Original Article
Journal of Forensic Dental Sciences, *Vol 13(1), DOI: 10.18311/jfds/13/1/2021.627, January - April 2021, p. 38-43*
ISSN (Print) : 0975-1475
ISSN (Online) : 0975-2137

Digitilized Radiographic Analysis of Coronal Pulp for Age Estimation in Adults using Tooth Coronal Index Method – A Pilot Study

Sailaja Joparti*, Madala Jaya Kiran, Guttikonda Venkateswara Rao, Yeluri Sivaranjani, Moni Thakur and Katakam Pradeepthi

Department of Oral Pathology and Microbiology, Mamata Dental College, Khammam – 507002, Telengana, India; jopartisailaja@gmail.com, jaikiran78@gmail.com, mamatadental@yahoo.co.in, ysivaranjani@yahoo.com, reddymoni@yahoo.com, pradeepthi0311@gmail.com

Abstract

Background: Teeth have become a valuable index to estimate age of an individual in forensic odontology. Although various methods have been reported in forensic literature for age estimation, radiographic methods are simple and require less expertise. Digitalization of panoramic radiographs and intraoral periapical radiographs helps in obtaining the more precise images and accurate measurements. Secondary dentin continuously gets deposited on pulpal surface throughout the life thus reducing the size of the pulp cavity. The Tooth Coronal Index (TCI) method is the indirect assessment of secondary dentin deposition for age estimation. **Aim:** This study aims to estimate the Tooth Coronal Index of mandibular first molar and its correlation with chronological age to derive a regression equation. **Materials and Methods:** A total of 50 adults above 20 years of age were selected from the outpatient department of our college. Digital intraoral periapical radiographs were taken by using Radiovisiography (RVG) for mandibular first molar. The crown height and Coronal Pulp Cavity Height were measured and then TCI was calculated. Further the data were subjected to statistical analysis. **Results:** Statistically significant difference was observed between age and TCI ($p<0.05$*) and statistically insignificant difference observed between gender and TCI ($p>0.05$). **Conclusion:** The Tooth Coronal Index provides more accurate estimation of age and it is a simple, non invasive and cost-effective method that could be easily applied for both living and dead individuals without any highly specialized equipment.

Keywords: Adults, Age Estimation, Teeth, Tooth Coronal Index

Introduction

Identification of deceased or living individuals is utmost important for any forensic investigation or medico legal cases. In forensic dentistry or odontology, dental tissues are used for estimation of chronological age of individuals[1–3]. Although various skeletal remains could be used to estimate age, teeth are more reliable indicators because teeth are more resistant to thermal, chemical or mechanical stimuli and could be preserved for longer time even after death than other skeletal tissues of the body[4–6].

Various morphologic, histological and biochemical methods have been reported in forensic literature for age estimation with the help of teeth but these methods require tooth extraction and are invasive for living individuals[7,8]. To overcome this limitation, noninvasive radiographic methods have been developed that are simple and require less expertise. The advent of digital radiography has various advantages over the conventional radiographs such as instant image viewing, decrease in radiation exposure, better quality of images, less duration of time, storage and accuracy of measurements. Digitalization of panoramic radiographs and intraoral periapical

*Author for correspondence

radiographs helps in obtaining more precise images and accurate measurements[9–11].

Progressive modification of the coronal pulp cavity throughout life occurs due to continuous deposition of the secondary dentin[12,13]. Ikeda *et al.*[14] in 1985 developed Tooth Coronal Index (TCI) method based on secondary dentin deposition for age estimation from radiographs taken for extracted teeth. The Tooth Coronal Index method is the indirect assessment of secondary dentin deposition, in which the Coronal Pulp Cavity Height (CPCH) was considered as parameter for age estimation.

The present study was conducted with an aim to assess the accuracy of age estimation from TCI of mandibular first molar using digital intraoral periapical radiographs and its correlation with chronological age to derive a regression equation.

Materials and Methods

A total of 50 adults above 20 years of age were selected from the outpatient department of our college. The research protocol was reviewed and approved by the committee of our institution. All the subjects were informed about the purpose and objectives of the study and an informed consent was obtained from all the subjects prior to their inclusion.

Inclusion Criteria

- Subjects above 20 years of age irrespective of sex were included.
- Fully erupted mandibular first molar with no defects were included in the study.

Exclusion Criteria:

- Subjects with systemic diseases.
- Carious/grossly decayed teeth, periapical pathology, prosthesis, restored/root canal treated teeth, missing selected teeth, severely attrited or fractured teeth, malaligned teeth, teeth with any developmental anomalies.
- RVG with distorted images were excluded.

Radiographic Measurements

Detailed case history and date of birth was obtained from enrolled subjects and were sent for RVG examination. Digital intraoral radiographs of mandibular first molar were taken by Kodak RVG 5100 with paralleling angle technique at 70 kVp, 8 mA and exposure time of 0.4 s. The image obtained was analyzed and the measurements were calculated by using Sidexis software. All the measurements were recorded in millimeters.

Measurement of TCI

To ensure the accuracy of the technique measuring lines were drawn on digital intraoral periapical radiographs. The measuring lines include one horizontal reference line (R) and two vertical measuring lines Crown Height (CH) and Coronal Pulp Cavity Height (CPCH) [Figure 1]. The horizontal reference line (R) which connects mesial and distal cement-enamel junction points and the Crown Height (CH) which measures the distance from the cervical line to the tip of the highest cusp of tooth, while the Coronal Pulp Cavity Height (CPCH) measures the distance from the cervical line to the tip of highest pulpal horn. The coronal height and the Coronal Pulp Cavity Height were digitally measured by using Sidexis Software on the computer screen. From these measurements, the Tooth Coronal Index (TCI) was calculated for each tooth with the help of following formula given by Ikeda *et al.*[14]

$$\mathbf{TCI = (CPCH \times 100)/CH}$$

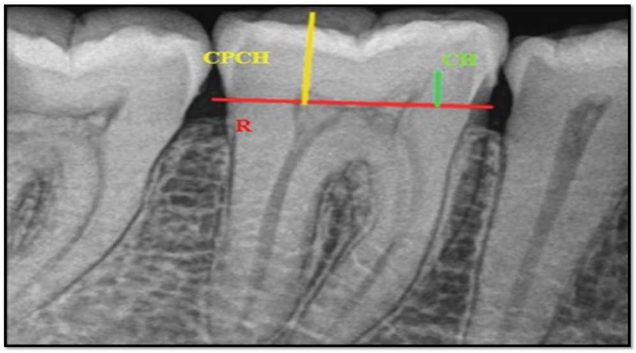

Figure 1. Measuring lines.

Statistical Analysis

The data obtained was statistically analyzed for the mean values, Standard Deviation (SD) and p value using statistical package software system (SPSS version 20). Age groups and mean TCI were compared by one way ANOVA. Karl Pearson correlation was done to detect the association between the age and TCI. Simple linear regression was carried out by regressing the TCI score against age. Comparison of chronological age with estimated age was done by student paired t test and $P < 0.05$ was considered as statistically significant.

Results

Out of 50 subjects, males represented 54%, whereas females represented 46%, with a mean age of 39.12 ± 11.62 years [Table 1]. Mean TCI was found to be 24.77 ± 6.24 and statistically significant difference was observed when TCI was compared with age (P = 0.001*) [Table 2]. Statistically insignificant difference was observed when TCI was compared with gender (P = 0.3059) [Table 3]. A negative correlation exists between TCI of mandibular first molar and age in all studied subjects (r = -0.9976, p = 0.0001*) [Table 4]. Regression analysis was used for TCI to determine the age (Y) [Table 5]. The standard error of mean between actual age and estimated age was 0.8050 with statistically insignificant difference (P = 0.9989) [Table 6]. Scatter plot shows strong correlation between the age and TCI [Figure 2]. The regression equation for the determination of age (Y) using the TCI score is:

Y = 85.121-1.857 x TCI

Table 1. Distribution of samples according to age group and gender

Age groups	Male	%	Female	%	Total	%
20-29 yrs	5	41.67	7	58.33	12	24.00
30-39 yrs	8	57.14	6	42.86	14	28.00
40-49 yrs	8	57.14	6	42.86	14	28.00
50+ yrs	6	60.00	4	40.00	10	20.00
Total	27	54.00	23	46.00	50	100.00
Mean age	40.63		37.35		39.12	
SD age	10.71		12.62		11.62	
Chi-square = 0.9910 P = 0.8030						

Table 2. Comparison of age groups with mean scores of TCI by one way ANOVA

Age groups	Mean	SD
20-29 yrs	32.93	1.64
30-39 yrs	27.05	1.96
40-49 yrs	21.65	1.76
50+ yrs	16.16	2.10
Total	24.77	6.24
F-value	168.1106	
p-value	0.0001*	

Table 3. Comparison of gender with mean scores TCI by t test

Gender	TCI		t-value	p-value
	Mean	SD		
Male	23.93	5.69	-1.0349	0.3059
Female	25.76	6.83		
Total	24.77	6.24		

Table 4. Correlation between age and TCI by Karl Pearson's correlation coefficient

Parameters	Correlation between age with		
	r-value	t-value	p-value
TCI	-0.9976	-99.7576	0.0001*

P<0.05*

Table 5. Simple liner regression equation of age in yrs by TCI

Independent variable	Regression coefficient	SE of Reg. Coefficient	t-value	p-level
Intercept	85.1208	0.4753	179.1052	0.0001*
TCI	-1.8570	0.0186	-99.7576	0.0001*
R = 0.9975, R^2 = 0.9951, F(1,48) = 9951.6 p<0.05, S, Std.Error of estimate: .81336				

Prediction equation is Age in yrs (Y) = 85.121-1.857 (TCI)

Table 6. Comparison of chronological age with estimated age by dependent t test

Ages	Mean	SD	Mean Diff.	SD Diff.	t-value	p-value
Chronological. age	39.1200	11.6192				
Estimated age	39.1198	11.5914	0.0002	0.8050	0.0020	0.9984

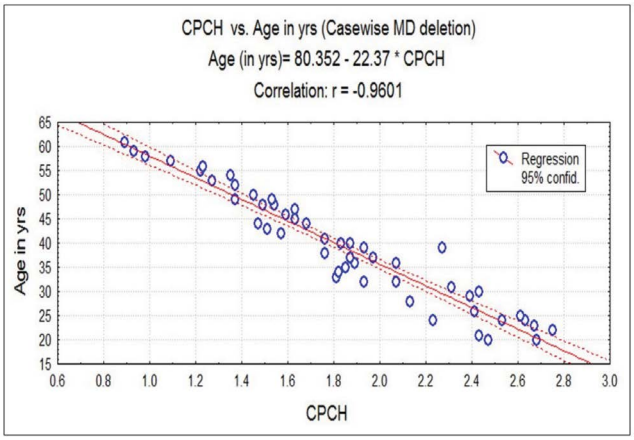

Figure 2. Scatter diagram showing the correlation between age with TCI scores.

4. Discussion

Identification of a person is first basis for any forensic investigation or medico legal cases. Age estimation is considered as one of the important parameters for persons identification[2]. According to Edwin Saunders, teeth are more reliable maturity indicators for age estimation than other skeletal tissues because they show low variability from environmental factors, nutritional or endocrine diseases[15].

Secondary dentin continuously get deposited on pulpal cavity throughout the life thus reducing the size of pulp cavity. In 1925, Bodecker reported the relation between secondary dentin deposition and chronological age[16]. Since then, several studies have suggested that dental pulp size decreases with increasing age as a result of continuous secondary dentin deposition, thus indicating that assessment of secondary dentin deposition with the help of pulp tooth volume is the best method to estimate the dental age[17–19]. Secondary dentin deposition is not uniform all over the pulpal cavity, i.e., in case of molars, it is more over the roof and floor than walls of the pulpal cavity, thus reducing the height rather than the width of the pulpal cavity[7,15].

Although various methods have been reported in forensic literature for age estimation, radiographic methods are simple, require less expertise and produce more accurate and precise images[20–22]. Gustafson made an earlier attempt to estimate the age based on secondary dentin apposition on periapical radiographs[23]. Later, Kvaal *et al.*[24] and Cameriere *et al.*[25] estimated the age on radiographs by measuring pulp/tooth ratio and they observed negative correlation with the chronological age.

Jain S *et al.*[26] estimated the age of an individual from mandibular premolar and molar by using Tooth Coronal Index method on digital intraoral radiographs. They observed a negative correlation between the real age and TCI. Sharma and Srivastava[11] estimated the age by measuring pulp size of six selected teeth by Kvaal's method on digital intraoral radiographs and they found significant correlation between decreasing pulp size with age[24].

In the present study, digital intraoral radiographic images were used to determine the age of 50 subjects by calculating the TCI of mandibular first molar. The results showed a statistically significant difference between TCI and age ($p < 0.05$). A negative correlation exists between TCI and age in all subjects with statistically significant difference ($r = -0.9976$, $p<0.05$*). These results are in accordance with the studies done by Veera *et al.*,[7] Drusini *et al.*,[12] Zadzinska *et al.*,[17] Igbigbi *et al.*[18] and Talabani *et al.*[19], thus emphasizing that the TCI values decrease with advancing age.

Further, the present study revealed that there was a statistically insignificant difference when TCI was compared with gender ($p > 0.05$). Hence, gender specific formula is not needed for age estimation. Agemastu *et al.*[27] and Igbigbi *et al.*[18] demonstrated that gender has significant influence on TCI values. They elucidated, that the gender significant difference may be due to influence of estrogen on the formation of secondary dentin[28,29]. According to Hietala *et al.*[30] and Silvana *et al.*[31], the existence of an estrogen receptor in odontoblast of human pulp tissue may be the reason for gender influence on secondary dentin deposition.

Moreover the present study showed that the standard error of mean was 0.8050 with statistically insignificant difference between the actual age and estimated age ($p > 0.05$). These results were in accordance with the studies done by Veera *et al.*[7] and Igbibi *et al.*[18] thus indicating that the TCI of mandibular first molar is more reliable indicator for age estimation. The present study further recommend that forensic odontologists should address applicability of TCI method using digital intraoral periapical radiographs on different teeth and conduct similar studies with larger population.

Conclusion

The Tooth Coronal Index provides more accurate estimation of age and it is a simple, noninvasive, less time-consuming, reproducible and cost-effective method that could be easily applied without any highly specialized equipment. The results concluded that the TCI values concurrently decreased with progression of age and gender has no influence on TCI values.

References

1. Nemsi H, Haj Salem N, Bouanene I, *et al.* Age assessment in canine and premolar by cervical axial sections of cone-beam computed tomography. Leg Med (Tokyo). 2017; 28:31–6. PMid: 28756305. https://doi.org/10.1016/j.legalmed.2017.07.004
2. Fernandes MM, Tinoco RL, de Braganca DP, de Lima SH, Francesquini Junior L, Daruge Junior E. Age estimation by measurements of developing teeth: Accuracy of

Cameriere's method on a Brazilian sample. J Forensic Sci. 2011; 56(6):1616–9. PMid: 21827459. https://doi.org/10.1111/j.1556-4029.2011.01860.x
3. Rai B, Kaur J, Cingolani M, Ferrante L, Cameriere R. Age estimation in children by measurement of open apices in teeth: An Indian formula. Int J Legal Med. 2010; 124(3):237–41. PMid: 20198380. https://doi.org/10.1007/s00414-010-0427-7
4. Shah PH, Venkatesh R. Pulp/tooth ratio of mandibular first and second molars on panoramic radiographs: An aid for forensic age estimation. J Forensic Dent Sci. 2016; 8(2):112. PMid: 27555734 PMCid: PMC4970410. https://doi.org/10.4103/0975-1475.186374
5. Panchbhai AS. Dental radiographic indicators, a key to age estimation. Dentomaxillofac Radiol. 2011; 40(4):199–212. PMid: 21493876 PMCid: PMC3520308. https://doi.org/10.1259/dmfr/19478385
6. Ubelaker DH, Parra RC. Application of three dental methods of adult age estimation from intact single rooted teeth to a Peruvian sample. J Forensic Sci. 2008; 53(3):608–11. PMid: 18471205. https://doi.org/10.1111/j.1556-4029.2008.00699.x
7. Veera SD, Kannabiran J, Suratkal N, Chidananada DB, Gujjar KR, Goli S. Coronal pulp biomarker: A lesser known age estimation modality. J Indian Acad Oral Med Radiol. 2014; 26:398–404. https://doi.org/10.4103/0972-1363.155684
8. Ohtani S, Yamamoto K. Age estimation using the racemization of amino acid in human dentin. J Forensic Sci. 1991; 36(3):792–800. PMid: 1856647. https://doi.org/10.1520/JFS13089J
9. Zaher JF, Fawzy IA, Habib SR, Ali MM. Age estimation from pulp/tooth area ratio in maxillary incisors among Egyptians using dental radiographic images. J Forensic Leg Med. 2011; 18(2):62–5. PMid: 21315299. https://doi.org/10.1016/j.jflm.2010.12.004
10. Lamendin H, Baccino E, Humbert JF, Tavernier JC, Nossintchouk RM, Zerilli A. A simple technique for age estimation in adult corpses: The two criteria dental method. J Forensic Sci. 1992; 37(5):1373–9. PMid: 1402761. https://doi.org/10.1520/JFS13327J
11. Sharma R, Srivastava A. Radiographic evaluation of dental age of adults using Kvaal's method. J Forensic Dent Sci. 2010; 2(1):22–6. PMid: 21189986 PMCid: PMC3009551. https://doi.org/10.4103/0974-2948.71053
12. Drusini AG. Age estimation from teeth using soft X-ray findings. Anthropol Anz. 1993; 51(1):41–6. https://doi.org/10.1127/anthranz/51/1993/41
13. Drusini AG, Toso O, Ranzato C. The coronal pulp cavity index: A biomarker for age determination in human adults. Am J Phys Anthropol. 1997; 103(3):353–63. https://doi.org/10.1002/(SICI)1096-8644(199707)103:3<353::AID-AJPA5>3.0.CO;2-R
14. Ikeda N, Umetsu K, Kashimura S, Suzuki T, Oumi M, Zasshi NH. Estimation of age from teeth with their soft X-ray findings. Jpn J for Med. 1985; 39(3):244–50.
15. Ekizoglu O, Er A, Bozdag M, *et al*. Sex estimation of the tibia in modern Turkish: A computed tomography study. Leg Med (Tokyo). 2016; 23:89–94. PMid: 27890111. https://doi.org/10.1016/j.legalmed.2016.10.004
16. Bodecker CF. A consideration of some of the changes in the teeth from young to old age. Dent Cosmos. 1925; 67:543–9.
17. Zadinska E, Drusini AG, Carrara N. The comparison between two age estimation methods based on human teeth. Anthropol Rev. 2000; 63:95–101. https://doi.org/10.18778/1898-6773.63.07
18. Igbigbi PS, Nyirenda SK. Age estimation of Malawian adults from dental radiographs. West Afr J Med. 2005; 24(4):329–33. PMid: 16483051. https://doi.org/10.4314/wajm.v24i4.28227
19. Talabani RM, Baban MT, Mahmood MA. Age estimation using lower permanent first molars on a panoramic radiograph: A digital image analysis. J Forensic Dent Sci. 2015; 7(2):158–62. PMid: 26005307 PMCid: PMC4430576. https://doi.org/10.4103/0975-1475.154597
20. Rajpal PS, Krishnamurthy V, Pagare SS, Sachdev GD. Age estimation using intraoral periapical radiographs. J Forensic Dent Sci. 2016; 8(1):56–7. PMid: 27051226 PMCid: PMC4799522. https://doi.org/10.4103/0975-1475.176955
21. Juneja M, Devi YB, Rakesh N, Juneja S. Age estimation using pulp/tooth area ratio in maxillary canines - A digital image analysis. J Forensic Dent Sci. 2014; 6(3):160–5.
22. Saxena S. Age estimation of Indian adults from orthopantomographs. Braz Oral Res. 2011; 25(3):225–9. PMid: 21503416. https://doi.org/10.1590/S1806-83242011005000009
23. Gustafson G. Age determination on teeth. J Am Dent Assoc. 1950; 41(1):45–54. PMid: 15428197. https://doi.org/10.14219/jada.archive.1950.0132
24. Kvaal SI, Kolltveit KM, Thomsen IO, Solheim T. Age estimation of adults from dental radiographs. Forensic Sci Int. 1995; 74(3):175–85. https://doi.org/10.1016/0379-0738(95)01760-G
25. Cameriere R, De Luca S, Alemán I, Ferrante L, Cingolani M. Age estimation by pulp/tooth ratio in lower premolars by orthopantomography. Forensic Sci Int. 2012; 214(1-3):105–12. PMid: 21821373. https://doi.org/10.1016/j.forsciint.2011.07.028
26. Jain S, Nagi R, Daga M, *et al*. Tooth Coronal Index and pulp/tooth ratio in dental age estimation on digital panoramic

radiographs - A comparative study. Forensic Sci Int. 2017; 277:115–21. PMid: 28645095. https://doi.org/10.1016/j.forsciint.2017.05.006

27. Agematsu H, Someda H, Hashimoto M, *et al*. Three-dimensional observation of decrease in pulp cavity volume using micro-CT: Age-related change. Bull Tokyo Dent Coll. 2010; 51(1):1–6. PMid: 20574128. https://doi.org/10.2209/tdcpublication.51.1
28. Jukic S, Prpic-Mehicic G, Talan-Hranilovc J, Miletic I, Segovic S, Anic I. Estrogen receptors in human pulp tissue. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2003; 95(3):340–4. PMid: 12627107. https://doi.org/10.1067/moe.2003.9
29. Yokose S, Zhungfeng C, Tajima Y, Fujieda K, Katayama I, Katayama T. The effects of estrogen deficiency on glycosylation of odontoblasts in rats. J Endod. 1998; 24(10):645–7. https://doi.org/10.1016/S0099-2399(98)80146-5
30. Hietala EL, Larmas M, Salo T. Localization of estrogen-receptor-related antigen in human odontoblasts. J Dent Res. 1998; 77(6):1384–7. PMid: 9649166. https://doi.org/10.1177/00220345980770060201
31. 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.e4126. PMid: 23664550. https://doi.org/10.1016/j.forsciint.2013.04.004

How to cite this article: Joparti, S., Kiran, M. J., Rao, G., Sivaranjani, Y., Thakur, M. and Pradeepthi, K. Digitilized Radiographic Analysis of Coronal Pulp for Age Estimation in Adults using Tooth Coronal Index Method – A Pilot Study. J Forensic Dent Sci 2021;13(1):38-43.

Access this article online	
Website: www.jfds.org	Quick Response Code