Age Estimation of Adults Using Permanent Mandibular First Molars on Digital Panoramic Radiographs

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Abstract

Background: Morphometric analysis of teeth on radiographs for age estimation are considered to be simple, reliable and non-invasive. The aim of this study was to analyse the efficacy of tooth coronal index (TCI) to estimate age in Indian population and to assess the influence of diet and masticatory habit on TCI. The study comprised of 160 subjects in the age range of 21-71 years, categorized into groups based on chronological age, gender, diet and masticatory habit. Coronal Height (CH) and Coronal Pulp Cavity Height (CPCH) of permanent mandibular first molars was measured on digital panoramic radiographs using Planmeca Romexis software measurement tools. TCI was calculated using the formula: TCI= (CPCH ×100)/CH. Statistical analysis was performed, ANOVA and Pearson correlation was applied along with regression analysis to obtain an estimated age using TCI.

Results: A negative correlation was obtained between the chronological age and TCI. Three-way ANOVA exhibited a significant difference in TCI within the age groups and dietary groups (p value = <0.05). There was no significant difference within the sexes, sides and masticatory groups. The most precise estimated age using the regression formula was in individuals between 31 – 40 years with an error of +/- 5 years in 55% of females, 65% of males.

Conclusions: This study suggests that although TCI is a good predictor of age, it is most suitable to determine age of individuals between 31-40 years with the least error in estimation. This study also throws a light on the influence of diet on TCI.

Key-words: *Morphometric analysis, digital panoramic radiograph, coronal height, coronal pulp cavity height, tooth coronal index*

Background

In spite of the advancement in science, medicine and technology natural calamities, crimes and unfortunate events such as plane crash, road traffic accidents etc. persists even today. Identification of a person is vital among the living and the dead. Age among other demographic data is an essential parameter in precisely identifying an individual. Teeth are important biomarkers for age estimation as they undergo age related physiological changes throughout life and are least likely to be affected by taphonomic process.[1,2] Morphometric analysis of teeth on radiographs for age estimation are considered to be simple, reliable and non-invasive than most other methods.

Digital panoramic radiographs and their computerized storage are available in today's modern era. These procedures exploit image analysis to obtain

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non-invasive metric measurements of both pulp chambers and teeth. Forensic Odontologists may now utilize these techniques that are relatively precise and accurate to measure the dimensions of the tooth and supporting structures. Also, computer assisted image analysis reduces the bias inherent in observer subjectivity and improves the reliability and the statistical analysis of data.[3]

Analysis of the pulp space offers new prospects in dental age identification. A frequently used method found to be effective is the evaluation of secondary dentine apposition. This apposition is an incessant, age associated process, which alters the dimensions of the pulp chamber and is only altered under pathological conditions (e.g. caries). Various methods have been developed to study the size of the pulp chamber, including tooth cross sections and radiographs.[4]

The secondary dentine deposition is indirectly measured by measuring the reduction of the pulp chamber. It is reported that secondary dentine deposition is not homogeneously spread all over the pulp cavity. In molars, as the age advances secondary dentine deposition occurs preferentially on the roof and floor of the pulp chamber reducing the height rather than width of the pulp chamber.[5] Studies in the past have shown a significant correlation between Tooth Coronal Index (TCI) of the coronal pulp cavity and advancing chronological age.

Owing to the limitations in the studies conducted earlier, the present study was designed to analyse the efficacy of TCI of permanent mandibular first molars to estimate age on digital panoramic radiographs with inclusion of influence of diet and masticatory habit.

Materials and Methods

Subjects and Methods:

The study group comprised of 160 subjects, 80 males and 80 females aged between 21 - 71 years visiting the Department of Oral Medicine and Radiology, JSS Dental College and Hospital, Jagadguru Sri Shivarathreeshwara University, Mysuru as outpatients for whom panoramic radiography was advised for assessment/treatment of any orodento-facial conditions were selected by simple random sampling technique.

The study sample was divided in to four groups on the basis of chronological age and each group comprised of 20 males and 20 females: group I: 21 - 30 years, group II: 31 – 40 years, group III: 41 – 50 years and group IV: above 50 years.

Inclusion criteria

- Individuals indicated for panoramic radiography for whom panoramic radiography has been advised for assessment/treatment of any orodento-facial conditions was selected.
- Individuals with bilateral permanent mandibular first molars, having integrated dentition and good occlusion.

Exclusion criteria

- Individuals with history/evidence of local/ systemic disease such as Diabetes Mellitus type I/ anomalies/trauma could affect the permanent mandibular first molars and their occluding maxillary teeth.
- Individuals with missing permanent maxillary second premolars, first molars and second molars which occlude with the permanent mandibular first molars.
- Individuals with bruxism and other para-functional habits as well as deleterious chewing habits.
- Pregnant individuals.

Ethical clearance was obtained from the JSS Dental College & Hospital Institutional Ethical Committee prior conducting the study. Based on the eligibility criteria subjects were selected. A relevant history of selected participants was obtained followed by a thorough clinical examination. The general data, history and clinical findings was recorded in individual proformas designed especially for the study.

The selected individuals were then subjected to digital panoramic radiography (Planmeca ProMax SCARA 3) by selecting the predefined kVp and mA based on the built and age option parameters adapting requisite radiation protection measures. Ideal digital panoramic images of optimum diagnostic quality were

included in the study. Radiographic evidence of any bony developmental anomalies/restorations and/or pathologies in or associated with permanent mandibular first molars and their occluding maxillary teeth were excluded.

Measurements:

Both the permanent mandibular first molars (tooth number 36 and 46 according to FDI tooth numbering system) were measured separately to calculate their respective TCIs. The TCI was calibrated with the computer software (Planmeca Romexis Viewer) for accuracy and precision (Figure 1). One of the features of the software is that it allows linear as well as curvilinear measurements between any two points or multiple points. A straight line traced between the cemento-enamel junctions (CEJ) is the division between the anatomical crown and root. The crown height (CH) was measured vertically from the cervical line to the tip of the highest cusp according to Moss et al.[6] and the coronal pulp cavity height (CPCH) was measured vertically from the cervical line to the tip of the highest pulp horn according to Ikeda et al. (Figure 2).[7] The measurements were displayed in millimetres along with the image. The measurements made were stored along with the captured image for further identification and reference. Reliability of measurements was assessed by re-measuring the above parameters after 15 days by the same observer.

These measurements provided the TCI for each tooth which was calculated using the formula: TCI = CPCH X 100/CH.

Statistical Analysis

Data was entered in a Microsoft EXCEL spreadsheet. Statistical analysis was done using the SPSS (Software Package for Social Sciences) Version 22.0 statistical analysis software. Pearson correlation coefficient was done between the chronologic age and TCI of 36, 46 and mean of 36+46. Three-way ANOVA was done to assess the difference in TCI among different age groups, gender and diet/masticatory habit. TCI and chronological age were subjected to regression analysis for males, females and combined sample separately. The equations derived through regression analysis were used for age estimation. Paired t test was applied to check for statistical difference between chronological age and estimated age where, p value <0.05 was considered to be statistically significant.

Results

Descriptive analysis of the study subjects according to their age group and gender along with their mean chronological age was done. The study sample comprised of 160 subjects, 80 females and 80 males who were within the age range of 21 – 71 years. The mean chronological age irrespective of the age group was 41.69 years in females, 40.73 years in males and 41.21 years in the combined sample. According to diet, 106 subjects consumed mixed diet and 54 subjects consumed vegetarian diet. The distribution of mean chronological age according to their diet, age group and gender is summarized in Table 1. According to masticatory habit, 115 subjects claimed to be bilateral chewers and 45 subjects claimed to be unilateral chewers. The distribution of mean chronological age according to their masticatory habit, age group and gender is summarized in Table 2.

The extent of the TCI-36, 46 and mean of 36+46 according to age and gender. Replicate measurements were nearly identical, with an intra-observer error of 2.96%. ANOVA test showed that there was a significant difference in TCI among age groups (p=<0.05) and there was no significant difference in TCI among the sexes and sides. There was a significant statistical interaction between TCI - 46 in subjects with different dietary habit according to their age group (p=<0.05) and no statistical difference was found between the TCI of unilateral and bilateral chewers for both the teeth (p=>0.05). Hence, TCI value was lesser in subjects consuming mixed diet.

There was a negative correlation between chronological age and TCI among both the sexes where, r value for 36, 46 and 36+46 among females was -0.586, -0.505 and -0.578 respectively; r value for 36, 46 and 36+46 among males was -0.436, -0.359 and -0.423 respectively and r value for 36, 46 and 36+46 among the combined sample was -0.502, -0.431, and -0.495 respectively (Table 3). Thus indicating TCI decreases with the process of aging.

Linear regression analysis was performed with age as a dependent factor and TCI as an independent factor. Nine formulae were obtained according to the tooth number and gender.

1. For females,

· Age = 77.600 + (-1.385*TCI_{36})

· Age = 70.231 + (-1.082*TCI_{46})

· Age = 77.765 + (-1.380*TCI_{mean})

2. For males,

· Age = 60.168 + (-0.749*TCI_{36})

· Age =57.145 + (-0.614*TCI_{46})

· Age = 61.059 + (-0.772*TCI_{mean})

3. For combined sample,

· Age = 67.33 + (-1.007*TCI_{36})

· Age = 63.157 + (-0.826*TCI_{46})

· Age = 68.341+ (-1.034*TCI_{mean})

The TCI values were substituted accordingly and estimated age was calculated. We obtained a difference of -0.0123 years in females, 0.0023 years in males and -0.4822 years in the combined sample between the mean chronological age and mean estimated age in regards to TCI-36; a difference of -0.008 years in females, 0.0025 years in males and -0.4936 years in the combined sample between the mean chronological age and mean estimated age in regards to TCI-46; a difference of 0.0051 years in females, 0.0115 years in males and -0.473 years in the combined sample between the mean chronological age and mean estimated age in regards to mean TCI-36+46. Paired t test suggested no significant statistical difference between the chronological age and estimated age (p=>0.05). Hence, TCI is a reliable method for age estimation. However, the most precise estimated age was for subjects in the age group of 31-40 years with a +/-5 years' error in estimation in 55% of females, 65% of males and 60% of the combined sample.

Table 1: Mean chronological age of the subjects in different age groups and gender according to their diet.

	Diet	Chronological age in years								
		Females			Males			Combined sample		
		Mean	SD	N	Mean	SD	N	Mean	SD	N
Group I (21-30 years)	Mixed	24.3571	3.12821	14	26.2222	2.72845	9	25.0870	3.05871	23
	Vegetarian	25.1667	2.92689	6	24.8182	2.63887	11	24.9412	2.65684	17
Group II (31-40 years)	Mixed	35.6000	3.33999	10	35.3571	3.58645	14	35.4583	3.41326	24
	Vegetarian	36.9000	1.79196	10	37.6667	1.03280	6	37.1875	1.55858	16
Group III (41-50 years)	Mixed	46.7143	2.81284	14	45.1875	3.16689	16	45.9000	3.05524	30
	Vegetarian	45.6667	3.50238	6	47.0000	2.94392	4	46.2000	3.19026	10
Group IV (>50 years)	Mixed	59.2000	5.51880	15	56.2143	5.68640	14	57.7586	5.70498	29
	Vegetarian	60.4000	6.94982	5	55.0000	3.03315	6	57.4545	5.64559	11
Total	Mixed	42.2453	14.05334	53	42.2830	11.30245	53	42.2642	12.69143	106
	Vegetarian	40.5926	12.41358	27	37.6667	12.57898	27	39.1296	12.46587	54

Table 2: Mean chronological age of subjects in different age groups and gender according to their masticatory habit.

	Masticatory habit	Chronological age in years								
		Females			Males			Combined sample		
		Mean	SD	N	Mean	SD	N	Mean	SD	N
Group I (21-30 years)	Unilateral chewers	25.4000	2.60768	5	24.8000	3.27109	5	25.1000	2.80674	10
	Bilateral chewers	24.3333	3.17730	15	25.6667	2.58199	15	25.0000	2.92433	30
Group II (31-40 years)	Unilateral chewers	36.8333	2.48328	6	35.2500	3.09570	4	36.2000	2.69979	10
	Bilateral chewers	36.0000	2.82843	14	36.2500	3.29646	16	36.1333	3.03694	30
Group III (41-50 years)	Unilateral chewers	46.2500	4.34933	4	45.6000	4.09878	5	45.8889	3.95109	9
	Bilateral chewers	46.4375	2.73176	16	45.5333	2.92445	15	46.0000	2.81662	31
Group IV (>50 years)	Unilateral chewers	58.9000	5.40473	10	53.8333	3.65605	6	57.0000	5.32917	16
	Bilateral chewers	60.1000	6.27960	10	56.7143	5.34111	14	58.1250	5.87043	24
Total	Unilateral chewers	44.8800	13.89940	25	40.8000	12.01578	20	43.0667	13.11210	45
	Bilateral chewers	40.2364	13.13599	55	40.7000	11.92817	60	40.4783	12.46704	115

Table 3: Correlation between chronological age and TCI.

	Gender		**TCI - 36**	**TCI - 46**	**TCI - 36+46**
Chronological Age	**Females**	Pearson Correlation (r)	-0.586	-0.505	-0.578
		p value	0.001	0.0001	0.0001
	Males	Pearson Correlation (r)	-0.436	-0.359	-0.423
		p value	0.001	0.0001	0.0001
	Combined Sample	Pearson Correlation (r)	-0.502	-0.431	-0.495
		p value	0.001	0.0001	0.0001

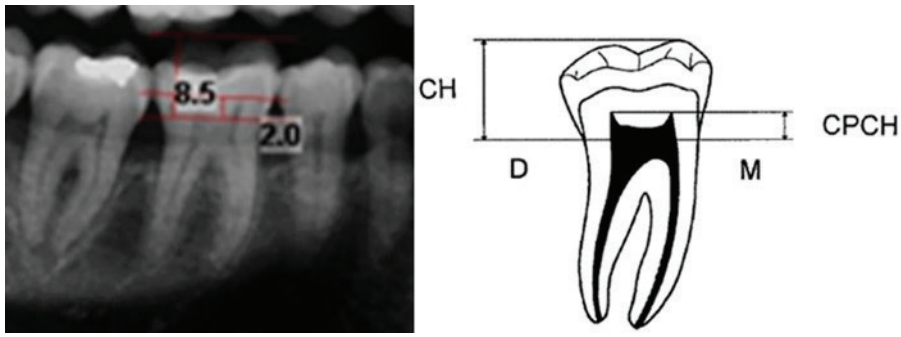

Figure 1: Cropped image of the digital panoramic radiograph showing the Crown Height (CH) and Coronal Pulp Cavity Height (CPCH) measurements.

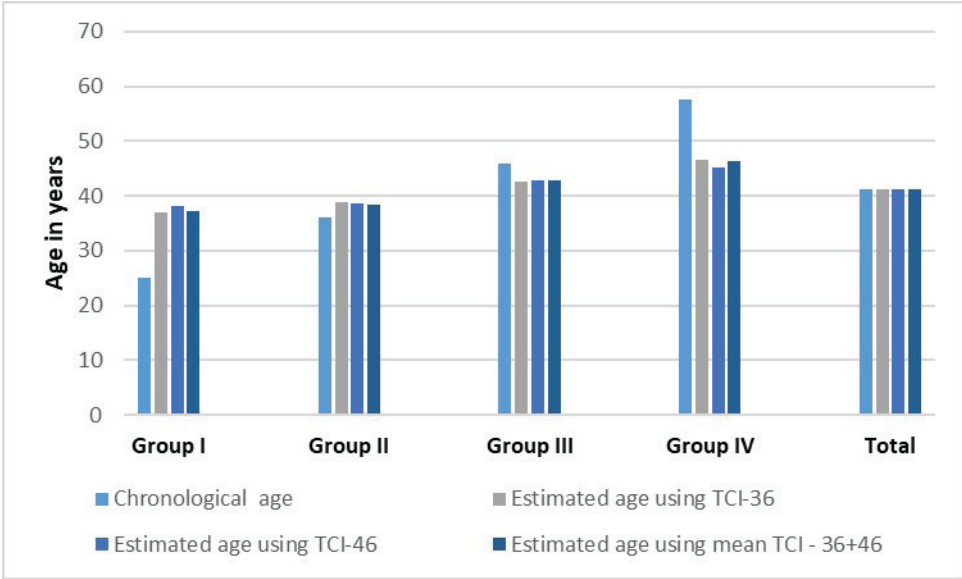

Figure 2: Graph showing difference in the chronological age and estimated age using Tooth Coronal Index (TCI) in the combined sample.

Discussion

Examination of the pulp space offers new opportunities in dental age identification. A commonly used method found to be effective is the evaluation of secondary dentine apposition. In molars, as the age advances secondary dentine deposition occurs preferentially on the roof and floor of the pulp chamber reducing the height rather than width of the pulp chamber.[5] Studies in the past have shown a significant correlation between Tooth Coronal Index (TCI) of the coronal pulp cavity and advancing chronological age.

The intra-observer error in the present study to calculate CH and CPCH was 2.96% whereas it was about 3.8% in a study conducted by Drusini et al. in 1997 on digitized panoramic images.[8] Hereby, the present study holds good to prove that measurements on digital panoramic radiographs are more accurate than on digitized panoramic radiographs.

In the present study, a negative correlation was obtained between chronological age and TCI with. They were all considered to be statistically significant with a p value <0.05, thus reassuring the fact that TCI decreases with increase in age. This was in agreement with studies conducted by DSrusini et al.[8], Igbigbi and Nyirenda[9], Veera et al[5]. Morsi et al.[10] and Talabani et al.[3] On the contrary, there was statistical significance in a study conducted by Karkhanis et al. with a p value >0.05.[11]

The present results revealed that there is no gender difference in TCI. This is in agreement with studies

done in Italy by Drusini et al.[8]; in India by Veera et al.[5]; in Egypt by Khattab et al.[12] and Morsi et al.[10] and in Western Australia by Karkhanis et al.[11] They stated that sex of individual appears to have no significant influence on age estimation, so that sex specific formulae are not necessary for age estimation in specimens of unknown sex. On the other hand, this result is contrary to that of Igbigbi and Nyirenda in Malawi who mentioned that gender has a significant influence on age estimation using TCI and hence there is need for sex – specific formulae in the sampled population.[9] They explained this difference by the influence of oestrogen on the formation of secondary dentin. Hietala et al. reported the existence of an oestrogen receptor in odontoblast of human pulp tissues.[13]

The difference between the teeth side was demonstrated to be negligible in various studies conducted by Drusini et al.[8] and Zadzinska et al.[14]; Igbigbi and Nyirenda[9]; Veera et al.[5]; Khattab et al.[12]; Karkhanis et al.[11] and Thevissen and Willems.[15] Kvaal et al. applied his study on left side and if due to tooth positioning, tilting or overlapping, insufficient tooth information was available, the corresponding tooth of right side was measured.[16] Although, we calculated the TCI for both 36 and 46, we did not find statistically significant difference between the two. This statement supports the above mentioned studies. However, Morsi et al. contradicts it by stating that there was a significant difference between the TCI of the right and left teeth because of the developmental or morphological changes or the accuracy of radiographs.[6]

Since our study was a prospective one, we included two other variables – diet and masticatory habit. These variables were included to assess the influence diet and masticatory habit on the TCI of the subjects. Several authors had concluded in their study that these factors may have a role to play in assessing the accuracy of the estimated age using TCI. To the best of our knowledge this is the first study which considered these variables.

We observed that the TCI (irrespective of age group and gender) was slightly higher in subjects consuming vegetarian food than those consuming a mixed diet with a TCI – 36 value of 27.2836 and 25.2573 respectively; TCI – 46 value of 27.5122 and 26.0746 respectively; mean TCI – 36+46 value of 27.3979 and 25.6660 respectively. However, statistically significant interaction between the age group and diet was found only in regards to TCI – 46 with a p value of 0.021. Thus concluding, those consuming mixed diet have a lesser value of TCI and this may lead to overestimation of age in people consuming mixed diet.

We observed that TCI (irrespective of age group and gender) was lesser in unilateral chewers than in bilateral chewers with a TCI – 36 value of 25.1795 and 26.2393 respectively; TCI – 46 value of 26.9379 and 26.4119 respectively; mean TCI – 36+46 value of 26.0587 and 26.3257 respectively. This implies that most unilateral chewers chewed on the left side, hence a lesser value was noted in relation to TCI -36. However, statistically there was no significant difference between the masticatory groups in regards to their TCI (p value is >0.05).

Simple regression analysis was done with age as a dependent variable and TCI as an independent variable. We obtained nine formulae keeping the TCI 36, 46 and 36+46 and females, males and combined sample in mind. This was similar to Kharkhanis et al. study.[11] However, they had conducted their study on premolars. Drusini et al. and Igbigbi and Nyirenda obtained 3 formulae keeping females, males and combined sample in regards to TCI of mandibular molars.[8,9] Veera et al. obtained ten formulae in reference to the four age groups and genders and also for the overall age range and genders.[5] Talabani et al. obtained a single formula which was irrespective of age group, gender and side.[3]

Drusini et al. demonstrated a mean age difference of 3.38 years between the mean chronological age and mean estimated age in females, 2.65 years in males and 3.02 years in the combined sample using the TCI of mandibular molars.[8] Veera et al. obtained a difference of 0.03 years between the mean chronological age and mean estimated age using TCI of mandibular first molars.[5] Talabani et al. obtained a difference of 0.1 year between the mean chronological age and mean estimated age using TCI of mandibular first molars.[3] In our study, we obtained a difference of -0.0123 years in females, 0.0023 years in males and -0.4822 years in the combined sample between the mean chronological age and mean estimated age in regards to TCI-36; a difference of

-0.008 years in females, 0.0025 years in males and -0.4936 years in the combined sample between the mean chronological age and mean estimated age in regards to TCI-46; a difference of 0.0051 years in females, 0.0115 years in males and -0.473 years in the combined sample between the mean chronological age and mean estimated age in regards to mean TCI-36+46. In all the former studies as well as in this study the difference in the chronological age and estimated age was statistically insignificant with a p value of >0.05.

In 1997, Drusini et al stated that the most precise age estimation was obtained for male molars with an error of +/- 5 years in 81.4% of the subjects.[8] Igbigbi and Nyirenda, in 2005 observed that only 53.25% of males, 28.07% of females and 37.31% of the combined sample showed accuracy of +/- 5 years between the chronological age and estimated age.[9] In our study, we found that the most precise age estimation was obtained for group II subjects (31-40 years) with an error of +/- 5 years in 55% of female, 65% of males and 60% of the combined sample using the TCI of mandibular molars irrespective of side on a digital panoramic radiograph.

This study tried to involve two other dimensions i.e.: diet and masticatory habit to assess its influence on TCI. Although, we proved that there was a significant decrease in TCI among subjects consuming mixed diet in regards to TCI – 46 (p value of 0.021) there was no statistically significant difference in the TCI between unilateral and bilateral chewers. This may support the fact that most people are naturally bilateral chewers unless there has been a pathology associated on either side which would cause discomfort to them leading to unilateral chewing habit. Knowing the duration of the habit will come in handy to assess the significant change in TCI.

In our study we also observed that there was an overestimation of age in the group I (21 – 30 years) subjects and an underestimation of age in group III (41-50 years) and group IV (>50years). The overestimation of age in group I could be due to premature eruption of mandibular permanent teeth in the younger generations these days since their preceding deciduous dentition are more likely to be prone to caries as observed in studies conducted by Ambika L et al. and Hägg and Taranger.[17,18] The underestimation of age in group III and IV could be because of consuming refined food.

Conclusion

The use of tooth coronal index for age estimation is a simple, practical, non-invasive and less time consuming method and is thus believed to be suitable for application in living and dead individuals. This method can be used for individuals above 21 years of age. However, it is most precisely suited for identification of individuals in their third dade of life

Abbreviations:

TCI : Tooth Coronal Index

CH : Coronal Height

CPCH : Coronal Pulp Cavity Height

Tooth number 36 (FDI tooth numbering system): Mandibular left first molar

Tooth number 46 (FDI tooth numbering system): Mandibular right first molar

Ethical Clearance - Taken from JSS Dental College & Hospital, JSSAHER, Mysore.

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Conflict of Interest – Nil.

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