp-tooth ratio is 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.

Conclusion

The growth of an individual is be influenced by various factors like genetics, nutritional status, race, hormonal influence, climatic conditions, social environment, etc. Teeth are the least influenced bio indicators and hence can be used for accurate age estimation. With technical advancements, in digital radiography and CBCT, the status of calcification can be determined precisely. However, there are a number of controversies regarding the dental age and the correlation with the chronological age. Racial difference and differences between genders has been seen. Several methods of age estimation have been devised, but their ability to estimate the age accurately with

the results being as close to the chronological age is the need of the hour. The main objective is to obtain the best standardized method for legal, medical age estimation, which is reproductive, simple and reliable and which can be applied in living and dead. Hence, for age estimation based on age, ethnicity/race we need to develop specific standards. Further studies are required to check validity, reliability, and applicability of various methods in different populations across the world and newer reference standards may be required depending on the race and ethnicity.

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Conflicts of interest

None.

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