Dental Age Estimation in Children and Adolescents

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Abstract
Age is estimated on basis of chronological age and bone age, dental age, mental age, and others. 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 so, it is considered to be vital in establishing the age of an individual. Every person of all ages whether they are neonate, adults, or adolescent got right to be identified during death or when they are alive, and with the help of forensic odontology now it has become easier to estimate the age in very less time by various methods. However, different methods are associated with varying degrees of uncertainty and precision. From a statistical-methodological point of view, a combination of different measurement methods and a more conscious use of the relevant statistical methodology may provide more reliable estimates and better quantification. This review will deal with various aspects of age estimation such as morphological, biochemical, and radiographical methods and its scope and limitation.

Keywords: Chronological age, dentition, incremental age

INTRODUCTION
Growth is a complex and dynamic process, and different physiologic systems, such as the skeletal system and dentition pass through a series of changes, eventually arriving at maturity. Subsequently, changes occur in adulthood as well and are reflected in the teeth. The physiologic systems, however, mature at a rate different than the actual age-the chronologic age-in different individuals. Still, when chronicologic age is unknown or disputed, physiologic changes that occur in the body can be used to derive the age since there is a correlation between the two. Various criteria, such as anthropometry (e.g., bone length), secondary sexual characteristics, and the dentition can be applied either separately or together to assess the age of an individual.

Historically, tooth eruption was first used as an indicator of age in England, when the Factory Act of 1837 prohibited a child without a second permanent molar from working in factories. The interest in the age determination of living young persons, for whom no birth certificates are available, is not a recent phenomenon but has a long history. As in ancient Rome, adolescents were considered mature enough to be drafted into military service, as soon as their second molars had fully emerged.¹ Another example for age assessment as an indicator for chronological age is the usage of tooth development in children and adolescents in the United Kingdom in the 19th century.²

For casualty identification, various invasive and noninvasive techniques, among them medical, radiological and dental, can be employed. Medical investigations are mainly based on the physical examination of the individual (e.g., body mass index and signs of sexual maturity), while radiographs are valuable tools for the determination of epiphyseal plate union in long bones, ossification of skull sutures, and others skeletal features.³

An important aspect of forensic odontostomatology is the age determination of an individual based on dental parameters. When looking at tooth composition and structure, the dental hard tissue, which is mainly composed of inorganic components, is the most resistant structure of the human body.⁴ By the age of 20 years, growth and dental development are complete, and thus become less important, while the physiological changes of use predominate. Therefore, beyond this age, an assessment of age, which is solely based on dental age, has to be judged less reliable.⁵

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The different methods applied for dental age assessment include the evaluation of tooth morphology, morphology of the primary and permanent dentition, the degree of skeletal ossification and the analysis of biochemical modifications within the dental hard tissues. Of course, these different techniques differ with respect to their possible field of application and their accuracy.

**VARIous METHODS ARE UTILIZED FOR DETERMINATION OF AGE FROM DENTITION**

Age assessment methods may be classified as follows:

A. According to the state of development of the dentition:
   - Methods applied to the forming dentition
   - Methods for the adult fully formed dentition.

B. According to the technique of investigation:
   - Clinical or visual
   - Radiographic
   - Histological
   - Physical and chemical analysis.

1. Clinical or visual method: Visual observation of the stage of eruption of the teeth and evidence of changes due to function such as attrition can give an approximate estimate of age

2. Radiographic method: Radiography can provide the gross stage of dental development of the dentition

3. 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 postmortem situations. It is also significant in the estimation of age of early development of dentition

4. Physical and chemical analysis: The physical and chemical analysis of dental hard tissues to determine alterations in ion levels with age have been proposed. While these techniques, as yet, are not of great value to the forensic odontologist, future developments might provide an adjunctive means of collecting evidence of value in the dental context. Among the various methods used to estimate the age of an individual dental age provides more accurate indications during first 18–20 year of life. However, both dentition and bone development are affected by genetic.

**AGE ESTIMATION METHODS**

Age estimation using the dentition may be grouped into three phases:

- Aging in prenatal, neonatal and early postnatal period
- Age estimation in children and adolescents
- Age estimation in adults.

Age estimation in children/adolescents: Age estimation in this group is relatively simple as the techniques used are easy to master, even among inexperienced dentists. Methods applied for age determination in children and adolescents,[12]

Schour and Masseler method (1941) 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.

Nolla’s method (1960) Nolla evaluated the mineralization of permanent dentition in 10 stages. 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.

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.

Moorees, Fanning and Hunt method (1963), 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.

**Demirjian’s Method**

Demirjian et al., proposed an age estimation method that makes use of 10 developmental stages (numbered 0–9) for the eight mandibular permanent teeth on the left side. Based on the developmental stage of each tooth, a sex-specific “maturity score” is assigned to them. The maturity score allocated to the teeth are added and a total maturity score obtained. This total is then substituted in a formula. Bearing in mind the differences in the dental development of females and males, the researchers provided separate maturity scores and formulas for the sexes.

**Open Apex Method (Cameriere Method)**

The open apex method is also an age estimation method for children and juveniles. Here, seven lower teeth (excluding the third molars) from the left side are used. The height of the calcifying teeth and width of their “open” apex is measured and the ratio calculated. Such a ratio is derived to compensate for magnification and angulation errors that may have been induced during radiography.

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

Where \( g \) is a variable equal to 1 for boys and 0 for girls.

**Some Legal Applications**

In India, legal necessities for age estimation in this age group include questions regarding criminal liability of an individual (a child <12 years is not, under certain circumstances, as per Indian Penal Code Section 83), employability (work by children <14 years constitutes child labor), status of majority (18 years), and eligibility for marriage. Growth
variations exist for different populations due to dissimilar genetic and environmental effects. Hence, population-specific formulas may need to be applied while estimating age.

**Age Estimation Using Charts Prepared from Population Surveys**
Radiographical evidence of formation of crowns and root completion has been utilized for the same purpose. These charts are based on dental surveys of cross sections of the population and show the progressive states of dental development for each year of age.

**Age Assessment by Examination of the Incremental Pattern of Tooth Formation**
The accuracy of age determination during the early part of the dental developmental period may be increased beyond that available from comparison with standard charts, by the use of a method described by Boyde (1963). The method involves a microscopic examination of the incremental markings found in longitudinal ground sections of the teeth and relies on the identification of the neonatal line in teeth forming at birth. The total number of daily increments will represent the age in days.

**Radiologically Determined Decayed, Missing, and Filled Index Variations for Forensic Age Estimation of Young Adults**
Olze et al. (2006) radiologically determined decayed, missing, and filled (DMF) index variations for forensic age estimation in young adults. They concluded based on orthopantomograms, of variations on the DMF teeth index appears to provide an unsuitable additional criterion for forensic age estimation of young adults. By contrast, the evaluation of single variables does not yield sufficient data to determine with the accuracy required in criminal proceedings whether a person has attained 21 years of age.

**Third Molars in Age Estimation**
Although the third molar is a valuable indicator of age in the age group 16–23 years when all other teeth have completely developed, its accuracy in age estimation is questionable due to.

**Limitations**
Estimation of age by studying tooth emergence, although convenient clinically, has the following limitations:
1. Emergence has varying clinical interpretations
   • Piercing of the gingiva and exposure of the crown
   • Bony emergence through the alveolar bone
   • Attainment of occlusion by the teeth.
2. Exact timing of emergence is often missed
3. They are under the influence of infection, arch space, and premature tooth loss.

**Why Age Estimation**
Age estimation is an important requisite in some judicial proceedings. Age assessment is required in following circumstances such as, asylum seekers of unknown age, young people accused of criminal activities, and convicted criminals whose age is claimed to be <18 years before sentencing Age estimation is also useful for human identification and in determining legal age for criminal responsibility. Both are related to local legal requirements and one can apply that to aging in both human remains and living people.

However, age estimation is a challenging task. Dental surgeon plays a major role in age estimation. The main objective is to obtain the best-standardized method for legal, medical age estimation, which is reproductive, simple and reliable, that we can apply in living and dead.

**Scope for Further Research**
However, several authors have shown that results are less accurate if one compares another population to Demirjian’s standards. 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 this method in different populations worldwide.

**Conclusion**
Determination of dental age is done by reference to the ever-growing human deciduous and permanent dentitions. The importance of age estimation includes an assessment of minor/major status in individuals without legal documents. Demirjian method, the widely used method with appropriate modifications shall be a reliable method.

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**Conflicts of interests**
There are no conflicts of interest.

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