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REVIEW ARTICLE

# Age Determination in Forensic Odontology

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## ABSTRACT

Age determination by means of assessment of the dentition is an application unique to forensic odontology. This process is especially relevant in those cases in which the rest of the skeletal remains are marred, as the tooth remains intact under adverse circumstances while the rest of the skeleton is obliterated. While the process remains complex, multiple methods have been devised to assess the dental age of an individual.


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## INTRODUCTION

Age determination finds its use in various situations, such as identification of unknown individuals, in scenes of crime and accidents, and is also widely used to estimate the chronological age of children of unknown birth records.[1]

In the various other methods available, dental age plays a vital role in the age estimation of the individual. The other methods include skeletal maturation, physical examination using anthropometric measurements, and combination of all these.[2]

The eruption of teeth into the oral cavity is influenced by local factors, such as lack of space and systemic factors, whereas dental maturity is considered as a more accurate indicator of biological maturity in children because it is least affected by the nutritional and endocrine status.[1]

This article will review various methods involved in age determination.

## Dental Age Estimation Methods

Various methods are utilized in determining the age from dentition. Age assessment methods may be classified as follows[3]:

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- According to the state of development of the dentition:
  - Methods applied to the forming dentition
  - Methods for the adults' fully formed dentition
- According to the technique of investigation:
  - Clinical or visual
  - Radiographic
  - Histologic
  - Physical and chemical analysis

### *Clinical or Visual Method*

The most reliable and easiest approach for age estimation would be clinical observation of the stages of eruption of teeth and the degenerative changes in the teeth, such as attrition; abrasion can give approximate age of the patient.[4]

### *Radiographic Method*

Radiography is a simple, noninvasive technique used in forensic odontology for age estimation of living and unknown dead. It gives information about appearance of tooth germs, stages of mineralization, degree of crown completion, and eruption of crown into oral cavity.[5]

### *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.[6]

### *Physical and Chemical Analysis*

The physical and chemical analyses of dental hard tissues to determine alternations in ion levels with age have been proposed.[1] While these techniques, as yet, are of great value to the forensic odontologist, future development might provide an adjunctive means of collecting evidence of value in the dental context.[3]

## Various Factors used for the Age Determination using Dentition[6]

- The appearance of the tooth germs
- Earliest detectable trace of mineralization
- Degree of completion of the unerupted tooth
- Rate of formation of enamel and formation of neonatal line
- Clinical eruption

- Degree of completion of roots of erupted teeth
- Degree of resorption of deciduous teeth
- Attrition of the crown
- Formation of physiologic secondary dentin
- Formation of cementum
- Transparency of root dentin
- Gingival recession
- Root surface resorption
- Discoloration and staining of teeth

## Methods to be Employed in Dental Age Estimation

Age estimation using the dentition can be grouped into three phases[7]:

1. Age estimation in prenatal, neonatal, and early postnatal child
2. Age estimation in children and adolescents
3. Age estimation in adults

### *Age Estimation in Prenatal, Neonatal, and Early Postnatal Child*

Forensic dentist is involved in age determination of the unknown fetus in case of premature birth and abortion specimens. Mineralization of deciduous dentition commences from 6 to 7 weeks intrauterine and with the help of histological methods odontologist can observe the tooth mineralization up to 12 weeks before being detectable by the radiographs.[8] Kraus and Jordan[9] studied the tooth development in 95 fetuses and recorded the chronology of the early stages in the formation of the deciduous dentition. They provided data showing various stages of permineralization and early mineralization of various deciduous teeth and first permanent molar during intrauterine development.[5]

*Age Assessment from the Neonatal Line*: The neonatal line is considered as an indicator of birth. Neonatal lines are incremental growth lines seen in histological sections of both enamel and dentin of deciduous teeth and permanent first molars, which indicate the development during the transitional period between intrauterine and extrauterine environment. So, with the help of prenatal and postnatal neonatal lines, amount of enamel formation can be assessed. These lines are used to estimate the age of the neonates.[6]

*Age Assessment from the Incremental Lines of Retzius*: Incremental lines of Retzius are caused by the variation in the rhythmic mineralization of enamel prisms.[6] These rhythmic patterns may be altered by various external factors, such as metabolic disturbance so that the lines may appear closer or the rest periods may be prolonged.[4]

*Age Assessment from the Weight of the Development of Dentin*: The technique of age estimation by weight of mineralized tooth was developed by STACK.

Developing teeth at 6th month of intrauterine – 60 mg, newborn – 0.5 gm, 6 months after the birth – 1.8 gm.[8]

### *Age Estimation in Children and Adolescents*

Age estimation of children and adolescents depends on the eruption of teeth and the tooth calcification.

*Schour and Massler's Method*: In 1941, Schour and Massler established a numerical developmental chart, which was first attempted at scientific dental age estimation. They studied the development of deciduous and permanent teeth and divided the development of teeth into 21 chronological steps from 4 months of age to 21 years.[10]

*Demirjian Method*: Demirjian et al developed an age estimation method that made use of a scoring system. In this method, developments of seven mandibular teeth on the left side as it appears on the radiograph were divided into 10 stages. For each developmental stage, a different maturity score was given for the tooth.[11]

### *Estimation of Age in Adults*

In the adult dentition, age estimation techniques are limited to the assessment of the progression of wear and age changes in the teeth. So most of the methods used in the adults use various regressive changes of hard and soft tissues of the teeth. Age estimation in adults with use of dentition is less accurate when compared with age estimation in children using dentition.[3]

## MORPHOLOGICAL METHOD

### Gustafson's Method (1950)

In 1950, Gosta Gustafson and in 1944 Thoma developed a method for age estimation based on morphological and histological age-related changes in teeth. They assessed regressive changes, such as[11]

- Amount of occlusal attrition (A)
- Coronal secondary dentin deposition (S)
- Loss of periodontal attachment (P)
- Cementum apposition at the root apex (C)
- Root resorption at the apex (R)

*Method*: In this method each change was scored on a scale of 0 to 4

Age estimation formula:

Age=11.43 + 4.56X (where X is the total score)

The error was ±3.6 years.

### Dalitz Method (1962)

To overcome the errors of Gustafson's method, Dalitz came up with a 5-point system to score the regressive changes.

The results suggested that the factors, such as attrition, periodontitis, secondary dentin deposition, and transparency of the root of the 12 anterior teeth are related to age, whereas the factors, such as root resorption and secondary cementum were discarded to achieve greater accuracy in age estimation.[9]

*Formula used was*: E = 8.691 + 5.146A + 5.338P + 1.866S + 8.411T

Drawback of the method was that it did not take bicuspids and molars into account.

### Bang and Ramm Method

The dentin becomes transparent over time as the dentin tubules narrow, causing a hardening of its tubular structure. This process can begin as early the third decade of life and is not affected by the health of the tooth pupal or by the sex of the individual. In 1970, this concept was used by Bang and Ramm to estimate age. It was found that transparency was first evident at the root apex and moves toward the crown of the tooth. Thus, root transparency as a means of age estimation is used throughout the adult life in the period in which dental eruption cannot provide reliable age estimates and very important when the sex of the individual cannot be determined.[11]

### Biochemical Method

Amino acids which are building blocks exist in two forms – L and D – both are nonsuperimposable images of each other. The protein formation in body is a form of L but by process of racemization it will be converted into D form during life. Aspartic acid is used in age estimation because it undergoes racemization process very fast when compared with other amino acid at body temperature. It has been proven that this method can be used 20 years after the death of the individuals. The presence of enamel caries will slightly affect the results. Thus, the D level of aspartic acid in the human enamel, dentin, and cementum will increase as the age of the individual.[3]

Helfman and Bada first suggested a relationship between dentinal age and the extent of aspartic acid racemization in dentin. This method accuracy is within ±3 years.

Rietz-Timme et al[12] used racemization method in dentinal biopsy specimens in order to estimate the age of living individuals without extraction of teeth.

### Radiographic Methods

The age estimation in adults is difficult and two methods are used to estimate the age of adults[2]:

1. Volume assessment of the teeth
2. Development of third molar

The age estimation in the adult can be assessed by radiographic assessment of the reduction in the size of the pulp cavity due to secondary dentin deposition, i.e., directly proportional to age of the individual.[13]

#### *Pulp to Tooth Ratio Method*

Kvaal et al[10] developed a method in which pulp–tooth ratio was calculated for six maxillary and six mandibular teeth and age was determined using the formula

$$\text{Age} = 129.8 - (316.4 \times m)\ (6.8 \times [W\ L])$$

#### *Coronal Pulp Cavity Index*

This method uses mandibular premolars and molars for the age assessment as mandibular teeth are more visible than the maxillary.

The reduction in the coronal pulp cavity is determined by taking panoramic radiography and measuring the length of tooth crown (CL) and length of coronal pulp cavity (CPCH).The tooth coronal index (TCI) is computed for each tooth with the formula.[5]

$$TCI = \frac{CPCH \times 100}{CL}$$

Yang et al[14] devised a custom-made voxel counting software for calculating the ratio of pulp canal *vs* tooth volume based on cone beam computed tomography (CT) imaging technique.

A total of 28 single-rooted teeth of 19 individuals with known chronological age were scanned by cone beam CT and images were analyzed using the software. Results showed that there was moderate correlation between the pulp/tooth volume ratio and biological age with coefficient of determination of 0.29. This technique is a noninvasive method for age estimation using cone beam CT images in living individuals.[7]

### Third Molar in Age Estimation

As the permanent dentition completes the age of 17 years, the age estimation by radiographical method becomes difficult. But, however, the development of third molar is taken as a guide in age estimation.[6]

*Harris and Nortje Method*: The third molar root development is divided into five stages and each stage is given a mean age and mean length.

*Van Heerden System*: By using radiographs, the development of mesial root is used in age estimation.

*Prosthetic Restorations, Dental Root Fillings, and Periodontal Bone Resorption as a Forensic Odontologic Aid for Determining the Age*: Friedrich et al[15] conducted a study for evaluation of chronological age in teenagers and young adults with the correlation of prosthetic

restoration, dental root fillings, and bone resorption findings on radiographs.[6]

In this method, the panoramic radiographs of 1,053 outpatients within the chorological age of 14 to 24 years were evaluated and above factors were recorded for each tooth and data were analyzed using statistical tools.

The correlation between the number of prosthetically restored teeth and the chorological age of 18 years proved to be very high.

The correlation between endodontically treated teeth was less with that of the chronological age.

The determination of periodontal bone loss gave reasonable positive predictive value for chronological age of 18 years or more.

## CONCLUSION

Age estimation presents a complex problem and requires considerable experience in recognizing significant changes and allowing for their variability within any population. With the multiple methods available, if done accurately, dental age estimation could help bringing about a breakthrough in forensics when the other options seem desolate.

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