

# Volumetric Analysis of Teeth using Cone Beam Computed Tomography for Age Estimation among the Indian Residents: A Pilot Study

Rasika Pawar<sup>1\*</sup>, Sangeeta Palaskar<sup>2</sup>, Swati Patil<sup>3</sup>, Pargatsingh Kathuriya<sup>4</sup>,  
Saurabhachandra B. Pawar<sup>5</sup> and Rucha Gore<sup>6</sup>

<sup>1</sup>Lecturer, Oral Pathology and Microbiology, Sinhgad Dental College and Hospital, Pune - 411041, Maharashtra, India; rasikapawar0710@gmail.com

<sup>2</sup>Professor & Head, Oral Pathology and Microbiology, Sinhgad Dental College and Hospital, Pune - 411041, Maharashtra, India

<sup>3</sup>Lecturer, Oral Pathology and Microbiology, Sinhgad Dental College and Hospital, Pune - 411041, Maharashtra, India

<sup>4</sup>MDS(Oral Pathology and Microbiology) Dental Practitioner, Pune, Maharashtra, India

<sup>5</sup>Post graduate student, Public Health Dentistry, Sinhgad Dental College and Hospital, Pune - 411041, Maharashtra, India

<sup>6</sup>Lecturer, Oral Pathology and Microbiology, D Y Patil Dental School, Pune - 412105, Maharashtra, India

## Abstract

**Background:** In forensic odontology, dental age estimation is important. Deposition of secondary dentin is a more significant method in dental age prediction. This secondary dentin decreases the size of the pulp cavity. Thus, pulp size is reduced with advancing age. Therefore, the tooth to pulp size area ratio goes on increasing as age increases. **Aim:** To assess the ratio of “pulp/tooth volume” in single and multi-rooted teeth by Cone Beam Computed Tomography (CBCT) and correlate with the age. **Objective:** 1. To analyse ratio of pulp/tooth volume in single and multi-rooted teeth, 2. To evaluate accuracy of the Yang’s formula available for age estimation, 3. To generate the formula for multi-rooted teeth and correlate with the age. **Methodology:** 150 extracted teeth of which 50 permanent maxillary canines, 50 maxillary first premolars and 50 permanent maxillary first molars were collected and subjected to CBCT scanning for volumetric analysis. ‘Pulp Volume (PV)’, ‘Tooth Volume (TV)’ and ‘Pulp/Tooth Volume Ratio (PTVR)’ were calculated. **Result:** Linear regression analyses established that the chronological age and PTVR correlated with each other. Pearson correlation coefficient showed TV, PV and PTVR were inversely proportional to age. **Conclusion:** This study revealed that permanent maxillary canine has the best correlation with age followed by First molar and First premolar.

**Keyword:** Secondary Dentin, Forensic Odontology, Pulp Volume, Total Tooth Volume, Cone Beam Computed Tomography

## Introduction

The use of dental evidence has inspired so much that forensic dentistry has become a single positive identification method that solve certain forensic cases<sup>1</sup>. The Federation Dentaire Internationale (FDI) has defined forensic odontology as “That branch of dentistry which, in the interest of justice, deals with the proper handling, examination of dental evidences, and with the proper evaluation and presentation of dental finding”<sup>2</sup>. It involves

the identification of dead or alive human beings. There is primarily gender identification and age estimation<sup>3</sup>. Many times an individual’s age estimation is required for legal purposes<sup>4</sup>. Various other reasons involving age estimation are in case of the refugees, immigrants or asylum seekers also in some criminal cases in references to false statements or witnesses<sup>5</sup>.

Physiological methods of age estimation depend on bones and teeth. Teeth are strongest hard tissue in the body and are proven to be preserved for longer than other hard

\*Author for correspondence

tissues like bone. Human dentition is generally preserved from decomposition, degradation, incineration and high-impact trauma because of its sturdiness. In addition, other advantages are that they remained protected from all sides by soft tissue like lips, cheek and tongue which protect it at the time of accident. They can be inspected and studied in living as well as in dead. All these benefits put teeth on top over other skeletal structures and as the most preferred tissue in forensic Odontology for age estimation and personal identification<sup>6</sup>. A gradual structural change takes place in the teeth throughout the life. These changes can be studied using the dental hard tissues like enamel, dentin, and cementum<sup>7</sup>.

A thorough literature search revealed many studies on assessment of secondary dentin using radiographic methods. Study of 'Pulp/ tooth area ratio' in teeth using intra oral periapical radiographs helped for age estimation but the primary disadvantage of radiograph is, it is a two dimensional (2D) view of a three dimensional (3D) object<sup>8</sup>. As the secondary dentin deposition may not be equal everywhere, assessment of Pulp/Tooth Volume Ratio (PTVR) must be considered. Limitations of two-dimensional projection also include magnification, distortion, superimposing and misinterpretation of structures<sup>9</sup>. Hence CBCT has been used for imaging internal structure of teeth<sup>10</sup>. The CBCT is specifically dedicated for oral and maxillofacial region imaging which leads to a paradigm shift from 2 Dimension to 3Dimensions<sup>11</sup>. CBCT scanning has provided an advanced technique to acquire 3 Dimensional images of teeth which can be used for pulp/ tooth volume calculation<sup>12</sup>. To best of our knowledge there are few studies available on the use of CBCT for determination of pulp/ tooth volume ratio in current literature<sup>13</sup>. Therefore, this study analyzed the 'pulp/ tooth volume ratio' in single rooted teeth and multi rooted teeth for age estimation using CBCT.

## Materials and Methods

This study consisted of total 150 extracted teeth of which 50 were permanent maxillary canines, 50 maxillary first premolars and 50 permanent maxillary first molar teeth. Extracted teeth for periodontal disease, orthodontic treatment, denture fabrication etc. were included whereas teeth with any periapical pathology, Dental caries, Attrition more than grade 1, Erosion, abrasion, Teeth with restorations, Teeth used for prosthetic fittings were excluded.

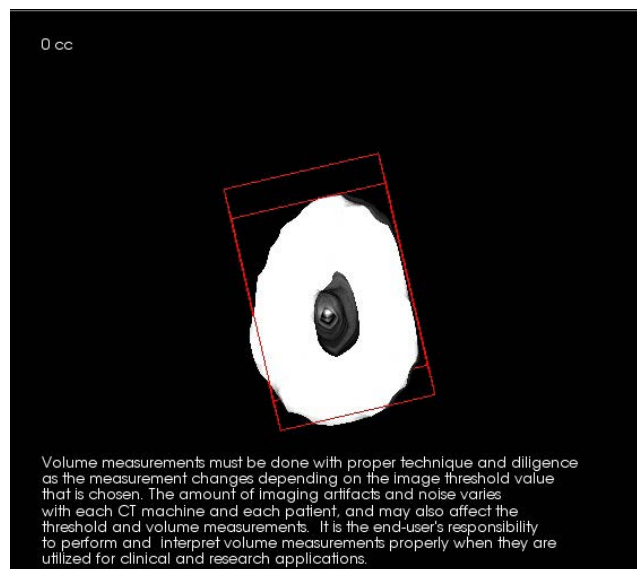
### Data Collection Procedure

Following extraction, the patient's name, age, gender and tooth number was recorded. Teeth were washed thoroughly under tap water and soft tissues were cleaned from the root surface using gauze, following which they were then kept in 2.5% sodium hypochlorite for 30 min to remove surface soft tissues. Scaling of extracted teeth was performed to remove hard deposits such as calculus from tooth surface with help of NSK ultrasonic scaler. Extracted teeth were coded with numbers from 1 to 50 for each tooth type i.e. maxillary canines, maxillary 1st premolars and maxillary 1st molars using a permanent marker pen. Then these specimens were stored in a bottle containing mixture of thymol iodide crystals in distilled water till the complete data collection.

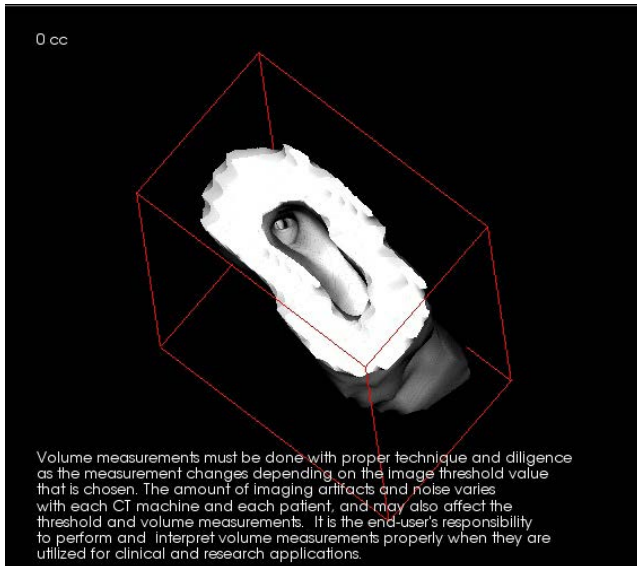
### Determination of Total Tooth Volume (TV) and Pulp Volume (PV)

After the completion of data collection, the extracted teeth were subjected to CBCT scanning at Insight CBCT, a 3D maxillofacial imaging center, Pune. The scans were obtained using CBCT imaging series and examination was achieved with iCAT 17-19 CBCT. Scan parameters: Voxel size: 0.125 mm Beam diameter: 4 x 16 cm Scan time: 26.9 sec

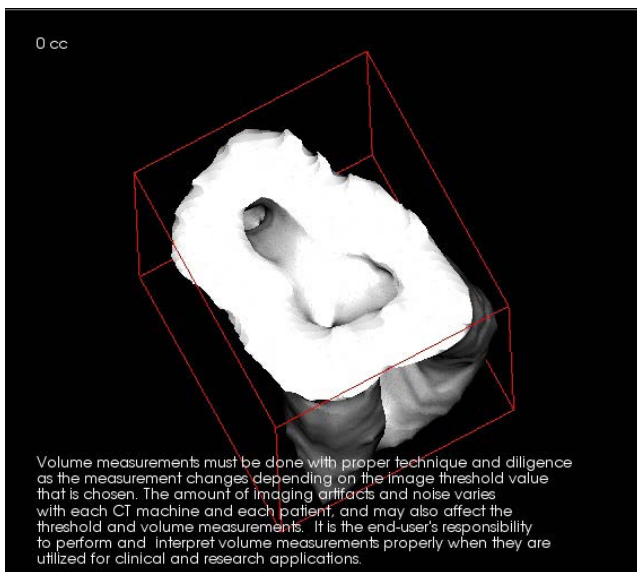
In each scan the tooth was examined in Section part of software INVIVO 5.1 by Anatomage, US; for any defect in axial, coronal and sagittal sections. The density in Hounsfield Units (HU) in various sections was obtained for each tooth simultaneously; for PULP space, dentin,



**Figure 1:** CBCT image of canine with tooth volume (572mm<sup>3</sup>) in its Cross sectional slice



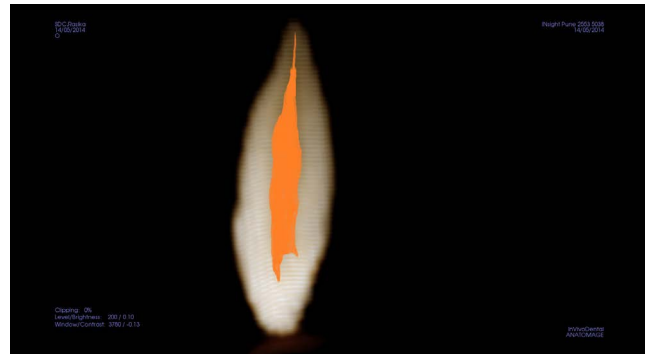
**Figure 2:** CBCT image of premolar with tooth volume (532mm<sup>3</sup>) in its Cross sectional slice



**Figure 3:** CBCT image of premolar with tooth volume (532mm<sup>3</sup>) in its Cross sectional slice

enamel and cementum to give the range of maximum and minimum HU value.

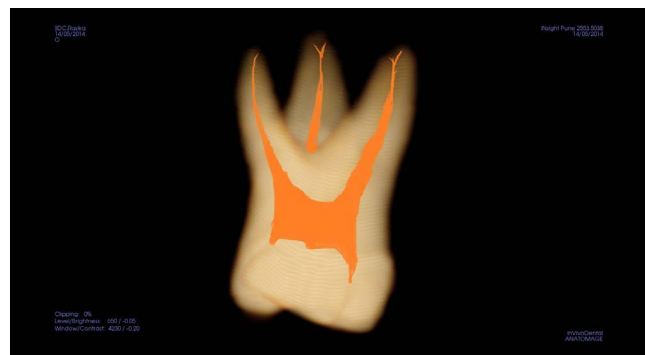
In 3D volume render; the desired tooth was cropped carefully from the surrounding so as to obtain a single tooth data; To measure the complete tooth volume: the readings obtained from section view for lowest HU value (Pulp Space) and highest HU Value (Enamel) are taken as a threshold limit in Volume measurement tool giving the volume of a data in between that range. The complete



**Figure 4:** Three dimensional reconstructed CBCT image of canine with marked pulp volume.



**Figure 5:** Three dimensional reconstructed CBCT image of premolar with marked pulp volume.



**Figure 6:** Three dimensional reconstructed CBCT image of molar with marked pulp volume.

tooth volume is thus recorded and also cross checked by clipping the volume and finding any void if present. The complete (without any void) data thus gave the total tooth volume (Figure 1,2,3).

To measure the Enamel-dentin-Cementum Volume (ECD): the HU readings of Enamel, Cementum and Dentin were observed and the lowest and max HU

readings were obtained for the ECD volume. Again, in volume measurement tool, the threshold limits were adjusted as the derived HU values giving the volume of ECD; which was crosschecked using clipping tool. Both the readings were captured using the software and thus the pulp space volume i.e. pulp volume was acquired as:

Pulp volume = Total Tooth Volume - ECD volume (Figure 4,5,6).

Similar method was employed for all the teeth.

## Result

### Data Processing

The teeth were decoded and divided into five different age groups for statistical analysis as follows: “1) 21-30 years, 2) 31-40 years, 3) 41-50 years, 4) 51-60 years and 5) 61- 70 year” (Graph 1).

All the data for TV and PV of individual tooth were tabulated using MS Office Excel spreadsheet for statistical analysis.

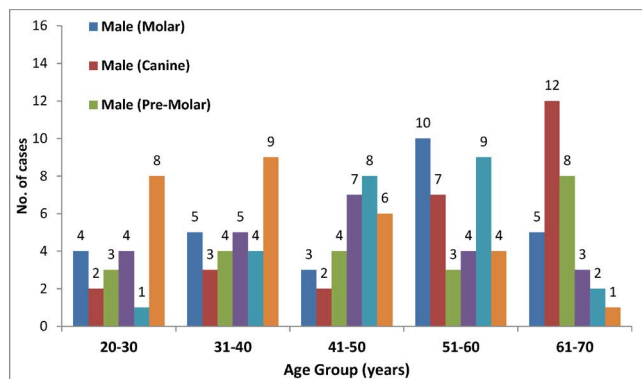
### Statistical Analysis

In order to fulfill the second objective, the available Yang’s formula was applied to PTVR of canines and accuracy of the formula for age estimation was evaluated. Where,

Estimated age (a) = 54.32 – (554.21 × PTVR of canine)

In this the result was not matching with the Yang’s values. Hence the present study was subjected to statistical analysis to derive a new formula for age estimation using ‘SPSS 11.5 statistical software program’ (SPSS Inc., Chicago, Illinois, USA).

Linear regression analyses were performed to the dataset using ‘chronological age’ as dependent variable and ‘PTVR’ as independent variable in order to establish



Graph 1: Age and sex distribution of the cases studied

a correlation between the ‘chronological age’ and the ‘pulp/tooth volume ratio’. Pearson correlation coefficient were calculated where TV, PV and PTVR were inversely proportional to age (Graph 2,3,4,5) examine.

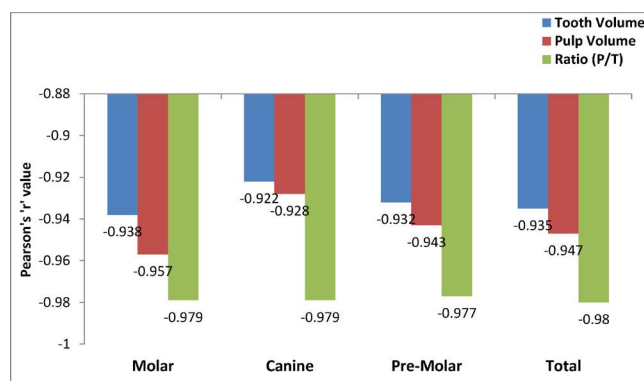
Regression equation calculated for each tooth type as:

For Molar Age = 85.33 – 384.24 x PTVR

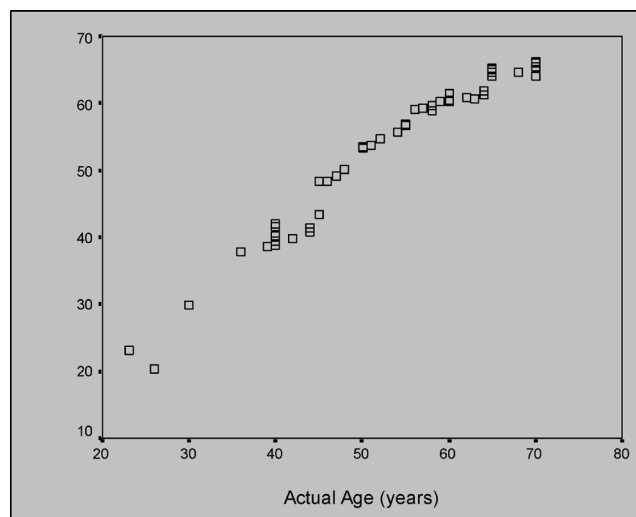
For Canine Age = 85.65 – 391.96 x PTVR

For Premolar Age = 84.82 – 380.28 x PTVR

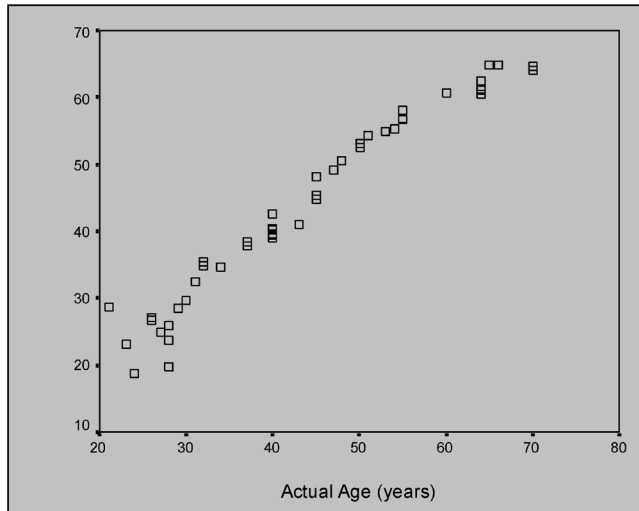
Sensitivity and specificity of the derived formula is defined here as the probability of correctly estimating the age within the acceptable limits of forensic dentistry. Therefore sensitivity and specificity for the derived formula have not been analyzed here because it allowed calculation of age within the acceptable margins.



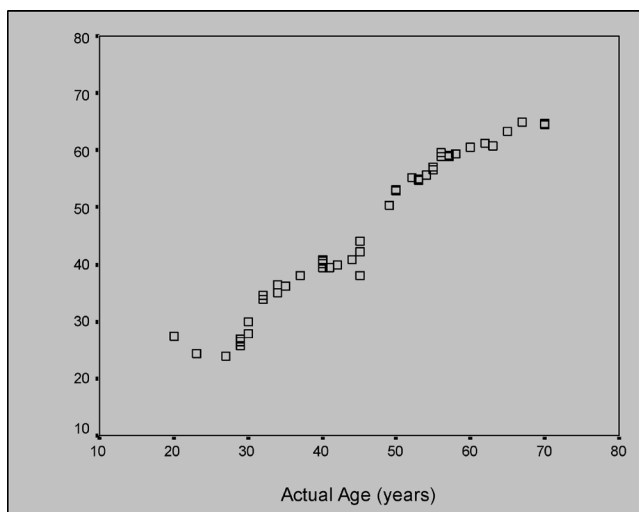
Graph 2: Correlation analysis of total tooth volume, pulp volume, ratio (P/T) with age.



Graph 3: The scatter-diagram showing distribution of actual and predicted age based on Regression analysis (Canine Tooth).



**Graph 4:** The scatter-diagram showing distribution of actual and predicted age based on Regression analysis (Premolar Tooth).



**Graph 5:** The scatter-diagram showing distribution of actual and predicted age based on Regression analysis (Molar Tooth).

## Discussion

In Forensic Odontology, age estimation using teeth is of particular value. Deposition of secondary dentin is one of the significant methods used for dental age prediction<sup>14</sup>. This secondary dentin decreases the size of the pulp cavity<sup>15</sup>. Radiographic studies performed on dental radiograph, uses two dimensional images to calculate the pulp / root size for dental age estimation<sup>16</sup>. Kolltveit *et al.*<sup>17</sup> and Sharma *et al.*<sup>18</sup> used intraoral periapical radiograph whereas Bosmansa *et al.*<sup>19</sup>, Singaraju *et al.*<sup>20</sup> Babshet *et al.*<sup>21</sup> used Orthopantomograph for same.

This radiographic technique uses ratio of pulp/ tooth size and is based on the fact that secondary dentin is continuously deposited throughout the life<sup>12</sup>, because of this pulp size is decreased with increased age. Hence the ratio of tooth area to pulp size goes on increasing as age increases.

In particular the secondary dentin is not deposited homogenously over all the pulpal walls and it also even changes as per the morphology and type of tooth type. The height of pulp cavity also decreases as the age advances<sup>14</sup>. Hence it is essential to study the teeth using 3 Dimensional radiographs either Computed Tomography (CT) scanner or by CBCT. These units allow the volume calculation of each tooth along with corresponding pulp chamber<sup>14</sup>. Present study, employed CBCT to examine. the reduction in the pulp cavity in three types of teeth i.e. maxillary 1st molar, maxillary canine and maxillary 1st premolar.

We have selected maxillary canines for our study because they are the largest single rooted teeth with the large pulp cavity and thus the analysis is easy. Other single rooted teeth in oral cavity are small in size that leads to less clear measurement of the pulp/tooth volume ratio<sup>22</sup>. Maxillary canines are the oldest teeth with less wear than posterior teeth<sup>23</sup>. In our study we have not distinguished between right or left sides and scanned the teeth based on the availability because Kvaal *et al.*<sup>24</sup> in their study did not find significant differences in the measurements of left and the right side teeth of the jaw.

Various radiographic studies utilized radiographs of anterior teeth to construct a formula for age estimation in Indian population<sup>20,21,25,26</sup>. Bosman *et al.* mentioned that anterior teeth are usually not available in elderly making age estimation difficult<sup>19</sup>. Hence Deepu George Mathew *et al* used mandibular first molar radiographs for age estimation<sup>27</sup>. Manjushree Juneja *et al.*<sup>22</sup> studied posterior teeth and mentioned that multi rooted teeth provide more pulp spaces so amount of secondary dentin formed can be better so correlated with age. Hence in this study, we have used maxillary posterior teeth including 1st premolar and 1st molar in order to find out better correlation with age and generate the formula for age estimation.

Previous literature suggested the changes in pulp/ tooth volume ratio was commonly studied in mandibular single rooted teeth that showed better correlation with age. No study has been performed and reported with use of maxillary 1st molar teeth because of relatively with complex morphology. But in present study, strongest

Pearson correlation coefficient was measured in maxillary canine followed by maxillary 1st molar and maxillary 1st premolar.

The previous formula was established for the Belgian population by Yang's was applied to PTVR of canines and accuracy of this formula was evaluated; where, Estimated age (a) =  $54.32 - (554.21 \times \text{PTVR of canine})$ . Our results showed that the formula was accurate for the "Belgian population", but did not hold correct for the Indian population. There was error in age estimates exceeding 'ten years', which is unacceptable in forensic age identification<sup>28</sup>. Indians are considered to be a hybrid of different ethnic groups which have characteristics of 'Caucasian', 'Negroid' and 'Mongoloid' races, and is referred to as the 'Dravidian group'<sup>29</sup>. The existent anthropological differences justify the need for deriving population specific equations for age estimation<sup>29</sup>.

It was stated in the literature that the difference in racial and genetic makeup is responsible for the difference in maturation and the deposition of secondary dentin. Hence the region and population specific formula provides more stable and accurate results<sup>7</sup>. In our study tooth specific formula was thus derived from the samples included, by using correlation regression analysis for age estimation; mentioned in results.

A statistically significant correlation was observed between age and PTVR in all the three types of maxillary teeth, of which the Canine (C) was the most closely correlated with age ( $r = -0.979$ ) followed closely by 1st molar (M) ( $r = -0.979$ ), and the 1st premolar (Pm) revealed the lowest correlation ( $r = -0.977$ ). The lower correlation in premolar could be because of variation in root trunk length of premolars; also, maxillary premolars possess morphological variability among the studied types of teeth. The Standard Errors of Estimates (S.E.E.) of the regression analyses for the individual teeth were as, C =  $\pm 2.428$  years; M =  $\pm 2.770$  years and Pm =  $\pm 3.018$  years. S.E.E.  $< \pm 10$  years is considered acceptable in forensic age prediction.

The linear regression analysis was performed where age was the dependent variable and PTVR was the independent variable, showed a 'coefficient of determination' for canine:  $R^2 = 95.9\%$ , for 1st molar  $R^2 = 95.8\%$  and for 1st premolar  $95.5\%$  which is the proportion of the variation in age that can be accounted for by variation in ratio. In previous study on volume matching of canine by Yang *et al.*<sup>30</sup> showed a 'coefficient

of determination':  $R^2 = 29\%$ . This major difference in  $R^2$  could be due to variation in sample as they have included different types of single rooted teeth including mandibular as well as types teeth. They have mentioned the use of recent generations in CBCT that have better contrast resolution '(12 bits 4096 gray levels that of 8 bits 256 gray levels)'. Thus the latter might give more detailed and improved visualization of the tooth segmentations. In our study we have used equal sample size for all three types of teeth and they are almost equally divided in all age groups. There was 84% to 99.8% accuracy observed when clinical data was compared with CBCT image analysis among all the teeth.

The Pearson correlation coefficient (r) was strongest between the pulp/tooth volume ratio and age was measured on all three teeth types. Total tooth volume, pulp volume, P/T volume ratio inversely and highly significantly correlated with age for Canine, Molar and Premolar tooth (P-value  $< 0.001$ ).

Star *et al.*<sup>14</sup> done a study on single rooted teeth for age estimation using PTVR on CBCT images, also showed similar results and proved that area or volume changes of 'pulp chamber' can be used in estimation of age.

Concerning the practical use of CBCT has been limited because of cost, accessibility, as well as training of professionals. Results of our study were promising; however, this cannot generalize to other populations. The study was limited to the maxillary canines, 1st molar and 1st premolars. Hence, in conditions where these teeth are missing the method cannot be employed. The adaptation of this technique to the teeth in vivo would help forensic odontologist in age estimation using a very objective technique.

This study showed a very promising outcome in terms of newer technique for age estimation based on the "PTVR". A research using larger sample size is therefore required to generalize the application of this technique in forensic research.

## Conclusion

We have analyzed the PTVR of 'maxillary canine', 'maxillary 1st premolar' and 'maxillary 1st molar' teeth in the Indian population using CBCT and correlated the age of the person. PTVR of all the three maxillary teeth revealed that maxillary canine has highest correlation with age followed by 1st molar and 1st premolar. This

study allows use of multi rooted teeth in forensic age estimation.

## References

- Gnanasundaram N. Guest editorial tooth for truth (The glory of forensic dentistry). *J Forensic Dent Sci.* 2010; 2(2):51-52. <https://doi.org/10.4103/0975-1475.81277>. PMID: 21731339 PMCID:PMC3125951.
- Kavitha B, Einstein A, Sivapathasundharam B, Saraswathi TR. Limitations in forensic odontology. *J Forensic Dent Sci.* 2009; 1(1):8-10. <https://doi.org/10.4103/0974-2948.50881>.
- Rajendra R, Shivpathsundaram B. *Shafer's Textbook of Oral Pathology 7th Ed.* Elsevier Publications; 2011. p. 889.
- Balogopal S. Forensic odontology in India. *J Forensic Dent Sci.* 2009; 1(1):1. <https://doi.org/10.4103/0974-2948.50879>.
- Acharya AB. An intersection of oral pathology and forensic odontology. *Int J Oral Maxillofac Pathol.* 2011; 2(1):3.
- Singh K, Anandani C, Bhullar RK, Agrawal A, Chaudhary H. Teeth and their secrets - Forensic dentistry. *J Forensic Res.* 2012; 3:141. <https://doi.org/10.4172/2157-7145.1000141>.
- Cameriere R et al. Age estimation by pulp/tooth ratio in lower premolars by orthopantomography. *Forensic Sci Int.* 2012; 214(1-3):105-12. <https://doi.org/10.1016/j.forsciint.2011.07.028>. PMID:21821373.
- Talreja PK, Acharya AB, Naikmasur VG. An assessment of the versatility of Kvaal's method of adult dental age estimation in Indians. *Arch Oral Biol.* 2012; 57(3):277-84. <https://doi.org/10.1016/j.archoralbio.2011.08.020>. PMID: 21930260.
- Someda H, Saka H, Matsunaga S, Ide Y, Nakahara K. Age estimation based on three-dimensional measurement of mandibular central incisors in Japanese. *Forensic Sci Int.* 2009; 185(1-3):110-14. <https://doi.org/10.1016/j.forsciint.2009.01.001>. PMID:19201557.
- Stein TJ, Corcoran JF, Arbor A, Mich. Pararadicular cementum deposition as a criterion for age estimation in human beings. *Oral Surg Oral Med Oral Pathol.* 1994; 77(3):266-70. [https://doi.org/10.1016/0030-4220\(94\)90297-6](https://doi.org/10.1016/0030-4220(94)90297-6).
- Nanci A. Ten Cate's. *Oral Histology: Development, Structure, and Function* Mosby; 2005. p. 404- 06.
- Stavrianos D, Mastaga I, Starianou, Karaiskou. Dental age estimation of adults: A review of methods and principals? *Res J Med Sci.* 2008; 2(5):258-68.
- Gustafson G, Age Determinations on Teeth. *J Amer Dent Ass.* 1950; 41(1):45-54. <https://doi.org/10.14219/jada.archive.1950.0132>. PMID:15428197.
- Hazha Star et al. Human Dental Age Estimation by calculation of pulp-tooth volume ratios yielded on clinically acquired cone beam computed tomography images of monoradicular teeth. *J Forensic Sci.* 2011; 56(S1):S77-81. <https://doi.org/10.1111/j.1556-4029.2010.01633.x>. PMID: 21182523.
- Sakuma A et al. Age Estimation based on pulp cavity to tooth volume ratio using postmortem computed tomography images. *J Forensic Sci.* 2013; 58(6):1531-35. <https://doi.org/10.1111/1556-4029.12175>. PMID:23879293.
- Vandevoort FM. et al. Age calculation using X- ray microfocus computed tomographical scanning of teeth: A pilot study. *J Forensic Sci.* 2004; 49(4):1-4. <https://doi.org/10.1520/JFS2004069>.
- Kristin MK, Solhim T, Sigrid I. Kvaal methods of measuring morphological parameters in dental radiographs Comparison between image analysis and manual measurements. *Forensic Sci Int.* 1998; 94:87-95. [https://doi.org/10.1016/S0379-0738\(98\)00058-9](https://doi.org/10.1016/S0379-0738(98)00058-9).
- Sharma R, Srivastava A. Radiographic evaluation of dental age of adults using Kvaal's method. *J Forensic Dent Sci.* 2010; 2(1):22-26. <https://doi.org/10.4103/0974-2948.71053>. PMID:21189986 PMCID:PMC3009551.
- Bosmans N, Annb P, Alya M, Willems G, The application of Kvaal's dental age calculation technique on panoramic dental radiographs. *Forensic Sci Int.* 2005; 153(2-3):208-12. <https://doi.org/10.1016/j.forsciint.2004.08.017>. PMID: 16139112.
- Singaraju S, Sharada P, Age estimation using pulp/tooth area ratio: A digital image analysis *J Forensic Dent Sci.* 2009; 1(1):37-41. <https://doi.org/10.4103/0974-2948.50888>.
- Babshet M, Acharya AB, Naikmasur VG, 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 Leg. Med.* 2011; 18(8):350-54. <https://doi.org/10.1016/j.jflm.2011.07.003>. PMID:22018166.
- Juneja M, Devi YB, Rakesh N, Juneja S. Age estimation using pulp/tooth area ratio in maxillary canines-A digital image analysis. *J Forensic Dent Sci.* 2014; 6(3):160-65.
- Cameriere R, Ferrante L, Belcastro GM, Bonfiglioli B, Rastelli E, Cingolani M. Age Estimation by Pulp/Tooth Ratio in Canines by Peri-Apical x-rays. *J Forensic Sci.* 2007; 52(1):121-26. <https://doi.org/10.1111/j.1556-4029.2006.00336.x>. PMID:17209930.
- Kvaal SI, Kolltveit KM, Thomsen IO, Solheim T. Age estimation of adults from dental radiographs. *Forensic Sci Int.* 1995; 74(3):175-85. [https://doi.org/10.1016/0379-0738\(95\)01760-G](https://doi.org/10.1016/0379-0738(95)01760-G).
- Babshet M, Acharya AB, Naikmasur VG. Age estimation in Indians from pulp/tooth area ratio of mandibular canines. *Forensic Sci Int.* 2010; 125:e1-e4. <https://doi.org/10.1016/j.forsciint.2009.12.065>. PMID:20106616.

26. Saxena S. Age estimation of Indian adults from Orthopantomographs. *Braz Oral Res.* 2011; 25(3):225-29. <https://doi.org/10.1590/S1806-83242011005000009>. PMID: 21503416.
27. Mathew DG et al. Adult forensic age estimation using mandibular first molar radiographs: A novel technique. *J Forensic Dent Sci.* 2013; 5(1):56-59. <https://doi.org/10.4103/0975-1475.114552>. PMID:23960417 PMCid: PMC3746475.
28. Ubelaker DH, Parra RC. Application of three dental methods of adult age estimation from intact single rooted teeth to a Peruvian sample. *J Forensic Sci.* 2008; 53(3):608-11. <https://doi.org/10.1111/j.1556-4029.2008.00699.x>. PMID:18471205.
29. Jagannathan N et al. Age estimation in an Indian population using Pulp/tooth volume ratio of mandibular canines obtained from cone beam computed tomography. *J Forensic Odontostomatol.* 2011; 29 (1):1-6.
30. Yang F, Jacobs R, Willems G. Dental age estimation through volume matching of teeth imaged by cone-beam CT. *Forensic Sci Int.* 2006; 159(S1):S78-83. <https://doi.org/10.1016/j.forsciint.2006.02.031>. PMID:16563678.

**How to cite this article:** Pawar, R., Palaskar, S., Patil, S., Kathuriya, P., Pawar, S.B. and Gore, R. Volumetric Analysis of Teeth using Cone Beam Computed Tomography for Age Estimation in the Indian Residents: A Pilot Study. *J Forensic Dent Sci* 2020;12(2):89-96.

Access this article online	
<p><b>Website:</b> <a href="http://www.jfds.org">www.jfds.org</a></p>	<p><b>Quick Response Code</b></p> 