AGE ESTIMATION AND GENDER PREDICTION USING PULP CHAMBER VOLUME OF MAXILLARY SECOND PREMOLAR AND MAXILLARY FIRST MOLAR FROM CONE BEAM COMPUTED TOMOGRAPHY IMAGES IN A SUBSET OF INDIAN POPULATION

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ABSTRACT

Age estimation and gender prediction has always been the forefront in forensic odontology. These kinds of studies do help in easy check on the parameters and help in the further process of age as well as gender distribution using noninvasive methods and techniques. Here in the study CBCT has been used to check the pulp chamber volume so that it helps in the age estimation as well as gender prediction.

Keywords: *Gender Prediction, Age estimation, Pulp Chamber, CBCT, Indian Population*

I. Introduction

With the development of forensic odontology, forensic medicine was redefined, with tooth determinants playing a crucial part in age and sex determination (1). The determination of a person's age, whether alive or dead, is a crucial part of forensic investigation. In circumstances where visual recognition is impossible, such as those afflicted by accidents or natural disasters, age is one of the triads of information that is critical in determining identification (2). However, age has a role in forensic investigations that goes beyond identification. Forensic Odontology, a subset of forensic sciences, employs the dentist's expertise in identifying victims of major disasters, sexual assault, and child abuse, to name a few. "Forensic" comes from the Latin term "forensic," which meaning "before the forum."

With 32 teeth and five clinical surfaces, there are 1.8 billion possible combinations. Forensic odontology is the branch of dentistry that deals with the proper handling and examination of dental evidence, as well as the proper evaluation and presentation of dental findings in the interest of justice.

Paul Revere, who had placed an ivory restoration in Joseph Warren's mouth, who was Revolutionary War dead and buried on the battlefield, is attributed with the first known case of a dentist reporting a postmortem identification. Paul was able to successfully identify the restoration he had created, which led to Joseph Warren's identification. In the 18th century, using a person's teeth to identify them was an unusual approach. The National Museum of Health and Medicine describes Paul Revere's use of simple forensic dentistry as "one of the earliest cases of forensic evidence used to identify a slain American soldier." (3)

The correct handling, analysis, and appraisal of dental evidence that will be presented in the interest of justice is referred to as forensic odontology. The age (in children) and identification of the individual to whom the teeth may belong can all be obtained from the teeth. Because the dental records gathered can identify an individual or provide the information needed by the police to prove case identification (4), forensic dentist knowledge must include a variety of areas.

In 19701, Keiser-Neilson described forensic dentistry as "that branch of forensic medicine that deals with the right handling and examination of dental evidence, as well as the proper interpretation and presentation of the dental results in the interest of justice." (5,6)

There are three key areas of activity that encompass current forensic odontology, which are :

1. The inspection and assessment of damage to teeth, jaws, and oral tissues caused by a variety of factors.
2. The inspection of marks with the goal of eliminating or identifying a suspect as the culprit in the future.
3. The examination of dental remains (whether fragmentary or complete, and including all forms of dental restorations) from unknown

people or bodies in order to determine if the latter may be identified.

Age changes can be used in the context of criminal investigation in addition to identifying extinct and existing populations

Age estimation, for example, can be crucial in assessing the severity of the punishment meted out to the accused, whose right to vote is based on such information. Other situations when age estimation is used are when immigrants (legal or illegal) lack precise proof of age and birth certificates. As a result, age estimation encompasses both living and deceased subjects, as well as children, adolescents, and adults. In cases of human identification in accidents or other natural disasters, age estimation is also necessary. Evidence of a person's death is critical for claiming belongings and protecting family members' property rights. A death certificate is required to claim insurance and to certify whether or not a person has reached the age of maturity (7).

The toughest known structures in the human body are dental structures, which are sometimes the only recognizable remains in major tragedies and calamities. In these situations, a forensic specialist is essential. Using stages of tooth mineralization to determine the dental age of a damaged body is now a relic of the past (8).

Various forensic specialties, such as forensic medicine, forensic odontology, and forensic anthropology, rely on sex prediction. The most common use of sex estimation is in the identification of skeletal remains and body parts. For sex estimation, odontological and anthropological methodologies are utilized, both of which include many metric and non-metric variables as well as biochemical studies (9). In the case of mishaps, chemical and nuclear bomb explosions, natural disasters, crime investigations, and ethnic studies, determining a person's sex becomes the first priority in the process of identification by a forensic investigator.

Sex determination is a crucial part of forensic odontology, especially when information about the deceased is absent (10). Age estimation is also crucial in anthropological study and treatment planning for a variety of disorders. Similarly, sex estimation aids in case identification, particularly in skeletonization scenarios (11). Furthermore, when it comes to living individuals, such estimates are significant in a variety of scenarios, including those arising under civil law and in the case of refugees and asylum seekers who lack identity information .

In forensic medicine and archaeology, age estimation is one of the most essential topics .

Despite numerous methodologies, age estimate is a never-ending challenge . Adults have completed their dental and skeletal growth, making age assessment more complex and challenging than that of youngsters. Adult approaches based on skeletal degenerative changes are less reliable than methods based on dental development, such as dental hard tissue mineralization and tooth eruption, which are utilised for youngsters.

The dental tissue is the hardest tissue in the human body, resistant to physiochemical damage, and capable of preserving its structure for a long period after death (12)

Various dental-based age estimate methods exist. The majority of these procedures take a long time, need expensive laboratory equipment, and necessitate teeth extraction (13). As a result, these technologies are inapplicable to living persons or bodies that do not have legal authorization for tissue harvesting. Extraction of teeth from living people is unethical and impossible. Another often utilised method is to do a dental wear analysis as a way for estimating one's age. The method's disadvantage is that tooth attrition is heavily impacted by diet and personal habits.

Despite numerous methodologies, estimating age remains a difficult task. The analyses of Gustafson and Johanson, as well as dentinal translucency and cementum annulations, are all routinely employed to determine an individual's age.

Secondary dentine apposition is an important morphological indicator of tooth age. It starts when the apical section of the root has fully formed, the tooth has erupted into the oral cavity, and the tooth has begun to function. This apposition lasts a person's entire life, resulting in a progressive narrowing of the pulp chamber in all teeth. The shrinking of the pulp cavity is an age-related phenomenon that can be influenced by local factors such as attrition, carious lesions, and osmotic pressure changes,

among others. Pulp evaluation has the ability to eliminate, at least in part, the impacts of external causes since secondary dentin is deposited along the inner surfaces of the tooth, insulating it from environmental influences.

To assess the size of the pulp cavity and connect it with age, many two-dimensional imaging such as panoramic or periapical radiographs have been used. Three-dimensional image datasets acquired from cone beam CT, CT, and Micro CT have been used to investigate the potential association between age and pulp volume as a helpful indication for age in recent years, with the widespread usage of three-dimensional imaging in practice. The best accurate approach for measuring pulp volume was reported to be computed tomography scans.

We discovered during our review of these studies that the research samples were limited and exclusively contained single-rooted teeth.

The goal of this study is to determine age and gender in a subset of the Indian population using cone beam computed tomography images of maxillary second premolar and first molar.

II. Methodology

SUBJECTS-

CBCT scans comprising of 100 maxillary first molars and 100 maxillary second premolars were retrospectively collected from female and male patients whose age between 20 and 60 years old from the achieves in the year of 2019-2020 in the Oral Medicine And Radiology Department of D.Y. Patil University School of Dentistry.

The birth date of all subjects was confirmed in the hospital's patient records. The age and sex distributions of the subjects are shown in Table1.

AGE(Years)	MALE	FEMALE	TOTAL
20-30	18	17	35
31-40	09	15	24
41-50	08	16	24
51-60	11	06	17

Table 1: Age and sex distribution of group samples

The Inclusion Criteria

1. High-quality images with maxillary second premolar and maxillary first molar was taken for the study.
2. Males and females between the age group of 20 to 60 years were selected for the study.
3. Sound tooth with normal functional occlusion free from traumatic manifestations were included in the study.

The Exclusion Criteria

1. Any teeth with caries.
2. Any missing maxillary second premolar and maxillary first molar.
3. Endodontically treated teeth.
4. Teeth with any periapical pathology.
5. Teeth with pulpal calcification.
6. Teeth with any restorative materials.
7. Teeth with fracture or pathological process.

III Methodology

The institutional ethical clearance was obtained before the study.

IMAGE ACQUISITION

100 CBCT scans were selected from past archives for analysis using Carestream 9000 CBVI software.

All The CBCT images were acquired using care stream 9000 3D Extraoral imaging system. Exposure parameters for CBCT image were 70 kVp and 10 mA as in accordance with patient size and field of view. Selection of field of view (FOV) was based on clinical needs.

The care stream 9000 Viewer software was used for the reconstruction of all the images. Acquired images were subsequently exported as DICOM data sets. The data was then imported into a 3D image semiautomatic segmenting and voxel-counting software ITK-SNAP 3.8 (open-source software, www.itksnap.org) for the calculation of pulp cavity/chamber volumes.

VOLUME CALCULATION

The acquired images were then opened in HP Laptop (15 11th generation 15s-fr2006TU) to calculate volume in the imported DICOM data, the pulp chamber floor is used as the cut plane to calculate the volume of tooth pulp chamber to avoid the influence of the complex root system. After opening the appropriate image using ITK-SNAP 3.8 software in the HP Laptop (15 11th generation 15s-fr2006TU); the brightness, contrast and sharpness of the images were modified, if needed, to get better results.

The volume of the pulp chamber was then calculated automatically using volume calculation tool in the software.

Inter-Observer and Intra-Observer Variability

All the measurements were carried out by the same examiner in a semi- dark room and was compiled in Microsoft excel worksheet. To test intra- observer reproducibility, another examiner who was blinded at the time of analysis repeated the measurements after 2 weeks interval. And compiled the data on Microsoft excel worksheet. Mean of the measurements were taken at the end.

III. Experimental Results

Regression analysis was done to estimate age (dependent variable) based on maxillary first molar volume (independent variable) using the least squares method. Within group regression analyses were done for sub- groups based on gender and age groups (20-30, 31-40, 41-50 and 51-60 years). Scatter plots are presented for each regression. All testing was done using two-sided tests with alpha 0.05.

This was confirmed again with an Analysis of Variance. Significance level P<0.0001 confirms statistically significant relationship between age and pulp chamber volume in maxillary first molar in all cases.

In all cases, Pulp chamber volume of maxillary first molar was found to be a significant predictor of age (P<0.001) and could explain up to 68.53% of the variation in age. This was confirmed again with a Analysis of Variance. Significance level P<0.0001 confirming Pulp chamber volume of maxillary first molar was found to be a significant predictor of age in all cases. In total 100 CBCT Scans were evaluated, comprising of 100 Maxillary first molars and 100 maxillary second premolars. The summary of the statistics of Maxillary First Molars is as follows-

Sample size	100
Lowest value	8.0030mm3
Highest value	32.8840mm3
Arithmetic mean	19.8659mm3
Standard deviation	6.7081mm3

Table 1: Sample Distribution of Maxillary First Molar

The total samples (100) were further divided into Group1- Males and Group 2-Females.

In the Group1(Males)-

Sample size	46
Lowest value	8.0030mm3
Highest value	32.6190mm3
Arithmetic mean	19.1591mm3
Standard deviation	7.1769mm3

Table 2: Gender(Male) Distribution

Sample size	54
Lowest value	8.9740 mm3
Highest value	32.8840mm3
Arithmetic mean	20.4794mm3
Standard deviation	6.2774mm3

Table 3: Gender (Female) Distribution

In the Group 1(male)

Sample size	46
Lowest value	8.0030mm3
Highest value	32.6190mm3
Arithmetic mean	19.1591mm3
Standard deviation	7.1769mm3
Coefficient of determination R^2	0.7224
Residual standard deviation	7.0609

Table 4-Numerical Data in Males

Age group = 1(20-30years)

Sample size	33
Lowest value	14.0030 mm3
Highest value	32.8840 mm3
Arithmetic mean	25.4936 mm3
Standard deviation	4.6082 mm3
Coefficient of determination R^2	0.6239
Residual standard deviation	2.0612

Table 7- Numerical Data in Group 1

RegressionEquationy= 38.7601+-0.5667x,P<0.0001

AnalysisofVarianceSignificancelevelP<0.0001

R^2 0.6239 indicates good relationship Exists between age and pulp chamber volume in maxillary first molar and could explain up to 62.39% of the variation in age in group1. This was confirmed again with a Analysis of Variance. Significance level P<0.0001 confirming Pulp chamber volume of maxillary first molar was found to be a significant predictor of age in group 1.

Age group = 2(31-40years)

Sample size	26
Lowest value	12.0060 mm3
Highest value	28.9230 mm3
Arithmetic mean	20.9175 mm3
Standard deviation	4.6930 mm3
Coefficient of determination R2	0.2783
Residual standard deviation	2.7548

Table 8- Numerical Data in Group 2

Regression Equation y=42.0467+-0.3571x,P<0.0001

Analysis of Variance Significance level P=0.0056

Pulp chamber volume of maxillary first molar was found to be a significant predictor of age (P<0.001) and could explain up to 27.83% of the variation in age in group 2. Analysis of Variance shows marginally significant (p=0.056).

Age group = 3(41-50 years)

Sample size	24
Lowest value	11.6430 mm3
Highest value	28.9000 mm3
Arithmetic mean	17.7178 mm3
Standard deviation	5.0031 mm3
Coefficient of determination R^2	0.1429
Residual standard deviation	2.6481

Table 9- Numerical Data in Group 3

RegressionEquationy=48.7453+-0.2114x,P<0.0001

AnalysisofVarianceSignificancelevelP=0.0056

Pulp chamber volume of maxillary first molar was found to be a significant predictor of age (P<0.001) and could explain up to 14.29% of the variation in age in group 3. Analysis of Variance shows marginally significant (p=0.056).

Age group = 4(51-60 years)

Sample size	17
Lowest value	8.0030mm3
Highest value	12.9930mm3
Arithmetic mean	10.6970mm3
Standard deviation	1.6419mm3
Coefficient of determination R2	0.5046
Residual standard deviation	2.6054

Table 10- Numerical Data in Group 4

Regression Equation y=48.7453+-0.2114x,P<0.0001

Analysis of Variance Significance level P=0.0014

Pulp chamber volume of maxillary first molar was found to be a significant predictor of age (P<0.001) and could explain up to 50.46% of the variation in age in group 4. Analysis of Variance shows statistically significant (P=0.0014)

Least squares regression All cases (table 11)

Sample size	100
Coefficient of determination R^2	0.7626
Residual standard deviation	5.9336

The equation for the regression analysis for all teeth was:

AGE=67.3781+-2.3836x (PULPCHAMBERVOLUME), P<0.0001

Analysisof Variance-P<0.0001

In all cases, Pulp chamber volume of maxillary second premolar was found to be a significant predictor of age (P<0.001) and could explain up to 76.26% of the variation in age. This was confirmed again with a Analysis of Variance. Significance level P<0.0001 confirming Pulp chamber volume of maxillary second premolar was found to be a significant predictor of age in all cases.

In the Group 1(male) Table 12

Sample size	46
Coefficient of determination R^2	0.7643
Residual standard deviation	6.5072

Regression Equation (Males)-
y=68.4875+-2.4857x,P<0.0001

Analysisof Variance-P<0.00

Pulp chamber volume of maxillary second molar was found to be a significant predictor of age (P<0.001) in males and could explain up to 76.43% of the variation in age in males. This was confirmed again with a Analysis of Variance. Significance level P<0.0001 confirming Pulp chamber volume of maxillary second premolar was found to be a significant predictor of age in males.

In Group 2 (Females) table 13

Sample size	54
Coefficient of determination R^2	0.7553
Residual standard deviation	5.4797

Regression Equation (Females)-
y=66.1023+-2.2801 x,P<0.0001
Analysisof Variance-P<0.0001

Pulp chamber volume of maxillary second molar was found to be a significant predictor of age (P<0.001) and could explain up to 75.53% of the variation in age in females. This was confirmed again with a Analysis of Variance. Significance level P<0.0001 confirming Pulp chamber volume of maxillary second premolar was found to be a significant predictor of age in females.

All the cases were further divided into four Age Groups

GROUP 1	20-30 Years
GROUP 2	31-40 Years
GROUP 3	41-50 Years
GROUP 4	51-60 Years

Table 14- Age distribution in Groups

Age group = 1(20-30years)

Sample size	33
Lowest value	10.7230mm3
Highest value	21.8820mm3
Arithmetic mean	17.0498 mm3
Standard deviation	3.7247 mm3
Coefficient of determination R^2	0.6239
Residual standard deviation	2.0612

Table 15- Numeric data Distribution in Group 1

RegressionEquationy= 36.3529+-0.7062x,P<0.0001

AnalysisofVarianceSignificancelevelP<0.0001

R^2 0.6239 indicates good relationship Exists between age and pulp chamber volume in maxillary second premolar and could explain up to 62.39% of the variation in age in group1. This was confirmed again with a Analysis of Variance. Significance level P<0.0001 confirming Pulp chamber volume of maxillary second premolar was found to be a significant predictor of age in group 1.

Age group = 2(31-40years)

Sample size	26
Lowest value	10.0010 mm3
Highest value	19.6230mm3
Arithmetic mean	12.6141mm3
Standard deviation	4.6930 mm3
Coefficient of determination R2	0.09461
Residual standard deviation	3.0854

Table 16- Numeric data Distribution in Group 2

RegressionEquationy=39.8464+-0.4177x,P<0.0001

AnalysisofVarianceSignificancelevelP=0.1264

R^2 was 0.09461, therefore it could explain only 0.94% variance of age in this group. Also the significance level (P value) in analysis of variance was 0.1264 which is not significant. Hence, pulp chamber volume was not a good predictor of age in maxillary second premolar in the group

Age group = 3(41-50 years)

Sample size	24
Lowest value	7.9240mm3
Highest value	11.8920mm3
Arithmetic mean	10.2103 mm3
Standard deviation	5.0031 mm3
Coefficient of determination R^2	0.3055
Residual standard deviation	2.3838

Table 17- Numeric data Distribution in Group 3

Regression Equation y=60.0638+-1.4754x,P<0.0001

Analysis of Variance Significance level P=0.0051

Pulp chamber volume of maxillary second premolar was found to be a significant predictor of age (P<0.001) and could explain up to 30.55% of the variation in age in group 3. Analysis of Variance shows marginally significant (p=0.051).

Age group = 4(51-60 years)

Sample size	17
Lowest value	5.0120mm3
Highest value	9.8120mm3
Arithmetic mean	6.9883mm3
Standard deviation	1.4472mm3
Coefficient of determination R2	0.5827
Residual standard deviation	2.3911

Table 18- Numeric data Distribution in Group 4

RegressionEquationy=69.9176+-1.8905x,P<0.0001

AnalysisofVarianceSignificancelevelP=0.0004

Pulp chamber volume of maxillary second premolar was found to be a significant predictor of age (P<0.001) and could explain up to 58.27% of the variation in age in group 4. Analysis of Variance shows statistically significant result (P=0.0004).

Consistency between observers for Molars : Intraclass correlation coefficient (ICC)

ICC describes how strongly units in the same group resemble each other. It is used for Assessment of consistency or reproducibility of

quantitative measurements made by different observers measuring the same quantity.

The number of observers were 2. The Intraclass correlation coefficient for molars is 0.9962 which shows excellent reliability.

Consistency between observers for Premolars : Intraclass correlation coefficient (ICC)

The number of observers were 2. The Intraclass correlation coefficient for premolars is 0.9917 which shows excellent reliability.

V. Discussion

The decreasing volume of the pulp chamber was widely acknowledged as an age estimation sign of age, notably in the field of forensic odontology, due to the apposition of secondary dentine. Although a variety of 2D imaging methods, such as panoramic radiography and periapical radiography, have been used to analyze the real 3D decrease of the pulp chamber, it appears that the use of 3D images that demonstrate real morphological change is the most appropriate in this type of dental age estimation method.

CBCT is a 3-Dimensional imaging technique that was recently created. It reconstructs isotropic high-spatial-resolution 3D images using a 2D X-ray detector and a cone- or pyramid-shaped X-ray beam. The advantages of CBCT imaging are its ease of use, accessibility, and capacity to provide a dataset of multiplanar cross-sectional and 3D reconstructions (from a single scan). When it comes to acquiring three-dimensional datasets, CBCT appears to have an advantage over micro-CT or medical CT. For starters, CBCT has a very big scanning area, whereas Micro CT only has a limited scan region that can only scan one extracted tooth at a time. Second, with a high-resolution Micro-CT scan, the radiation dose is significant. Furthermore, a Micro CT scan requires extracted teeth, which is not suitable for a living individual. Computed tomography (CT).

When compared to CBCT, it can be obtained for a live individual but at a higher cost and radiation dose.

ITK-SNAP 3.8 is a tool for segmenting structures in neuroimaging and other applications that has been validated by its developers. Another advantage is that it is free software, allowing forensic anthropologists and medical practitioners to utilize it extensively. This software allows for 3D segmentation and volume calculation using tools, and it has already been used in prior research to estimate age using teeth analysis, with demonstrated efficiency and reliability.

In contrast to prior research that used the pulp cavity to tooth volume ratio as an indicator for determining human age, the current study used the volume of the pulp chamber. The following are the reasons why we chose the pulp chamber volume as the indicator: First, the production of secondary dentine with age is directly tied to a reduction in pulp cavity volume, whereas the volume of a complete tooth is mostly affected by enamel attrition. As a result, the ratio of pulp cavity to tooth volume may not accurately reflect the true change in secondary dentine apposition. Second, due of the high image contrast between dentine and pulp chamber, the pulp chamber volume calculation was more accurate than the overall tooth volume calculation (1).

The pulp chamber volume was measured and used to create a mathematical equation, which was then evaluated and used as a method to estimate the age of a subset of the Indian population. Because the production of secondary dentine is directly proportional to the decrease of the pulp chamber volume of the tooth, which is mostly affected by physiological enamel wear, the pulp chamber volume was employed as a variable in the study (14).

The pulp chamber volume of maxillary first molars and maxillary second premolars was found to be a good tool for predicting age in this study, but the mathematical method differs between populations and was adapted in this case for a subgroup of Indians. Our findings indicate that a formula developed for one demographic may not be applicable to another. This could be due to anthropological differences among ethnic groups, but it could also be because pulp volume is computed using radiographs, which are two-dimensional representations of a three-dimensional item.

In contrast to numerous papers that just describe the age to be determined from the capacity of the pulp chambers, the current

study found a statistically significant variation in volume between the genders.

The precise measurement of the pulp chamber capacity could potentially be used to assess sex, according to Ge, Zhu-pu et al. According to Agematsu et al regression analysis for age calculation based on pulp chamber volume using micro-CT images of premolars and central incisors, age could be accurately predicted using the estimation equation that takes sex into account. Using Micro-CT images of the mandibular second premolars and/or mandibular central incisors as samples, Someda et al. performed regression analysis for age estimation based on the correlation between age and decrease in pulp chamber volume, and reported that age can be more reliably estimated by selecting an estimation equation that considers sex. Dr. Shiva Kumar.B discovered that the male group had a greater connection between pulp chamber capacity and age than the female group. In contrast, Star et al found that the ratio of pulp volume to tooth volume was not gender dependent in their investigation.(1,9)

The current study adds to the work of Ge, Zhu, Agematsu, and Someda et al. by giving distinct evidence for sex differences. And, as compared to the female group, the male group revealed a higher correlation between pulp chamber volume and age, with statistically significant differences between maxillary first molar and maxillary second premolar molars. (p0.001) and add to the evidence that there is a distinct sex difference.

The pulp chamber volume of the maxillary first molar could explain up to 68.53 percent of the variation in age in this study, whereas the pulp chamber volume of the maxillary second premolar could explain up to 76.26 percent of the variation in age. This research backs up prior research by Ge, Zhu-pu et al., and Dr. Shiva Kumar, who found that the pulp volume of first molars is a good indication of age. It also revealed that when the sex is known, greater age estimation results are obtained.

The pulp chamber volume of the maxillary first molar could explain up to 68.53 percent of the variation in age in the 20-30 age group, which was the highest of all the groups, whereas R2 was lowest in the 41-50 age group. In contrast, Dr. Shiva Kumar (1) discovered that the pulp chamber volume of the maxillary first molar was a significant predictor of age (P0.001) in the 41-50 age range, and it could explain up to 62.0 percent of the variation in age. In the 21-30 year age group, however, it could only explain 27.0 percent of the difference in age. The findings of this study are comparable to those of Ge,Zhu-pu et al (40,43), who found that the amount of secondary dentine deposition in the elderly stage was more than in the young stage. Similarly, the pulp chamber volume of the maxillary second premolar in the 20-30 year age group may explain up to 62.39 percent of the difference in age, the greatest of all the age groups.

In the current study, R2 0.09461 was lowest in the 31-40 age range. The intra observer consistency was high, with intraclass correlation coefficients of 0.9962 and 0.9917 for molars and premolars, respectively.

In this study, we compared the pulp chamber volume of maxillary second premolar (R2 0.76260) with the pulp chamber volume of maxillary first molar (R2 0.76260) to see which is a better predictor of age for age estimation. We discovered that the pulp chamber volume of maxillary second premolar (R2 0.76260) is a better predictor of age in this subset of Indian population with low residual standard deviation/error (5.9336). In contrast, Ge,Zhu-pu et al. looked at 13 different types of teeth in a Chinese population and discovered that the maxillary first molar could explain the most variance in age of all the 13 types of teeth, including the maxillary second premolar. The disparity in results could be attributed to anthropological variances across diverse ethnic groups, confirming that a formula developed for one group may not be applicable to another. (15,16)

We also developed a model to predict gender based on age and pulp chamber volume of maxillary first and second premolars in this study. When all three factors, age and pulp chamber volume of molar and premolar, were included, the overall accuracy of the model to predict gender was 62.63 percent. The sex prediction formulae' validation results were largely positive.

When other biological profile information, such as age, was provided, it was even better. During validation, the sex estimate algorithms

demonstrated great accuracy, which was higher for the female sample utilising one or both types of teeth (73.58 percent). The use of molar/premolar volumetric measures alone provided low accuracy for the male sample when sex estimation was performed without the information of age. As a result, using the pulp volume without other biological profile information to estimate sex is not recommended. It was in line with a study conducted in the Brazilian population by Vanessa M Andrade, in which the best results were observed for age estimation in females and sex prediction when the age was known (17).

Because the underlying idea for age estimation by using the pulp cavity is that teeth are less susceptible to nutritional, hormonal, and systemic pathological changes following permanent dentition formation, the patients' systemic illnesses status was not explored in this study. According to the literature, various systemic diseases can produce pulpal calcification, but teeth with pulpal calcification were not included in our investigation. Previous investigations by Ge, Zhu-pu et al, Dr. Shiva Kumar, Vanessa M Andrade, Agematsu, and Someda et al have all used this concept to estimate age.

As a result, the age estimation and gender prediction model developed in this work can be used to accurately estimate age and gender in the Indian population. The age estimate model can be employed with the greatest accuracy in the 20-30 year old age range. In the Indian population, this model can also be used to predict female gender with high accuracy.

VI. Conclusion

The purpose of this research was to —

1. Calculate age using cone beam computed tomography images of the pulp chamber volume of maxillary second premolars and first molars.
2. Use cone beam computed tomography scans to predict gender based on pulp chamber volume of maxillary second premolars and first molars.
3. Determine whether of the maxillary second premolar and maxillary first molar is a superior age indication for age estimate.

• The findings of this research show that-

Although correlations may vary in different groups with good precision of age assessment, the pulp chamber volume of the maxillary first molar and the maxillary second premolar is a strong predictor of age and can be used to determine age with high accuracy.

Individuals in their 20s and 30s, as well as males, have better age estimation outcomes.

In male, female, and pooled gender samples, the pulp chamber volume of the maxillary second premolar is a better predictor of age than the pulp chamber volume of the maxillary first molar, with the highest correlation coefficient with age.

With good accuracy, sex prediction can be done using age and pulp chamber capacity. When one or both types of teeth are used in a female sample, sex prediction is more accurate.

• To estimate age, a mathematical model specific to the regional population is required.

• CBCT is a useful instrument for determining the capacity of the pulp chamber.

Because teeth are the best-preserved elements of the human body, they are frequently utilised in forensic and anthropological examinations to determine the sex and age of human remains. In forensic investigations, determining an individual's age and sex is critical for constructing a biological profile. In forensic odontology, the formulas developed in this work to assess age and determine gender could be useful.

References

1. Kumar, Shiva & Setty, Jyothsna.. Age Estimation Using Pulp Chamber Volume of First Molars from Cone Beam Computed Tomography Images in Indian Population. International Journal of Science and Research 2016, IJSR. 5. 2421-2425.
2. Wood R. Forensic aspects of maxillofacial radiology. Forensic Sci Int. 2006;159(Suppl 1):S47-S55.
3. Transforming Health Care Scheduling and Access: Getting to Now Military Medicine, Volume 181, Issue 7, July 2016, Pages 714,715,

4. Max M. Houck, Jay A. Siegel, Chapter 1 - Introduction, Editor(s): Max M. Houck, Jay A. Siegel, Fundamentals of Forensic Science (Second Edition), Academic Press,2010, Pages 3-27, ISBN 9780123749895,https://doi.org/10.1016/B978-0-12-374989- 5.00001-6.
5. Keiser-Neilsen, S., Person Identification by Means of Teeth. John Wright & Sons, Bristol, 1980]
6. Keiser-Neilsen, S., Forensic Odontology. Int Dent J, 1968. 18(3): p. 668-681.
7. Rai A, Acharya AB, Naikmasur VG. Age estimation by pulp-totooth area ratio using cone-beam computed tomography: a preliminary analysis. J Forensic Dent Sci. 2016;8:150-4.
8. Karkhanis S, Mack P, Franklin D. Age estimation standards for a Western Australian population using the coronal pulp cavity index. Forensic Sci Int 2013; 231(1-3): 412.e1–412.e6.
9. Capitaneanu C, Willems G, Thevissen P. A systematic review of odontological sex estimation methods. J Forensic Odontostomatol. 2017;35(2):1-19. Published 2017 Dec 1.
10. Ramakrishnan K, Sharma S, Sreeja C, Pratima DB, Aesha I, Vijayabanu B. Sex determination in forensic odontology: A review. J Pharm Bioallied Sci. 2015;7(Suppl 2):S398-S402.
11. Du C, Zhu Y, Hong L. Age-Related changes in pulp cavity of incisors as a determinant for forensic age identification. J Forensic Sci 2011; 56 Suppl 1: S72–S76
12. Yekkala R, Meers C, Van Schepdael A, Hoogmartens J, Lambrichts I, Willems G. Racemization of aspartic acid from human dentin in the estimation of chronological age. Forensic Sci Int. 2006;159:S89- S94.
13. A.S. Panchbhai, Dental radiographic indicators, a key to age estimation, Dentomaxillofac. Radiol. 40 (4)(2011) 199–212
14. Elmoazen, Ramy & Eldin, Mohamed & Elkhalek, Wael. (2017). Three Dimensional observation of Age related change in pulp Volume using CBCT among Egyptians' Mandibular Canines.Egyptian dental journal. 63. 597-602
15. Elmoazen, Ramy & Eldin, Mohamed & Elkhalek, Wael. Three-Dimensional observation of Age-related change in pulp Volume using CBCT among Egyptians' Mandibular Canines. Egyptian dental journal.2017; 63. 597-602
16. Ge ZP, Ma RH, Li G, Zhang JZ, Ma XC. Age estimation based on pulp chamber volume of first molars from cone-beam computed tomography images. Forensic Sci Int. 2015 253:133.e1-7.
17. Farhadian M, Salemi F, Saati S, Nafisi N. Dental age estimation using the pulp-to-tooth ratio in canines by neural networks. Imaging Sci Dent. 2019 Mar;49(1):19-26.