Pesquisa Brasileira em Odontopediatria e Clínica Integrada 2021; 21:e0215
https://doi.org/10.1590/pboci.2021.057
ISSN 1519-0501 / eISSN 1983-4632

ORIGINAL ARTICLE

Tooth Coronal Index: A Novel Tool For Age Estimation on Cone-Beam Computed Tomography

Bharati R. Doni [1], Santosh Rayagouda Patil[2], Ruchi Agrawal[3], Narges Ghazi[4], Kazuyuki Araki[5], Garima Dewangan[2], Mohammad Khursheed Alam[6]

[1]Department of Dentistry, Koppal Institute of Medical Sciences, Koppal, Karnataka, India.
[2]Department of Oral Medicine and Radiology, New Horizon Dental College and Research Institute, Chhattisgarh, India.
[3]Department of Public Health Dentistry, New Horizon Dental College and Research Institute, Chhattisgarh, India.
[4]Department of Oral and Maxillofacial Pathology, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran.
[5]Division of Radiology, Department of Oral Diagnostic Sciences, School of Dentistry, Showa University, Tokyo, Japan.
[6]Department of Orthodontics, College of Dentistry, Jouf University, Sakaka, Saudi Arabia.

Correspondence: Santosh R. Patil, Department of Oral Medicine and Radiology, New Horizon Dental College and Research Institute, Sakri, Bilaspur, Chhattisgarh, 495001, India. **E-mail:** drpsantosh@gmail.com

Academic Editor: Catarina Ribeiro Barros de Alencar

Received: 01 October 2020 / **Review:** 09 November 2020 / **Accepted:** 19 November 2020

How to cite: Doni BR, Patil SR, Agrawal R, Ghazi N, Araki K, Dewangan G, Alam MK. Tooth coronal index: a novel tool for age estimation on cone-beam computed tomography. Pesqui Bras Odontopediatria Clín Integr. 2021; 21:e0215. https://doi.org/10.1590/pboci.2021.057

ABSTRACT
Objective: To evaluate dental age assessment reliability through Tooth Coronal Index (TCI) method. **Material and Methods:** The cone-beam computed tomography (CBCT) scans of 160 individuals aged between 20-70 years were analyzed in the present study. The height of the crown, i.e., coronal height, and the height of the coronal pulp cavity, i.e., coronal pulp cavity height, of mandibular second premolars and first molars were calculated and then TCI was measured. The actual age of a subject was compared with TCI of tooth and the acquired data were subjected to Pearson's correlation and unpaired t-tests. **Results:** Negative correlation was observed between the real age and TCI of mandibular first molar ($r = -0.094$, $p=0.382$) and second premolar ($r = -0.176$, $p=0.0961$. Statistically significant difference was observed between actual age and TCI for mandibular second premolar and first molar ($p<0.001$). **Conclusion:** Tooth coronal index has the potential to estimate age of an individual on CBCT scans. It is simple, cost-effective than histological methods and can be applied to both living and unknown dead.

Keywords: Diagnostic Imaging; Cone-Beam Computed Tomography; Age Determination by Skeleton.

Introduction

Assessment of an individual's age in forensic odontology is a significant aspect of biological identification. In recent times, skeletal and dental age estimation has become progressively significant in legal cases for determining an individual's age. Age estimation of an individual is a somewhat difficult task, which needs an interdisciplinary methodology [1]. The selection of methods to be employed in age estimation depends on the materials available for examination, their condition, and the individual's age category [2]. Even though skeletal methods could be used to estimate the age of an individual, changes in bone maturation are regulated by various environmental factors. Tooth development shows minor changes than other developmental features and shows minimal discretion corresponding to chronological age [3]. Also, dental tissues are more impervious to various environmental stimuli and are minimally influenced by endocrinal disorders or nutritional deficiency state than other body tissues. In this manner, teeth form an exclusive and appropriate parameter for dental age assessment [4]. According to the age group to which the individual belongs, different methods of age estimation can be used. In this way, dental development could be used in age estimation of younger persons [2,5].

"Secondary dentin" is the calcified nontubular substance deposited by the pulp on the pulp chamber walls and root canal and continues throughout life. Continuous deposition of secondary dentin on the primary dentin's pulpal surface leads to narrowing the pulpal cavity with increasing age. The secondary dentin is deposited all over the pulpal cavity uniformly, i.e., in the molars, it is higher over the roof and floor,, leading to a decrease in height comparison to the width of the pulpal cavity [4].

In younger individuals, age estimation from teeth is uncomplicated and precise and is based primarily on stages of tooth formation and its eruption. In older population, numerous approaches have been proposed for age estimation from dental tissue and tooth morphology [6]. Most common and popular among these are radiologic and morphologic methods. Various morphologic methods include clinical, histological, and biochemical assessment. Radiographic approaches are simple and require a relatively less time and expertise than morphologic approaches [4].

Previous studies in the literature used cuspids, bicuspids using intraoral periapical and panoramic radiographs to assess dental age as these teeth have a well recognizable outline of pulp cavity chamber [4,7-11]. Studies using lower first molar for dental age estimation have also been reported in the literature [12-14] and limited data is available regarding studies performed on lower second molars for dental age estimation [12,15]. This study was carried out to evaluate reliability of dental age assessment through tooth coronal index (TCI) on cone-beam computed tomography (CBCT) images in mandibular second premolar and mandibular first molars.

Material and Methods

Participants

One hundred sixty CBCT scans were selected for the study from the archives of Radiology Department based on the inclusion and exclusion criteria. The CBCT scans of individuals aged between 20-70 years were assessed for the following criteria: 1) Should be of ideal quality (no artefacts); and 2) Should present ideal image and ideal morphology (no developmental anomalies) of mandibular second premolar and mandibular first molar.

The following exclusion criteria have been adopted: Scans with grossly carious teeth or with periapical pathologies, prosthesis, restorations, severely attrited, rotated or fractured teeth and teeth with any developmental anomalies and teeth with gross evidence of hypercementosis were excluded.

CBCT Measurements

All the CBCT scans were taken for various needs of the patients. The CBCT unit used in this study was Scanora 3D (Soredex, Tuusula, Finland) with 6 mA and 89 kVp and the evaluation of the scans were carried out by two maxillofacial radiologists with the dedicated software (NewTom 3G: NT, QR SRL; Scanora 3D: OnDemand®, Cypermed Inc., Irvine, CA, USA).

Measurement of TCI

On the saggital section of the scan, a straight line (cervical line) was traced from the cementoenamel junction, which is the division between anatomical crown and root. Coronal height (CH) was calculated vertically from the cervical line to the tip of the highest cusp (Figures 1 and 2) [16]. Coronal pulp cavity height (CPCH) was calculated vertically from the cervical line to the tip of the highest pulp horn (Figures 1 and 2) [17]. The measurements provided the TCI of each tooth, which was then calculated as follows: TCI = CPCH × 100/CH. The mean estimated age by TCI was correlated with the subject's real age.

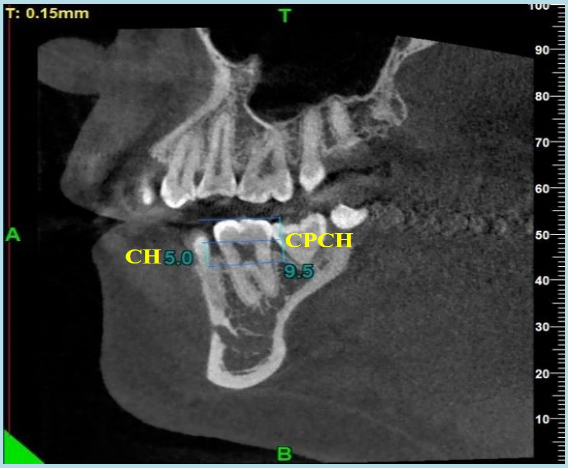

Figure 1. Saggital section of CBCT with measurements on left mandibular first 147x143 mm (150 x 150 DPI).

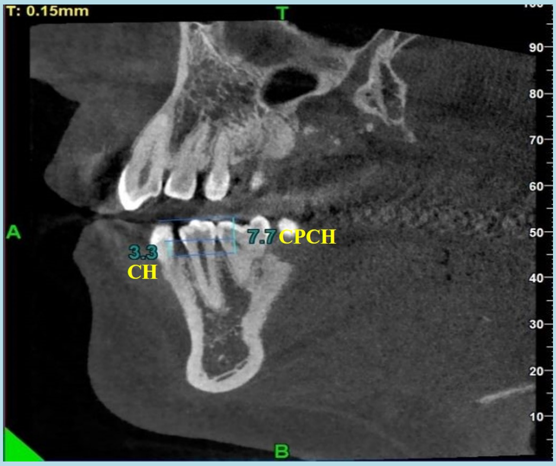

Figure 2. Pearson correlation test showing a correlation between actual age and TCI of mandibular second premolar 171x142 mm (150 x 150 DPI).

Statistical Analysis

Statistical analysis was carried out using Statistical Package for the Social Sciences, Version 21.0 (SPSS Inc., Chicago, IL, USA). Pearson's correlation coefficient was applied between the actual age and TCI of lower second premolar and first molar. Unpaired t-test was applied to compare the difference between the actual age and TCI for both lower first molar and second premolar. A p-value of ≤ 0.05 was considered statistically significant. Twenty percent of the CBCT scan were randomly selected and reevaluated after 14 days of interval. The intra-class correlation coefficient (ICC) was used to test the error.

Results

The average ICC value of all the variables was 0.931, which reveals excellent reliability of the measurements. CBCT images of 160 individuals were assessed, and by using TCI, a negative correlation was noted between the actual age and TCI of mandibular first molar (r = -0.094, p=0.0384) (Table 1) and second premolar (r = -0.176, p=0.091) (Table 2).

Table 1. Pearson correlation test showing a correlation between actual age and TCI of mandibular first molar.

Variables		Original Age	TCI Mandibular First Molar
Actual Age	Pearson Correlation	1	-0.094
	Sig. (two-tailed)		0.0382
	N	160	160
TCI Mandibular First Molar	Pearson Correlation	-0.094	1
	Sig. (two-tailed)	0.382	
	N	160	160

Table 2. Pearson correlation test showing a correlation between actual age and TCI of mandibular second premolar.

Variables		Original Age	TCI Mandibular First Molar
Actual Age	Pearson Correlation	1	-0.176
	Sig. (two-tailed)		0.091
	N	160	160
TCI Mandibular First Molar	Pearson Correlation	-0.176	1
	Sig. (two-tailed)	0.091	
	N	160	160

By applying unpaired t-test, a significant difference was noted between the mean actual age (36.5 ± 11.13 years) and TCI (35.3 ± 9.12 years) for mandibular first molar with a ($p<0.001$) (Table 3).

Table 3. Comparison between mean actual age and TCI of mandibular second premolar.

Variables	N	Mean (SD)	Std. Error Mean	t-value	p-value
Actual Age	160	36.5 ± 11.13	1.2615	31.562	0.001
TCI Mandibular First Molar	160	35.3 ± 9.12	0.9432	39.346	

Similarly, for mandibular second premolar, the difference between TCI (36.1 ± 8.54 years) and mean actual age (37.2 ± 9.38 years) was significant ($p<0.001$) (Table 4).

Table 4. Comparison between mean actual age and TCI of mandibular first molar.

Variables	N	Mean (SD)	Std. Error Mean	t-value	p-value
Actual Age	160	36.1 ± 8.54	0.9654	25.573	<0.001
TCI Mandibular Second Premolar	160	37.2 ± 9.38	0.8124	36.217	

Discussion

Age alludes to a time of human life, estimated by years, from birth, and is generally set apart by a specific mental or physical development phase and includes lawful responsibility and capacity. The human body grows and matures with age, particularly in youngsters and teenagers. In this way, the fundamental thought behind the different strategies for age assessment is to compare and contrast the measurements of physical development of the body with age. In any case, because of individual varieties in skeletal and dental maturity, the inference of any modality is subject to ambiguity when applied to a solitary person.

There are also issues concerning the available, accessible reference populations [18]. Be that as it may, there will always be biological deviations and ambiguity related to age estimation methods. The indelible research objectives are to evolve, corroborate, and expedite the utilization of the most precise techniques for age assessment.

Several studies have implied that the size of dental pulp reduces with advancing age because secondary dentin deposition, along these lines making secondary dentin deposition as the perfect modality to assess the age even past 25 years [4,12]. Previous studies used digital panoramic radiographs to assess age [4,11,12,14], but the panoramic images are subjected to magnification, unsharpness and distortion [14,19], so we used CBCT in the present study.

Paewinsky et al. [16] estimated the size of pulp chamber of six types of teeth on digital panoramic radiographs of subjects in the age group of 14-81 years and observed a significant correlation between reduced size of pulp chamber with age with r^2 higher for upper lateral incisors. Talabani et al. [14] calculated TCI of 96 lower first molars on digital panoramic radiographs and noted a strong negative correlation between TCI and age ($r^2 = 0.49$, $p<0.001$).

The use of secondary dentin as an age estimation was introduced by Ikeda et al. [20]. In the study by Koranne et al. [21], the correlation coefficient "r" was −0.865 (for premolar combined sample) and -0.850 (for molar combined sample). The observations of the present study were in accordance with previous studies in the literature, which suggested a negative correlation between actual age and TCI for both lower premolars and molars ($p<0.001$), thus confirming that the height of pulpal cavity reduces with increasing age [4,11,14,22-26]. Talabani et al. [14] noted a strong negative correlation ($r^2 = 0.49$) between age and TCI regarding the lower first molar. Analogous results were found in the studies by Igbigbi and Nyirenda [24] (r ranged from -0.650 to -0.799) for premolars and molars and Veera et al. [4] observed decreasing TCI values with increasing age.

In this study, lower premolars and molars are primarily considered to estimate TCI as a measure of pulpal cavity is precisely observed in these teeth, which was also justified in the previous studies [11,22]. We observed a highly negative correlation for lower second premolar (-0.176) than first molar ($r = -0.0094$), which suggests that lower second premolar can be used to estimate dental age more precisely. A statistically significant difference between actual age and TCI of lower second premolar and first molar assert TCI as a reliable indicator of age. This was similar to previous studies [11,14]. In the present study, a much lower correlation coefficient than studies on two-dimensional radiographs like periapical or panoramic radiographs, this discrepancy may be seen due to limited sample size, but the values are comparable with a similar CBCT study.

Conclusion

This study's observations confirm that TCI is a reliable marker of dental age. TCI in CBCT showed a negative correlation with age, i.e., when age increased, the TCI values decreased. Future studies on diverse populations among different races and in different geographical locations may be carried out, taking into account various environmental, dietary, genetic, and cultural factors.

Authors' Contributions

BRD	https://orcid.org/0000-0001-9721-1039	Conceptualization, Investigation and Data Curation.
SRP	https://orcid.org/0000-0003-0715-497X	Conceptualization, Methodology and Writing - Review and Editing.
RA	https://orcid.org/0000-0001-8024-3317	Writing - Original Draft and Writing - Review and Editing.
NG	https://orcid.org/0000-0002-7356-1509	Methodology, Formal Analysis and Writing - Review and Editing.
KA	https://orcid.org/0000-0003-3524-5123	Writing - Original Draft and Writing - Review and Editing.
GD	https://orcid.org/0000-0001-5837-592X	Writing - Original Draft and Writing - Review and Editing.
MKA	https://orcid.org/0000-0001-7131-1752	Conceptualization, Methodology and Writing - Review and Editing.

All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

Financial Support

None.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

References

[1] Santoro V, De Donno A, Marrone M, Campobasso CP, Introna F. Forensic age estimation of living individuals: a retrospective analysis. Forensic Sci Int 2009; 193(1-3):129.e1-4. https://doi.org/10.1016/j.forsciint.2009.09.014

[2] Schour I, Massler M. Development of human dentition. J Am Dent Assoc 1941; 20:379-427

[3] Demirijian A, Goldstein H. New systems for dental maturity based on seven and four teeth. Ann Hum Biol 1976; 3(5):411-21. https://doi.org/10.1080/03014467600001671

[4] 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(4):398-404. https://doi.org/10.4103/0972-1363.155684

[5] AlQahtani SJ, Hector MP, Liversidge HM. Brief communication: The London atlas of human tooth development and eruption. Am J Phys Anthropol 2010; 142(3):481-90. https://doi.org/10.1002/ajpa.21258

[6] Jain RK, Rai B. Age estimation from permanent molar's attrition of Haryana population. Indian J Forensic Odontol 2009; 2(2):59-61.

[7] 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. https://doi.org/10.4103/0975-1475.137047

[8] Saxena S. Age estimation of Indian adults from orthopantomographs. Braz Oral Res 2011; 25(3):225-9. https://doi.org/10.1590/s1806-83242011005000009

[9] Jeevan MB, Kale AD. Age estimation by pulp/tooth area ratio in canines: Cameriere's method assessed in an Indian sample using radiovisiography. Forensic Sci Int 2011; 204(1-3):209.e1-5. https://doi.org/10.1016/j.forsciint.2010.08.017

[10] Cameriere R, De Luca S, Aleman 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. https://doi.org/10.1016/j.forsciint.2011.07.028

[11] Nagi R, Jain S, Agrawal P, Prasad S, Tiwari S, Naidu GS. Tooth coronal index: Key for age estimation on digital panoramic radiographs. J Indian Acad Oral Med Radiol 2018; 30(1):64-7. https://doi.org/10.4103/jiaomr.jiaomr_139_17

[12] 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. https://doi.org/10.4103/0975-1475.186374

[13] Mathew DG, Rajesh S, Koshi E, Priya LE, Nair AS, Mohan A. Adult forensic age estimation using mandibular first molar radiographs: A novel technique. J Forensic Dent Sci 2013; 5(1):56-9. https://doi.org/10.4103/0975-1475.114552

[14] Talabani RM, Baban MT, Mahmood MA. Age estimation using lower permanent first molars on a panoramic radiograph: A digital image analysis. J For Dent Sci 2015; 7(2):158-62. https://doi.org/10.4103/0975-1475.154597

[15] Cameriere R, Ferrante L, Cingolani M. Precision and reliability of pulp/tooth area ratio (RA) of second molar as indicator of adult age. J Forensic Sci 2004; 49:1319-23. https://doi.org/10.4103/0975-1475.154597

[16] Paewinsky E, Pfeiffer H, Brinkmann B. Quantification of secondary dentine formation from orthopantomograms – a contribution to forensic age estimation methods in adults. Int J Legal Med 2005; 119(1):27-30. https://doi.org/10.1007/s00414-004-0492-x

[17] Jain S, Nagi R, Daga M, Shandilya A, Shukla A, Parakh A, 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. https://doi.org/10.1016/j.forsciint.2017.05.006

[18] Shrestha M. Comparative evaluation of two established age estimation techniques (two histological and radiological) by image analysis software using single tooth. J Forensic Res 2014; 5(4):3-6. https://doi.org/10.4172/2157-7145.1000237

[19] Devlin H, Yuan J. Object position and image magnification in dental panoramic radiography: a theoretical analysis. Dentomaxillofac Radiol 2013; 42(1):29951683. https://doi.org/10.1259/dmfr/29951683

[20] Ikeda N, Umetsu K, Kashimura S, Suzuki T, Oumi M. Estimation of age from teeth with their soft X-ray findings. Nihon Hoigaku Zasshi 1985; 39(3):244-50.

[21] Koranne VV, Mhapuskar AA, Marathe SP, Joshi SA, Saddiwal RS, Nisa SU. Age estimation in Indian adults by the coronal pulp cavity index. J Forensic Dent Sci 2017; 9(3):177. https://doi.org/10.4103/jfo.jfds_60_16

[22] 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.

[23] Zadzinska E, Drusini AG, Carrara N. The comparison between two age estimation methods based on human teeth. Anthropol Rev 2000; 63:95-101.
[24] Igbigbi PS, Nyirenda SK. Age estimation of Malawian adults from dental radiographs. West Afr J Med 2005; 24(4):329-33. https://doi.org/10.4314/wajm.v24i4.28227
[25] Gotmare SS, Shah T, Periera T, Waghmare MS, Shetty S, Sonawane S, et al. The coronal pulp cavity index: A forensic tool for age determination in adults. Dent Res J 2019; 16(3):160-5.
[26] Nagammai N, Saraswathi Gopal K, Srividhya S. Tooth coronal pulp index as a tool for age estimation: an institutional based retrospective cone beam computed tomography study. Indian J Forensic Odontol 2019; 12(2):35-43. https://doi.org/10.21088/ijfo.0974.505X.12219.1