Dental age assessment in children and adolescents

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Abstract
Dental age estimation is an important part of Forensic Odontology. Dental age is considered to be important as dental development and mineralization show less variability than other developmental features and has low variability in relation to chronological age. Dental development is more reliable as an indicator of biological maturity in children and less effected by nutritional and hormonal changes. UN convention on the Rights of the Child (1989) and section 55 of the Borders Citizenship and Immigration Act 2009 defined "Child" as a person under the age of 18 (eighteen) years. Indian Juvenile Justice (Care and Protection of Children) Act, 2000 designates an individual who has not attained the age of 18 years as juvenile. Dental age estimation in children is required for various reasons viz. children of refugees who doesn't possess proper birth certificates, asylum seeker, victims and suspects of crime, identification of mutilated bodies, criminal liability, child labor etc. This paper reviews the various methods to determine the dental age in children.

Introduction

In 19th century, the idea of using teeth for age estimation originated in England during industrial revolution. Edwin Saunders (1837) was the first dentist who presented the dental implication in age assessment entitled "Teeth A Test of Age" to the English parliament (1). Dental age estimation in children and adolescent is based on the time of emergence of the tooth in the oral cavity and the tooth calcification. Many studies have concluded that the tooth formation is a more reliable indicator of dental maturity than gingival emergence or eruption.

Need for age estimation (2) (3) (4) (5): The application of dental age estimation is manifold-

1. For the purpose of identification of mutilated body of the victim.
2. For age estimation of refugee children not having proper birth documentation.
3. For anthropological study.
4. For treatment planning of various dental and skeletal abnormalities.
5. Medico-legal issues.

Some legal applications in India are (4) (5) (6).
1. Minimum age for criminal responsibility –In India a child below the age of 12 is not held for criminal liability as per IPC Sec.83

2. Minimum age for employability- Work by children below 14 years of age constitutes child labour.
3. Status of majority: It is attained at the age of 18 years.
4. Legal permissible age for marriage for boys is 21 years and for girls is 18 years.

Methods of dental age estimation in children and adolescents. -
1. **Visual Method**: It is based on the sequence of eruption of the teeth. Tooth eruption is considered first as the incisal/occlusal tip of tooth piercing the gingiva to be clinically visible in the mouth. Eruption of teeth is affected by climate, race, diet and geographical factors. Townsend and Hamell (1990) showed that the dental eruption sequence in children, i.e. number of teeth present in mouth is independent of environmental factors and can result in precise and accurate dental age estimation than height measurement. From primary teeth, dental age can be estimated from 6 months to 33 months. There is no evidence of tooth eruption

from age 2.5 to 6 years. From permanent teeth, age can be estimated from 6 years to 14 years and third molar shows the most variation in the eruption from 16 years to 23 years (7) (8) (9). This method is less reliable than radiographic method.

2. **Radiographic Method**: There are three methods used—
   (I) Atlas method: In this the dental development is compared with established standardized dental development charts corresponding to chronological age.
   (II) Scoring Method: In this the dental development is divided into various stages and given individual scores to determine dental age by statistically derived formulae.
   (III) Measurement method: The measurement of length of crown and roots of third molar especially; and width of open apices are used in dental age estimation.

(I) **Atlas method**- includes-
   A) **Schour and Masseler method**: Schour and Masseler (1941) studied the development of deciduous and permanent teeth, describing 21 diagrams from 5 months in utero to 35 years of age and published the numerical development charts for them. These charts do not have separate surveys for males and females. **Kahl and Schwarze** (1988) updated Schour and Masseler's atlas using 993 radiographs of children and produced charts for separate sex for each age (10).
   B) **Ubelaker's Atlas** (1978): Ubelaker's atlas of dental formation and eruption among American Indians was compiled from a variety of sources, because some studies suggest that teeth probably form and erupt earlier among Indians.
   C) **London Atlas** (2010): Al Qahtani et al (2010) developed a comprehensive evidence based atlas to estimate age using both tooth development and alveolar eruption for human individuals between 28 weeks in-utero and 23 years. This study is based on the examination of the developing teeth from 72 prenatal and 104 postnatal skeletal remains of known age at death at Royal college of Surgeons of England and Natural History Museum, London, UK. This atlas covers as much of the developing dentition as possible and all ages are represented. Developmental stages are illustrated as radiographic representation and clarified by the addition of written description (11).

(II) **Scoring methods** includes-
   A) **Nolla's Method**: C.M. Nolla (1960) 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. It is reliable method as girls and boys are dealt separately (12).
   B) **Moorees method**: Moorees et al (1963) studied the developmental stages in the 14 stages of mineralization for developing single and multi-rooted. Permanent teeth and the mean age for the corresponding stage were determined (13).
   C) **Demirjian method**: Demirjian et al (1973) introduced a method which estimated dental age based on the development stages of seven teeth (excluding third molar) from left side of the mandible of French Canadian children. They used the stages, usually been marked by recognizable tooth shapes, from the beginning of calcification to final mature form. The formation stages of the teeth are assessed, the individual score for each of seven stages are summed and this is converted to a single dental age by comparing to tables of dental maturity scores for boys and girls separately. This system is applicable from ages 3 to 17. **Chaillet and Demirjian (2004)** modified this method and included third molar. The previous Demirjian's 8 developmental stages were numbered 2-9 and stage 0 and stage 1 were added and called crypt stage, it represents the stage when crypt is

visible without dental germ in it. Now there are 10 stages for each tooth (0-9). Each stage is given a gender specific biologically weighted score. The sum of scores for all teeth is calculated and is converted in dental age using appropriate tables of percentiles, which were derived by using fifth degree polynomial interpolation. Acharya (2011) has developed India-specific regression formula based on Demirjian's 8 teeth method which gave better age estimates (14) (15) (16).

D) **Haavikko method**: Haaviko (1974) studied 1162 Finnish children's radiograph 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 taken to determine dental age (17).

E) **Willem's method** (2001): This was based on a study on Belgian Caucasian population and formed new tables for the dental maturity for boys and girls. The dental 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 reduction in overestimation of age (18).

(III)   Measurement Method:

a) **Open apices method** (19,20): Cameriere et al (2006) derived a formula for dental age estimation in children based on relationship between age and measurement of open apices in teeth. The seven left mandibular teeth are used to calculate dental age. The number of teeth with complete root formation and closed apical end are noted as N_0. In the teeth with open apex, the distance between the inner side of open apex is measured [A]. For the teeth with the 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/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 number of teeth with root development complete [N_0]. The values are substituted in the following regression formula for age estimation.

Age= $8.971+0.375g+1.631x5+0.674 N_0 -1.034s-0.176$ s. N_0

Many authors have found Cameriere's method with modification to be the most accurate method of age estimation. However, a regression model for different population is required for accurate estimation. Balwant Rai et al (2010) evaluated Cameriere's method and yielded specific formula by linear regression for Indian population.

Age = $9.402 - 0.879C + 0.663 N_0 - 0.711s – 0.106$ s N_0

Where C is a dummy variable equal to 0 for the centre or north of India and 1 for the south.

b) **Harris and Nortje method (**1984**)**: The age assessment is difficult after 17 years of age. They have given five stages of third molar root development with corresponding mean ages and mean length (21).

c) **Van Heerden system**: The development of the mesial root of the third molar was assessed to determine the age using panoramic radiograph (22).

Determination of juvenile/adult status: Bhowmik et al (2013): assessed Belgian formulae in determining minor/major status in Indians by third molar development and suggested that this formula is valid in age estimation in Indian context, but it should be used carefully and judiciously. **Acharya et al** (2014) reported reliable success in determining the juvenile/adult status in Indian population by using Kohler's

grading for third molar and logistic regression formulae (23) (24).

Conclusion

The notion behind any method of age estimation is to compare the physical development and maturity with the age. There are biological variations and uncertainty associated with age estimation. Therefore, combination of various methods provides reliable age estimation. There is no single method which can precisely estimate an individual's age. Considering the acceptance of level of error rates, more reliable method is to be found to be within maximum acceptable limit and validity.

References

1. Saunder E. The teeth a test of a age. The Lancet 1838;30(774):492-496.
2. Kumar CL, Srdhar MS. Estimation of the age of an individual based on time of eruption of permanent teeth. Forensic Sci Int 1990;48:1-7.
3. Smith T, Brownlees L. Age assessment practices: A literature review & annotated bibliography. New York: United Nations Children's Fund (UNICEF);2011.https://www.unicef.org accessed on 22/12/2018
4. Franklin D, Flavel A, Noble J, Swift L, Karkhanis S. Forensic age estimation in living individuals: methodological consideration in the context of medicolegal practice. Research and reports in forensic medical science 2015;5:53-66
5. Jayaraman J, Roberts GJ, Wong HM, McDonald F, King NM. Ages of legal importance: Implications in relation to birth regulation and age assessment practices. Medicine, Science and the Law 2016;56(1):77-82.
6. Adenwalla M. Child rights and law: a guidebook for legal interventions 2002 https://www.childlineindia.org.in>pdf Accessed on 22/12/2018.
7. Singh K, Gorea RK, Bharti V. Age estimation from eruption of temporary teeth. JIAFM 2004;26(3):107-109.
8. Townsend N, Hammel EA.Age estimation from the number of teeth erupted in young children.An aid to demographic surveys. Demography 1990;27(1):165-174.
9. Foti B,Lalys L, Adalian P, Giustiniani J, Maczel M, Signoli M, Dutour O, Leonetti G. New forensic approach to age determination in children based on tooth eruption. Forensic Sci International 2003;132:49-56.
10. Kahl B, Schwarze CW. Updating of the dentition tables of I. Schour and M. Massler of 1941. Fortschritte der Kieferorthopadre 1988;49(5):432-43.
11. AlQahatani SJ, Hector MP, Liversidge HM. Brief communication: The London Atlas of human tooth development and eruption. American Journal of Physical Anthropology 2010;142:481-490.
12. Nolla CM. The development of the permanent teeth.J Dent Child.1960;27:254-266.
13. Moorrees CFA,Fanning EA, Hunt jr EE. Age variations of formation stages for ten permanent teeth.J Dent Res 1963;42:1490-1502.
14. Chaillet N, Demirjian A. Dental maturity in South France: A comparison between Demirjian's method and polynomial functions. J Forensic Sci 2004;49(5):1-8.
15. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Human Biology 1973;45(2):211-27.
16. Acharya AB, Age estimation in Indians using Demirjian's 8-teeth method. J Forensic Sci 2011;56(1):124-127.
17. Haavikko K.Tooth formation age estimated on a few selected teeth.A simple method for clinical use. Proc.Finn.Dent. Soc.1974;70:15-19
18. Gunst K, Mesotten K, Carbonez A, Willems G. Third molar root development in relation to chronological age: a large sample sized retrospective study. Forensic Sci International 2003;136:52-57
19. Cameriere R, Ferrante L, Cingolani M. Age estimation in children by measurement of open apices in teeth. Int J Legal Med 2006;120:49-52
20. Rai B, Kaur J, Cingolani M, Ferrante L, Cameriere R. Age estimation in children by measurement of open apices in teeth: an Indian formula. Int J Legal Med 2010;124:237-241.
21. Harris MJ, Nortje CJ. The mesial root of the third mandibular molar: A possible indicator of age. J Forensic Odontostomatol 1984;2(2):39-43.
22. Van Heerden PJ.The mesial root of the third mandibular molar as a possible indicator of age. Dissertation for diploma in Forensic Odontology, London Hospital Medical College,1985.
23. Acharya AB, Bhowmick B, Naikmasur VG. Accuracy of identifying juvenile/adult status from third molar development using prediction probabilities derived from logistic regression analysis. J Forensic Sci 2014;59(3):665-670.
24. Bhowmik B, Acharya AB, Naikmasur VG.The usefulness of Belgian formulae in third molar-based age assessment of Indians. Forensic Sci Int 2013;226: 300.e1-300.e5.