Indian Internet Journal of Forensic Medicine & Toxicology
Vol. 11, No. 2 April-June 2013, 41-46
DOI : 10.5958/j.0974-4487.11.2.009

Brief Review

Age Estimation from Newer Radiographic Methods in Developing and Adult Dentition: Methods and Historical Review

B Viswakanth[1]*, VT Venkatesha[2], P Shruthi[1], NC Shreedhar[3], Senthil Kumar[1]

[1]Post Graduate, [2]Professor, Department of Forensic Medicine and Toxicology, Kempegowda Institute of Medical Sciences, Bangalore, Karnataka-560070, India
[3]Assistant Professor, Department of Forensic Medicine and Toxicology, Srinivas Institute of Medical Sciences and Research Centre, Mangalore, Karnataka, India

*E-mail id: drviswakanth@gmail.com

ABSTRACT

In clinical forensic medicine, age estimation plays a key role to answer the status of majority and criminal liability. The preferred dental radiographic method by a forensic expert is the lateral view of lower jaw and age is estimated based on the development/ calcification of the tooth crown and roots. This, however, is a method without intermediate grading and through this article, we make an attempt to highlight other dental radiographic methods (Demirjians 8-teeth method and Pulp-Tooth Area Ratio), which when used in combination with conventional methods may help the expert to estimate age more accurately.

Keywords: Forensic odontology, Age estimation, Demirjian's method, Pulp-Tooth area Ratio, India

INTRODUCTION

Forensic age estimation is important in clarifying issues pertaining to unknown or disputed ages of living individuals.

eeth are considered to be a reliable indicator of age and provide a number of parameters for age prediction. While traditional methods of adult dental age estimation require tooth extraction and processing, radiographic methods require neither extraction nor processing[1].

In clinical forensic practice, the most common dental radiograph used by the expert in estimating age is a lateral view of the lower jaw. Further comment is made depending on the development/calcification of the crown and roots of teeth. For instance, if the crown is formed inside the alveolar space-well developed/not well developed; similarly, if roots have appeared/calcified - well developed/not well developed[2]. This method thereby lacks intermediate grading and, moreover, age can be estimated only up to 22 years based on the calcified roots of 3rd molar[3]. The International Organisation for Forensic Odonto-stomatology recommends to use as many appropriate parameters as possible in dental age estimation and make reference to the methods used[4].

Two such methods are discussed below (Demirjians 8-teeth method and Pulp-Tooth Area Ratio), which have gained popularity due to their simplicity in evaluation and less inter-observer variations[5].

AGE ESTIMATION USING DEMIRJIANS 8-TEETH METHOD IN DEVELOPING DENTITION

Historical Perspective

In 1973, Demirjian *et al*. put forth a method of age prediction, which utilised seven mandibular teeth on the left side on an orthopantamogram (Figure 1)[6]. This technique has been widely applied but revealed variations in age estimates in Indian population[7,8,9]. In 2004, Chaillet and Demirjian[10] the 3rd molar and published regression formulas for age estimation. This revised method and formulas were tested by Acharya *et al*. on an Indian sample and developed India-specific formulas, which could predict age accurately[11].

Figure 1

Method

The method makes use of mandibular permanent teeth on the left side-from the central incisor to the 3rd molar. If any tooth is missing on the left side, the corresponding right-side tooth may be utilised.

The radiograph is compared to the 'Tooth Developmental Chart' (Figure 2), each tooth is assigned any one of ten developmental stages (0, 1, 2, 3, 4, 5, 6, 7, 8 or 9). Tooth development is a continuous process and teeth on the radiograph may not always match those on the developmental chart. To simplify comparison, the developmental stages are defined by certain criteria. Each developmental stage may have one, two or three criteria marked (a), (b) and (c).

1. If only one criterion is given, this must be observed on the radiograph in order to select the stage.
2. If two criteria are given, the first one must be observed on the radiograph in order to select the stage.
3. If three criteria are given, the first two of them must be observed on the radiograph in order to select the stage.

In borderline cases, the earlier stage is always considered.

Developmental Stage 0

(a) Dental calcification has not yet begun.

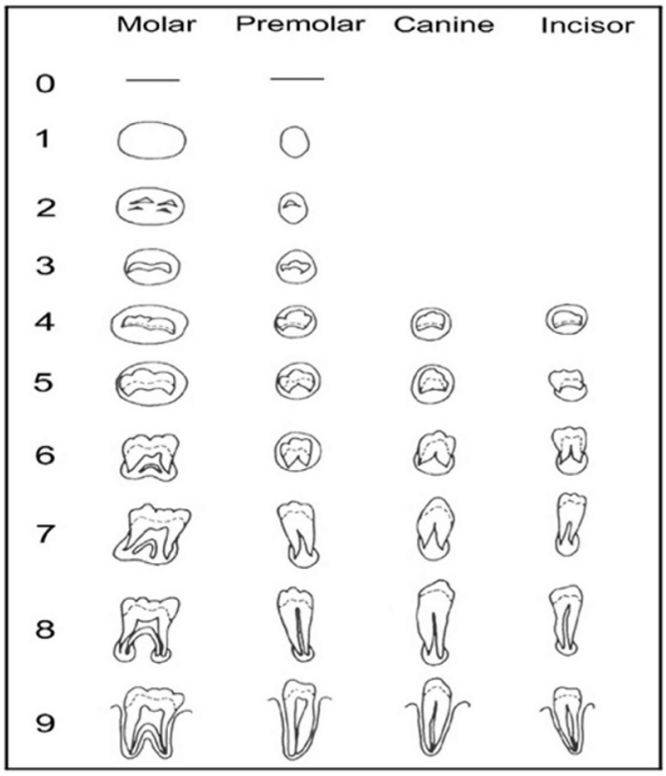

Figure 2

Developmental Stage 1

(a) The bone crypt has formed, but no sign of tooth germ.

Developmental Stage 2

(a) In both uniradicular and multiradicular teeth, a beginning of calcification is seen at the superior level of the crypt, in the form of inverted cone or cones. There is no fusion of these calcified points.

Developmental Stage 3

(a) Fusion of the calcified points forms one or several cusps, which unite to give a regularly outlined occlusal outline.

Developmental Stage 4

(a) Enamel formation is complete at the occlusal surface. Its extension and convergence towards the cervical region is seen.

(b) The beginning of dentinal deposit is seen.

(c) The outline of the pulp chamber has a curved shape at the occlusal border.

Developmental Stage 5

(a) The crown formation is completed down to the cemento-enamel junction.

(b) The superior border of the pulp chamber in uniradicualr teeth has definite curved form, being concave towards the cervical region. The projection of the pulp horns, if present, gives an outline like an umbrella top. In molars, the pulp chamber has a trapezoidal form.

(c) Beginning of root formation is seen in the form of a spicule.

Developmental Stage 6

Uniradicular teeth

(a) The walls of the pulp chamber now form straight lines, whose continuity is broken by the presence of the pulp horn, which is larger than in the previous stage.

(b) The root length reaches at least one-third of the crown height.

Multiradicular teeth

(a) Initial formation of the radicular bifurcation is seen in the form of either a calcified point or semi-lunar shape.

(b) The root length reaches at least one-third of the crown height.

Developmental Stage 7

Uniradicular teeth

(a) The walls of the pulp chamber now form a more or less isosceles triangle. The apex ends in a funnel shape.

(b) The root length is equal to or greater than the crown height.

Multiradicular teeth

(a) The calcified region of the bifurcation has developed further down from its semi-lunar stage to give roots a more definite and distinct outline, with funnel-shaped endings.

(b) The root length is equal to or greater than the crown height.

Developmental Stage 8

(a) The walls of the root canal are now parallel (distal root in molars).

(b) The apical ends of the root canals are still partially open (distal root in molars).

Developmental Stage 9

(a) The apical end of the root canal is completely closed (distal root in molars).

(b) The periodontal membrane has a uniform width around the root and apex.

Corresponding to the selected Developmental Stage, each tooth is given a numerical score (refer 'Scoring Table' on next page). Eight numerical scores are obtained (one score for each tooth). These scores are added to obtain a total maturity score. This total score is usually between 0 and 100. The total maturity score (S) is then substituted in the following formula to derive the age.

Existing Formula for Age Estimation (based on tooth development of French children reported by Chaillet and Demirjian):

1. For males, Age = (0.000055 x S3) – (0.0095 x S2) + (0.6479 x S) – 8.4583

(Confidence intervals: 95% = ±1.73 years; 99% = ±2.28 years)

2. For females, Age = (0.0000615 x S3) – (0.0106 x S2) + (0.6997 x S) – 9.3178

(Confidence intervals: 95% = ±2.01 years; 99% = ±2.65 years)[10]

Indian Formulas for Age Estimation[11]

1. For males, Age = 27.4351 – (0.0097 x S2) + (0.000089 x S3)

2. For females, Age = 23.7288 – (0.0088 x S2) + (0.000085 x S3)

Scoring table for females

Stage	31	32	33	34	35	36	37	38
0								6.40
1							2.57	7.74
2					2.43			8.92
3				2.56	3.43		2.65	9.31
4			2.55	3.54	3.83		4.10	10.22
5	2.58	2.65	3.15	5.09	5.75	2.58	6.51	11.04
6	3.10	4.54	5.40	6.31	6.81	3.25	8.00	12.65
7	5.02	5.40	7.19	8.09	8.70	4.25	9.13	13.77
8	6.66	7.02	9.22	9.82	10.80	6.88	11.00	14.45
9	10.61	10.89	11.99	12.29	12.79	10.94	13.84	16.65

Scoring table for males

Stage	31	32	33	34	35	36	37	38
0							1.70	6.19
1					1.69		2.98	7.64
2				1.70	2.27		3.41	8.28
3			1.70	1.98	3.41		4.74	8.86
4			2.67	3.52	3.41		4.88	9.89
5	2.31	2.55	4.34	5.19	5.59	2.13	6.69	11.17
6	4.35	4.71	6.14	6.47	6.96	3.73	7.89	12.25
7	5.16	5.75	7.59	8.18	8.68	4.94	9.08	13.66
8	6.56	6.97	9.52	9.84	10.64	7.00	11.13	14.07
9	10.68	10.91	12.56	12.57	13.11	11.22	13.63	15.32

PULP-TOOTH AREA RATIO METHOD

Historical Perspective

In 1995, Kvaal *et al*. indirectly measured secondary dentin deposition (Pulp radiolucency) using peri-apical radiographs and correlated age. They selected mandibular lateral incisors, canines and first premolars and maxillary central and lateral incisors and second premolars (from either jaw) as their preliminary study with these teeth strongly correlated with age. They also proposed a number of length and width measurements of the tooth and pulp which are shown in Figure 3.

a. Pulp-Root length (P)

b. Pulp-Tooth length (R)

c. Tooth-Root length (T)

d. Pulp-Root width at CEJ (A)

e. Pulp-Root width at mid root Level (C)

f. Pulp-Root width at mid-point between C and A (B)

g. Mean value of all ratios excluding T (M)

h. Mean value of width ratios B&C (W)

i. Mean value of length ratios P and R (L)

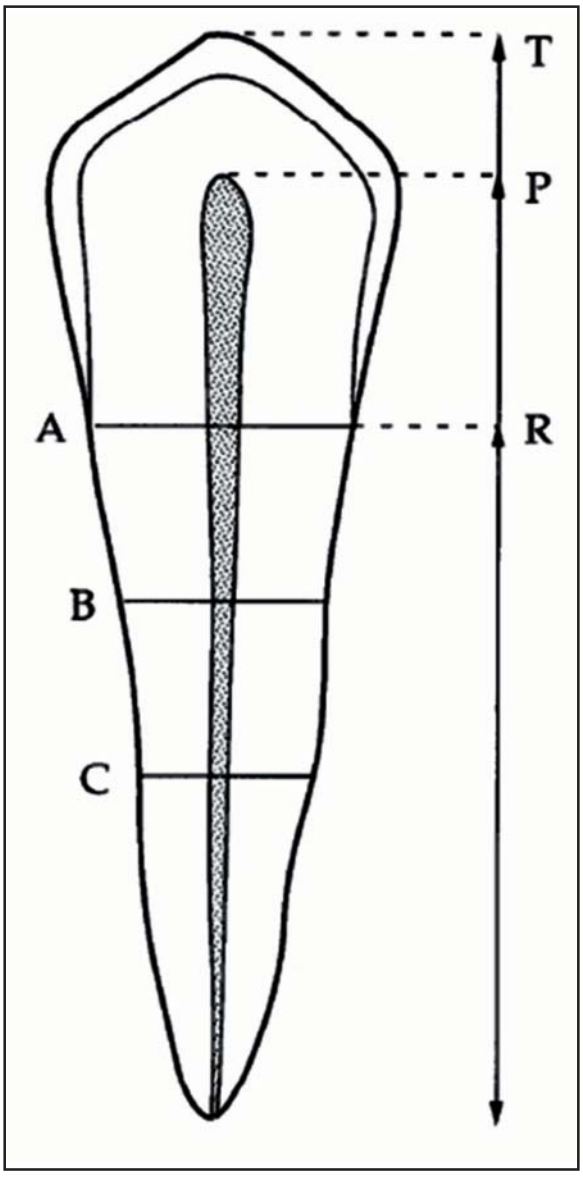

Figure 3: Diagram showing the measurements made on the radiographs of each tooth. T, maximum tooth length; R, root length on the mesial surface; P, maximum pulp length; A, root and pulp width at enamel-cementum junction (ECJ); B, root and pulp width midway between measurement levels A and C; C, root and pulp width midway between apex and ECJ.

These measurements were calculated using a computer and special software programme and put forward the regression formula: **Age = 129.8-316.4 (M) – 66.8 (W-L).** However, they concluded that this method needed further investigation[12].

In 2011, Acharya *et al*. investigated this method on an Indian sample and developed India-specific formulas with slight modification in the materials and methods used. Briefly, radiographs were saved as high-resolution JPEG files on a computer and imported to Adobe Photoshop CS2 image-editing software programme (Adobe Systems Inc., Mountain View, CA, USA) wherein the teeth's long axes were aligned vertically using the measure tool. A number of horizontal reference lines were marked at specific intervals along the length of the tooth, after which the images were once again saved as high-resolution JPEG files. Next, on an AutoCAD 2004 software programme (Autodesk Inc., San Rafael, CA, USA), the pulp and tooth areas were measured using the point and line tools on the Draw toolbox and the pulp/tooth area ratio (PTR). Through their statistical analysis they put forward **India-specific regression formulas as follows**[13]:

Regression coefficients and formulae for the lateral incisor, first premolar (PM1) and various tooth combinations[13].

Tooth/tooth combination	Regression equation	Standard Error (+/-)
Lateral incisor	Age = 60.703 + (-184.286 x PTR)	12.28
Canine	Age = 55.888 + (-144.466 x PTR)	13.08
First premolar	Age = 58.441 + (-169.436 x PTR)	12.45
All three teeth	Age = 68.014 + (-36.743 x PTRC) + (-92.949 x PTRPM1) + (-128.898 x PTRLI)	12.22
Lateral incisor + Canine	Age = 66.493 + (-71.21 x PTRC) + (-170.755 x PTRLI)	12.31
Lateral incisor + first premolar	Age = 65.381 + (-100.579 x PTRPM1) + (-131.906 x PTRLI)	12.13
Canine+first premolar	Age = 62.767 + (-56.945 x PTRC) + (-155.177 x PTRPM1)	12.52

DISCUSSION

Age is one of the essential factors in establishing the identity of a person. Estimation of the human age is a procedure adopted by anthropologists, archaeologists and forensic scientists[14,15]. Forensic odontology is an important branch of the study of dentistry that would assist in solving cases of abuses and deaths. A study was conducted among the dental practitioners of Chennai to assess their awareness about forensic odontology. The results show that the knowledge of forensic odontology among the dental practitioners is not adequate[16]. Greater knowledge and awareness of forensic odontology among the forensic experts would be required in the growing field of medicine as the need for forensic experts has increased greatly over the last decades due to the unprecedented demand from the criminal justice system[17,18].

It is vital that a person interested in forensic odontology be properly educated and trained[19,20]. However, the application of this special knowledge and skill in the field of forensics is minimal in India[21]. Forensic odontology is now an upcoming speciality branch for dental practitioners and it would take a considerable time in India to have specialised forensic odontology experts. At this juncture, there is a need for the experts who are specialised in forensic medicine to keep themselves updated with newer techniques being researched and developed in the field of odontology.

CONCLUSION

Accurate age estimation is essential in forensic practice. This requires implementation of various methods such as physical, dental and radiological examination. Pertaining to newer dental radiographic techniques for age estimation, there is a certain need to use these methods as it would help the expert to estimate age more accurately. In addition, the expert must keep himself updated by subscribing to scientific journals and papers on recent developments in odontology, attend conferences and workshops to enrich their knowledge in forensic odontology.

Conflict of Interest: None

Source of Support: None

REFERENCES

1. Johanson G. Age determination from teeth. Odontologisk Revy 1971; 22(21 Suppl): 1-126.

2. Govindiah D. Forensic Radiology Made Easy, 2nd edn; pp-39-46.

3. Reddy KSN. The essentials of forensic medicine and toxicology, 31st edn Om Sai Graphics, Hyderabad 2012; p-62.

4. International Organisation for Forensic Odonto-stomatology (Internet) (cited on 2008 February 2012) Available from http://www.iofos.eu/Quality-Ass/Age-IOFOS.htm

5. Foti B *et al*. New forensic approach to age determination in children based on tooth eruption. Forensic Sci Int 2003, 132: 49–56.

6. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol 1973; 42: 211–27.

7. Koshy S, Tandon S. Dental age assessment: the applicability of Demirjian's method in south Indian children. Forensic Sci Int 1998; 94: 73–85.

8. Prabhakar AR, Panda AK, Raju OS. Applicability of Demirjian's method of age assessment in children of Davangere. J Indian Soc Pedod Prev Dent 2002; 20(2): 54–62.

9. Hedge RJ, Sood PB. Dental maturity as an indicator of chronological age: radiographic evaluation of dental age in 6 to 13 years children of Belgaum using Demirjian's methods. J Indian Soc Pedod Prev Dent 2002; 20(4): 132–8.

10. Chaillet N, Demirjian A. Dental maturity in South France: a comparison between Demirjian's method and polynomial functions. J Forensic Sci 2004; 49(5): 1059–66.

11. Acharya AB. Age Estimation in Indians Using Demirjian's 8-teeth Method. J Forensic Sci, January 2011; Vol. 56, No. 1.

12. Kvaal IS, Kolltveit KM. Age estimation of adults from dental radiographs. Forensic Sci Int 1995; 74: 175-185.

13. Acharya AB *et al*. Age estimation from pulp/tooth area ratio (PTR) in an Indian sample: A preliminary comparison of three mandibular teeth used alone and in combination. J Forensic Legal Med 2011, 18: 350-354.

14. Singh A, Gorea RK, Singla U. Age estimation from the physiological changes of teeth. J Indian Acad Forensic Med 2004; 26: 94–6.

15. Balwant Rai. Five markers of changes in teeth: An estimating of age. Internet J Forensic Sci 2006;1

16. Preethi S, Einstein A *et al*. Awareness of forensic odontology among dental practitioners in Chennai: A knowledge, attitude, practice study. J Forensic Dent Sci 2011 Jul-Dec; 3(2): 63–66.

17. Almirall JR, Furton KG. Trends in Forensic science education: Expansion and increased accountability. Anal Bio anal Chem 2003; 376: 1156–9.

18. Herschaft EE, Rasmussen RH. The teaching of forensic dentistry: A status report. J Dent Educ 1978; 42: 532–6.

19. Johanson G, Drinnan AJ, Keiser-Nielsen S. Education in forensic odontology. Int Dent J 1981; 31: 6–13.

20. Acharya AB. A decade of forensic odontology in India. J Forensic Dent Sci 2010; 2: 1.

21. Shetty P, Raviprakash A. Forensic odontology in India, an oral pathologist's perspective. J Forensic Dent Sci 2011 Jan-Jun; 3(1): 23–26.