

# Age Estimation in South Indian Population using Pulp/Tooth Ratio of Mandibular Lateral Incisor, Canine and First Premolar

Priyanka Madhavan<sup>1</sup>, Sudeendra Prabhu<sup>2</sup>, Vina Vaswani<sup>3</sup>, Leena Pramod<sup>3</sup>, Syed Miqdad<sup>2</sup>

## ABSTRACT

**Background:** Radiographic method of determining pulp-tooth ratio for age estimation has kindled so much interest in the field of forensic dentistry in past few decades. Age estimation has an important role in the process of human identification. The size of pulp cavity is known to decrease with age and can therefore serve as an indicator for age estimation. Aim: To estimate the age of south indian population by using pulp/tooth ratio of mandibular lateral incisor, canine and first premolar.

**Method:** The outlines of the pulp cavity and whole tooth of interest (mandibular lateral incisor, mandibular canine and mandibular first premolar) were marked using the free selection tool in a software and the area was determined by activating histogram by counting the number of pixels involved. Pulp-tooth ratio was determined and age estimation was done using Babshet al's method.

**Result and Conclusion:** In the present study we conclude that though the Indian formula derived from this study showed no recognizable improvement in age estimation, it is recommended that the population specific formula produces more 'acceptable' age estimates.

## INTRODUCTION

Age estimation is a prime step in the identification of living and non-living individuals and remains an important step in medical and legal conditions.<sup>1</sup> Age estimation, in forensic science has a major role in diagnosis, treatment, prognosis and, in medico-legal identifications.<sup>2</sup> In large-scale disasters where identification of an individual remains crucial, teeth and bones play a major role in the identification.<sup>3</sup> The human tooth is one of the hardest structures which is least affected when compared to other skeletons by external factors such as nutritional, hormonal, genetics and environmental factors and also less affected by adverse changes such as mechanical and thermal changes.<sup>1</sup> Tooth and bone play a major role in personal identification as the tooth and bone can be preserved for a long time even after the soft tissue decay.<sup>3</sup> Structure of human tooth remains intact for a long years even after the death of an individual and hence, teeth remain as a chief specimen in forensic sciences.<sup>2</sup> Dental age estimation can be of two types: invasive and non-invasive procedures. Numerous methods of invasive dental age estimation have been proposed so far in the literature such as biochemical, histological and morphological methods which require extraction of the tooth.<sup>4</sup> Non-invasive dental age estimation is chiefly based on radiographs.<sup>5</sup> Degenerative and morphological age changes such as dentin transparency, cementum annulations, racemization of aspartic acid, physiological wear and tear and secondary dentin deposition helps in the identification

**Department and Institution Affiliation:** <sup>1</sup>Department of Oral Pathology, Yenepoya Dental College, Karnataka, India; <sup>2</sup>Centre for Forensic Odontology, Department of Oral Pathology and Microbiology, Yenepoya Dental College, <sup>3</sup>Department of Forensic Medicine, Yenepoya Medical College, Yenepoya (Deemed to be) university, Mangalore, Karnataka.

**Corresponding Author:** Dr. Sudeendra Prabhu, Professor and Head, Department of Oral Pathology, Incharge, Centre for Forensic Odontology, Yenepoya Dental College, Yenepoya (Deemed to be) university, Mangalore. E-mail – drsudeendra@yenepoya.edu.in

**How to cite the article:** Madhavan P., Prabhu S., Vaswani V., Pramod L., Miqdad S.. Age Estimation in South Indian Population using Pulp/Tooth Ratio of Mandibular Lateral Incisor, Canine and First Premolar. *Oral Maxillofac Pathol J* 2026; 17(1); 23-27.

**Source of Support:** Nil

**Conflict of Interest:** None

of age in adult.<sup>6</sup> Secondary dentin deposition is a continuous process throughout the life of an individual and it is the best morphometric indicator of age in an adult. A mesenchymal tissue called Dental pulp is enclosed by dentin which has the odontoblastic process, releases dentin under the influence of pulp and reduces the area of pulp.<sup>7</sup> The reduction in the pulp area is an important factor for the estimation of age in an individual.<sup>8</sup> In recent years, the usage of dental radiographs has

become very important in the estimation of age as it is more practical, non-invasive and non-destructive in nature. IOPA, lateral cephalogram, orthopantomogram and digital radiograph are the types of radiographs that had been used in the estimation of age in the literature so far.<sup>9</sup> The present study is aimed at the estimation of age by measuring pulp/tooth ratio in mandibular lateral incisor, canine and first premolars in the south Indian population with the help of digital OPG.

## MATERIALS AND METHODS

The study was commenced after obtaining ethical clearance from the institutional ethics. This study was conducted to estimate the age in South Indian population by using the pulp/tooth ratio of lateral incisor, canine and first premolar.

### STUDY DESIGN:

The study was conducted with the help of retrieved Orthopantomograph (OPG) from the year 2015 to 2020 from the Department of Oral Medicine and Radiology of our institution. Hence, the study design is a cross-sectional retrospective design.

### COLLECTION OF OPG:

A total of 112 (male - 56 and female - 56) digital Orthopantomograph (OPG) was selected from the archives of Department of oral medicine and radiology of our institution from the year 2015 to 2020. The following inclusion and exclusion criteria were considered during the selection of the OPG.

### INCLUSION CRITERIA:

- i. OPG with Mandibular lateral incisor, canine and first premolar of patients from age 18 to 45 years was included in the study.
- ii. Teeth with minimum decay was included in the study (pit and fissure caries).
- iii. The root of the teeth that are fully formed was selected.

### EXCLUSION CRITERIA

- i. Teeth with resorbed roots were excluded.
- ii. Teeth with broken roots due to trauma were excluded.
- iii. Teeth with developmental disturbances were excluded.
- iv. Rehabilitated teeth were excluded.
- v. Severely decayed teeth were excluded.
- vi. Teeth with attrition, abrasion and erosion were excluded.

### MEASURING THE TOOTH AREA:

The measurement of pulp/tooth ratio was carried out using an image analysis software known as GIMP software (Version 2.10). The outlines of the whole tooth of interest (mandibular lateral incisor, mandibular canine and mandibular first premolar) were marked using the free selection tool and the area was determined by activating histogram by counting the number of pixels involved. The determined area was then noted in an excel sheet (Figure: 1).

### MEASURING THE PULP AREA:

The measurement of pulp/tooth ratio was carried out using an image analysis software known as GIMP software (Version 2.10). The outlines of the pulp of the tooth of interest (mandibular lateral incisor, mandibular canine and mandibular first premolar) were marked using the free selection tool and the area was determined by activating histogram by counting the num-

ber of pixels involved. The determined area was then noted in an excel sheet (Figure: 2).

### PULP/TOOTH RATIO:

The ratio of the determined tooth area and the pulp area of the tooth of interest was determined.

### AGE ESTIMATION:

The age estimation was done by using Babshat. M et al's method. The estimated age was tabulated in Microsoft excel sheet (2007). The radiographs used were then decoded and the actual age of the individual was obtained. The difference between the actual and the predicted age was then tabulated in Microsoft excel 2007. Multiple linear regression analysis was done to obtain new population specific formula.

## RESULT

In this study, the age estimation was done by using PTR of the lateral incisor, canine and first premolar. Study subjects age was ranged between 18 to 45 years and was well distributed across different age groups (Table 1). The Subjects were divided into a base sample of 87 individuals and a control group of 25 (randomly chosen test sample), taking care to ensure that age-distribution was similar in both the groups. Linear regression analysis for the Indian sample produced a statistically significant albeit low correlation between pulp/tooth area ratio and age. Among these, age estimation using lateral incisor and canine were statistically significant ( $p < 0.05$ ). The multiple linear regression equation generated from this study population is,

$$Y = 34.879 - 55.483 * PTR1 - 8.946 * PTR2 - 26.902 * PTR3,$$

Where, PTR is pulp/tooth ratio.

Here  $R^2 = 0.143$ , i.e., 14.3% of the variation in the actual age is explained by the Lateral incisor, canine and premolar in the model. Intercept value 34.879 is the value of actual age when Lateral incisor, canine and premolar measures are ignored.

The regression analysis of simple linear regression between dependent variable as actual age and independent variable as Lateral incisor is tabulated (Table:2). The population-specific formula generated from our study sample with lateral incisor pulp-to-tooth area ratio is

$$Y = 32.429 - 72.627 * PTR1$$

Where, PTR 1 is the pulp/tooth ratio.

Here  $R^2 = 0.131$ , i.e., 13.1% of the variation in the actual age is explained by the PTR1 in the model. Intercept value 32.429 is the value of actual age when PTR1 is ignored. The correlation between PTR and age is low (0.36)

The regression analysis of simple linear regression between dependent variable as actual age and independent variable as the canine (Table:3). The population-specific formula generated from pulp/tooth ratio of mandibular canine is,

$$Y = 29.319 - 43.296 * PTR2$$

where, PTR 2 is the pulp/tooth ratio of mandibular canine.

Here  $R^2 = 0.059$ , i.e., 5.9% of the variation in the actual age is explained by the PTR2 in the model. Intercept value 29.319 is the value of actual age when PTR2 is ignored. The correlation between PTR and age is low (0.24).

These generated formulae of lateral incisor and canine have been randomly tested on the control group (25 samples) to de-



termine the Mean absolute error (MAE). The absolute value of the errors and its average calculated gives the 'mean absolute error' or MAE. The MAE depicts the average magnitude of error in the age predictions. It is also used as a measure of the accuracy of the age estimation method. The same control group was tested also with the Indian formula derived by Babshet. M et al and the Italian formula derived by Cameriere. R et al to determine the MAE. The MAE obtained is tabulated as follows (Table:4). It is seen that the lateral incisor MAE was around 1.21

years, which is the least when compared to mandibular canine (4.61 years) and the previous Indian and Cameriere formula.

The errors of age estimation on the control group with our formula was group under two categories as errors  $\leq 5$  and  $>5$  years of actual age. Among 25 control samples, 16/25 were  $\leq 5$  years of actual age and 9/25 were  $>5$  years of actual age. (Table:5). Hence, the formula generated produced an 'acceptable' age estimate. The actual versus predicted age was plotted in scatter graph (Fig. 3a) showed that the regression model



Fig. 1: Measuring the tooth area using a software



Fig. 2: Measuring the pulp area using a software

does not fit well with the actual age of the data. Numerous factors including variation in the pattern of secondary dentine deposition in Indians and the ethnic differences contribute to large differences between estimated and actual ages. Moreover, the residual plot (Fig. 3b) shows a pattern of systematic over-estimation of age in younger samples and under-estimation in older sample of our study group.

## DISCUSSION

Age of human remains can be estimated from several anatomical structures in the human body. Age estimation is important in the setting of a criminal investigation or a mass disaster because the age can guide investigators to the correctly identify the unknown human bodies among a large number of possible matches. Teeth can however be more advantageous as they are usually more resistant to most of the environmental and post-mortem changes. Age can be estimated with the help of teeth in both dead and alive individuals, with the help of a whole tooth specimen or with a radiograph.<sup>11</sup>

Today gender can be determined with DNA methods whereas, age determination is not as straightforward as gender estimation. Morphological methods, such as radiological examination of skeletal and dental development can be used to determine age in children and adolescents. However, age estimation based on these methods is less accurate in adults. Current methods of age estimation include simple, yet less precise morphological methods or more complex, yet more accurate laboratory methods.<sup>12</sup> Even though there are numerous methods of age estimation of an individual with the help of teeth, the study of morphological parameters of teeth on a radiograph is the most reliable method of age estimation. Quantification of secondary dentine deposition is a very important and indirect method of determining the age, by measuring the pulp/tooth ratio.<sup>13</sup>

In this study, age estimation was determined by in a panoramic radiograph using pulp/tooth ratio (PTR). Study subjects age ranged between 18 to 45 years and was well-distributed across different age-groups. Subjects were divided into a base sample of 87 individuals and a control group of 25 (randomly chosen test samples), taking care to ensure that age-distribution was similar in both groups. Previous study of age estimation carried out by Babshet. M et al, used only mandibular canine, whereas in the present study we had taken the pulp/tooth ratio of mandibular lateral incisor, canine and first premolar. Study conducted by Cameriere. R et al, used both upper and lower canine teeth for estimation of age.

In this present study among mandibular lateral incisor, canine and first premolar, age estimation using PTR of lateral incisor and canine showed statistically significant correlation ( $p$ -value<0.05) with the actual age whereas, age estimation with PTR of first premolar is not having any significant correlation with the actual age. However, the correlation value for mandibular lateral incisor and canine was lower (0.36) and (0.24) respectively.

With these data, multiple linear regression equation was generated as

$$Y=34.879 - 55.483 * PTR1 - 8.946 * PTR2 - 26.902 * PTR3$$

Using multiple linear regression R2 value 0.143 in the pre-

vious research, Babshet. M et al they had hypothesized since they are using only canine, they were getting lesser R2 value and probably multiple linear regression formula using lateral incisor, canine and first premolar might increase R2 value with less MAE. However, our study indicates even after generating multiple linear regression formula using PTR of lateral incisor, canine and first premolar, R2 value and MAE is not improving. This suggests that modest correlation between age and secondary dentin deposition may be inherent in Indians resulting in optimal age estimation.

Owing to these wide variations, generating population specific equation is very significant in improving age estimation.<sup>14</sup> The formula generated from this data using lateral incisor PTR

$$Y= 32.429 - 72.627 * PTR1$$

However, age estimation using PTR of lateral incisor was having R2 value of 0.13 was derived which is a low correlation with actual age, similar to the previous study by Babshet. M et al.

However, when this formula has been randomly applied on our test sample, the MAE improved to 1.21 years. In the previous study conducted by Babshet. M et al, the MAE was improved to 10.76 years. Therefore, our study showed the least MAE.

The formula generated from this data using canine PTR is

$$Y= 29.319 - 43.296 * PTR2$$

However, age estimation using PTR of canine was having R2 value of 0.54 was derived which is a low correlation with actual age, similar to the previous study by Babshet. M et al. Even though the correlation was less.

However, when this formula has been randomly applied on our test sample, the MAE improved to 4.61 years. In the study conducted by Cameriere. R et al, even though the correlation was high (0.925), the MAE was around 4.38 years of the actual age in Italian sample. The same formula when tested on our sample gave a higher MAE of around 11.42 years.

The larger variation in the difference between estimated and actual age was attributed to the combination of factors such as ethnic difference and variation in pattern of secondary dentin deposition in Indians.<sup>15</sup> It appears that the rate of secondary dentine deposition does not progress with increase in age or the deposition is slow and irregular in this population.

The low correlation between the secondary dentine and age in Indian was responsible for the sub-optimal age estimation. According to Schmeling. Aet al the evaluation of age depending upon only a single parameter like dentin translucency or secondary dentine deposition alone can have higher error. There may be no other suitable dental parameter available for non-invasive adult age estimation in a fully developed tooth other than the secondary dentin deposition.<sup>16</sup>

Among the least mean absolute error in age estimation is the one developed by our study based on PTR of Lateral incisor. Therefore, our method is most appropriate compared to Cameriere and Indian formula.

However, increasing the sample size and involving further mandibular central incisor, second premolar and if possible maxillary single rooted teeth may enhance better correlation and lesser MAE in the estimation of age in future studies.



## CONCLUSION

In the present study after the estimation of age by using pulp/tooth ratio of mandibular incisor, canine and premolar among the South Indian population, we conclude that though the Indian formula derived from this study showed no recognizable improvement in age estimation, it is recommended that the population specific formula produces more 'acceptable' age estimates. The low correlation obtained is attributed to the fact in variation of secondary dentin deposition patterns among individuals in India. However, increasing the sample size and involving further mandibular central incisor, second premolar and if possible maxillary single rooted teeth may enhance better correlation and lesser mean absolute error (MAE) in the estimation of age in future studies.

## REFERENCES

- Gulsahi A, Kulah CK, Bakirarar B, Gulen O, Kamburoglu K. Age estimation based on pulp/tooth volume ratio measured on cone-beam CT images. *Dentomaxillofacial Radiology*. 2018 Jan;47(1):20170239.
- Uğur Aydın Z, Bayrak S. Relationship Between Pulp Tooth Area Ratio and Chronological Age Using Cone-beam Computed Tomography Images. *Journal of forensic sciences*. 2019 Jul;64(4):1096-9.
- Sakuma A, Saitoh H, Suzuki Y, Makino Y, Inokuchi G, Hayakawa M, Yajima D, Iwase H. Age estimation based on pulp cavity to tooth volume ratio using postmortem computed tomography images. *Journal of forensic sciences*. 2013 Nov;58(6):1531-5.
- Afify MM, Zayet MK, Mahmoud NF, Ragab AR. Age estimation from pulp/tooth area ratio in three mandibular teeth by panoramic radiographs: Study of an Egyptian sample. *Journal of Forensic Research*. 2014 May 1;5(3):1.
- Hidayat SR, Oscandar F, Malinda Y, Sasmita IS, Dardjan M, Murniati N, Lita YA. Human age estimation based on pulp volume of canines for chronological age estimation: Preliminary research. *Padjadjaran Journal of Dentistry*. 2018 Nov 30;30(3):184-9.
- Afify MM, Salem WS, Mahmoud NF. Age estimation from pulp/tooth area ratio of canines using cone-beam computed tomography image analysis: study of an Egyptian sample. *Journal of Forensic Research*. 2019;10(1):1-7.
- Das M, Nayyar AS, Punhani N, Puri H, Rohilla R, Chalapathi KV, Babu BA. Validation of Kvaal's and Cameriere's methods of age estimation in people of Marathwada origin. *CHRISMED Journal of Health and Research*. 2017 Oct 1;4(4):238.
- Jeon HM, Jang SM, Kim KH, Heo JY, Ok SM, Jeong SH, Ahn YW. Dental age estimation in adults: A review of the commonly used radiological methods. *Journal of Oral Medicine and Pain*. 2014 Dec;39(4):119-26.
- Singal K, Sharma N. Dental radiology: an adjunctive aid in age estimation. *Journal of Research in Dentistry*. 2018 Mar 27;5(5):90-4.
- Babshet M, Acharya AB, Naikmasur VG. Age estimation in Indians from pulp/tooth area ratio of mandibular canines. *Forensic Science International*. 2010 Apr 15;197(1-3):125-e1.
- Alkass K, Buchholz BA, Ohtani S, Yamamoto T, Druid H, Spalding KL. Age estimation in forensic sciences: application of combined aspartic acid racemization and radiocarbon analysis. *Molecular & Cellular Proteomics*. 2010 May 1;9(5):1022-30.
- Schmeling A, Dettmeyer R, Rudolf E, Vieth V, Geserick G: Forensic age estimation— methods, certainty, and the law. *Deutsches Ärzteblatt International* 2016; 113: 44–50. DOI: 10.3238/arztebl.2016.0044
- R.S. Meindl, C.O. Lovejoy, Ectocranial suture closure: a revised method for the determination of skeletal age at death based on the lateral-anterior suture, *American Journal of Physical Anthropology*. 68 (1985) 57–66.
- D.H. Ubelaker, R.C. Parra, Application of three dental methods of adult age estimation from intact single rooted teeth to a Peruvian sample, *Journal of Forensic Science*. 53 (3) (2008) 608–611.
- R.G. Aykroyd, D. Lucy, A.M. Pollard, T. Solheim, Technical note: regression analysis in adult age estimation, *American Journal of Physical Anthropology*. 104 (1997) 259–265.
- A. Schmeling, G. Geserick, W. Reisinger, A. Olze, Age estimation, *Forensic Science international*. 165 (2–3) (2007) 178–181.

