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ORIGINAL ARTICLE

Structural Changes of Tooth, Root and Root Canal Morphometrics using Conebeam Computed Tomography for Assessment of Age in South Indian Population-A Retrospective Study

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Abstract:

The estimation of age has been an antiquated exercise. The tooth with its highly resistant morphometrics provides us with a non-invasive modality to determine the age of the person. The major aim of this current study is to assess the accuracy of a chronological age of an individual by measuring the structural changes of tooth, root and root canal morphometrics, tooth and root length from CBCT images of mandibular right and left 1st premolar. A retrospective study involving 200 CBCT images between the age of 20–60 years were retrieved from the department database. The samples were further divided into five groups based on their age, each group contains 20 samples. Mandibular 1st premolar on both left and right side were analysed. The structural changes of teeth, attrition, secondary dentine and periodontal recession were graded according to Gustafan's method, the tooth length and root length were measured. The tooth length and root canal diameter were positively corelated to the chronological age of the patient on right and left side. In multiple regression analysis attrition on right and left side were positively corelated to the chronological age of the patient, secondary dentine and periodontal recession on the right and left side respectively were positively correlating to the chronological age of the patient. The reliability of chronological age estimation using the structural changes of teeth, root and root canal morphometrics provides fairly reliable results. This has resulted in the error of age prediction narrowing down to +/- 1.7 years to 2.35 years.

Keywords: Age estimation; Tooth; Root; Root canal; Structural changes; Forensics; Morphometrics; CBCT.

Introduction:

Age estimation is one of the crucial factors in human identification. The identification of human bodies from circumstantial data in the absence of clues to identity poses a strenuous problem to the investigator.[1] Age estimation in children and adults often relies on morphological methods, such as radiological examination of skeletal and dental development, however. in children, age estimation using teeth is relatively simple which is done based on the developmental stage of the teeth. But, age estimation in adults is a challenge in Forensic Medicine.[2] The changes in the dentition are reflected in every individual tooth.[3]

Human dentition is considered as a hard tissue analogue to fingerprints, it is unique to every individual.[3,4] Teeth are present with unique and distinguishable features of age-associated regressive changes which make them a mirror reflection of age changes from birth to the death of an individual. Forensic Odontologists are often called into action for age determination of the unknown deceased individual or a living individual in case of a criminal investigation.[5] There have been various methods for assessing the age of an individual employed by several authors for many years. In the year 1950, Gustafson introduce a scientific methodology for estimating age using six age-related structural changes in the tooth such as secondary dentine formation, periodontal recession, attrition, apical translucency, cementum apposition, and external root resorption.[6]

Assessment of morphological changes requires tooth sectioning, which is not feasible to perform in living humans. To overcome this, Matsikidis et al. reported that the characteristics studied by Gustafson (except apical translucency) concerning extracted and ground teeth can also be determined using dental films.[7] Assessment of the pulp to tooth area ratio, in particular, is an indirect indicator of secondary dentin deposition.[8] This apposition is effective in age estimation as it is a continuous, age-associated process that alters the size of the pulp chamber. Since tooth ground sections are a destructive process and impossible to do in living humans to overcome these hassles radiographic assessment would be helpful to do age estimation in living individuals[9] CBCT is well suitable for the craniofacial area investigation as it delivers clear images of highly contrasted structures and is useful for evaluating teeth and bones. CBCT shows high contrast between bone, empty spaces, and soft tissues so it helps in visualization and evaluation of structural changes of teeth and pupal canal with good precision and accuracy.[10,11]

The major aim of this current study is to assess the accuracy of a

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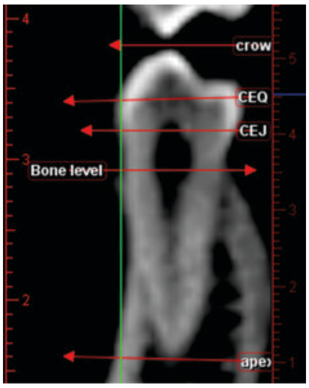
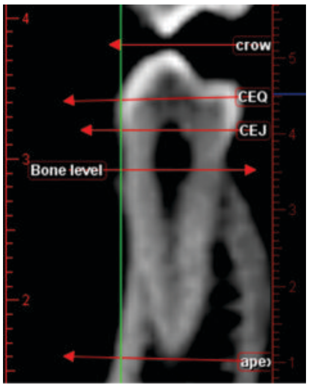


Figure 1.



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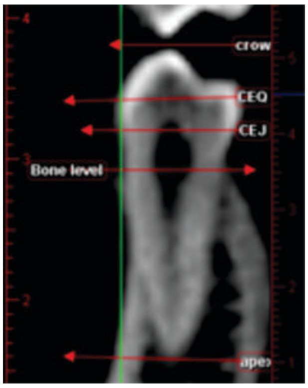

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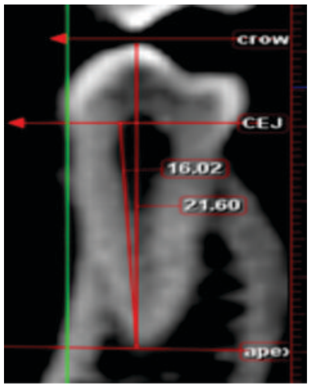

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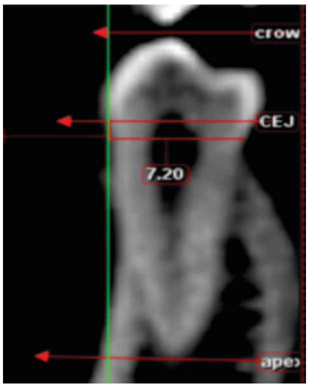

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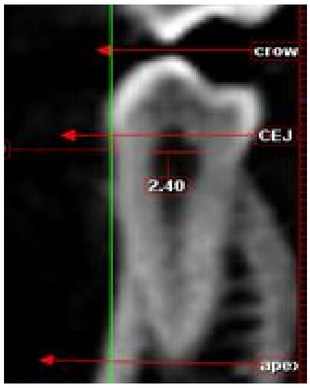


Figure 6.

chronological age of an individual by measuring the structural changes of tooth, root and root canal morphometrics, tooth and root length from CBCT images of mandibular right and left 1st premolar.

Materials and methods:

Sample collection: 200 Cone Beam Computed Tomography images were collected from the department database. All the images were recorded in Planmeca Promax 3D Mid Pro Face machine and were processed using Planmeca Romexis software version 5.2.0

The inclusion and exclusion criteria of the study are as follows.

Inclusion criteria:

- Full mandible CBCT images of patients above the age of 20.
- Good image and morphology of selected teeth with complete root formation. (i.e lower right and left mandibular first premolar)

Exclusion criteria:

- Carious/grossly decayed
- Prosthesis/Restored selected teeth
- Severely attrited/fractured/rotated /maligned.
- Teeth with developmental anomalies

Sample size: Sample of 200 CBCT images obtained from the archives. Ages from 20- above 60 yrs and each group contain 40 images.

- Group I: 20-29years (20.1 to 29.9 years)
- Group II: 30-39 years (30.1 to 39.9 Years)
- Group III: 40-49years (40.1-49.9 Years)
- Group IV:50-59years (50.1-59.9Yeras)
- Group V: 60years and above (60.1<)

Further, each CBCT image was analyzed using Planmeca Romexis software. The images were sliced at 1.2 mm size thickness.

Methodology for metric analysis

Structural changes of teeth : To Assess the structural changes of teeth, Gustafson criteria for attrition, secondary dentine deposition, and periodontal recession were measured in the sagittal section of the image in the center of the tooth and classified in accordance to the stages reported by Olze et al.

Step 1: The attrition is staged based on Gustafan's criteria

Gustafson criteria: I - Attrition

Stage 0: No attrition

Stage 1: Early attrition with loss of cusp tips

Stage 2: Attrition reaching into dentine

Stage 3: Attrition reaching into dentine opening of the pulp cavity

Gustafson's criteria: II - Secondary dentine formation

- A horizontal line traced between the cemento-enamel junction of the tooth, considered to be the division between the anatomical crown and the root.
- Parallel to the CEJ, another line is drawn across the crown's equator connecting the most convex surfaces of a tooth.
- The highest point of the pulpal horn is analysed.
- The secondary dentine is staged based on Gustfan's criteria.

Secondary dentine formation

Stage 0: Pulp horn crosses above the crown equator

Stage 1: Pulp horn approximates at maximum to the crown equator

Stage 2: Pulp horn falls short to the crown equator but exceeds enamel-cementum boundary

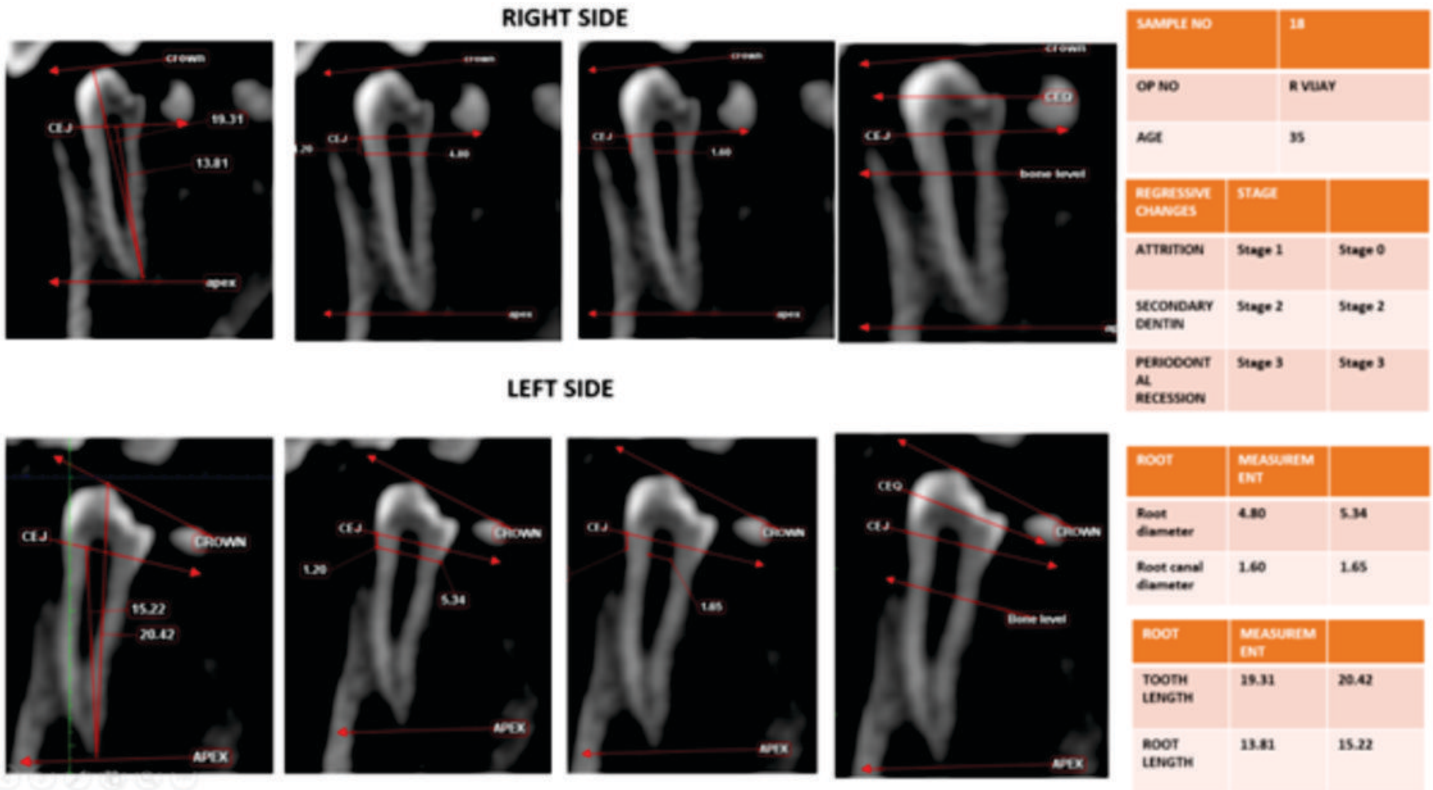


Figure 7. Samples of right and left premolar tooth.

Stage 3: Pulp horn reaches at maximum to the enamel-cementum boundary

Gustafson's criteria- III - Periodontal recession

- A horizontal line traced between the cementoenamel junction of a tooth which is considered to be the division between anatomical crown and root
- Parallel to this line the alveolar bone level is marked by drawing a line across the root connecting the distal and mesial surface of the root.
- The periodontal recession is graded according to the Gustafson's criteria

Periodontal recession

Stage 0: No periodontal recession.

Stage 1: Periodontal recession at cervical root third.

Stage 2: Periodontal recession at middle root third.

Stage 3: Periodontal recession at apical root third.

Step 4:Tooth length

Tooth length was measured by drawing a vertical line connecting the most prominent cuspal tip to the apex of the tooth.

Step 5: Root length

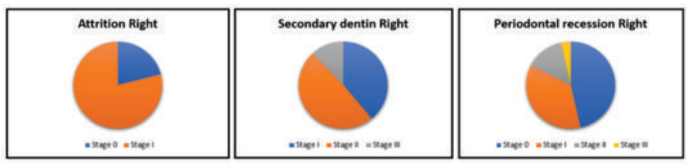
- Horizontal line traced at the cemento-enamel junction of the tooth, considered to be the division between anatomical crown and root.
- The root length was measured by drawing a vertical line from the midpoint of CEJ to the most prominent tip of the apex.

Step 6: Root diameter

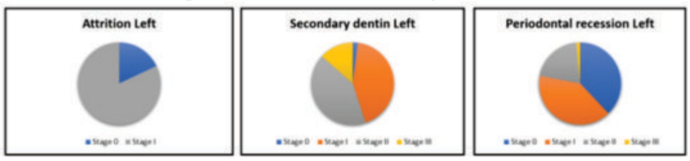
- Horizontal line traced at cemento-enamel junction of tooth which is considered to be the division between anatomical crown and root
- For the root diameter the linear measurement is taken 1cm away from the CEJ, a horizontal line is drawn across the root connecting the mesial surface of the root to the distal aspect of the root.

Step 7: Root canal diameter

- A horizontal line traced at the cemento-enamel junction of the tooth, considered to be the division between anatomical crown and root.



Graph 1. Frequency distribution of attrition, secondary dentine, periodontal recession on right side.



Graph 1. Frequency distribution of attrition on left side.
Graph 2. Frequency distribution of attrition, secondary dentin and periodontal recession on left side.

- For root canal diameter, a linear measurement is taken 1cm away from the CEJ a horizontal line is drawn across the pulp canal connecting the mesial to the distal surface of the pulpal canal.

The collected data were analysed with IBM SPSS statistics for windows, version 23.0.

Results:

The collected data were analyzed with IBM SPSS Statistics for windows, version 23.0.

Correlation between the tooth length & root length, root diameter and root canal diameter with chronological age on right and left side of an individual. (Table I and Table II)

On analysing the tooth length, root length and root diameter and root canal diameter, on the right and left side using Pearson's correlation, the tooth length (p-value of 0.0005) and root canal diameter (0.0005) on the right and left side, were statistically significant to the age, were statistically significant to the age.

A statistical regression equation was curated using tooth length, root length, root diameter and root canal diameter on both right and left side

Regression formula for right side:

Age= TL (-1.299) +RL (1.024) +RD (0.726) +RCD (-6.607) +58.955

Regression formula for left side:

Age= TL (-0.092) +RL (0.007) +RD (-0.866) +RCD (-0.980) +52.629

Table 1. Correlation between the tooth length & root length with chronological age on right and left side.

Parameters	Patient Age	
Tooth length Right	r-value	-.375**
	p-value	.0005 **
	N	200
Root length Right	r-value	.045
	p-value	.524 #
	N	200
Root diameter Right	r-value	-.041
	p-value	.566 #
	N	200
Root Canal Diameter Right	r-value	-.590**
	p-value	.0005 **
	N	200

Table 2. Correlation between root diametre and root canal diametre with chronological age on right and left side.

Parameters	Patient Age	
Tooth length Left	r-value	-.610**
	p-value	.0005 **
	N	200
Root length Left	r-value	.109
	p-value	.124 #
	N	200
Root diameter Left	r-value	-.059
	p-value	.404 #
	N	200
Root Canal Diameter Left	r-value	-.546**
	p-value	.0005 **
	N	200

Table 3. Regression analysis for individual variables on right side.

Model		Unstandardized Coefficients		Standard -ized Co-efficients	t	Sig.	95.0% C.I for B	
		B	Std. Error	Beta			LB	UB
1	(Constant)	58.955	12.268		4.805	.000	34.759	83.151
	Tooth length Right	-1.299	.213	-.403	-6.086	.0005 **	-1.720	-.878
	Root length Right	1.024	.688	.098	1.490	.138 #	-.332	2.381
	Root diaeter Right	.726	1.366	.036	.531	.596 #	-1.969	3.421
	Root Canal Diameter Right	-6.607	2.642	-.169	-2.500	.014 *	-11.818	-1.396

Table 4. Regression analysis for individual variables on left side.

Model		Unstandardized Coefficients		Standard -ized Co-efficients	t	Sig.	95.0% C.I for B	
		B	Std. Error	Beta			LB	UB
1	(Constant)	55.629	13.946		3.774	.000	25.125	80.133
	Tooth length Left	-.092	.518	-.013	-5.043	.0005 **	-1.114	.931
	Root length Right	.007	.005	.101	1.409	.160 #	-.003	.017
	Root diaeter Left	-.866	1.756	-.037	-.493	.622 #	-4.329	2.597
	Root Canal Diameter Left	-.980	3.051	-.024	-2.791	.014*	-6.998	5.037

Table 5. Correlation of attrition to the chronological age of the patient on right side.

Attrition Right		N	Mean	SD	t-value	p-value
Patient Age	Stage 0	42	35.143	15.1054	4.801	0.0005 **
	Stage I	158	47.816	15.2327		

Table 6. Correlation of attrition to the chronological age of the patient on left side.

Attrition Left		N	Mean	Std. Deviation	t-value	p-value
Patient Age	Stage 0	36	35.278	10.7188	5.502	0.0005 **
	Stage I	164	47.323	16.2061		

Table 7. Corelation of secondary dentine to the chronological age of the patient on right side.

Stages	N	Mean	SD	F-value	p-value
Stage 0	76	40.605	15.0218	4.960	0.002 **
Stage I	80	45.888	15.1072		
Stage II	41	52.122	17.6977		
Stage III	3	45.667	3.5119		
Total	200	45.155	16.0267		

Table 8. Post Hoc Test for secondary dentin stages.

Multiple Comparisons						
Tukey HSD						
(I) Secondary dentin Right		Mean Difference (I-J)	Std. Error	p-value	95% C.I	
					LB	UB
Stage I	Stage II	-9.3993*	2.3469	.0003**	-14.942	-3.857
	Stage III	-2.5481	3.6103	.760 #	-11.074	5.978
Stage II	Stage III	6.8512	3.5225	.129 #	-1.467	15.170
*. The mean difference is significant at the 0.05 level.						

Table 9. Correlation of periodontal recession to the chronological age of the patient on left side.

Stages	N	Mean	SD	F-value	p-value
Stage 0	76	40.605	15.0218	4.960	0.002 **
Stage I	80	45.888	15.1072		
Stage II	41	52.122	17.6977		
Stage III	3	45.667	3.5119		
Total	200	45.155	16.0267		

This regression formula can be utilised among south Indian population assess the age of the individuals.

✔ Correlation of structural changes of teeth to the chronological age of the patient

Attrition (Table V & VI) (Graph I & II)

Out of 200 samples analyzed, 42 samples had stage 0 of attrition and 158 were in stage 1 on the right side, on the left side 36 of the samples were in stage 0 and 164 samples were in stage 1.

An independent T-test was carried out to find the correlation of attrition on right and left sides to the chronological age which revealed statistically significant results with a P value of 0.005 on right and left sides respectively.

Secondary dentin (Table VII & VIII) (Graph I & II)

Out of 200 samples analyzed 78 samples were in stage I, 98 samples were found to be in stage II and 24 samples were in stage 3 on the right side. On the left side, 4 samples were in stage 0, 86 were in stage I, 83 were in stage II and 27 were in stage III.

An independent T-test was carried out to find the correlation of secondary dentin on right and left sides to the chronological age which revealed statistically significant results with a P value of 0.003 on right. This was followed by Post hoc Test in which stage I and stage II had a better correlation with the patient's age.

Periodontal recession (Table IX & X) (Graph I & II)

Out of 200 samples analyzed 93 samples were in stage 0, 72 samples were in stage I, 28 samples were in stage II, 7 samples were in stage III on the right side. On the left 76 samples were in stage 0, 80 samples were in stage I, 41 samples were in stage II, 3 samples were in stage III.

Independent T-test was carried out to find the correlation of Periodontal recession on right and left sides to the chronological age which revealed statistically significant results with a P value of 0.001 on the left this was followed by a post hoc test to find out the most significant stage of periodontal recession to the age. Stage II correlated better with chronological age with a p-value of 0.001.

Regression analysis for individual variables on right side

Regression analysis for tooth length had a standard deviation of +/- 0.213, root length had a standard deviation of +/- 0.688 root canal diameter had a standard deviation of +/- 1.366 and root diameter had a standard deviation of +/- 2.642

Regression analysis for individual variables on left side

Regression analysis for tooth length had a standard deviation of +/-0.518, root length had a standard deviation of +/-0.005 root canal diameter had a standard deviation of +/-1.756 and root diameter had a standard deviation of +/-3.051

Table 10. Post HOC Test for periodontal recession.

Tukey HSD						
(I) Secondary dentin Right		Mean Difference (I-J)	Std. Error	p-value	95% C.I	
					LB	UB
Stage 0	Stage 0	-5.2822	2.4938	.151 #	-11.744	1.180
	Stage II	-11.5167*	3.0168	.001 **	-19.334	-3.700
	Stage III	-5.0614	9.1643	.946 #	-28.808	18.685
Stage II	Stage II	-6.2345	2.9902	.162 #	-13.983	1.514
	Stage III	.2208	9.1556	1.000 #	-23.503	23.945
Stage III	Stage III	6.4553	9.3116	.900 #	-17.673	30.584

*. The mean difference is significant at the 0.05 level.

Discussion:

On analysing 200 samples recruited from the department archives the tooth length on right and left sides showed statistically significant results to the chronological age of the patient. This study was in accordance with the study conducted by Hugo FV et al. (2009)[13] he analysed skeletal remains of 88 patients and measured the tooth length for all the mandibular teeth on right and left side using periapical radiographs revealed a high accuracy of tooth length in estimating the chronological age.

On contrary, Study conducted by Sudhanshu Saxena et al. (2011)[14] analyzed right maxillary canines in 120 ortho-pantomography, she evaluated pulp/tooth area ratio, pulp/root length ratio, pulp/tooth length ratio, pulp/root width ratio at the cementoenamel junction level and correlated to the chronological age of the patient. He inferred that the pulp/tooth area ratio was positively correlated to the chronological age of the patient. Whereas the pulp/tooth length did not have a significant correlation with the age variation in these results could be due to the fact the maxillary canine in ortho-pantograph can have magnification and image distortion.

In our study, root length did not have any influence on the chronological age of the individual. Various studies have been conducted on the root length, where the root length had a positive significance for the sexual dimorphism rather than the age estimation.

The study performed by Soundarajan et al. (2020)[15] on age estimation from root diameter and root canal diameter of maxillary central incisors among chennai population using cone beam computed tomography concluded that the root canal diameter had a higher correlation compared to root diameter. This study was analogous to our present study which had significant results for root canal diameter compared to root diameter. Gustafson (1950)[9] was the first person to introduce a scientific method for age estimation using six age-related changes in tooth structure. Matsikidis et al. reported that the characteristics studied by Gustafson (except apical translucency) in relation to extracted and ground teeth can also be determined using dental films.

On evaluating the structural changes of teeth such as attrition, secondary dentine, and periodontal recession on right and left side, in our study the attrition on right and left were found to be statistically significant which was in accordance with the study conducted by Lewis AJ et al. (2021)[17] where he conducted a study on occlusal tooth wear on Karnataka population. He concluded that as age increases the occlusal tooth wear also increased.

A study conducted by Yayun Wu (2016)[18] he analysed 420 CBCT images for the occlusal tooth wear on Chinese and Malaysian population as predictor of age his results revealed good correlation between age and teeth wear and lower standard error of the estimate. This study was analogous to our present study irrespective of ethnic differences among both the samples.

A study performed by Koh et al. (2016)[61] on age estimation from structural changes of teeth and buccal alveolar bone level on a total of 284 CBCT images on Malays and Chinese patients using lower first premolars. He concluded that the characteristic of attrition seems to be a stronger predictor of age when compared to secondary dentine, periodontal recession, and also when all three characteristics were combined these results were in best accordance with the present study where the attrition on right and left side of the jaw were strongly correlating to the chronological age of the individual than secondary dentine and periodontal recession.

Conclusion:

Teeth can act as a biological marker of aging; dental age assessment is one of the most definitive methods of chronological age estimation. Teeth have a highly mineralized structure, which offers them resistance to post-mortem decomposition. CBCT is the most revolutionary imaging modality in dentistry which can be successfully utilized in the Forensic forum.

In our study, among the various parameters, analysed we were able to conclude that a linear correlation exits between the attrition and tooth length on the right and left side to the chronological age of the patient. When a multiple regression analysis was carried out, we were able to infer that the attrition on both the right and left side, secondary dentine on the right side, and periodontal recession on the left side had a positive correlation to the chronological age of the patient. So, we were able to formulate a regression equation based on the influencing parameters of the teeth and predicted the chronological age of the patient with the standard error of estimate between -1.75 years to 2.35 years, from the inference of the present study, the data analysis could be expanded by trying out the regression equation between the genders and formulate individual equations for age estimation among both genders.

Conflict of interest: Nil

Source of funding: Self

Ethical Clearance: Ethical clearance obtained from the institutional review board (MADC/IEC-II/69/2021)

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