

# Study of Correlation of Dental Age with Radiological Age

Sharad V. Kuchewar<sup>1</sup>, Trishul O. Padole<sup>2</sup>, Santosh H. Bhosle<sup>2</sup>, Anil K. Batra<sup>3</sup>

<sup>1</sup>Associate Professor, Dept. of Forensic Medicine, Govt. Medical College, Nagpur, Maharashtra State, India, <sup>2</sup>Associate Professor, <sup>3</sup>Professor & Head, Dept. of Forensic Medicine, SVN Govt. Medical College, Yavatmal, Maharashtra state, India

## Abstract

Age is defined as the length of time an organism or individual has survived after birth. Age assessment is necessary for people without birth registrations, getting access to education, government policies, employment, marriage registration, young criminals claiming to be underage, and so on. Under 25 years of age, following parameters are key factors to opine about age of individual - Dental eruption, Bone size and maturity, ossification centre & epiphysial union. Aim of the study was age determination by Correlation of Dental findings with Radiological findings. This study included 83 individuals brought by police to SVN Govt. Medical college, Yavatmal, for age determination, out of them 56 were males and 27 were females between age group of 10-25 years. The oral cavity was examined for dentition as per Federation Dentaire Internationale (F.D.I.) system. X-rays of the body joints are recommended for determining the age groups. The results obtained were compared with reference value available for same parameter, for standard deviation, Pearson correlation and p values.

Very strong correlation found between Radiological age and Final age (0.9994) while correlation between Dental age and Radiological age was 0.9961. Concluded highly significant p-value ( $p < 0.0001$ ) found between Dental, Radiological and Final age.

**Keywords :** Age; Correlation; Dental findings; Ossification centre; Radiological findings.

## Introduction

Age estimation, a sub-discipline of the forensic sciences, is of immense importance in forensic medicine for identification of deceased victims as well as in connection with crimes and accidents<sup>1</sup>. Chronologic age conveys only a rough approximation of the maturational status of a person, hence dental and skeletal ages have been explored as maturity indicators since decades. Age is defined as the length of time an organism or individual has survived after birth<sup>2</sup>. There are increasing cases like sexual offences, abduction, juvenile offences which have shown rise particularly in the recent one

decade. In the above said group of cases, age of either victim or the accused is very much critical either for the Prosecution or for the Defence. In these cases, depending on the age of the accused or victim the entire Legal procedure may be influenced at the time of filling charge- sheet or at the time of pronouncing the judgment and while awarding the quantum of punishment if the accused is guilty. In most of the cases even though there is documentary proof of age in the form of birth certificate, school certificate and hospital record written at the time of birth, the value of these certificates can be questionable in the court of law. In such cases the role of Medical expert comes into picture that furnishes the age basing on the scientific parameters and court requires the evidence of the Medical expert. In majority of cases of determination of age, Medical expert takes into consideration various parameters like dentition and the ossification of various bones in the human skeleton, as these factors are influenced by the number of extrinsic

---

### Corresponding author -

**Dr. Trishul O. Padole**

Associate Professor, Dept. of Forensic Medicine  
SVN Govt. Medical College, Yavatmal  
Maharashtra state, India - 445001  
Email – trishulopadole@gmail.com

and intrinsic factors, one cannot determine the exact age of an individual<sup>3</sup>.

Röntgen discovered X-rays. His discovery opens a new dimension for age estimation in living subjects. The applications of his discovery in Legal Medicine were nearly immediate and age estimation in living subjects rapidly changed to include these new tests based on radiographies of the skeleton as a complement to the teeth eruption classical methods. During the last 40 years, different researches focused in defining the standard radiological maturation of human skeleton with age. Between decades of 50 to 80 of 20th century, main definitive methods of age estimation based on radiological analysis of carpus and dental maturation were defined<sup>4</sup>. Under 25 years of age, following parameters are key factors to opine about age of individual - Dental eruption, Bone size and maturity, ossification centre & epiphysial union<sup>5</sup>. There are many factors like environmental, genetic and dietetic, which affect physical, dental and radiological development. Though the given age is a fairly accurate estimate, a margin of error to certain extent, is still expected. The range of margin of error up to 16 years of age is 6 month: 16-21 years of age is one year and 21-25 years of age is 1-2 years; (with meticulous dental and radiological examination.) As far as possible and when facilities exist, the dental and radiological examination should be conducted by concerned different specialists. In such cases, the comprehensive final opinion regarding age needs to be provided by the examination doctor in consultation with and after calculating mean of ages obtained from all three methods<sup>6</sup>.

The Hon'ble courts observed that an X-ray ossification test may provide a surer test for determining the age of an individual than the opinion of a Medical expert but it can by no means be so infallible and accurate a test as to indicate the correct number of years and days he has lived<sup>7</sup>. All other evidence of age is wholly unsatisfactory, the ossification test may be accepted as a surer ground for determination of age particularly when the accused gets a benefit of doubt on that basis<sup>8</sup>. Many other studies established a good correlations between dental & radiological age<sup>9</sup>. In this study, all efforts are made to give the age of individuals as close as possible

by correlation of dental with radiological findings, which would be helpful in medico-legal cases.

## Material and Methods

This present study was conducted at SVN Govt. Medical college, Yavatmal from Jan 2017 to June 2020. The cases included in this study were the 83 individuals between age group of 10 to 25 yrs, brought by police for age determination, out of them 56 were males and 27 were females. The institutional ethical committee approval was obtained. Proper written consent was obtained from each & every subject (more than 12 years of age) while consent was collected from the parents, guardians or respective head of the institute (in case of subject less than 12 years of age) as per section 89 Indian Penal Code. All preliminary details of each subject was collected along with their photograph & identity proof. The oral cavity was examined for dentition as per Federation Dentaire Internationale (F.D.I.) Two digit system. Under the National Health Service Act 1971 regulations, the following symbols are used for charting<sup>10</sup>: Tooth present and sound (·), Tooth missing (-), Tooth recently extracted (X), Root present (+), Tooth to be extracted (/), Cavity (°), Filling present (•), Artificial tooth (A), Crown (C), Indication of direction of tooth movement ( ). Under FDI System, number of tooth is same like palmer notation, another number (1,2,3,4) (5,6,7,8) is placed before the tooth number of palmer notation denoting the side and quadrant; or temporary and permanent<sup>11</sup>.

Sequence of eruption of temporary teeth in Indian population as central incisor (6-8 months), lateral incisor (7-9 months), first molar (12-14 months), canine (17-18 months), second molar (20-30 months) & permanent teeth as first molar (6-7 years), central incisor (6-8 years), lateral incisor (7-9 years), first bicuspid (9-11 years), second bicuspid (10-12 years), canine (11-12 years), second molar (12-14 years), third molar (17-25 years). The mandibular permanent teeth tend to erupt before maxillary teeth<sup>12</sup>. X-rays of the following body joints are recommended for determining the age groups: 5-16 years (Elbow), 16-17 years (Wrist), 17-18 years (Shoulder), 7-22 years (Pelvis), 18-19 years (Crest of ilium), 21-22 years (Ischial tuberosity), 21-22 years (Clavicle - Inner end of clavicle), 3-22 years (Jaw), 7-18

years (second and third molar development)<sup>6</sup>.

## Results

Chronological, Dental, Radiological and Final age of all 83 subjects was analyzed here in this study. Young ages (from 10 yr to 25 yr) subjects were involved.

**Table No. 1: Age and Sex distribution (n=83)-**

Age group (in yrs)	Sex		Total
	Male	Female	
10-15	20	14	34
15.1 -20	32	11	43
20.1 -25	04	02	06
Total	56	27	83

Table No. 1 shows that, out of total 83 subjects, 56 were male (67.46%) and 27 were female (32.53%).

**Table No. 2: Education wise distribution of Subjects (n=83)-**

Education	Number	Percent (%)
Primary	41	49.4%
Secondary	37	45.5%
Higher secondary	4	3.9%
Graduate	1	1.3%
Total	83	100.0%

Table No. 2 interpreted that 49.4 % subjects were studied primary education, 45.5 % subjects were studied secondary education, 3.9 % subjects were studied higher secondary education and only 1.3 % subjects were graduate.

**Table No. 3: Mean age with Standard deviation of Chronological, Dental, Radiological & Final age (n=83)-**

Age group (in yrs)	Sex	Mean $\pm$ SD of Chronological Age (in yrs)	Mean $\pm$ SD of Dental Age (in yrs)	Mean $\pm$ SD of Radiological Age (in yrs)	Mean $\pm$ SD of Final Age (in yrs)
10-15	Male (20 in no.)	13.35 $\pm$ 1.1820	13.5769 $\pm$ 0.645	13.2333 $\pm$ 0.54	12.3928 $\pm$ 0.5
	Female (14 in no.)	12.14 $\pm$ 1.7947	12.5769 $\pm$ 1.88	12.5384 $\pm$ 2.2	12.1818 $\pm$ 1.73
15.1-20	Male (32 in no.)	17.59 $\pm$ 1.1030	16.4 $\pm$ 0.28	16.1833 $\pm$ 1.11	16.9655 $\pm$ 1.07
	Female (11 in no.)	16.63 $\pm$ 2.8849	16.5 $\pm$ 0.5	16.75 $\pm$ 0.55	16.5714 $\pm$ 0.45
20.1-25	Male (4 in no.)	23 $\pm$ 2.3093	21.4444 $\pm$ 1.25	21.5454 $\pm$ 1.64	21.3461 $\pm$ 1.58
	Female (2 in no.)	22 $\pm$ 1	21 $\pm$ 0	22 $\pm$ .5	22 $\pm$ .5

Table No. 3, summarised with Mean age and Standard Deviation of Chronological, Dental, Radiological and Final age of all 83 individuals.

**Table No. 4: Pearson correlation (r) between all age variables (n=83)-**

	Chronological Age	Dental Age	Radiological Age	Final Age
Chronological Age	1.0000			
Dental Age	0.9768			
Radiological Age	0.9843	0.9961		
Final Age	0.9843	0.9965	0.9994	1.0000

Note - P values ( $p < 0.0001$ ) observed between all age variables (n=83).

From Table No. 4, Pearson Correlation (r) between Dental, Radiological and Final age was assessed and analyzed. Following observation were found, Chronological age shows the highest degree of correlation with Radiological & Final age (0.9843) and the lowest correlation with Dental age (0.9768). Dental age shows the highest degree of correlation with Final age (0.9965) and the lowest correlation with Radiological age (0.9961). Correlation between Radiological age and Final age was 0.9994. Significant P value ( $p < 0.0001$ ) observed between all age variables. Very strong correlation found between Radiological age and Final age (0.9994) while correlation between Dental age and Radiological age was 0.9961.

### Discussion

Age estimation is an important requisite in some judicial proceedings. Age assessment is required in following circumstances like, asylum seekers of unknown age, young people accused of criminal activities, and convicted criminals whose age is claimed to be less than 18 years prior to 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 be apply that to ageing in both human remains and living people<sup>13</sup>. The issue of unregistered children has been noted with its huge number and characters, such as descendants of floating

population, unplanned births, female children, or adopted children. Age assessment is necessary in many situations for people without birth registrations, such as children applying for social welfare and benefits, getting access to health care, education, or even employment, marriage registration, young criminals claiming to be underage, and so on<sup>14</sup>.

There is extensive documentation on the differences between different populations relative to the age for determining dental maturation markers, mostly tooth eruption, which makes ethnicity a quite attractive factor. Other less tangible factors, such as climate, nutrition, socioeconomic levels and urbanization, may also influence maturation rates<sup>13</sup>. Considering the regional differences, establishing specific parameters for each region would be extremely valuable<sup>15</sup>. The correlation coefficient for comparing dental and chronological age was statistically significant with a  $P < 0.001$  similar to that reported by Engstrom *et al*<sup>16</sup>, Pareikh and Parulkar<sup>17</sup>, and Demisch and Wartmann<sup>18</sup>. Skeletal maturity has shown to be a better indicator of age in previous studies. In the present study, the subjects were found to have normal skeletal development as shown from the strong correlation between chronological and skeletal age, which is consistent with the reports of Engstrom *et al*<sup>16</sup>, Pareikh and Parulkar<sup>17</sup>, and Demisch and Wartmann<sup>18</sup>. The difference between Dental & Radiological age as per the Pearson correlation, which revealed high and

statistically significant ( $p < 0.05$ ) values. Thus a high correlation found between Dental & Radiological age. Dental age correlates closely with chronological age in children development. Studies have shown that dental development relates more closely to chronological age than skeletal, somatic or sexual maturity indicators<sup>19</sup>.

In Table no.4, Chronological age (minimum 10 yrs while maximum 25 yrs), Dental age (minimum 10 yrs while maximum 25 yrs), Radiological age (minimum 9 yrs while maximum 25 yrs) and Final age (minimum 9.5 yrs while maximum 25 yrs) of all 83 subjects was analyzed. Pearson correlation and P values between all age variables were analyzed, in which each variables was positively correlated with all the other variables. The correlation for the age variables observed here showed positive correlation (ranging from 0.9768 to 0.9994). Krogman WM (1962)<sup>20</sup> dental developments have been strongly related to skeletal maturation and Helm S (1990)<sup>21</sup> studied the relation between dental and skeletal maturation. His results also showed that the skeletal age, rather than dental maturity alone, would be of important in assessing the age in children of unknown chronological age or any birth record but against Hagg & Taranger (1980)<sup>22</sup> study the relationship between dental eruption finding a low correlation between skeletal and dental development.

Strong correlation found between Dental age and Radiological age (0.9961). Chronological age shows the highest degree of correlation with Radiological and Final age (0.9843) and the lowest correlation with Dental age (0.9768). Dental age shows the highest degree of correlation with Final age (0.9965) and the lowest correlation with Radiological age (0.9961). A very strong correlation found between Radiological age and Final age which was 0.9994. Similarly significant P value (0.0001) was seen between the Chronological age, Dental age, Radiological age and Final age which is consistent with Green LJ (1961)<sup>9</sup>. Overall a very strong correlation was observed in between Dental age and Radiological age.

### Conclusions

- 1) Dental status and Radiological findings are

good parameter for estimation of age.

- 2) Dental & Radiological findings together gives even more reliable estimation of age.

- 3) Highly significant p-value ( $p < 0.0001$ ) found between Dental, Radiological and Final age.

- 4) Strong correlation found between Dental age and Radiological age.

#### Benefits of study-

- 1) The method opted is very simple and requires no special training.

- 2) Study specifically beneficial for young individuals (i.e. 10 yrs to 25 yrs.)

- 3) From this study, we can minimize x-ray exposure to the individual by advising exact x-ray of appropriate joints.

- 4) The procedure sheds a new light on estimation of age of medico-legal significance in an individual's by correlating Dental findings and Radiological findings.

#### Limitations of the study-

1. This study cannot be employed, if teeth are absent (not erupted at all).

2. Not practicable, if X-ray services and Radiologist are not available.

3. Possibility of observer's error can be possible.

4. Sex wise distribution not studied here in this study.

5. Dietary, economical, environmental factors are not studied in the present context.

#### Suggestion about suitable recommendations-

1. As this study was performed in living subjects, further studies about correlation of age estimated by various findings in dead bodies is suggested.

2. Study to investigate the interrelationship between dental maturity and radiological findings for age estimation are inevitable. If strong correlation found

between age estimation by these two parameters over a large sample and smaller age groups, then there is a possibility that combination of all these findings for age estimation may be enough to reduce the age range in years, if it is indeed so, multiple skeletal x-ray may be avoided.

3. As the numbers of subjects are less, for confirmation of various variations found in this study, further studies about correlation of age estimated by various findings for a larger number of subjects of both sexes are required.

**Acknowledgements:** We would like to express our gratitude to Dr. Manish Shrigiriwar, Professor & Head in the department of Forensic Medicine of AIIMS Nagpur, Maharashtra state (India) for his guidance during the study.

**Conflict of Interest:** None

**Funding:** This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

### References

- (1) William B, Fremingston M, Singh M, Blona K. Age determination in girls of North Eastern region of India. *J Indian Acad Forensic Med.* 2007;29:102–8.[Google Scholar].
- (2) Wikipedia. The online Encyclopedia. [Last accessed on 2011 Jul 21]. Available from: <http://en.wikipedia.org>.
- (3) Urbanisation, demographic transition, and the growth of cities, [www.theigc.org](http://www.theigc.org) > Tumble-2016-Working-paper
- (4) Schmeling A, Garamendi PM, Prieto JL. Forensic Age Estimation in Unaccompanied Minors and Young Living Adults. In: Vieira DN, editor. *Forensic Medicine - From Old Problems to New Challenges*. 1sted. Germany:InTech; 2011. p. 77.
- (5) Tedeschi CG, Eckert WG and Tedeschi LG. Methods in Age determination in chapter on Forensic anthropology in Book- *Forensic Medicine*. 1st ed. Philadelphia: W.B Saunders Company; 1978; 73:p1104-1110.
- (6) *Medicolegal & Post mortem Training Module (For Medical Officers)*, by Public Health Department, National Rural Health Mission, Govt. of Maharashtra, 2013: p41-42.
- (7) *Kishorilal v State* AIR. 1957 Punj 78.
- (8) *Alekh Prasad V state* (1964) 2 Cr LJ 102.
- (9) Green LJ. The interrelationships among height, weight and chronological dental and skeletal ages. *Angle Orthod*;1961; 31:1890-6.
- (10) Camps F E, *Gradwohl's Legal Medicine*, 3rd edition 1976: p136.
- (11) *Karmakar R N. Forensic Medicine & Toxicology, Oral, Practical & M.C.Q.*, 3<sup>rd</sup>ed.2010: p11.
- (12) Vij K. *Textbook of Forensic Medicine and Toxicology Principles & Practice*. 5<sup>th</sup> ed. Chennai: Elsevier; 2011.Ch3; p39.
- (13) Priyadarshini C, Puranik M P, Uma S R. Dental Age Estimation Methods: A Review. *Int J Adv Health Sci* 2015;1(12):19-25.
- (14) Wong HM, Wen YF, Jayaraman J, Li J, Sun L, King NM, Roberts GJ. Northern Chinese dental ages estimated from southern Chinese reference datasets closely correlate with chronological age. *Heliyon*. 2016;2:e00216. doi: 10.1016/j.heliyon.2016.e00216.
- (15) Mappes MS, Harris EF, Behrents RG. An example of regional variation in the times of tooth mineralization and hand-wrist ossification. *Am J Orthod Dentofacial Orthop.* 1992;101(2):145-51.
- (16) Engstrom C, Engstrom H, Sagne S. Lower third molar development in relation to skeletal maturity and chronological age. *Angle Orthod.* 1983;53:97–106.
- (17) Parekh BK, Parulkar PP. Radiographic examination of tooth age and its correlation with the chronological age. *J Indian Acad Oral Med Radiol.* 1997;8:27–35.
- (18) Demisch A, Wartmann P. Calcification of the mandibular third molar and its relation to skeletal and chronological age in children. *Child Dev.* 1956;27:461–73.
- (19) Lewis AB, Garn SM. The relationship between tooth formation and other maturational factors. *Angle Othod.* 1960;30(2):70-7.
- (20) Krogman WM, Iscan, MY in *The human skeleton in Forensic Medicine*, Charles C.Thomas Publisher, Illinois, USA. II Edition, 1986. (21) Helm S: Relationship between dental and skeletal maturation in Danish School children.

Scandinavian Journal of Dental Research, 1990; 98(4):313-7. (22) Hagg U, Taranger J. Skeletal stages of the hand and wrist as indicators of the pubertal growth. Acta Odontol Scand 38(3):187-200, 1980.