

# Age Estimation of an Individual by Pulp-Tooth Ratio measurement using radiographs - A forensic perspective

Krishna A Rao<sup>1</sup>, Abdulaziz Abdolah Y Althari<sup>2</sup>, Nasser Fayed M Aldhumayri<sup>3</sup>, Talal Eid Alruwaili<sup>4</sup>, Amjad Abdulrahman S Albulayhid<sup>5</sup>, Santosh R Patil<sup>1</sup>

<sup>1</sup>Department of Preventive Dentistry, College of Dentistry, Jouf University, Kingdom of Saudi Arabia.

<sup>2</sup>College of Dentistry, Jouf University, Kingdom of Saudi Arabia.

<sup>3</sup>College of Dentistry, Jouf University, Kingdom of Saudi Arabia.

<sup>4</sup>College of Dentistry, Jouf University, Kingdom of Saudi Arabia.

<sup>5</sup>College of Dentistry, Jouf University, Kingdom of Saudi Arabia.

<sup>6</sup>Department of Oral Medicine and Radiology, New Horizon Dental College and Research Institute, Bilaspur, Chhattisgarh, India.

Email: drpsantosh@gmail.com

DOI: 10.47750/pnr.2022.13.S06.467

## Abstract

**Objective:** To estimate the age of a person by pulp/tooth ratio using digital intraoral periapical radiographs (IOPARs) of maxillary permanent lateral incisors.

**Material and Methods:** The present study analyzed radiographs from randomly selected sample of 100 (50males and 50 females) individuals, within the age group of 16–65 years, further grouped as: Group A – 16 – 25 years of age, Group B – 26 – 35 years, Group C – 36 – 45 years, Group D – 46 – 55 years and Group E – 56 – 65 years of age. The pre-existing digital intraoral periapical radiographs(IOPARs) were collected from the archives of the institution. The images were saved as a high resolution JPEG files on a desktop computer and imported to the Adobe Photoshop CS7 image-editing software program for further analysis.

**Results:** A statistically significant correlation between age and pulp/tooth ratio was observed and no significant difference between chronological and estimated ages was noted.

**Conclusion:** An accurate age of a person can be estimated by pulp/tooth ratio using digital intraoral periapical radiographs(IOPARs) of maxillary permanent lateral incisors

**Keywords:** Age estimation, chronological age, permanent maxillary lateral incisors, IOPAR.

## INTRODUCTION

Over a period of time, forensic age assessment in living individuals has become more and more important.<sup>1</sup> In country like Kingdom of Saudi Arabia, wherein a large number of people who are expats arriving as labourers from many parts of the world may sometimes have no knowledge or records of their date of birth which is required by law enforcing agencies in matters such as attainment of majority, criminal responsibilities, judicial punishment, consent, employment etc. Age estimation is also essential during the enhancement of pensions in the old age.<sup>2-4</sup> Hence, scientific determination of age becomes very much essential.<sup>5-6</sup>

Age can be estimated from a variety of factors such as the appearance of ossification centers and their fusions during skeletal development, from height and weight which is applicable in early periods of life, dental development and changes occurring at puberty such as appearance of hair and their growth and color changes to mention a few.<sup>7</sup> It is a recognized fact that the assessment of the tooth development can be related to an individual's age, but after the age of 21 years when the wisdom teeth also complete their development, there arises a need for an ideal age estimation procedure. It is a well know phenomenon that as age advances, there is decrease in the size of the pulp due to secondary dentin deposition and analysis of this reduction can be used as a parameter in assessing the age of the individuals, in not only the living, but also the deceased.<sup>8-11</sup> In the present

study, the pulp/tooth ratio obtained from the two dimensional digital intraoral periapical radiographs (IOPARs) was considered for the estimation of age.

## Material and methods

This retrospective study was undertaken after the approval by Institutional Review Board of College of Dentistry and Jouf University. Two dimensional (2D) IOPARs of patients who were in-between 16 to 65 years of age were collected from the archives of the institution after obtaining the kind approval from the concerned authorities of the hospital administration in order to access the patients' records. High-resolution images of completely erupted maxillary permanent lateral incisors, which were normal in occlusion were assessed. Teeth with caries, filling or crown restorations, periapical pathologies, developmental anomalies or pulpal pathologies were excluded.

A total of 100 teeth from 100 patients were evaluated. Sample size calculation was done by using software – G Power 3.1.9.2 (Heinrich Heine Universität Düsseldorf, Germany) at confidence interval ( $\alpha$ ) 0.05 & Power ( $1-\beta$ ) 95% - 0.95; for chi-square test with a df of 1. With the effect size ( $f$ ) of 0.30. Based on the age given by the patient and as recorded in the case history, the study sample was equally divided into five groups with 20 patients in each group. With an equal distribution in gender, the samples were categorized into the following groups - Group A – 16 – 25 years of age, Group B – 26 – 35 years, Group C – 36 – 45 years, Group D – 46 – 55 years and Group E – 56 – 65 years of age.

### Image analysis

Radiographic images were saved as high resolution JPEG files on a desktop computer and imported to the Adobe Photoshop CS7. Once, the image file was opened; the working area was zoomed in and enlarged. The polygonal lasso tool was selected from the toolbar. To select the entire tooth area, it was necessary to click on the image of the tooth to set the starting point of the tooth shape. Then the cursor was moved to a close point of the tooth profile along the margins and clicked again. A straight line from the first point selected was drawn. Clicking was continued at the margins to set endpoints for subsequent segments along the tooth profile. The selected area was then copied and pasted on a new layer, which was added to the active working area superimposed on the tooth image. This new layer was renamed based on the tooth that was analyzed and it was further added to the layer palette. To select the pulp chamber area, it was necessary to proceed as previously for the entire tooth, following the pulp chamber profile with the polygonal lasso. The pulp chamber selection was copied, pasted to a new layer and renamed as “Pulp Chamber” (Figure 5). The new “Pulp Chamber” layer contained only the pulp chamber area pixels, as the “Tooth” layer contained the pixels for the entire tooth area. In order to know how many pixels were there in each layer, the histogram palette (windows > histogram) was activated and the “Pulp Chamber” layer was selected by double-clicking on the layer name. Once the selected layer was chosen, double-click on the histogram image was made. The number of pixels was shown in the “Pulp Chamber” layer in the histogram palette. This value represented the first required variable (pulp chamber area). Next to be selected was the “Tooth” layer, and double-click was made on the histogram image. The number of pixels contained in the entire incisor represented the second required variable (Figure 4).

All statistical analyses were performed using SPSS for Windows 11.5 software program (SPSS Inc., Chicago, IL).

## Results

Gender wise distribution of study participants is presented in the table 1 and the age wise distribution is presented in the table 2. The descriptive statistics for different age groups, for pulp/tooth ratios are shown in the table 3.

Table 1: Distribution of male and females by age groups

Age groups in Years	Male	Female	Total
16-25	10	10	20
26-35	10	10	20
36-45	10	10	20

46-55	10	10	20
56-65	10	10	20
Total	50	50	100

Table 2: Descriptive statistics for the chronological age

Age groups in Years	N	Min	Max	Mean	SD
16-25	20	16.00	20.00	17.80	1.36
26-35	20	22.00	27.00	24.90	1.62
36-45	20	33.00	39.00	37.10	1.86
46-55	20	45.00	49.00	47.10	1.41
56-65	20	55.00	59.00	56.90	1.33

Table 3: Descriptive statistics for the pulp/tooth ratio

Age groups	N	Min	Max	Mean	SD
16-25	20	0.73	0.76	0.74	0.01
26-35	20	0.69	0.75	0.74	0.02
36-45	20	0.67	0.72	0.68	0.01
46-55	20	0.65	0.71	0.70	0.02
56-65	20	0.60	0.69	0.66	0.03

Table 4: Age estimation by pulp/tooth ratio (total samples)

Samples	Independent variable	Estimates	SE	t-value	P-value
Total	Constant	259.82	17.09	15.2013	0.0001*
	Pulp/tooth ratio	-316.85	24.25	-13.0677	0.0001*
Male	Constant	243.17	25.45	9.5529	0.0001*
	Pulp/tooth ratio	-293.04	36.01	-8.1387	0.0001*
Female	Constant	278.83	23.00	12.1246	0.0001*
	Pulp/tooth ratio	-344.14	32.72	-10.5182	0.0001*

\*p<0.05

Table 5: Summary of prediction of age by pulp/tooth ratio (total samples)

Samples	R	R <sup>2</sup>	Adj. R <sup>2</sup>	F-value	P-value	SE of estimate
Total	0.7971	0.6353	0.6316	170.76	0.0001*	8.7289
Male	0.7614	0.5798	0.5711	66.29	0.0001*	9.4167
Female	0.8351	0.6974	0.6911	110.63	0.0001*	8.0677

Table 6: Comparison of chronological and predicted age by dependent t test

Samples	Groups	Mean	Std.Dv.	Mean Diff.	SD Diff.	t-value	p-value
Total	Actual age	36.76	14.38	0.00	8.68	0.0000	1.0000
	Predicted	36.76	11.46				
Males	Actual age	36.28	14.38	0.00	9.32	0.0000	1.0000
	Predicted	36.28	10.95				
Females	Actual age	37.24	14.52	0.00	7.98	0.0000	1.0000
	Predicted	37.24	12.12				

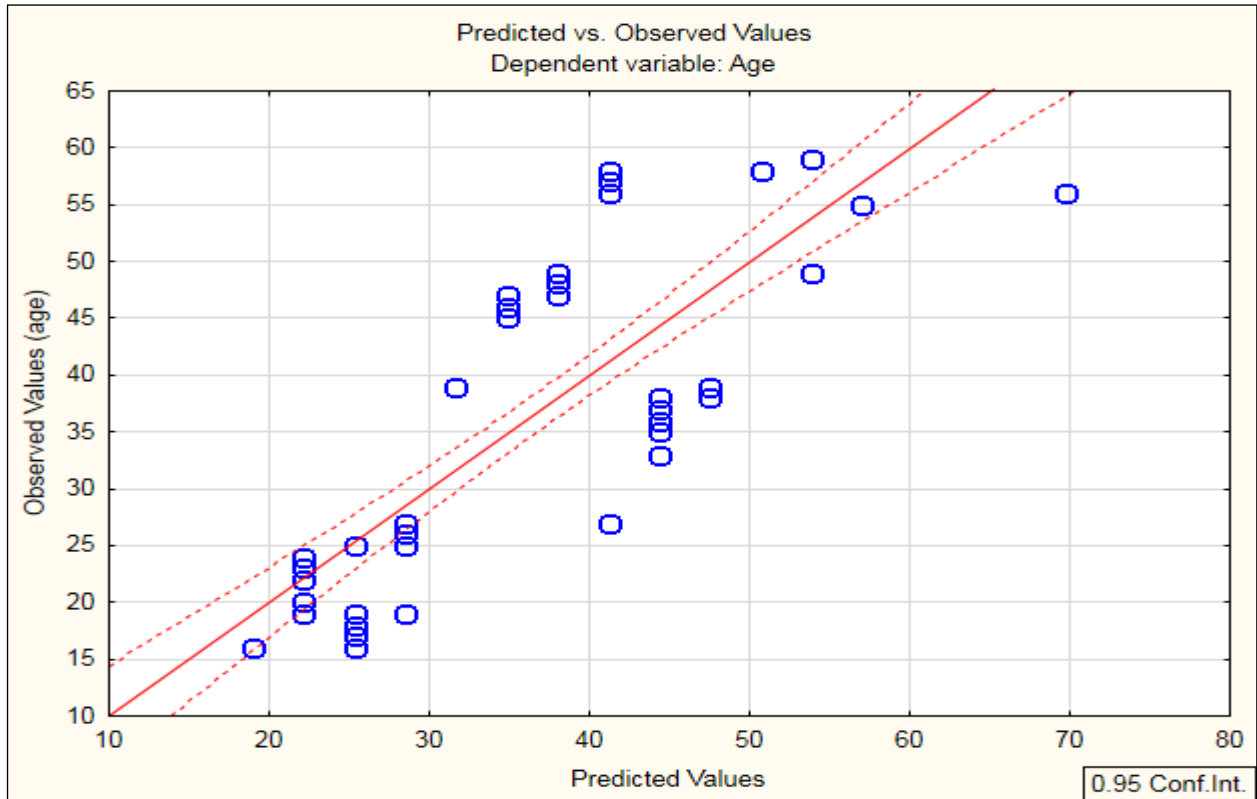


Figure 1: Graph showing the chronological age vs predicted age as a whole

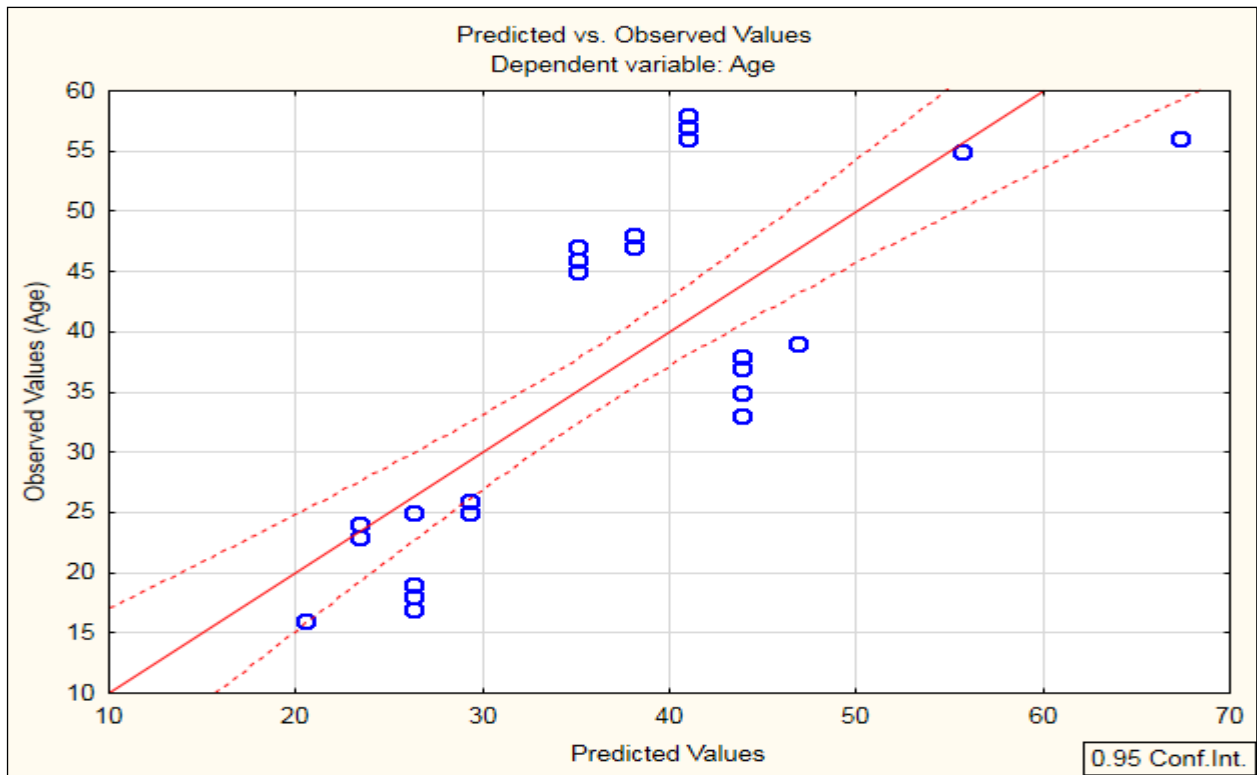


Figure 2: Graph showing the chronological age vs predicted age (males)

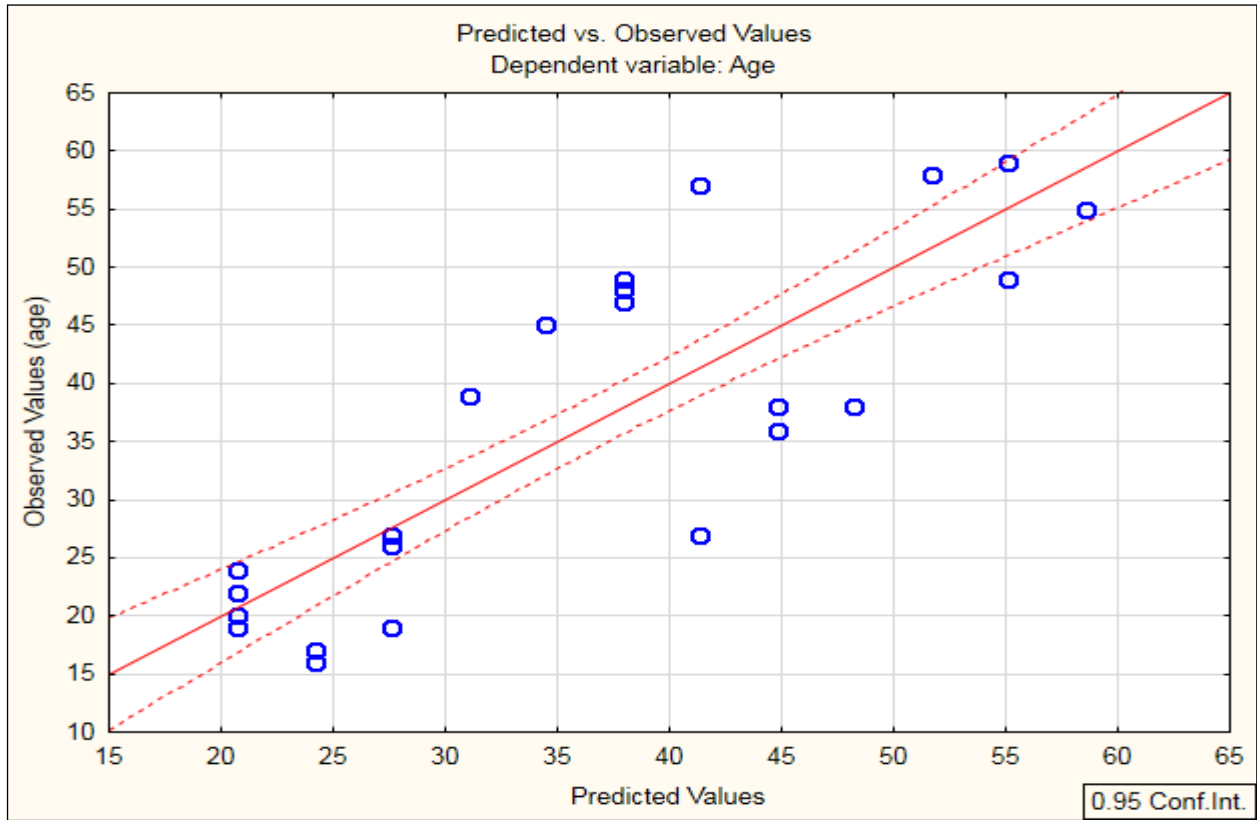


Figure 3: Graph showing the chronological age vs predicted age (females)



Figure 4: 2D Digital IOPAR showing maxillary permanent lateral incisor

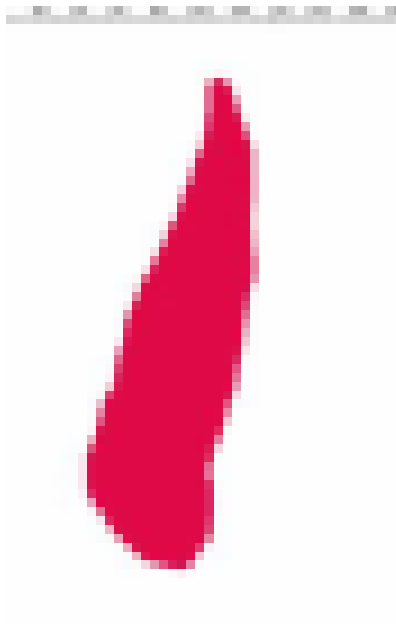


Figure 5: Tooth area as histogram image on Adobe Photoshop software

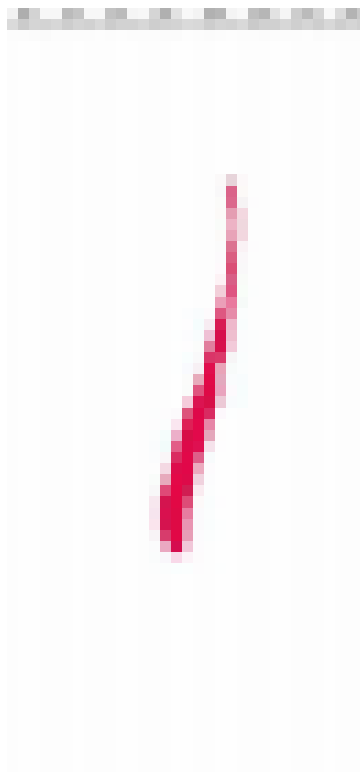


Figure 6: Pulp area as histogram image on Adobe Photoshop software

The pulp/tooth ratio is predicting age significantly in total, male and female samples (Table 4). The summary of prediction models are presented in the table 5. Pearson's correlation produced a statistically significant correlation between pulp/tooth area ratio and chronological age ( $r=0.7971$ ,  $p=0.0001$ ) for entire sample. Similarly, in males the Pearson's correlation i.e.  $r=0.7614$ ,  $p=0.0001$  and in females the Pearson's correlation i.e.  $r=0.8351$ ,  $p=0.0001$  showed statistically significant results (Table 5).

Linear regression analysis, where age was the dependent variable and pulp/tooth ratios was the independent variables, showed a coefficient of determination in total sample is  $R^2 = 0.6353$ , for males,  $R^2 = 0.5798$  and in female samples i.e.  $R^2 = 0.6974$ . Regression equations have been computed separately for each gender. The table also exhibits standard error of estimate (SEE) along with every linear regression equation. The SEE predicts the deviation of estimated age from calculated age (actual age). A low value indicated greater reliability in the estimated age.

The scatter diagram showing the relationships between age and pulp ratio is highlighted in the figures 1-3. No significant difference was observed between chronological age and estimated ( $p > 0.05$ ) in total, male and female samples (Table. 6). The prediction equation of age by pulp ratio in total, male and female samples respectively were obtained by

Prediction equation (total):  $\text{Age} = 259.82 - 316.85(\text{Ratio})$

Prediction equation (males):  $\text{Age} = 243.17 - 293.04(\text{Ratio})$

Prediction equation (Females):  $\text{Age} = 278.83 - 344.14(\text{Ratio})$

## Discussion

Kvaal et al., proposed a method based on measurements of secondary dentine deposition on radiographs by estimating pulp radiolucency and correlated it to chronological age.<sup>12, 13</sup> Age estimation according to radiographic measurements of teeth has been carried out in many studies and is most frequently used to estimate age in living individuals.<sup>14</sup>

Since it has been reported and advocated that finding out population-specific equations is necessary to precisely predict the age,<sup>15-19</sup> this study was undertaken to estimate age from pulp/tooth area ratio from digital IOPARs in a part of Saudi Arabian population.

To limit the influence of any variations in the magnification and angulations of the radiographs, the ratio between the tooth and pulp measurements was computed and employed in the analysis of this study.

In the present study, Maxillary tooth were used as they are more convenient for age determination than mandibular and a stronger correlation coefficient was reported for all types of maxillary teeth.<sup>20</sup> A statistically significant correlation between Saudi sample aged 16 to 65 years and pulp/tooth area ratio, was observed in the present study. These results are in agreement with Bosmans et al.,<sup>22</sup> who utilized radiographs of upper and lower incisors of adult Belgian population and noted that all correlations were significant. Our results were also in accordance with Yang et al.,<sup>23</sup> who reported moderate correlation between pulp/tooth volume ratio of incisors and biological age by using CBCT in Belgian population. This work revealed no significant difference between chronological and estimated ages. This was consistent to Zaher et al.,<sup>12</sup> and Bosmans et al.,<sup>22</sup> who found no significant differences between chronological and calculated ages.<sup>22</sup>

In terms of the legal implications of these findings, this study provides encouraging results for noninvasive dental age assessment using digital IOPARs from the maxillary permanent lateral incisor, albeit a more population specific equation must be developed to increase accuracy.

Additional researches with a larger sample size are needed to determine the relationship between sex and pulp/tooth ratio, as well as the influence of oestrogen on pulp/tooth ratio with age. Future research refining the provided approach, together with anticipated advancements in periapical radiography via direct digital radiography or CBCT, might result in a simple and optimal dental age assessment technique. This technique's enhanced picture quality will most likely reduce age estimate errors and improve dental age estimation. Additionally, more research on different types of teeth and different demographic groups might aid in the construction of numerous regression models that could improve age prediction.

## Conclusion

Our study was based on the estimation of the chronological age of an adult from pulp/tooth ratio dimensions measured from 2D IOPARsof maxillary permanent lateral incisors. From the observations of the present study, it may be concluded that the use of this method in maxillary permanent lateral incisors and the application of the new regression formulae on data obtained from digital periapical radiograph provides an accurate age estimation

## REFERENCES

1. Karaarslan B, Karaarslan ES, Ozsevik AS, Ertas E. Age estimation for dental patients using orthopantomographs. *Eur J Dent* 2010;4:389-94.
2. Priyadarshini C, Puranik MP. Dental age estimation methods: A review. *Int J Adv Health Sci* 2015;1:19-24.
3. Helman CG. Cultural aspects of time and ageing. Time is not the same in every culture and every circumstance; our views of aging also differ. *EMBO Rep* 2005;6:S54-8.
4. Saini A, Garg A. Age Estimation of an Individual by Pulp/Tooth Ratio by Maxillary Lateral Incisor Using Periapical Radiographs (RVG). *International J of Forensic Odontology* 2019;4 (1):27-33.
5. Pathak SK, Mathur PN, Jain S, Saini OP. A study of eruption of 3rd molar in relation to estimation of age in people of thirteen to twenty five years age group. *J Forensic Med Toxicol* 1999;16:17-9.
6. Olze A, Pynn BR, Kraul P. Dental age estimation based on third molar eruption in first nations people of Canada. *J Forensic Odontostomatol* 2010;28:32-8.
7. Panchbhai AS. Dental radiographic indicators, a key to age estimation. *DentomaxillofacRadiol* 2011;40:199-212.
8. Ashwini P, Meena N. Effect of long term corticosteroids on dental pulp. *World J Dent* 2010;1:17-20.
9. Cameriere R, Cunha E, Wasterlain SN, De Luca S, Sassaroli E, Pagliara F, et al. Age estimation by pulp/tooth ratio in lateral and central incisors by periapical X-ray. *J Forensic Leg Med* 2013;20:530-6.
10. Cameriere R, De Luca S, Alemán I, Ferrante L, Cingolani M. Age estimation by pulp/tooth ratio in lower premolars by orthopantomography. *Forensic SciInt* 2012;214:105-12.
11. Cameriere R, Ferrante L, Cingolani M. Variations in pulp/tooth area ratio as an indicator of age: A preliminary study. *J Forensic Sci* 2004;49:317-9.
12. Zaher JF, Fawzy IA, Habib SR, Ali MM. Age estimation from pulp/tooth area ratio in maxillary incisors among Egyptians using dental radiographic images. *J Forensic Leg Med*. 2011 Feb;18(2):62-5.
13. Kvaal SI, Kalltveit KM, Thomsen IO, Solheim T. Age estimation of adults from dental radiographs. *Forensic SciInt* April 1995;74:175e85.
14. Cameriere R, Brogi G, Ferrante L, Mirtella D, Vultaggio C, Cingolani M, et al. Reliability in age determination by pulp/tooth ratio in upper canines in skeletal remains. *J Forensic Sci* July 2006;51(4):861e4.
15. Cameriere R, Ferrante L, Cingolani M. Precision and reliability of pulp/tooth area ratio (RA) of second molar as indicator of adult age. *J Forensic Sci* 2004; 49(6):1319e23.
16. Kanchan T, Menezes R, Moudgil R, Kotian M, Garg R. Stature estimation from foot dimensions. *Forensic SciInt*2008;179(2e3). 241.e1e5.
17. Kvaal S, Solheim T. A non destructive method for age estimation. *J Forensic Odontostomatol* 1994;12:6e11.
18. Solheim T. Recession of periodontal ligament as an indicator of age. *J Forensic Odontostomatol* 1992;10:32e43
19. Prapanpoch S, Dove S, Band Cottone JA. Morphometric analysis of dental pulp chamber as a method of age determination in humans. *J Forensic Med Pathol* 1992;13:50e5.
20. Brkic H, Milicevic M, Petroveckii M. Age estimation methods using anthropo- logical parameters on human teeth. *Forensic SciInt* 2006;162:13e6.
21. Fancy SG. Preparation of mammalian teeth for age determination by cementum layers: a review. *WildlSoc Bull* 1980;8(3):242e8.
22. Bosmans N, Ann P, Aly M, Willems G. The application of Kvaal's dental age calculation technique on panoramic radiographs. *Forensic SciInt* 2005;153:208e12.
23. Yang F, Jacobs R, Willems G. Dental age estimation through volume matching of teeth imaged by cone-beam CT. *Forensic SciInt*; 2006:S78e83.