

# Age estimation in Western Indian population by Cameriere's and Drusini's methods

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## Abstract

**Objectives:** The aim of the present study is to determine applicability of Cameriere's and Drusini's methods in Western Indian population.

**Methodology:** Panoramic radiographs of total 300 Gujarati individuals, equally divided into four study groups were studied by two investigators. The pulp/tooth area ratio (AR) were calculated for maxillary and mandibular canines and tooth coronal indexes (TCI) i.e., the ratio between coronal pulp cavity height and crown height were calculated for mandibular premolars and first and second molars. The acquired data were subjected to correlation and regression analysis and also inter and intraobserver reliability was obtained for both the investigators.

**Results:** The ARs and TCIs for all the respective teeth were significantly correlated with the age of the individuals. The individual regression formulae were derived for all the teeth and were then used separately to calculate the age. There was no statistically significant difference between the mean chronological age and mean calculated age for all the teeth. ( $P > 0.05$ ). The mean absolute errors for all the teeth were  $< 10$  years.

**Conclusion:** The findings of this study prove the applicability of Cameriere's and Drusini's age estimation methods for Western Indian population. However, the weak correlation coefficients suggest the need for further studies to get more accurate results.

**Keywords:** Area ratio, panoramic radiography, secondary dentin, tooth coronal index

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## INTRODUCTION

Age estimation is an important aspect of forensic dentistry and it is necessary for both dead and living individuals. Age is one of the triads of information that is vital in reconstructive identification of bodies where no circumstantial evidence is available and visual recognition is not possible.<sup>[1]</sup> Estimation of age is required for many judicial and civil purposes.<sup>[2]</sup> Several parts of the body

can be used for age estimation, for example, long bones and skull bones.<sup>[3]</sup> The severe circumstances of death like crashes or fires in cases of recent demises and also in cases of historic subjects, the environmental and burial conditions make many parts of the body unusable.<sup>[4]</sup> Teeth are the hardest part of the body and are least affected by the taphonomic process.<sup>[5]</sup> When different parts of the body used for age estimation were compared, tooth was found

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to be the most durable and least affected by postmortem changes.<sup>[6]</sup>

Based on the stages of development and eruption of teeth, age estimation is relatively simple in children. However, in adults, age estimation can become both difficult and challenging.<sup>[7]</sup> Analysis of cementum annulations, root transparency and determination of aspartic acid racemisation are the various methods of age estimation using tooth.<sup>[6]</sup> These methods are very complex and requires extraction of tooth and destruction of tooth structure. While extraction of a healthy tooth in living individual is both unethical and impractical, it is important to preserve the teeth of a dead individual for various legal and cultural reasons.<sup>[8]</sup> Dental radiographic methods do not require any compromise of tooth or tooth structure and provide a more conservative and yet reproducible approach for age estimation.

After root completion, secondary dentine is deposited throughout one's life reducing the pulp chamber dimension. It is known that the size of the pulp chamber reduces as the chronological age advances and it is least influenced by other environmental factors.<sup>[6]</sup> The study of tooth radiographs to measure secondary dentin deposition is a nondestructive and simple process which can be applied to both living and deceased persons.<sup>[4]</sup> Previous studies have described various radiographic measurements on different teeth providing with the ratio representing secondary dentin deposition which can be co-related with chronological age with different success in age estimation.<sup>[3,5,6,9,10]</sup>

Since 2004, Cameriere *et al.*<sup>[11-14]</sup> have studied different teeth for age estimation using the pulp/tooth area ratio to quantify the apposition of secondary dentine. In one of their studies,<sup>[14]</sup> it is stated that the pulp/tooth area ratio measurements are more precise by using canine teeth because canine teeth have larger pulp areas and experience less wear due to their specific occlusion.

By partly following the method developed by Ikeda *et al.*,<sup>[15]</sup> in 1997, Drusini *et al.*<sup>[16]</sup> has developed a method to correlate the reduction in coronal pulp cavity determined as tooth coronal index (TCI) with age. In this method, the measurements were performed on the mandibular premolar and molar teeth.

Various studies have been performed by using Cameriere's and Drusini's techniques in Turkish,<sup>[9]</sup> Brazilian,<sup>[17]</sup> Sulaimani,<sup>[18]</sup> Australian,<sup>[19]</sup> Italian,<sup>[11,16]</sup> North Indian,<sup>[8]</sup> South Indian,<sup>[2,20,21]</sup> and various other population. Hence, the present study is designed to determine the applicability

of Cameriere's and Drusini's age estimation technique in Gujarati population representing Western Indian population.

## METHODOLOGY

The permission to conduct this study was obtained Institutional Ethics Committee.

### Subject Selection

A total of 300 digital panoramic radiographs of Gujarati population obtained using Kodak 8000 C Digital Panoramic and Cephalometric Imaging System were selected from the archives of the department. The digital panoramic radiographs of patients between 21 and 60 years of age with good contrast/resolution, showing good images of maxillary and mandibular canines, mandibular premolars and mandibular first and second molars were included in the study. The panoramic radiographs with positioning and magnification errors, any pathology (tumors, fractures, developmental anomaly, etc.) in upper or lower jaw or with missing, impacted, carious and periapical pathologies in any of the tooth of interest were excluded from the study. The radiographs obtained were equally divided into four age groups i.e., 21–30, 31–40, 41–50 and 51–60 years with each group comprising of 75 radiographs [Table 1].

### Radiograph measurements

All 300 radiographs were subjected to measurements. The radiographs were exported into JPEG format using trophy Digital Imaging and Communications in Medicine (DICOM) software. The measurements were performed on these JPEG images by using area tool and distance tool in Adobe Acrobat Professional 7.0 software according to the methods described by Cameriere *et al.*<sup>[14]</sup> and Drusini *et al.*<sup>[16]</sup> Canine pulp area (CPA) and canine tooth area (CTA) of maxillary and mandibular canines and crown height (CH) and coronal pulp cavity height (CPTH) of mandibular premolars and first and second molars were measured. All the measurements were performed on the teeth of the right side of jaws. The ratio of CPA and CTA was calculated as pulp/tooth area ratio (AR) and the ratio of CPTH and CH was calculated as TCI using the formula  $TCI = CPCH \times 100/CH$ . To test intra and interobserver reliability, the measurements were repeated by investigator

**Table 1: Age and sex distribution of study subjects**

Age group (years)	Male	Female	Total
21-30	46	29	75
31-40	52	23	75
41-50	49	26	75
51-60	55	20	75
Total	202	98	300

1 and 2 separately for randomly selected 50 radiographs after 20 days [Figures 1 and 2].

### Statistical analysis

The collected data were analyzed by statistical software International Business Machines Corporation, Statistical package for social sciences, SPSS 19.0, IBM, New York. Pearson correlation was performed between chronological age and AR of maxillary and mandibular canines and TCI of mandibular premolars and 1<sup>st</sup> and 2<sup>nd</sup> molars. Linear regression analysis was done for AR and TCI of each tooth and six separate regression formulae were derived. To test the accuracy of age estimation by these two methods, all six regression formulae were applied for all the 300 radiographs. The difference between chronological age and calculated age was recorded as error. The mean absolute error (MAE) was calculated to predict the deviation of estimated age from the chronological age. The independent samples *t*-test was performed between chronological age and calculated age for each tooth. For the determination of intra- and inter-observer reliability, the reliability analysis was performed and Chronbach's alpha values were obtained. The level of significance was set at  $P < 0.5$ .

### RESULTS AND OBSERVATIONS

A total of 300 panoramic radiographs were analyzed in the present study of which there were 202 males and 98 females [Table 1].

Statistically significant negative correlation was found between chronological age and AR of maxillary and mandibular canines and TCI of mandibular premolars and 1<sup>st</sup> and 2<sup>nd</sup> molars [Table 2].

Although the values of Pearson correlation coefficients (*r*) were suggestive of weak co-relation, the regression formulae were derived for each ratio as the correlation was statistically significant. Gender did not influence the regression model for any of the tooth of interest ( $P > 0.05$ ). The regression formulae derived were as follows:

For AR of maxillary canine: Age = 49.212 – 83.637 × AR

For AR of mandibular canine: Age = 47.018 – 64.320 × AR

For TCI of mandibular 1<sup>st</sup> premolar: Age = 26.436 + 0.42 × TCI

For TCI of mandibular 2<sup>nd</sup> premolar: Age = 24.939 + 0.494 × TCI

For TCI of mandibular 1<sup>st</sup> molar: Age = 21.231 + 0.604 × TCI

For TCI of mandibular 2<sup>nd</sup> molar: Age = 22.903 + 0.590 × TCI

The formulae were applied for each and every tooth and the estimated ages were calculated for all 300 panoramic radiographs. The MAEs were 10 years for maxillary canine, mandibular canine and mandibular 1<sup>st</sup> premolar and 9 years for mandibular 2<sup>nd</sup> premolar, 1<sup>st</sup> molar and 2<sup>nd</sup> molar. The difference between chronological age and calculated age was found to be statistically not significant for any of the tooth [ $P > 0.05$ , Table 3].

The intra-observer and inter-observer reliability were found to be good (Chronbach's alpha = 0.9 and 0.8 respectively).

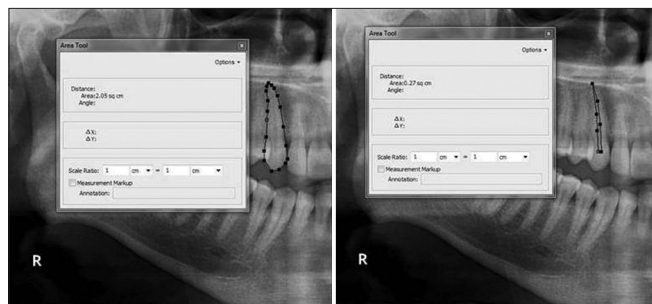
### DISCUSSION

Secondary dentin formation is a continuous process throughout the individual's life. It is mainly associated with aging process and certain environmental factors like caries and attrition influence it to some extent. The dimensions of pulp chamber decreases with advancing age and hence its radiographic measurements can be

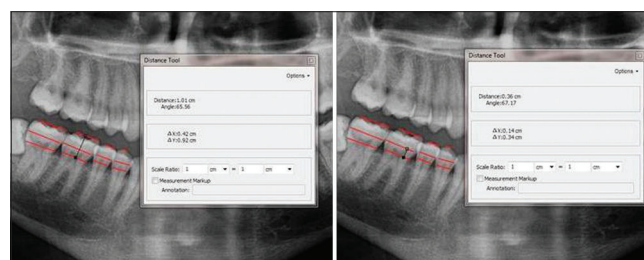
**Table 2: Correlation coefficients between age and indexes**

Indexes	Pearson co-relation coefficient (r)	P
AR of maxillary canine	-0.344	0.013
AR of mandibular canine	-0.306	0.026
TCI of mandibular 1 <sup>st</sup> premolar	-0.279	0.000
TCI of mandibular 2 <sup>nd</sup> premolar	-0.303	0.000
TCI of mandibular 1 <sup>st</sup> molar	-0.420	0.000
TCI of mandibular 2 <sup>nd</sup> molar	-0.407	0.000

AR: Area ratios, TCI: Tooth coronal indexes



**Figure 1: Measurement of canine pulp area and canine tooth area**



**Figure 2: Measurement of crown height and coronal pulp cavity height**

**Table 3: Difference between chronologic age and estimated age**

Tooth	Mean chronologic age (years)	Mean estimated age (years)	P
Maxillary canine	40.1267±11.6598	40.1321±1.6537	0.977
Mandibular canine	40.1267±11.6598	40.1366±1.2241	0.976
Mandibular 1 <sup>st</sup> premolar	40.1267±11.6598	40.1526±3.1740	0.966
Mandibular 2 <sup>nd</sup> premolar	40.1267±11.6598	40.1209±3.5297	0.992
Mandibular 1 <sup>st</sup> molar	40.1267±11.6598	40.1156±4.8974	0.949
Mandibular 2 <sup>nd</sup> molar	40.1267±11.6598	40.1348±4.7513	0.993

co-related for adult forensic age estimation.<sup>[6,9]</sup> This theory has been supported by various authors in previous studies. Bodeckar<sup>[22]</sup> established that deposition of secondary dentin can be correlated with age in 1925. Secondary dentin deposition was also introduced for age estimation in the method proposed by Gustafson.<sup>[23]</sup> In 1995, Kvaal *et al.*<sup>[10]</sup> presented a radiographic method for age estimation based on secondary dentin deposition.

By following the same concept of secondary dentin deposition, Cameriere *et al.*<sup>[11-14]</sup> co-related pulp/tooth AR of various teeth with age. Drusini *et al.*<sup>[16]</sup> introduced a parameter called TCI, which can also be obtained on the principle of secondary dentin deposition, to correlate for age estimation. The concepts of Cameriere and Drusini were well supported in the literature.<sup>[9,16-21]</sup> Hence, the present study was conducted to determine the applicability of these two methods in Gujarati population representing Western Indian Population.

For Cameriere's method, the AR of maxillary and mandibular canines were co-related with age as the canine is most reproducible for AR measurements<sup>[14]</sup> and it is the last tooth to be lost in the dentition. For TCI measurement we have chosen mandibular left premolars and 1<sup>st</sup> and 2<sup>nd</sup> molars as per the method described by Drusini *et al.*<sup>[16]</sup> We have used all the teeth of the right side for the measurement to maintain the uniformity.

In the present study, statistically significant negative correlation was obtained between the AR of both maxillary and mandibular canine and TCI of mandibular premolars and 1<sup>st</sup> and 2<sup>nd</sup> molars and age [Table 2]. Negative co-relation suggests that as the age advances, the particular ratio decreases. This finding supports the basis of our research concept that deposition of secondary dentin can be co-related with age. This finding of the present study was consistent with Hatice *et al.*,<sup>[9]</sup> Cameriere *et al.*<sup>[14]</sup> and Drusini *et al.*<sup>[16]</sup> The *r* values for AR for both the canines were suggestive of weak co-relation. This finding was consistent with Gazge *et al.*<sup>[20]</sup> but were in contrast with Hatice *et al.*<sup>[9]</sup> and Cameriere *et al.*<sup>[14]</sup> The *r*

values for TCI of all four teeth were also suggestive of weak co-relation. This finding was similar to Hatice *et al.*<sup>[9]</sup> and Karkhanis *et al.*<sup>[19]</sup> but was different from the studies conducted by Gotmare *et al.*<sup>[21]</sup> and Drusini *et al.*<sup>[16]</sup> The difference in the findings can be attributed to population difference and also use of different radiographs for measurement.

Regression equation derived for AR and TCI of all the teeth measured and age was calculated. There was no statistically significant difference ( $P > 0.05$ ) between mean chronologic age and mean calculated age for any of the tooth [Table 3]. The MAE was also  $<10$  for all the teeth in question which was falling into acceptable range of forensic age estimation.<sup>[24]</sup> Thus, our study proves the applicability of Cameriere and Drusini's age estimation techniques for Western Indian population. Our findings were in accordance with Dar *et al.*,<sup>[2]</sup> Kumar and Choudhary,<sup>[8]</sup> Hatice *et al.*<sup>[9]</sup> for Cameriere's technique and Gotmare *et al.*<sup>[21]</sup> and Talabani *et al.*<sup>[18]</sup> for Drusini's technique.

Our study demonstrated that gender does not influence the regression model and we obtained the regression formulae applicable for both the sex. This finding was supported by previous studies.<sup>[5,9,14]</sup> In our study, a high level of inter and intraobserver reliability was found which represents the reproducibility of the techniques. This finding was also in accordance with previous studies.<sup>[9,13]</sup>

Personal identification is an important aspect of forensic odontology. Age estimation serves a critical role in the triad of reconstructive personal identification. The association of secondary dentin deposition with increasing age is one of the vital facts utilized for adult forensic age estimation. Radiographic methods are many a times method of choice due to their noninvasive nature. Various methods<sup>[3,5,6,9,10]</sup> are described in the literature for radiographic assessment of secondary dentin deposition and its correlation with age of the individual with different accuracy. The present study provides insight into two such methods, i.e., the Cameriere and Drusini's age estimation methods for Western Indian population. The present study adds population-specific data to the global literature. Furthermore, our study provides baseline data future research in this field using different population. One major limitation of this study was weak correlation found between age and AR and TCI ratios. Future studies can explore this by using larger sample size and different radiographs. Despite this limitation, the regression model was found to be suitable for age estimation and provided clinically applicable results.

## CONCLUSION

The Cameriere and Drusini's age estimation methods were applied for age estimation in Gujarati population in the present study. The no statistically significant difference between calculated age and chronological age and the MAE <10 proves the applicability of these methods for the Western Indian population. However, the weak correlation coefficients suggest the need for further studies to get more accurate results.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

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