International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

Check for updates

Utilizing the tooth coronal pulp index for age estimation: A retrospective cone beam computed tomography study

Saraswathi Gopal K and Sumithra A *

Department of Oral medicine and Radiology, Faculty of Dentistry, Meenakshi Ammal Dental college and hospital, MAHER University, Chennai-95, India.

International Journal of Science and Research Archive, 2024, 12(01), 688–697

Publication history: Received on 03 April 2024; revised on 12 May 2024; accepted on 15 May 2024

Article DOI: https://doi.org/10.30574/ijsra.2024.12.1.0850

Abstract

Background: Age estimation through teeth is one of the most reliable method as teeth are hardest part of body and could be preserved for long time without gross changes. Thus, age estimation from tooth coronal index using CBCT is based on reduction in size of dental pulp cavity with advancing age as a result of secondary dentin deposition.

Aim: To evaluate dental age assessment reliability through Tooth Coronal Index (TCI) method

Methodology: A retrospective study involving 60 CBCT images from age group of 20 to 60 years were retrieved from department data base. The age groups were divided into eight groups (Group I – VIII). Mandibular canine, 2nd premolar and 1st molar either of one side is considered. The height of crown and height of coronal pulp cavity were calculated and TCI was measured for each tooth. Age estimated was compared with chronological age to evaluate reliability of age assessment through TCI. Statistical analysis was done using SPSS version 19.

Results: Negative correlation was observed between real age and TCI of mandibular 1st molar, mandibular 2nd premolar and mandibular canine. Thus, best dental age estimation was obtained in age group of Group I and VIII.

Conclusion: Teeth are more resistant to thermal, chemical and mechanical stimuli and thus considered as one of the reliable indicators. Thus, Tooth coronal index can be considered as one of the reliable parameters in estimating age of individual because of its accuracy.

Keywords: Tooth coronal pulp index; Forensic Dentistry; CBCT; Age; CBCT

1. Introduction

The term Forensics means “forum or a place where legal matters are discussed [1]. Federation Dentaire Internationale (FDI) defined Forensic odontology as “that branch of dentistry, which deals with the proper handling and examination of dental evidence, with proper evaluation and presentation of dental findings to the court of law” [2]. Forensic odontology evolves around the two distinct areas, Identification and Bite marks [3]. The three important steps in forensics are Age estimation, Gender estimation and Personal identification.

Age is one of the essential factors, which plays a key vital principle in every aspect of life. The presence of particular teeth and position of various teeth aids in identification. Precise and thorough documentation holds paramount importance, as such data can be invaluable for making comparisons when identifying individuals [4]. These dental records are used in age assessment by evaluating various parameters such as attrition, periodontal attachment levels,

* Corresponding author: A. Sumithra

root resorption, secondary dentin and cementum apposition. Estimation of age of human remains can assist in person identification. Measurement of root transparency, which require sectioning of tooth, are some of the characteristic's features evaluated during forensic age estimation [5].

There are several methods available for estimating age, including Dental age, Skeletal age, and Mental age. Among these, Dental age is regarded as the most reliable because it is rarely influenced by systemic, nutritional, or endocrine factors [6]. Teeth consist of an outer layer called enamel and a layer of dentin beneath it, both of which are extremely durable tissues resistant to decay. Beneath these layers lies the innermost soft tissue core known as the pulp [7]. Primary dentin, secondary dentin and tertiary dentin are the three types of dentin. Secondary dentin develops after a tooth has fully erupted and begun functioning. It gradually forms throughout life, continuously deposited by the odontoblasts that line the pulp chamber. This process leads to a reduction in the size of the pulp cavity as individuals age, a clinical condition known as pulp recession. Bodecker 1925 identified the secondary dentin opposition as being related to chronological age [8]. Pulp size decreases with age due to dentin deposition. In 1985, Ikeda et al developed tooth coronal index (TCI) for age estimation by taking radiographs on extracted teeth. In 1993, Drusani [9] had studied age estimation by TCI by taking radiographs on living individuals. Where TCI is,

$$\text{Tooth Coronal Index(TCI)} = \frac{\text{Coronal pulp cavity height(CPCH)} \quad \text{x } 100}{\text{Crown height (CH)}}$$

Most of the studies done for age estimation using two dimensional radiographs such as Periapical radiograph, Orthopantomograph. This present study focuses age estimation using CBCT, a three dimensional imaging modality that provides better image accuracy without any geometric distortion.

Aim and objectives

- To assess the credibility of dental age assessment through Tooth Coronal Index(TCI) method
- To evaluate the dental age of the individuals using tooth coronal index(TCI)
- To assess the reliability and accuracy of age assessment using tooth coronal index(TCI)
- To compare the estimated dental age to the chronological age of the individual

2. Materials and method

Total of 60 CBCT images, acquired from the department database from the age ranges from 20 to 60 years. The ages were further grouped into Group I to VIII. Each group contains 7-8 images. All images were generated using PLANMECA PROMAX 3D MID PROFACE CBCT machine and were processed using Planmeca Romexis software.

2.1. Inclusion Criteria

CBCT images with morphology of selected teeth with complete root formation (mandibular canine, mandibular second premolar and mandibular first molar) were included.

2.2. Exclusion Criteria

CBCT images with caries teeth, restored teeth, prosthesis teeth, severely attrited teeth, fractured teeth, rotated teeth, mal aligned teeth, teeth with developmental anamolies were excluded

2.3. Step 1

Horizontal line connecting between cementoenamel junction of tooth which is considered to be the division between anatomical crown and root.

The traced horizontal line has been cross checked in coronal and axial view. In coronal view, the midsagittal plane splits the tooth into two equal halves. In axial view, the axial planes touches the outer tooth surface (Fig 1)

2.4. Step 2

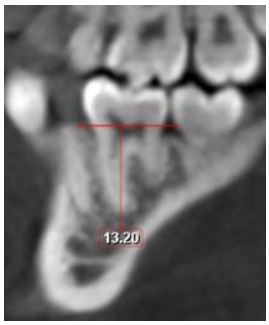
Crown height (CH) measured vertical line joining from horizontal line to the highest cusp of tooth (Fig 2a, 2b and 2c)

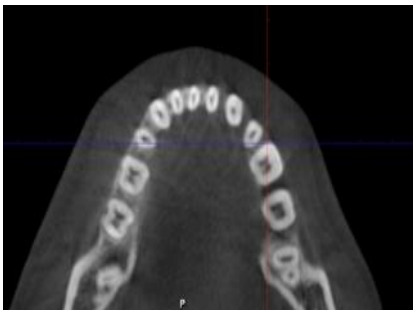
2.5. Step 3

Coronal pulp cavity height(CPCH) measured vertical line joining from horizontal line to the pulp horn (Fig 3a, 3b and 3c)

2.6. Step 4

$$\text{Tooth Coronal Index} = \frac{\text{Coronal pulp cavity height(CPCH)}}{\text{Coronal height(CH)}} \text{ x } 100$$





Sagittal	Coronal	Axial

Figure 1 Image Standardisation

Figure 2a Measurement of mandibular canine coronal height in sagittal view

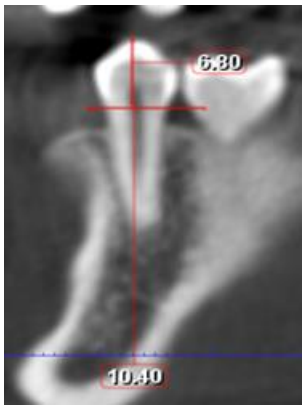


Figure 2b Measurement of mandibular 2nd premolar coronal height in sagittal view

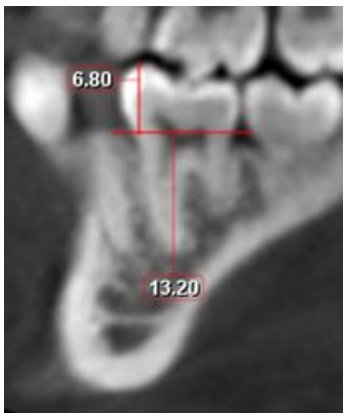


Figure 2c Measurement of mandibular1stmolar coronal height in sagittal view

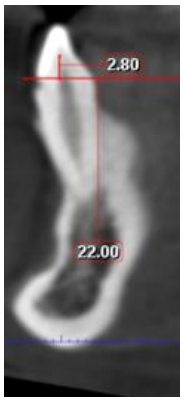


Figure 3a Measurement of mandibular canine pulpal height in sagittal view

Figure 3b Measurement of mandibular 2nd premolar pulpal height in sagittal view

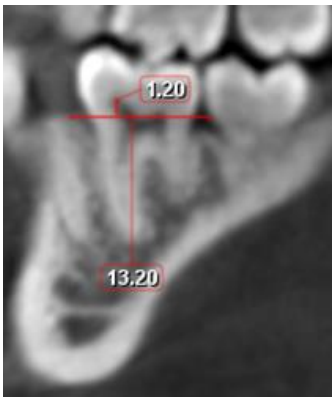


Figure 3c Measurement of mandibular 1st molar pulpal height in sagittal view

3. Results

The collected data were subjected for statistical analysis using IBM SPSS Statistics for Windows, Version 23.0.(Armonk, NY: IBM Corp). To describe about the data descriptive statistics frequency analysis, percentage analysis were used for categorical variables and the mean & Standard deviation were used for continuous variables. To find the significant difference between the bivariate samples in Independent groups (Gender) the Unpaired sample t-test was used. For the multivariate analysis (Age groups) the one way ANOVA with Tukey's Post-Hoc test was used. In all the above statistical tools the probability value(P) <0.05 is considered as significant level.

Table 1 and Table 2: Total of 60 images divided as 30 males and 30 females from the age ranging from 20 to 60 years. The ages were further divided into eight groups (Group I to VIII) each constituting 7 to 8 samples was done.

Table 3 and Figure 4: Descriptive analysis of mean value and standard deviation of the study subjects. The mean value of TCI of mandibular canine for males was calculated to be 30.05 ± 9.71, females 27.80 ± 8.77; the mean value of TCI of mandibular 2nd premolar for males was calculated to be 26.56 ± 6.93, females 24.68 ± 6.32 and the mean value of TCI of mandibular first molar was calculated to be 27.74 ± 7.79, females 26.07 ± 7.26.

Table 1 Frequency distribution of age groups

Age group	Frequency	Percent
20 - 25 years	8	12.5
26 - 30 years	8	12.5
31 - 35 years	8	12.5
36 - 40 years	8	12.5
41 - 45 years	8	12.5
46 - 50 years	8	12.5
51 - 55 years	8	12.5
56 - 60 years	8	12.5
Total	64	100.0

Table 2 Frequency distribution of age groups

		Gender		Total
		Male	Female	
Age groups	20 - 25 years	4	4	8
	26 - 30 years	4	4	8
	31 - 35 years	4	4	8
	36 - 40 years	4	4	8
	41 - 45 years	4	4	8
	46 - 50 years	4	4	8
	51 - 55 years	4	4	8
	56 - 60 years	4	4	8
Total		32	32	64

Table 3 Descriptive analysis of mean and standard deviation of the study subjects

SUBJECTS	GENDER	N = 60	MEAN ± SD
TCI of Mandibular canine	Male	30	30.05 ± 9.71
	Female	30	27.80 ± 8.77
TCI of Mandibular 2nd premolar	Male	30	26.56 ± 6.93
	Female	30	24.68 ± 6.32
TCI of Mandibular 1st molar	Male	30	27.74 ± 7.79
	Female	30	26.07 ± 7.26

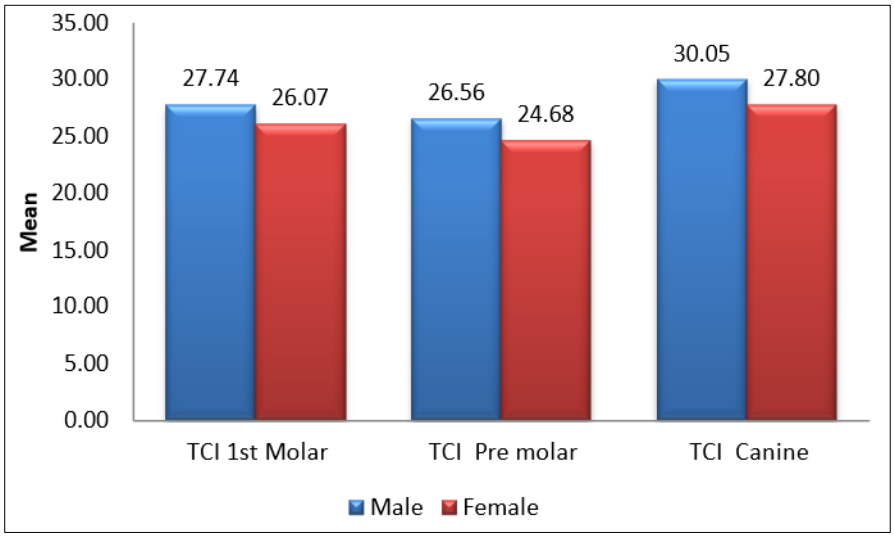


Figure 4 Mean distribution of TCI of mandibular canine, mandibular 2nd premolar and mandibular 1st molar

3.1. Descriptive analysis of mean value and standard deviation for individual age groups using one way ANOVA (Table 4)

In Group I (20-25 years) the mean of TCI of Canine is 42.29 ± 1.79, for 2nd Premolar is 34.20 ± 1.61 and for 1st Molar is 35.94 ± 1.62. In Group II (26-30 years) the mean of TCI of Canine is 39.05 ± 1.47, for 2nd Premolar is 32.56 ± 4.28 and for 1st Molar is 32.63 ± 1.78. In Group III (31-35 years) the mean of TCI of Canine is 36.81 ± 1.04, for 2nd Premolar is 29.38 ± 2.10 and for 1st Molar is 33.05 ± 3.51. In Group IV (36-40 years) the mean of TCI of Canine is 31.57 ± 1.64, for 2nd Premolar is 27.11 ± 2.35 and for 1st Molar is 29.64 ± 1.73. In Group V (41-45 years) the mean of TCI of Canine is 26.90 ± 1.62, for 2nd Premolar is 23.50 ± 1.42 and for 1st Molar is 25.02 ± 2.11. In Group VI (46-50 years) the mean of TCI of Canine is 23.88 ± 1.60, for 2nd Premolar is 25.37 ± 1.68 and for 1st Molar is 22.78 ± 1.72. In Group VII (51-55 years) the mean of TCI of Canine is 20.51 ± 1.16 and for 2nd Premolar is 22.36 ± 1.30 and for 1st Molar is 19.33 ± 2.97. In Group VIII (56-60 years) the mean of TCI of Canine is 14.62 ± 1.91, for 2nd Premolar is 13.07 ± 1.95 and for 1st Molar is 13.49 ± 0.81.

Table 4 Descriptive analysis of mean value and standard deviation for individual age groups using one way ANOVA

DESCRIPTIVES									
		N	**Mean**	**SD**	**Std. Error**	**95% Confidence Interval for Mean**		**Minimum**	**Maximum**
						Lower Bound	**Upper Bound**		
Mandibular 1st Molar	20 - 25 yrs	8	35.94	1.62	0.57	34.58	37.29	33.44	38.04
	26 - 30 yrs	8	32.63	1.78	0.63	31.14	34.12	30.21	35.06
	31 - 35 yrs	8	33.05	3.51	1.24	30.11	35.98	28.42	37.72
	36 - 40 yrs	8	29.64	1.73	0.61	28.20	31.09	27.09	31.84
	41 - 45 yrs	7	25.02	2.11	0.80	23.07	26.97	22.61	28.59
	46 - 50 yrs	7	22.78	1.72	0.65	21.19	24.38	20.81	25.75
	51 - 55 yrs	7	19.33	2.97	1.12	16.58	22.09	14.83	23.65
	56 - 60 yrs	7	13.49	0.81	0.31	12.74	14.24	12.54	14.93
Mandibular 2nd Premolar	20 - 25 yrs	7	34.20	1.61	0.61	32.72	35.69	31.45	35.89
	26 - 30 yrs	7	32.56	4.28	1.62	28.61	36.52	27.48	38.52
	31 - 35 yrs	7	29.38	2.10	0.79	27.44	31.32	26.09	31.83
	36 - 40 yrs	7	27.11	2.35	0.89	24.94	29.28	24.62	30.62
	41 - 45 yrs	8	23.50	1.42	0.50	22.31	24.68	21.05	25.71
	46 - 50 yrs	8	25.37	1.68	0.59	23.97	26.78	23.01	27.89
	51 - 55 yrs	8	22.36	1.30	0.46	21.27	23.45	20.54	24.03
	56 - 60 yrs	8	13.07	1.95	0.69	11.44	14.70	10.78	15.92
Mandibular Canine	20 - 25 yrs	7	42.29	1.79	0.68	40.63	43.95	40.12	44.92
	26 - 30 yrs	7	39.05	1.47	0.55	37.69	40.41	37.01	40.92
	31 - 35 yrs	7	36.81	2.04	0.77	34.93	38.70	34.57	39.99
	36 - 40 yrs	7	31.57	1.64	0.62	30.06	33.09	29.04	33.92
	41 - 45 yrs	8	26.90	1.62	0.57	25.54	28.25	24.66	29.06
	46 - 50 yrs	8	23.88	1.60	0.57	22.55	25.22	21.35	26.03
	51 - 55 yrs	8	20.51	1.16	0.41	19.53	21.48	18.93	22.04
	56 - 60 yrs	8	14.62	1.91	0.68	13.02	16.22	12.03	17.47

3.2. Comparison of TCI of Mandibular canine, 2nd Premolar and 1st Molar for age groups within the groups (Table 5)

On comparison with all the age groups TCI of Mandibular Canine, 2nd Premolar and 1st Molar showed highly significant value, i.e. $p < 0.001$.

Comparison of TCI of Mandibular Canine, 2nd Premolar and 1st Molar for age groups and among various groups were obtained.

Table 5 Within group comparison for all the age groups were done for TCI of Mandibular Canines, 2nd Premolars and 1st Molars

ANOVA						
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Mandibular 1st Molar	Between Groups	3081.407	7	440.201	91.827	0.0005
	Within Groups	249.278	52	4.794		
	Total	3330.685	59			
Mandibular 2ndPremolar	Between Groups	2349.371	7	335.624	67.857	0.0005
	Within Groups	257.194	52	4.946		
	Total	2606.566	59			
Mandibular Canine	Between Groups	4892.730	7	698.961	251.536	0.0005
	Within Groups	144.496	52	2.779		
	Total	5037.227	59			

p-value<0.05*Statistically highly significant, p-value,0.001***Statistically very highly significant

3.3. Correlations between different gender, Age, Groups, TCI of Mandibular Canine, Mandibular 2nd Premolar and Mandibular 1st Molar done using Pearson's correlation (Table 6)

TCI of Canine, 2nd Premolar and 1st Molar showed highly significant values, i.e. p<0.001. Thus all three values could be used for normal regression analysis.

Table 6 Correlations between different gender, Age, Groups, TCI of Mandibular Canine, Mandibular 2nd Premolar and Mandibular 1st Molar done using Pearson's correlation

	PEARSON CORRELATION			
			Pre molar	**Canine**
Combined	**First Molar**	r - value	0.890**	0.966**
		p - value	0.0005	0.0005
		N	56	56
	Pre molar	r - value		0.904**
		p - value		0.0005
		N		60
Male	**First Molar**	r - value	0.918**	0.970**
		p - value	0.0005	0.0005
		N	28	28
	Pre molar	r - value		0.909**
		p - value		0.0005
		N		30
Female	**First Molar**	r - value	0.852**	0.962**
		p - value	0.0005	0.0005
		N	28	28
	Pre molar	r - value		.895**
		p - value		0.0005
		N		30
**. Correlation is significant at the 0.01 level (2-tailed).				

3.4. Multivariate regression analysis is done for TCI of 1st Molar

The regression equation is formulated as follows:

Linear regression formula: Y= a-b(X), Y= Dependent variable , X= Independent variable, a= intercept, b= slope

Thus, when correlating with the values of multivariate regression analysis

Age estimation on test random sample using the regression formula (Table 7).

Table 7 Age estimation on test random sample using the regression formula

AGE GROUPS	CHRONOLOGICAL AGE IN YEARS	TCI OF 1st MOLAR	ESTIMATED AGE IN YEARS
Group I	22	38.04	21
Group II	26	35.06	26
Group III	34	29.39	34
Group IV	36	27.65	37
Group V	42	25.02	41
Group VI	46	22.78	44
Group VII	51	19.33	50
Group VIII	59	13.49	59

- Regression analysis for combined sample = 79.679-1.53x (X) (where X is the value of TCI of 1st Molar).
- Thus, the best estimation was obtained in age group of Group II, III, VIII, whereas in the other age Groups I,IV,V,V,VI,VII with the mean error of ±2years.
- Clearly states that no sex specific formula is needed for the population and no statistical significant difference between the teeth of 1st molar right and left.

4. Discussion

Forensic dentistry may be defined as that branch of forensic medicine that applies dental knowledge to civil and criminal problems. It encompasses the utilization of dental knowledge to process, assess, and present dental evidence, aiming to provide scientific and impartial information in legal proceedings. The process of gathering data has evolved greatly with the advent of advanced technologies. These methods encompass various techniques such as dental imaging, analysis of bite marks, DNA analysis using oral tissues, cheiloscopy, and rugoscopy. Additionally, more recent contributions to forensic odontology include facial reconstruction, denture identification, comparison microscopes, and the analysis of tongue prints [10].

Various studies have suggested that dental pulp size decreases with increasing in age due to secondary dentin deposition[11]. Numerous studies have explored age estimation using two-dimensional imaging methods like Digital Intraoral Periapical Radiographs (IOPA) and Panoramic radiographs. However, the information acquired from these 2D radiographs is insufficient for assessing the intricate details of tooth structure. This limitation has prompted the introduction of Cone Beam Computed Tomography (CBCT), a three-dimensional imaging [12].CBCT has its greatest advantage due to its spatial resolution[13,14]. The first study on the secondary dentin deposition for age estimation using historical methods was done by Gustafon[15]. Later in 1925 Brodecker identified secondary dentin is being related to chronological age[8].

Our study spotlight on estimating the age using tooth coronal pulp index in mandibular canine, mandibular 2nd premolar and mandibular molar using CBCT imaging. The main principle of the study is to analyze the deposition of secondary dentin at the pulpal floor which occurs as a normal physiological process as age advances.

Our study stated TCI decreases with increasing in age which was in accordance with the study done by Philipas and Applebarnum[16]in 1966 proved that secondary dentin deposition is more in floor of pulpal chamber than on the lateral

and occlusal walls and also with Ikeda et al[17] in 1985 who studied the secondary dentin deposition by analyzing premolars and molars in the radiographs.

Our study resulted that Correlations of males is higher than females and also the age estimated was very much accurate in the age Group II(26-30years) and Group VIII(56-60years) and with the mean error of ±2 years in the age Group I(20-25 years), Group III(31-35 years), Group IV(36-40 years), Group V(41-45 years), Group VI(46-50 years) and Group VII(51-55 years) which was in accordance with the study done by Drusini et al. in 1991 and 1993[18,9] considered panaromic radiograph of age ranged from 9-76 years in Caucasian individuals.

The current study states that there is no gender difference in TCI and thus no gender specific formula is needed. This is in accordance with the studies done in Egyptian population by El Morsi et al in 2015[19], Italian population by Drusini et al. in 1997[20], Drusini et al in 1993[9], Zadinska et al in 2000[21], in India by Shrestha in 2014[22], in Egypt by Khattab et al. in 2013[23].

On the other hand the results of Agematsu et al in Japan 2010[24], Igbibi and Nyirenda in Malawi 2005[25] were on contradiction with ours stating that gender has a significant influence on age estimation using TCI and hence there is need for gender specific formula in the sample population.

There was a negative correlation being observed, i.e., when TCI increases when age decreases which was in agreement with Dursini et al in 1997[20], Zadinska et al in 2000[21], Nyirenda et al in 2005[25]. But few studies El Moris et al in 2015[19], Shrestha et al in 2014[22].

5. Conclusion

From the present study, it can be concluded that mandibular canine, mandibular second premolar and mandibular first molar can be one of the reliable marker for age estimation in male, female, or combined sample of the Indian population. Regressive equations derived from TCI are applicable for age estimation in 20–60 years of age groups in Indian population. Thus, age estimation by TCI is precise, non-invasive, less time-consuming, and an inexpensive method that can be easily used in adult population of developing country like India. However, for the use of regression equation, there is a need for further studies founded on a larger sample size and use of other teeth.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Saferstein R, Hall AB, editors. Forensic science handbook. Upper Saddle River: Prentice Hall;2002

[2] Senn DR, Weems RA, editors. Manual of forensic odontology. CRC press; 2013 Jan 22

[3] Avon SL. Forensic odontology: the roles and responsibilities of the dentist. Journal-Canadian Dental Association. 2004 Jul;70(7):453-8

[4] Balachander N, Babu NA, Jimson S, Priyadharsini C, Masthan KMK. Evolution of forensic odontology: An overview. J Pharm Bioallied Sci. 2015;7(Suppl 1): S176-80.

[5] Charangowda BK. Dental records: An overview. J Forensic Dent Sci. 2010;2(1):5-10

[6] Lewis JM, Senn DR. Dental age estimation utilizing third molar development: A review of principles, methods, and population studies used in the United States. Forensic science international. 2010 Sep 10;201(1-3):79-83.

[7] Yang F, Jacobs R, Willems G. Dental age estimation through volume matching of teeth imaged by cone-beam CT. Forensic science international. 2006 May 15;159:S78-83.

[8] Bodecker CF. A consideration of some of the changes in the teeth from young to old age. Dental Cosmos. 1925 Jun;67(6):543-9.

[9] Drusini AG. Age estimation from teeth using soft X-ray findings. Anthropologischer Anzeiger. 1993 Mar 1:41-6.

[10] Prabhu Manickam Natarajan, Asok Mathew2 , Vijay Bhavrao Desai3 , Shibu Thomas4 , Eyas Abuhijleh5 , S. Srinivasan6. (2020). Forensic Odontology-A Review. *Indian Journal of Forensic Medicine & Toxicology*, *14*(4), 4143–4147.

[11] Vazquez L, Nizamaldin Y, Combescure C, Nedir R, Bischof M, Dohan Ehrenfest DM, Carrel JP, Belser UC. Accuracy of vertical height measurements on direct digital panoramic radiographs using posterior mandibular implants and metal balls as reference objects. Dentomaxillofacial Radiology. 2013 Feb;42(2):20110429.

[12] Venkatesh E, Elluru SV. Cone beam computed tomography: basics and applications in dentistry. Journal of istanbul University faculty of Dentistry. 2017;51(3 Suppl 1):S102.

[13] White SC, Pharoah MJ. White and Pharoah's Oral Radiology: Principles and Interpretation. Elsevier Health Sciences; 2018 Sep 12.

[14] Palomo L, Palomo JM. Cone beam CT for diagnosis and treatment planning in trauma cases. Dental Clinics. 2009 Oct 1;53(4):717-27.

[15] Gustafson G. Age determination from teeth. J Am Dent Assoc 1950;41:45-54.

[16] Philippas GG, Applebaum E. Age factor in secondary dentin formation. Journal of dental research. 1966 May;45(3):778-89.

[17] Ikeda N, Umetsu K, Kashimura S, et al. Estimation of Age from Teeth with their Soft X-Ray findings. JPN J for Med 1985;39:244-50.

[18] Drusini AG. Age-related changes in root transparency of teeth in males and females. Am. J. Hum. Biol 1991;3:629-37.

[19] El Morsi DA, Rezk HM, Aziza A, El-Sherbiny M. Tooth coronal pulp index as a tool for age estimation in Egyptian population. J Forensic Sci Criminol. 2015;3(2):201.

[20] Drusini AG, Toso O, Ranzato C. The coronal pulp cavity index: a biomarker for age determination in human adults. American Journal of Physical Anthropology: The Official Publication of the American Association of Physical Anthropologists. 1997 Jul;103(3):353-63.

[21] Zadinska E, Drusini AG, Carrara N. The Comparison Between Two Age Estimation Methods Based On Human Teeth. Przeglad Antropologiczny – Anthropological Review 2000;63:95-101.

[22] Shrestha J. Comparative Evaluation of Two Established Age Estimation Techniques (Two Histological and Radiological) by Image Analysis Software Using Single Tooth.Forensic Res 2014;5:1-6.

[23] Khattab NAF, Marzouk HM, Abdel Wahad TM. Application of Tooth Coronal Index For Age Estimation In Egyptian Population. Schoolary. Res;2013-15.

[24] Agematsu H, Someda H, Hashimoto M, Matsunaga S, Abe S, Kim HJ, Koyama T, Naito H, Ishida R, Ide Y. Three-dimensional observation of decrease in pulp cavity volume using micro-CT: age-related change. The Bulletin of Tokyo Dental College. 2010;51(1):1-6.

[25] Igbigbi PS, Nyirenda SK. Age estimation of Malawian adults from dental radiographs. West African journal of medicine. 2005;24(4):329-33.