# Role of Pulp Volume Method in Assessment of Age and Gender: An Observational Study from Lucknow, India

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## ABSTRACT

**Introduction:** In forensics, age and gender determination are required for victim identification. Secondary dentine deposition occurs throughout life, resulting in decreased pulp volume and size. Evaluation of pulp volume using Cone Beam Computed Tomography (CBCT) is a non invasive method used to evaluate age and gender.

**Aim:** To evaluate the efficacy of the pulp volume method in determining age and gender.

**Materials and Methods:** An observational study was conducted in the Oral Medicine and Radiology Department of King George's Medical University, Lucknow, Uttar Pradesh, India from July 2019 to August 2020. Pulp volume measurements were obtained from CBCT data of randomly selected individuals (n=90) aged 18-70 years, focusing on maxillary Central Incisors (CI) and maxillary Canine (C). Statistical analyses, including Chi-square test, Pearson's correlation, linear regression, and logistic regression, were performed on the data.

**Results:** The CBCT data from 90 individuals, aged 18-70 years, were evaluated for pulp volume of maxillary CI and C. The Pearson correlation coefficient indicated a decrease in pulp volume with age. The validation of the equations for sex determination revealed higher prediction accuracy for CI (56.70%) compared to C (53.30%).

**Conclusion:** Pulp volume obtained from CBCT can serve as a reliable indicator for age estimation and gender prediction.

## INTRODUCTION

The term "forensic" originates from the Latin word "forensis," meaning "before the forum." Forensic science has a long history, with trials and debates for identifying convicts taking place in public squares in ancient Rome. This extensive field involves the use of various body parts for victim identification in cases of disasters and murders, serving not only the settlement of medicolegal issues but also humanitarian purposes [1].

Age and gender estimation in forensic science refers to the expertise of accurately determining the chronological age and gender of an unknown person involved in legal or judicial proceedings. In medical forensics, age and sex determination primarily rely on long bones and the skull. Sex determination using the complete skeleton has an accuracy of 98%, 90% with the skull, and 95% if pelvic bones are available. When only long bones such as the femur and humerus are present, the accuracy of sex determination by an expert is approximately 80% [2]. Consequently, the accuracy increases with the number of bones available for examination. However, most body parts tend to deteriorate over time or can be destroyed in mishaps [2].

Teeth, on the other hand, are less affected by external factors due to the presence of enamel and its chemical constituents. The use of teeth in forensics is justified by the fact that they also undergo stages of development and maturation, like long bones. Moreover, dental development is not significantly impacted by diseases, drugs, or other factors, unlike bones. These characteristics make teeth highly valuable in forensic as well as in anthropological investigations [3,4].

Age estimation and sex determination in forensic odontology rely on morphological, histological, biochemical, and radiological assessments of teeth. Most odontological assessments use developmental methods for age determination, which pose challenges in adults when tooth development is completed. Therefore, it is essential to devise new methods to assess age even after tooth development is complete [5].

Estimating dental pulp volume can serve as a post-tooth development age estimation method. After a tooth erupts in the oral cavity, secondary dentin deposition begins. This process continues throughout the tooth's lifespan, leading to the narrowing of the pulp chamber and a reduction in pulp size and volume [5].

Assessing the secondary dentin deposited in teeth can be done through tooth sectioning or radiological methods. Tooth sectioning methods, like aspartic acid racemisation, are invasive, complicated, and time-consuming, making them less commonly used. Conversely, radiological methods are simpler, more convenient, and ethically sound, as radiographs can be obtained without tooth extraction in living individuals or cadavers. These methods measure the decrease in pulp volume over time using various third-party software [3,4,6].

In the determination of pulp volume, non invasive 3D modalities such as Computed Tomography (CT) and CBCT are preferred over 2D radiological techniques. 3D scans provide comprehensive information in all three planes unlike a 2D scans [7]. CBCT offers advantages over CT by exposing the patient to lesser radiation. With its isotropic voxels and ability to differentiate objects of different attenuation separated by small distances, CBCT is an appealing imaging method [7].

Although studies have been conducted by Tardivo D et al., and Andrade VM et al., to estimate age and gender based on the pulp volume method [8,9], no similar study had been conducted in Lucknow, Uttar Pradesh. Therefore, the present study was planned to assess both criterias, similar to the study by Andrade VM et al., and provide age and gender estimation formulas with determination coefficients specific to the North Indian population [9]. The present study aimed to estimate age and determine sex in adults using the dental pulp volume method with the assistance of CBCT.

## MATERIALS AND METHODS

An observational study was conducted at the Department of Oral Medicine and Radiology, King George's Medical University, Lucknow, Uttar Pradesh, India from July 2019 to August 2020.

Ethical approval was obtained from the Institutional Ethical Committee (ethical reference no. 103rdECM II B-Thesis/P27). Verbal consent was obtained from individuals whose CBCT data was utilised for the study, based on the inclusion and exclusion criteria mentioned below.

**Inclusion criteria:** CBCT scans of individuals aged between 18 and 70 years with at least one fully erupted CI and one C on either side of the quadrant, with completed root formation, were included. These teeth were considered due to their smaller internal anatomical variation [8].

**Exclusion criteria:** CBCT scans of dentition with decay, ongoing endodontic treatment, restorations, orthodontic or prosthetic devices, severe attrition reaching up to the incisal/occlusal third of the teeth, fractured tooth, pulp calcifications, impaction, gross malocclusion, and periodontal pathologies were excluded.

**Sample size calculation:** The sample size was calculated based on the minimum correlation between pulp volume and age in the study population, similar to the study done by Andrade VM et al., using the formula [9]:

$$n = c\left[\left(\frac{z_\alpha + z_\beta}{C(r)}\right)^2 + 3\right]$$

$$C(r) = \frac{1}{2}\log_e\frac{1+r}{1-r}$$

r=0.872 (minimum correlation between pulp volume and age)

c=9, (overall combinations of gender and tooth type)

Type-I error $\alpha$=5% (corresponding to 95% confidence level)

Type-II error $\beta$=10% (detecting results with 90% power of the study)

Based on these parameters, the required sample size was determined to be 90.

## Procedure

**Data collection:** The study enrolled only one group with CBCT data from 90 individuals. CBCT scans of the CI and C were randomly selected, following the inclusion/exclusion criteria of the study.

**Pulp volume analysis:**

1. The scans were transferred from the Carestream CS 9300® CBCT machine console in the form of a DICOM (Digital Imaging and Communications in Medicine) files to a system with third-party software called "Dolphin" for assessment and measurement of the pulp volume of the desired tooth.

2. The tooth of interest was snipped from the arch, creating a Region of Interest (ROI), using the cutting tool in the software for pulp volume measurement.

3. The outer portion of the selected tooth was roughly cut using the tool to expose the coronal and radicular pulp.

4. The remaining layer of dentin surrounding the pulp was snipped to fully expose the pulp.

5. The pulp obtained was measured using the software. The age and sex of the subjects were known prior to the study, so the obtained pulp volumes were analysed statistically to find correlations between pulp volume and age and sex.

## STATISTICAL ANALYSIS

The results were analysed using descriptive statistics and comparisons were made among various groups. Categorical data were summarised as proportions and percentages (%), while quantitative data were summarised as mean±Standard Deviation (SD). Statistical analyses included the Chi-square test, Pearson's correlation, linear regression analysis, and logistic regression analysis. The data were analysed using the Statistical Package for Social Sciences (SPSS 23.0) software and Microsoft excel.

## RESULTS

In the present study, the majority of cases were aged between 20-29 years (44.4%), followed by the age range 30-39 years (30%). There were more males (n=47) included in the study compared to females (n=43) [Table/Fig-1].

| Age | No. of cases | Percentage (%) |
|---|---|---|
| ≤19 years | 5 | 5.6 |
| 20-29 years | 40 | 44.4 |
| 30-39 years | 27 | 30.0 |
| 40-49 years | 8 | 8.9 |
| ≤50 years | 10 | 11.1 |
| **Sex** | | |
| Female | 43 | 47.8 |
| Male | 47 | 52.2 |
| Total | 90 | 100.0 |

**[Table/Fig-1]:** Age distribution of subjects.

The overall mean volume of the CI in the study cases was 20.78±9.47 mm³ (range 7.34-47.46 mm³), while the mean volume of the C was 43.13±20.39 mm³ (range 14.45-99.40 mm³) and the mean average volume of CI and C was 31.96±14.14 mm³ (range 10.90-73.43 mm³). The CI volume, C volume, and average volume were higher for females than males [Table/Fig-2].

| Sex | | CI (mm³) | C (mm³) | Average volume |
|---|---|---|---|---|
| Female | N | 43 | 43 | 43 |
| | Mean | 22.80±9.93 | 45.73±20.18 | 34.26±14.69 |
| | Minimum | 7.34 | 14.45 | 10.90 |
| | Maximum | 47.46 | 99.40 | 73.43 |
| Male | N | 47 | 47 | 47 |
| | Mean | 18.93±8.73 | 40.76±14.46 | 29.84±13.43 |
| | Minimum | 7.34 | 14.46 | 10.90 |
| | Maximum | 47.44 | 99.39 | 73.42 |
| Total | N | 90 | 90 | 90 |
| | Mean | 20.78±9.47 | 43.13±20.39 | 31.96±14.14 |
| | Minimum | 7.34 | 14.45 | 10.90 |
| | Maximum | 47.46 | 99.40 | 73.43 |

**[Table/Fig-2]:** Descriptive summary of CI and C volumes with gender.
Central Incisors (CI) and Canines (C)

The data in [Table/Fig-3] is divided into five age categories: ≤19 years, 20-29 years, 30-39 years, 40-49 years, and ≥50 years. Each age category provides information on the number of participants (N), the mean, Standard Deviation (SD), minimum (Min.), and maximum (Max.) values for the CI volume, C volume, and average pulp volume. The overall data for all age groups combined (Total) consisted of 90 participants. The mean values for CI pulp volume, C volume, and average pulp volume were 20.78 mm³, 43.13 mm³, and 31.96 mm³, respectively, with standard deviations of 9.47, 20.39, and 14.14, respectively.

| Age | | CI mm³ | C mm³ | Average Volume |
|---|---|---|---|---|
| ≤19 years | N | 5 | 5 | 5 |
| | Mean | 21.30 | 44.49 | 32.90 |
| | SD | 3.38 | 2.81 | 0.29 |
| | Min. | 19.77 | 39.47 | 32.76 |
| | Max. | 27.35 | 45.75 | 33.41 |
| 20-29 years | N | 40 | 40 | 40 |
| | Mean | 21.55 | 48.48 | 35.02 |
| | SD | 8.83 | 19.03 | 12.36 |
| | Min. | 9.89 | 22.28 | 16.60 |
| | Max. | 47.44 | 99.39 | 73.42 |

| | | | | |
|---|---|---|---|---|
| | N | 27 | 27 | 27 |
| | Mean | 23.17 | 42.55 | 32.86 |
| 30-39 years | SD | 9.94 | 22.38 | 15.96 |
| | Min. | 9.88 | 22.27 | 16.59 |
| | Max. | 47.46 | 99.40 | 73.43 |
| | N | 8 | 8 | 8 |
| | Mean | 21.53 | 44.02 | 32.77 |
| 40-49 years | SD | 11.49 | 22.61 | 16.87 |
| | Min. | 12.70 | 32.00 | 23.22 |
| | Max. | 47.44 | 99.39 | 73.42 |
| | N | 10 | 10 | 10 |
| | Mean | 10.33 | 21.96 | 16.15 |
| ≥50 years | SD | 3.86 | 8.23 | 5.96 |
| | Min. | 7.34 | 14.45 | 10.90 |
| | Max. | 19.97 | 37.57 | 28.77 |
| | N | 90 | 90 | 90 |
| | Mean | 20.78 | 43.13 | 31.96 |
| Total | SD | 9.47 | 20.39 | 14.14 |
| | Min. | 7.34 | 14.45 | 10.90 |
| | Max. | 47.46 | 99.40 | 73.43 |

**[Table/Fig-3]:** Descriptive summary of CI and C$^1$ volumes with age.

The regression equation to predict age by CI volume among males is given by: Age=48.824-0.747 (CI). The Pearson's correlation coefficient between age and CI volume among males was calculated to be -0.409 (r-value=-0.409), indicating a negative correlation. This suggests that the volume of the CI decreases with age. The p-value was <0.05 (0.004), which was statistically significant, that suggests that the regression equation was valid [Table/Fig-4]. The scatterplot suggested that only about 17% of the total cases follow the line of best fit [Table/Fig-5]. The regression equation to predict age by C volume among males was given by: Age=46.798-0.297 (C). The Pearson correlation coefficient between age and C volume among males was -0.248, which is less negative than the correlation with CI volume. This indicates a lesser decrease in pulp volume of the maxillary canine with age.

| Parameter | β | SE | t | p-value | r | R$^2$ |
|---|---|---|---|---|---|---|
| (Constant) CI | 48.824 | 5.17 | 9.45 | <0.001 | -0.409 | 0.168 |
| CI mm$^3$ | -0.747 | 0.25 | -3.01 | 0.004 | | |
| (Constant) C | 46.798 | 4.87 | 9.60 | <0.001 | -0.248 | 0.062 |
| C mm$^3$ | -0.297 | 0.11 | -2.78 | 0.008 | | |

**[Table/Fig-4]:** Regression analysis to predict age by Central Incisors (CI) and Canines (C) volume among males.
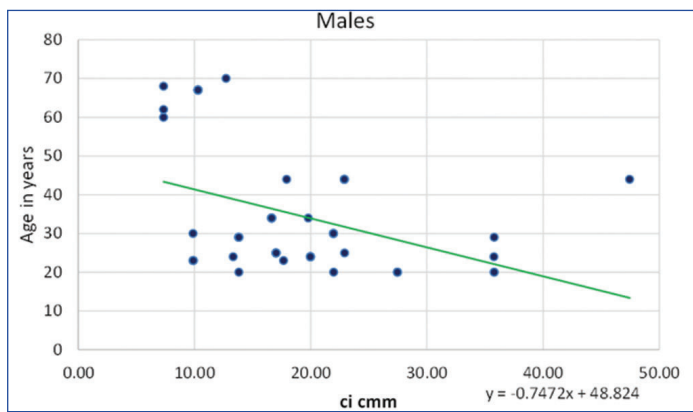


**[Table/Fig-5]:** Scatter plot between variables of age and CI volume among males.

The p-value is <0.05 (0.008), which was statistically significant, confirming the validity of the equation. The determination coefficient for age estimation in males for the maxillary canine is R$^2$=0.062,

which was significantly less. The scatterplot suggests that less than 1% of the total cases follow the line of best fit [Table/Fig-6].
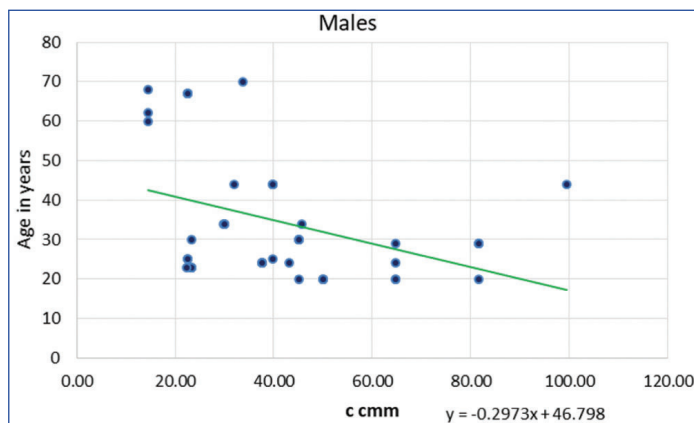


**[Table/Fig-6]:** Scatterplot between variables of age and Canine (C) volume among males.

The regression equation to predict age by CI volume among females was given by: Age=35.351-0.179 (CI). The Pearson correlation coefficient between age and CI volume among females was found to be -0.162, indicating a weak negative correlation. This suggests that there is very little decrease in CI volume with age in females. The p-value (0.299) was significantly higher than 0.05, indicating that the linear regression equation was not valid in the present case and age estimation cannot be accurately done based on CI pulp volume in females. The determination coefficient (R$^2$) was 0.026.

The regression equation to predict age by C volume among females was given by: Age=36.462-0.113 (C). The Pearson correlation coefficient between age and C volume among females was -0.209, indicating a weak negative correlation. This suggests that there is a lesser decrease in pulp volume of the maxillary canine with age in females. The p-value (0.179) was higher than 0.05, indicating that the above equation was not significant for age estimation in females using C pulp volume. The determination coefficient (R2) was 0.044 [Table/Fig-7].

| Parameters | β | SE | t | p-value | r | R$^2$ |
|---|---|---|---|---|---|---|
| (Constant) CI | 35.351 | 4.22 | 8.38 | <0.001 | -0.162 | 0.026 |
| CI mm$^3$ | -0.179 | 0.17 | -1.05 | 0.299 | | |
| (Constant) C | 36.462 | 4.14 | 8.82 | <.001 | -0.209 | 0.044 |
| C mm$^3$ | -0.113 | 0.08 | -1.37 | 0.179 | | |

**[Table/Fig-7]:** Regression analysis to predict age by Central Incisors (CI) and Canines (C) volume among females.

The regression equation to predict age by average volume among males was given by: Age=49.749-0.505 (average volume). The Pearson correlation coefficient between age and average tooth volume of CI and C among males was found to be -0.425, indicating a moderately negative correlation. The p-value (0.003) was less than 0.05, indicating statistical significance and validating the equation. The determination coefficient (R$^2$) was 0.181.

The linear regression equation to predict age by average volume among females was given by: Age=36.342-0.148 (average). The Pearson correlation coefficient between age and average tooth volume among females was found to be -0.198, indicating a weak negative correlation. This suggests that the decrease in average pulp volume of CI and C with age was less in females. The p-value (0.203) was significantly higher than 0.05, indicating that the above equation was not significant for age estimation in females using pulp volume of CI and C. The determination coefficient was 0.039 [Table/Fig-8].

The regression equation to predict age by CI volume when gender was not known was given by: Age=42.569-0.458 (CI). The Pearson correlation coefficient between age and CI tooth volume

| Parameters | β | SE | t | p-value | r | R² |
|---|---|---|---|---|---|---|
| Constant (male) | 49.749 | 5.23 | 9.51 | <0.001 | -0.425 | 0.181 |
| Average volume (male) | -0.505 | 0.16 | -3.15 | 0.003 | | |
| Constant (females) | 36.342 | 4.25 | 8.56 | <0.001 | -0.198 | 0.039 |
| Average volume (females) | -0.148 | 0.11 | -1.29 | 0.203 | | |

**[Table/Fig-8]:** Regression analysis to predict age by average volume (mm³) among males and females.

among females was found to be -0.314, indicating an intermediate negative correlation. The p-value is less than 0.05 (0.003), indicating statistical significance and validating the equation. The determination coefficient is 0.099.

The regression equation to predict age by C volume when gender is not known is given by: Age=42.462-0.218 (C). The Pearson correlation coefficient between age and C tooth volume among females was found to be -0.322, indicating an intermediate negative correlation. The p-value was less than 0.05 (0.003), indicating statistical significance and validating the equation. The determination coefficient is 0.104.

The regression equation to predict age by average tooth pulp volume of CI and C when gender is not known is given by:

Age=43.586 -0.330 (average volume)

The Pearson correlation coefficient between age and average pulp volume of CI and C among subjects with unknown gender was found to be -0.334, indicating an intermediate negative correlation. The p-value was highly statistically significant (p=0.001), validating the equation. The determination coefficient was 0.114 [Table/Fig-9].

| Parameters | β | SE | t | p-value | r | R² |
|---|---|---|---|---|---|---|
| Constant (CI) | 42.569 | 3.37 | 12.64 | <0.001 | -0.314 | 0.099 |
| CI mm³ | -0.458 | 0.15 | -3.10 | 0.003 | | |
| Constant (C) | 42.462 | 3.26 | 13.03 | <0.001 | -0.322 | 0.104 |
| C mm³ | -0.218 | 0.07 | -3.19 | 0.002 | | |
| Constant | 43.586 | 3.42 | 12.73 | <0.001 | -0.334 | 0.114 |
| Average volume | -0.330 | 0.10 | -3.36 | 0.001 | | |

**[Table/Fig-9]:** Regression analysis to predict age by Central Incisors (CI) and Canines (C) volume and average volume (mm³) if gender is not known.

The logistic regression equation to predict gender by CI volume when age is not known is given by: M=1.040-0.046 (CI). Male would be predicted if M>0, else female would be predicted. The prediction accuracy of the equation is 56.70%.

The logistic regression equation to predict gender by C volume when age is not known was given by: M=0.618 - 0.012 (C). Male would be predicted if M>0, else female would be predicted. The prediction accuracy of the equation is 53.30%.

The logistic regression equation to predict gender by average volume when age is not known is given by: M=0.825-0.023 (average volume). Male would be predicted if M>0, else female would be predicted. The prediction accuracy of the equation was 51.10% [Table/Fig-10].

| Parameters | β | SE | p-value | Exp (B) | Prediction accuracy (%) |
|---|---|---|---|---|---|
| Constant (CI) | 1.040 | 0.544 | 0.056 | 2.829 | 56.70 |
| CI mm³ | -0.046 | 0.024 | 0.059 | 0.955 | |
| Constant (C) | 0.618 | 0.506 | 0.222 | 1.856 | 53.30 |
| C mm³ | -0.012 | 0.011 | 0.250 | 0.988 | |
| Average volume | -0.023 | 0.016 | 0.144 | 0.977 | 51.10 |
| Constant (average) | 0.825 | 0.545 | 0.130 | 2.283 | |

**[Table/Fig-10]:** Logistic regression analysis to predict gender by Central Incisors (CI) and Canines (C) volume and average volume (mm³) if age is not known.

## DISCUSSION

In the present study, the authors measured the pulp volumes of the maxillary CI and C in the right maxillary quadrant for age estimation and sex determination. The sample size included 90 subjects, ranging in age from 18 to 70 years, with a total of 43 females and 47 males. The authors compared the study with previous research, as shown in [Table/Fig-11] [9-15].

Andrade VM et al., conducted a study including upper CI and C, which found a strong correlation between chronological age and pulp volume of the selected teeth. They reported Pearson correlation coefficients of -0.8782 for CI and -0.8738 for C, whereas the present study showed significant but lower coefficients for maxillary CI (r=-0.409) in males and maxillary C (r=-0.209) in females [9].

Biuki N et al., conducted a study on the relationship between pulp-tooth volume of upper and lower anterior teeth and chronological age. They found an inverse relationship, indicating a decrease in pulp volume with increasing chronological age, which aligns with the findings [10]. Asif MK et al., also determined the relationship between pulp-tooth volume and chronological age, using the pulp chamber/crown ratio, and found a strong correlation [11].

Gulsahi A et al., conducted a study that showed a negative correlation between pulp volume and chronological age, similar to the present study [12]. Santos MA et al., aimed to formulate regression equations for age estimation in maxillary CI teeth and concluded that pulp measurements are more accurate, supporting the present findings [13]. Kazmi S et al., had similar findings to the present study, indicating that mandibular canines with known sex of the subjects had the best age prediction ability [14].

However, Abdinian M et al., concluded in their study that CI had higher age predictive ability in females than canines, unlike the present findings where canines had better age predictive ability [15].

| S. No. | Author name and study year | Place of the study | Aim of the study | Findings of the study |
|---|---|---|---|---|
| 1 | Andrade VM et al., 2019 [9] | Forensic Odontology Service, Afrânio Peixoto Legal Medicine Institute, Rio de Janeiro, Brazil. | To develop and validate formulas for age and sex estimation based on the pulp cavity volume of teeth using Cone Beam Computed Tomography (CBCT). | There was a strong correlation between chronological age and pulp volume of the selected teeth. Furthermore the determination coefficient was higher for women than men using Cs, better than CI. The determination coefficient for age estimation was higher when sex was known and vice versa. The same was with sex determination when the age was unknown. |
| 2 | Biuki N et al., 2017 [10] | Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Tabriz University of Medical Sciences, Tabriz, Iran. | To evaluate the correlation between chronological age and pulp-to-tooth volume ratios in anterior teeth with the use of the CBCT technique and to determine a regression model to estimate human age. | There was an inverse relationship between pulp-tooth volume and the chronological age which indicated a decrease in pulp volume with increasing chronological age which was similar to the present study. This was higher for CI in men with a Pearson coefficient of (r=-0.409) and higher for Cs in women with a Pearson coefficient t (r=-0.209) and overall higher for men. |
| 3 | Asif MK et al., 2018 [11] | Department of Oral & Maxillofacial Clinical Sciences, Faculty of Dentistry, University of Malaya, 50603, Kuala Lumpur, Malaysia. | To investigate which amongst the two methods of volumetric analysis of maxillary CI displayed higher strength of correlation between chronological age and pulp/tooth volume ratio for Malaysian adults. | Study concluded that pulp cavity/tooth ratio is a reliable age estimation method and is independent of gender. |

| 4 | Gulsahi A et al., 2018 [12] | Department of Dentomaxillofacial Radiology, Faculty of Dentistry, Baskent University, Ankara, Turkey. | To investigate the relation between the chronological age and the ratio of Pulp Volume (PV) to Tooth Volume (TV) measurements using CBCT images of single rooted teeth. | The study concluded that, pulp volume to tooth volume ratio was gender independent but had correlation with age of the subject with strongest correlation with ratio pertaining to maxillary CI followed by other teeth selected in the study. |
|---|---|---|---|---|
| 5 | Santos MA et al., 2022 [13] | Radiology Unit of the Medicine and Dentistry School at the Santiago de Compostela University, Portugal. | To develop regression equations to determine age in adults by means of linear measurements and ratios on sagittal, coronal and axial slices of maxillary CI using Cone Bean Computed Tomography (CBCT). | The study concluded that upper CI were most reliable method for age estimation and horizontal pulp measurements and horizontal pulp measurements improve the accuracy for age estimation. |
| 6 | Kazmi S et al., 2019 [14] | Lahore, Pakistan. | To investigate the relationship strength between C pulp volumes and chronological age from homogenous age distribution and to assess the effect of sex as predictor in age estimation. | Mandibular C were found most reliable teeth for age estimation when the sex of the subject was known. |
| 7 | Abdinian M et al., 2021 [15] | Dental Implants Research Center, Department of Oral and Maxillofacial Radiology, Dental Research Institute, School of Dentistry, Isfahan University of Medical Sciences, Isfahan 81746, Iran. | To investigate the correlation between chronological age and pulp-tooth volume ratio in anterior teeth using Cone Beam Computed Tomographic (CBCT) images and provides equations for age estimation based on pulp-tooth volume ratio. | A significant inverse relationship between age and pulp-tooth volume ratio was observed for all the teeth selected under study. And the strongest correlation registered was between age and pulp-tooth volume ratio for mandibular CI and the weakest was for mandibular lateral incisor. Age estimation was most accurate among females using the maxillary CI and among males using the mandibular CI and C and Cs. |
| 8 | Present study | Department of oral medicine and radiology, King George's Medical University, Lucknow. | Role of pulp volume method in assessment of age and gender in Lucknow, India- An observational study. | In the study, conducted, authors found statistically significant correlation between age/gender and pulp volumes of the selected teeth i.e., the pulp volume of the selected teeth decreased with the increasing subject's age. The gender prediction was also just adequate. |

**[Table/Fig-11]:** Comparison of the findings in present study with contrast studies [9-15].

## Limitation(s)

One limitation of the present study is the limited sample size, focusing only on CI and C, with known ages of the subjects.

## CONCLUSION(S)

In conclusion, the present study found a statistically significant correlation between age/sex and pulp volumes of the selected teeth, indicating a decrease in pulp volume with increasing age. Gender prediction was moderately accurate. The authors recommend conducting future studies with a larger sample size, including more teeth for pulp volume measurements, and blinding the age of the individuals for more accurate and valid results.

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AUTHOR DECLARATION:
• Financial or Other Competing Interests:    None
• Was Ethics Committee Approval obtained for this study?    Yes
• Was informed consent obtained from the subjects involved in the study?    Yes
• For any images presented appropriate consent has been obtained from the subjects.    No