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Age estimation using pulp to tooth area ratio: a comparison between maxillary anterior teeth

Running title- ROLE OF MAXILLARY ANTERIOR TEETH IN AGE ESTIMATION: A CBCT ANALYSIS

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Abstract

Background: Age estimation is one of the most important factors in forensic medicine. Measuring secondary dentin deposition using cone-beam computed tomography images is an easy and non-invasive method. Thus, CBCT is used in a variety of studies to investigate the relationship between age and secondary dentin accumulation such as pulp tooth area ratio (PTR).

Aim: To evaluate the method of age estimation by pulp to tooth area ratio of maxillary anterior teeth using CBCT and assess its role in forensic dentistry.To compare estimated age with chronological age and to assess the reliability of age estimation using maxillary anterior teeth singly or in combination.

Methodology: A total of 90 CBCT images (30 maxillary central incisors, 30 lateral incisors and 30 canines) patients aged between 20 and 80 years were evaluated. Pulp/tooth ratio (PTR) in maxillary central incisor, lateral incisors and canines were measured in the axial and sagittal sections. The samples will be analysed using SPSS software.

Results: The maximum PTR was 230(0.23) with the maximum predictive power (R^2) was R^2= 0.3296 in maxillary Central Incisors. The maxillary canine in sagittal section PTR showed the highest corelation coefficient (r=-0.3123).

Conclusion: The present study concluded that the maxillary Central Incisors have the highest predictive power for age estimation. The use of cone-beam computed tomography in age estimation

by PTR of anterior teeth is useful and a reliable method for age estimation and can be used in forensic odontology.

Key Words: Chronological age, cone beam computed tomography, linear regression.

Introduction:

The identification of age in anthropology and forensic medicine is sometimes difficult, but nonetheless important. Several methods based on the analysis of teeth have been reported in the literature to estimate the unknown age of individuals.[1] Age estimation in adults is more difficult and challenging compared with that of children, since dental and skeletal growth are completed in adults.[2].

Secondary dentin deposition is a significant morphological dental age predictor.[3]Dentin and tooth pulp experience age-related pathological and physiological changes.[4]

In Drusini in 2008 argued that age has greater influence on secondary deposition, it is expected that the age of the individual can be reliably estimated from the total dentin thickness relative to the dental pulp diameter at the same cross-sectional tooth level. Thus, the area of pulp chamber in intact teeth can be used as a dental age predictor. {5]

Data analysis is not possible in 2D images of teeth with crowding, rotation or superimposition.[3]Cone-beam computed tomography provides accurate anatomical information on sagittal, axial, coronal, and multiplanar sections for diagnosis and treatment planning for clinicians. For this reason.

The purpose of this study was to use radiographic images of the maxillary central incisor, lateral incisors and canines for chronological age estimation and to establish age estimation methods from CBCT sagittal and axial sectional images using AutoCAD software for reliability of maxillary anterior teeth for age estimation.

Aims

Aim of the study was to evaluate the method of age estimation by pulp to tooth area ratio of maxillary anterior teeth using CBCT and assess its role in forensic dentistry.Also aims to assess the reliability of age estimation using maxillary anterior teeth singly or in combination.

Materials and method:

The present analytical study was conducted in the Department of Oral Medicine & Radiology, Darshan Dental College and Hospital, Loyara (Udaipur), Rajasthan and was approved from the institutional ethical committee.

The retrospective study included evaluation of maxillary 30 central incisors, 30 lateral incisors and 30 canines on cone beam computed tomography scans taken at different CBCT centres.

The assessments were made using CS 3D and NNT imaging software and measurements were made by using AutoCAD 3D software 2020 for cone beam computed tomography (CBCT) scans which were taken with predetermined parameters for exposure.

Cone beam computed tomography (CBCT) scans were included in this study based on following inclusion and exclusion criteria.

Maxillary anterior teeth that have fully erupted into the oral cavity and maxillary anterior teeth with complete root formation were included.

Teeth with any pathology, such as, caries or periodontitis or periapical lesions, which would alter the surface area of the tooth, malaligned or rotated teeth, Teeth with prosthetic fittings.Fractured, Impacted and unerupted teeth were excluded.

CBCT scans were evaluated by the following parameters:

The pulp/tooth ratio is measured in two planes: sagittal plane and axial plane.

To determine the pulp/teeth ratio (PTR) in the sagittal plane.[2]First, the longitudinal axis of the tooth from the crown tip to root apex is determined using the coronal sections. Then the best midsagittal section with the largest tooth and pulp areas was selected by scrolling the image on the cross-sectional plane of the software. The tooth area was measured using the area tool in the tool bar of the software. A set of points is used to determine the entire tooth outline and after completion of the tracing, the area is obtained. Next, the outline of the pulp from pulp chamber in the crown to root apex was traced and the area of the pulp is measured similarly. Finally, PTR sagittal is measured by dividing the area

of the pulp by the area of the tooth. The method is repeated for maxillary central incisor, maxillary lateral incisor and maxillary canine of any one quadrant.

To determine PTR in the axial plane [2], First, the longitudinal axis of the tooth from the crown tip to root apex was determined using the coronal section. Then, the axial section of the tooth was set at the cementoenamel junction (CEJ) region by scrolling the image on the axial plane of the software. Similar to the sagittal plan, a set of points was used to measure the tooth and pulp areas, and then the PTR axial is calculated(Figure 1).

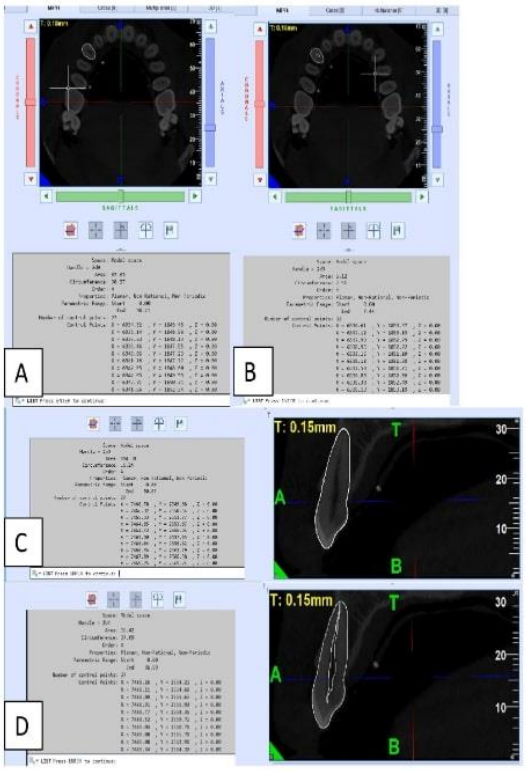


Figure 1: tooth and pulp area calculation in maxillary lateral incisors using AutoCAD software.

A. Tooth area calculation in axial section.
B. Pulp area calculation in axial section.
C. Tooth area calculation in sagittal section.
D. Pulp area calculation in sagittal section.

The method was repeated for maxillary central incisor, maxillary lateral incisor and maxillary canine of any one quadrant. The data will be entered in Microsoft office excel spreadsheet and analysed.

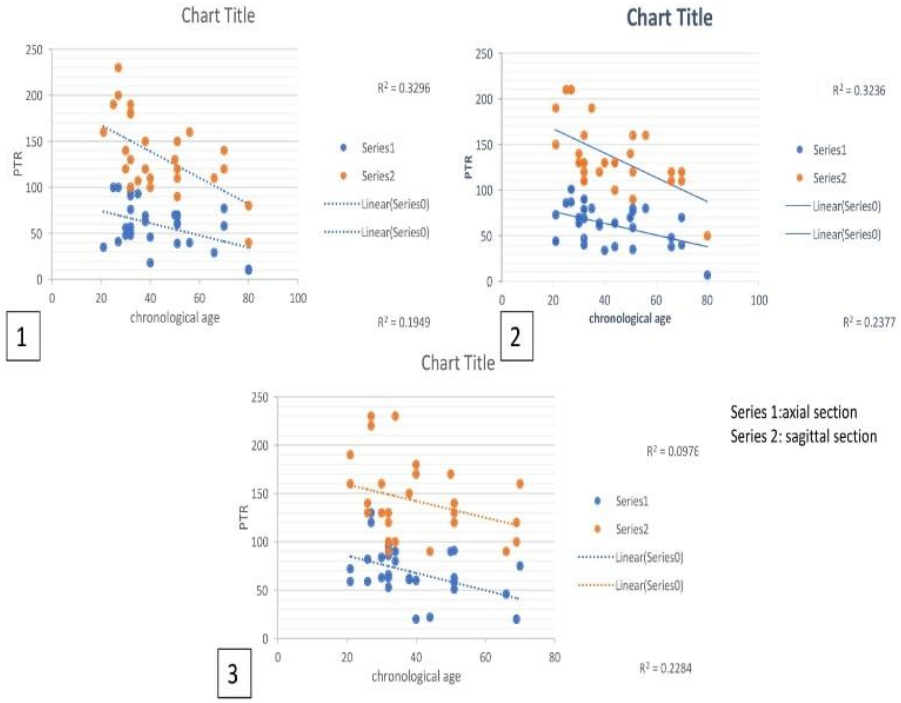
The PTR data obtained will be subjected to regression analysis for estimated age.[4] It will be correlated to chronological age. The chronological age of the patient is calculated by subtracting the date of birth of the patient from the CBCT acquisition date.[2]

A linear regression analysis will be undertaken with all anterior teeth variables which are entered together to determine whether there is any improvement in the correlation between estimated age and chronological age.

Results:

The collected data was tabulated in master chart using Microsoft excel sheets. Summarised data was presented using tables and graphs. The data was analysed by Linear regression analysis, Pearson's correlation coefficient(graph 1, 2 and 3 and table 1) and Student T test to obtain the final result using

SPSS (statistical package of social science) software SYSTAT version 7.0. the following comparison were made (table 2):



Graph1: linear regression analysis in maxillary central incisors
Graph2: linear regression analysis in maxillary lateral incisors
Graph3:linear regression analysis in maxillary canine.

Table 1: Linear Equation Of Maxillary Central Incisors, Lateral And Canine And Values Of Pearson's Correlation Coefficient For Same.

		Linear Regression	R^2	r
Central incisors	Axial	y = -0.6608x + 87.497	0.1949	-0.4415
	Sagittal	y = -1.4337x + 196.4	0.3296	-0.5741
Lateral incisors	Axial Lateral	y = -0.6444x + 89.497	0.2377	-0.48754
	Sagittal	y = -1.3308x + 193.85	0.3236	-0.56888
canines	Axial Canines	y = -0.8964x + 103.6	0.2284	-0.47795
	Sagittal	y = -0.8606x + 176.64	0.0976	-0.31238

Table 2: Comparison between chronological age and estimated age in axial and sagittal section in maxillary central incisors, lateral incisors and canine

	Chronological age	Central incisors		Chronological age	Lateral incisors		Chronological age	Canines	
		Axial	Sagittal		Axial	Sagittal		Axial	Sagittal
P value		0.606	0.483		0.243	0.108		0.224	0.452
Mean	44.03	46.25	47.25	42.47	46.86	36.18	39.87	44.96	42.23
SD	16.41	16.63	17.54	15.91	12.73	13.87	14.35	17.54	16.23

Among the three observed groups maximum chronological age was 80 years in central and lateral incisors and minimum was 21 years which was same for all the three groups. In axial section the maximum estimated age was 84.38 years in lateral incisors for 80 year old patient and minimum was 21.5 in central incisors in 21 year old patient. In sagittal section the maximum estimated age was 95.68 years for 80 year old patient and minimum was 15.25 years in 21 year old patient for maxillary central incisors.

Also, difference between estimated age in sagittal and axial section were within the age range of the chronological age for all the three groups.

The mean chronological age was highest 44.03 years for maxillary central incisors and minimum 39.87years for canines. The maximum mean estimated age in axial section was 46.86 years for maxillary lateral incisors and minimum mean estimated age in axial was for 36.18 years for lateral incisors. The maximum estimated age in sagittal section was 47.13 years and minimum mean for estimated age in sagittal section was 36.18 years for lateral incisors.

The p value between the estimated age and chronological age were >0.05 (0.243 for axial sections and 0.108 for sagittal section), with SD of 12.73 and 13.87 for axial and sagittal section respectively for central incisors. The p value between the estimated age and chronological age were >0.05 (0.243 for axial sections and 0.108 for sagittal section), with SD of 12.73 and 13.87 for axial and sagittal section respectively for lateral incisors. And the p values between the estimated age and chronological age were >0.05(0.224 for axial sections and 0.452 for sagittal section), with SD of 17.54 and 16.23 for axial and sagittal respectively for maxillary canines.

The comparative value for all the three groups were found to be statistically nonsignificant (p>0.05) when compared between chronological age and estimated age.

Whereas the p value for PTR and chronological age was highly significant for maxillary canine (in axial section p value=0.0002 and for sagittal section p value=0.00015) and nonsignificant for maxillary central incisors (in axial section p value=0.032 and for sagittal section p value=0.196).

Discussion:

Age estimation is an important aspect of forensic odontology, and in our experience, postmortem age estimation using radiography has been used extensively—particularly, using the dimensional changes of the pulp area in relation to the tooth area and the ratio therein. The assessment of PTR is an indirect quantification of secondary dentine deposition and generally correlates well with the chronological age of the subject.[6,7,8] Secondary dentine—which is encased by harder tissue such as enamel and cementum and in addition, by primary dentine—is preferred for age estimation.[7] Better correlation with chronologic age by the assessment of secondary dentine is thought to result since it may be more

insulated from the effect of environmental factors on human remains.[9] The introduction of CBCT creates new opportunities to get 3D tooth views, resulting in a reasonable image quality at a low-radiation dose (skin dose 1.19 mSv, total dose 20 mSv per examination).[10] There are several advantages of CBCT over conventional radiographic methods, including controlled magnification, lack of superimposition, absence of geometric distortion, and convenient multiplanar and 3D.

SinaHaghanifar[2]et al concluded that the predictive power of axial section in age estimation was higher than that of the sagittal section (R^2=0.48 for axial plans, R^2=0.328 for sagittal plans). Also, in the same study it was concluded that that maxillary central incisor has the highest predictive power for estimated age R^2 = 0.586 indicating the superiority of the tooth similar to our study (0.3296).

Similar results were obtained by Wu et al[11] R^2= 0.567 and Biuki et al[12] and Gulsahi et al[13] in which pulp to tooth volume ratio was used for age estimation in axial and sagittal sections.

Saini A et al[14] in his study had concluded correlation between chronological age and PTR was statistically significant r= 0.807. in similar study it was derived that r was 0.785 for female 0.835 for males which was higher than our study with r being -0.48754in axial section and in sagittal section being -0.56888.

A study by **Rai** et al[15] showed that maxillary canine the least predictive power R^2= 0.392 in sagittal plane R^2 0.48 in axial plane and similar to our study with predictive power of 0.0976 for sagittal section and 0.2284 for axial section.

He also has stated that Pearson's correlation coefficient to be maximum for the axial section of the maxillary canine at CEJ (r=0.42) and minimum at the axial section at the mid root level whereas in our study the axial section at CEJ showed r=-0.47795.

In study by **Saini A**[14] the conducted the that the mean PTR in his study was 0.625 with 0.59 for males and 0.61 for females the correlation between age and PTR was statistically significant p=0.000, similar to our study which was 62.333(0.623) for axial section and 137.333(1.37) for sagittal section.

In the study by **Singaraju S**et al[16] the mean chronological age 31.30 and the estimated age was 31.52 with the p value of 0.859 which was nonsignificant. It was correlative of our study where mean chronological age was 39.87 for axial section 44.96 and 42.86 for sagittal section thus suggesting that estimating the chronological using PTR is relatively accurate.

In the study by **Kumar M**et al[17] had concluded that morphological value had statistically significant correlation with chronological age. Thus, PTR can be used for deriving the chronological age.

The study conducted by **Salemi** et al[18] had conducted a study with 300 CBCT scan with mean age of 37 years concluded that corelation between actual age and estimated age was 0.88 with a significant inverse corelation. The paired t test done to compare the actual and estimated age was not significant for 30 to 40 years old. This result was consistent with the studies by **Saxena** et al[19] and **Singaraju** et al[16]. Similar as our study where it had nonsignificant result in the similar age group.

Studies by **Bodekeret et** al [20], **Camreiere**et al[21]**Babchet** et al[22] and **Kvaal** et al[23] had conducted studies on maxillary canines and concluded that the PTR is an indicator of age was promising.

In a study by **Affify M M**[4] had concluded the maximum mean PTR in the sagittal section of maxillary canine (0.15) and minimum mean for axial section of mandibular canine (0.07) and the result showed high statistically significant correlation with age, which was corelative with our study.

In a study by **Murlidhar N** et al[24] between maxillary central incisors and canines had concluded that the maximum mean of the PTR was of mandibular canine in sagittal (0.162) section and maxillary canine in axial section (0.047). This study showed the significant corelation between chronological age and physiological ratio, with strongest corelation for men in axial section and in maxillary section sagittal section in women.

A study by **Haghnifer S** at el[2]which was done on 649 CBCT images in maxillary and mandibular central incisors and canines with the mean age 38.9 years The comparison between the maxillary central incisors and canine revealed sagittal section of maxillary central incisors has maximum PTR (0.23) and minimum was for axial section of maxillary canine (0.07), which was similar to our study where the sagittal section of maxillary central incisors has the maximum PTR (0.23).

Conclusion:
In the present study it was concluded the maxillary central incisors have the highest predictive power suggesting that maxillary central incisors are found to be most reliable for age estimation, followed by maxillary canines and lateral incisors.
The chronological age of the individual increases, the PTR decreases in the three groups (maxillary central incisors, lateral incisors and canines) and it was found to be statistically significant reason being, the increase in the secondary dentine deposition along with increasing age. The chronological age and estimated age came within the same age suggesting that this method can be used for age estimation in forensic dentistry.
Conflict of interest: Nil
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