Teeth as age estimation tool in children and adolescents

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Abstract

Age is an important factor in clinical practice, research, and court of law. One of the interesting applications of forensic odontology is age estimation by means of teeth. Dental development is relatively independent from other systems maturation. Detectable variation in the tempo of tooth mineralization and duration of tooth maturation between children from different geographical regions were reported. Age estimation from teeth by radiological analysis in both children and adolescents has wide applications in several scientific and forensic fields. In 2006, Cameriere et al. proposed a method to estimate chronological age in children, according to measurements of open apices of permanent teeth. The techniques are categorized in morphological, radiological, and biochemical. To reach to reliable estimation different techniques should be used as and repeated measurements should be made. In humans, age determination is done for various reasons. Age determination of cadavers is carried out in victims of mass disasters such as fires, crashes, accidents, homicides, feticides, and infanticides. In living person, the age estimation is done to assess whether the child has attained the age of criminal responsibility such as rape, kidnapping, employment, marriage, premature births, adoption, illegal immigration, pediatric endocrinopathy, and orthodontic malocclusion, and when the birth certificate is not available and records are suspect for reasons such as criminal cases.

Introduction

Since ages, teeth have been the mode of identification of unknown persons, estimating age for forensic, and other scientific purposes.[1] In 19th century, Edwin Saunders was the first one to present a paper in British Parliament suggesting that teeth can be used for age estimation.[2] Many odontological methods have been carried out in age estimation, assessment of eruption phases within acceptable error limits. On the whole, these methods define the stage of mineralization of teeth observed in radiographs. Demirijan et al. published a method in 1973 which is most commonly used for age estimation and subsequently modified by other authors.[3] The identification of children and adolescent age becomes important to assess whether the child has attained the age of criminal responsibility such as rape, employment, marriage, and adoption, and when the birth certificate is not available and records are suspect for reasons such as criminal cases.[4]

Discussion

Various methods are used for age estimation from dentition. These are divided into four categories,[5]

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

Clinical/visual methods

In this method, observation of erupted teeth, its stage of eruption and physical characteristics are considered. For age estimation following entities is considered.

Age is estimated depending on presence of teeth
Schour and massler modified kronfeld’s table which gives long history of development and chronology of the growth of human teeth. Given in Table 1.

Depending on 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 help in differentiating primary or permanent dentition.[7]

Gorea et al. conducted a study which correlates the prevalence of the mamelons with age, sex, and occlusal relationship. They found more mamelons present in the first decade of life and decreases with
Table 1: Estimation of age by chronology of eruption given by Masseler and Scholer(1941)[6]

<table>
<thead>
<tr>
<th>Dentition</th>
<th>Tooth</th>
<th>Eruption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary (upper)</td>
<td>i1</td>
<td>10 (8-12)</td>
</tr>
<tr>
<td></td>
<td>i2</td>
<td>11 (9-13)</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>19 (16-22)</td>
</tr>
<tr>
<td></td>
<td>m1</td>
<td>16 (13-19)</td>
</tr>
<tr>
<td></td>
<td>m2</td>
<td>29 (25-33)</td>
</tr>
<tr>
<td>Primary (lower)</td>
<td>i1</td>
<td>8 (6-10)</td>
</tr>
<tr>
<td></td>
<td>i2</td>
<td>13 (10-16)</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>20 (17-23)</td>
</tr>
<tr>
<td></td>
<td>m1</td>
<td>16 (14-18)</td>
</tr>
<tr>
<td></td>
<td>m2</td>
<td>27 (23-31)</td>
</tr>
<tr>
<td>Permanent (upper)</td>
<td>i1</td>
<td>7-8 year</td>
</tr>
<tr>
<td></td>
<td>i2</td>
<td>8-9 year</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>11-12 year</td>
</tr>
<tr>
<td></td>
<td>P1</td>
<td>10-11 year</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>10-12 year</td>
</tr>
<tr>
<td></td>
<td>M1</td>
<td>6-7 year</td>
</tr>
<tr>
<td></td>
<td>M2</td>
<td>12-13 year</td>
</tr>
<tr>
<td></td>
<td>M3</td>
<td>17-21 year</td>
</tr>
<tr>
<td>Permanent (lower)</td>
<td>i1</td>
<td>6-7 year</td>
</tr>
<tr>
<td></td>
<td>i2</td>
<td>7-8 year</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>9-10 year</td>
</tr>
<tr>
<td></td>
<td>P1</td>
<td>10-12 year</td>
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<tr>
<td></td>
<td>P2</td>
<td>11-12 year</td>
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<tr>
<td></td>
<td>M1</td>
<td>6-7 year</td>
</tr>
<tr>
<td></td>
<td>M2</td>
<td>11-13 year</td>
</tr>
<tr>
<td></td>
<td>M3</td>
<td>17-21 year</td>
</tr>
</tbody>
</table>

Increasing age. They are more prominent in permanent maxillary central incisor and persists more in females than males.[7]

Depending on color of the teeth present in the oral cavity
Dental color is the important morphological feature which can be of great significance in dental age estimation.

The study conducted by Vivek et al. considered the color of enamel and matched with shade guide. They found that color of the enamel is associated with chronological age. The enamel shade changed from reddish to grayish with age and no variation among the genders were observed.[8]

Devos et al. conducted a study using spectrophotometer in determining tooth color. Apart from its shortcomings, the shade-matching system was considered as a convenient adjunct to dental age estimation in both living and dead.[9]

Martin de et al. found that dentinal colors white, cream, and yellow were associated with age 12-37 years.[10]

Radiographic Method[2]

Radiographic assessment of teeth plays an important role in age estimation. It is simple, non-invasive, and reproducible method. It can be used both for in-vivo and in-vitro methods. The archives of radiological images can also be used for age estimation.

The radiographic images which can be used for age estimation are:
- IOPA
- Lateral oblique
- Cephalometric radiograph
- Panoramic or other advanced imaging techniques.

The following factors are considered for age determination in children and adolescents
1. Jaw bones
2. Appearance of tooth germs
3. Earliest detectable trace of mineralization or beginning of mineralization
4. Degree of crown completion
5. Eruption of the crown into the oral cavity
6. Degree of root completion of erupted or unerupted teeth
7. Measurement of open apices in teeth
8. Third molar development and topography.

Radiographic Method

Schour and Masseler (1941) studied the development of deciduous and permanent teeth, describing 21 chronological steps from 4 months to 21 years of age and published numerical chart.[11]

Nolla’s method (1960) - according to this method age was evaluated based on mineralization. This method divided permanent dentition into 10 stages. Advantages of this method are it can be applied with or without the third molar and genders are dealt separately.[12]

Cameriere method[2] - previous two methods considered chronology and stage of mineralization for age determination. Various studies were conducted using measurement of open apices for age estimation, among them Cameriere method is very popular.

According to Cameriere method age is estimated using following formula:

\[
\text{Age} = 8.971 + 0.375 + 1.631 \times 5 + \text{No}\]

where:
- No = Apex completely closed
- A = Open apex with some of distance between inner sides
- L = For multirooted teeth
- A/length of the tooth
- S = The distal maturity was calculated as the sum of

Table 1: Estimation of age by chronology of eruption given by Masseler and Scholer(1941)[6]
remineralized open apices and the number of teeth with root development complete.

\[ G = g \]

where 1 is for boys and 0 is for girls.

In a study conducted by Shrestha et al., a Cameriere method was applied in subcontinental and it was validated. This method can be accurately used for children and adolescents in age estimation.\(^\text{[3]}\)

Demirjian et al.\(^\text{[3]}\) - this method was formulated considering Tanner et al. study. They considered maturity of hands and wrists for estimation of chronological age. In this method, 8 stages of maturity scores for teeth were evaluated and assigned a score. They have considered 7 mandibular teeth on the left side. The final score or average sum should be 100 for all the teeth. Later on, this method was modified in 1976 into 3 more methods by Demirjian.

**Histological Methods**

This method can be used as in-vitro method when it requires preparation time for microscopic examination. Based on microscopic findings, an accurate age can be determined. This technique is applicable for post-morbidity and postmortem changes.\(^\text{[5]}\)

The following histological factors can be considered for age estimation in children and adolescents.

**Neonatal line in enamel and dentin**

Neonatal line is considered as an indicator of birth. Miles (1958) estimated the age by measuring the thickness of enamel and dentin from the neonatal line and divided it by daily rate of formation.\(^\text{[14]}\)

**Incremental lines of Retzius**

Lines of Retzius are caused by disturbance in the rhythmic mineralization of enamel prisms causing lines to appear closer or prolonged rest periods.\(^\text{[10]}\)

**Incremental lines of Von Ebner and contour lines of Owen**

These two incremental lines are present in dentin and so far these are considered only in neonatal studies.\(^\text{[10]}\)

Boyle (1963) did a study by considering the incremental lines. Beginning from the neonatal line, the numbers of small incremental lines counted till the edge of the forming enamel front.\(^\text{[10]}\) Ultrastructural methods can also be used in age estimation by observing pritubular/intratubular dentin.\(^\text{[10]}\)

Further studies are required to elucidate the importance of these histological structures.

**Physical and Chemical Methods**\(^\text{[2,5]}\)

Formation of tooth involves continuous deposition of ions at different ages. Hence, alteration in the ion levels can be used for age estimation by physical and chemical methods. Various methods employed are:

**Herfman and Bada methods (1975, 1976)**

Their study focused on racemization of amino acids. They found a significant correlation between age and ratio of D-/l-enantiomers in aspartic acid in enamel and coronal dentin.

**Ritz et al. method (1995)**

They estimated the age of living individual using recimization method in dentinal biopsy specimens. This method emerged as a in-vivo technique.

**Conclusion**

Age estimation from human teeth is well recognized. Formation of teeth is extensively used to assess maturity and predict age. This information helps in diagnosis and treatment planning in clinical as well as in forensic dentistry. Studies have revealed that it is important to create a database for dental maturity for every population and compare it to others. It is also important in India as more and more child and adolescent abuse cases being reported. Their accurate age estimation becomes forensic odontologist prerogative. This can be applied in various condition of Indian judiciary till Indian population specific studies are developed.

**References**

10. Shruti DN, George R, Shenoy A, Shivapathasundaram B.