The Relationship between Age and Pulp Cavity Size Using Cone-Beam Computed Tomography

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Abstract

Introduction This study aims to determine the relationship between chronological age and pulp cavity size and determine which type of tooth has a strong relationship between age and pulp cavity size.

Materials and Methods Cone-beam computed tomography images from 200 patients aged between 18 and 55 years were analyzed. The software program (version 2.21) exported the images in the DICOM format, and the MIMICS software program (version 10.01) was used to calculate. The relationship between chronological age and pulp cavity size and determination of which type of tooth strongly relates to age and pulp cavity size were evaluated by Pearson correlation coefficient and Linear regression model.

Results A total of 200 patients were included in the study. The minimum age recorded was 18 years, and the maximum period recorded was 55 years. The mean age was 35 years. The relationship between chronological age and pulp cavity size was statistically significant. Maxillary central incisor and mandibular first molar showed a strong relationship between chronological age and pulp cavity size.

Conclusions In this study, the pulp cavity size of both maxillary central incisor and mandibular first molar showed a statistically significant correlation with age. The correlation between right and left is strong. So, maxillary central incisor and mandibular first molar is a valuable index for human age estimation with reasonable precision and accuracy.

Keywords
- age estimation
- cone-beam computed tomography
- pulp cavity size
- secondary dentin
- radiation

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Introduction

Age estimation is an integral part of every identification process, especially in those conditions where the information related to the deceased is unavailable.[1] It is used in everyday casework such as missing people, suspected culprits, terrorists, refugees with disputed birth records, and in cases of casualties resulting from natural catastrophes such as Typhoon Nina.[2] Bermudez, Nicolas, and Townsend et al stated that tooth dimensions are influenced by different factors such as genes, nutrition, hormones, and climate. Hence, a new method using more straightforward and advanced tools must be developed for age estimation.[3]

Teeth, as compared with other parts of the body, are far less affected by external factors.[4,5] This makes teeth valuable indicators for the estimation of age.[1] Burke and Sammarawickrama stated that dental pulp responds to different aspects. These factors slowly and gradually, with age, cause the formation of secondary dentin and decrease the size of the pulp cavity.[6] Kvaal et al developed a standard method for age estimation by measuring pulp cavity size using two-dimensional (2D) radiographs[7]

A study by Ge et al mentioned that the first molar pulp chamber volume is a convenient indicator for the human age assessment.[8] A survey by Gulsahi et al notes that maxillary central incisors show the strongest association between chronological age and pulp volume and tooth volume ratio.[4] Teeth can be categorized into anterior, posterior, upper, and lower quadrants. Therefore, considering only one kind of tooth will always give us limited information.[9] Secondary dentin deposition can be evaluated using 2D radiographic methods because it is a noninvasive procedure for age estimation. The main disadvantage of these radiographs is that they do not show proper three-dimensional (3D) morphological changes in the pulp cavity and have restricted visualization of dental structures.[10]

Cone-beam computed tomography (CBCT) is a newly developed device that enables 3D visualization of the teeth. It is a straightforward method that provides accurate measurement of tooth size and reduces the working time compared with other techniques.[11] The primary aim of this study was to determine the relationship between age and pulp cavity size and to determine which type of tooth should be considered for age estimation. Data collected can be used for forensic purposes and in endodontic procedures.

Materials and Methods

Patients aged between 18 and 55 years visiting the Department of Radiology in our institution who were prescribed a CBCT examination as part of their routine examination and treatment regimen were enrolled in the study; thus, there was no unnecessary radiation exposure to the patients. The entire methodology of the study was explained to them, and their compliance to participate in the survey was ensured. They were assured of maintaining the confidentiality of their personal data. The date of birth of individuals was confirmed through a national identity card. All subjects were required to have fully developed maxillary central incisor and mandibular first molar. Due to the bilateral symmetry of tooth anatomy, right or left teeth were selected randomly. The subjects went through clinical and radiographic examinations.

All the images were taken with a Scanora. It consists of a cone-beam-shaped X-ray source with a rotation of 180 to 360 degrees and a flat panel image detector with a pixel size of 0.5mm and with field of view size of 75×100 that are attached to a revolving stand. The exposure condition consisted of pulsed exposure at 90 kV, variable current at 12.5 mA, and a total scan time of 4.9 seconds. When the X-ray source and detector start revolving around the individual, it produces numerous sequential images in a single rotation around the concerned area. The images were exported in the DICOM format using a software program (version 2.21), and the on-demand 3D software was used to carry out calculations. First, the image of each tooth was cropped in coronal and sagittal dimensions using the above-mentioned software program. All structures, including the cortical bone, lamina dura, and the adjacent tooth, were removed in the next stage except for the concerned tooth. Finally, the object was reconstructed, and measurements were performed in millimeters using the software program by one examiner.

Pearson correlation coefficient (r) was used to calculate the relationship between chronological age and pulp cavity size. The linear regression model (R2) was used in which the pulp cavity size was considered the independent variable, and chronological age was considered the dependent variable to determine the formula for chronological age estimation. All statistical analyses were performed using SPSS 22. Statistical significance was set at p-value less than 0.05.

Results

A total of 200 patients were included in the study. The mean (standard deviation) age was 35.3 (10.6) years. Among total samples, 106 (53%) were males, while 94 (47%) were females.

No significant difference was present between the right and left sides in both maxillary central incisor and mandibular first molar pulp cavity size of the tooth (►**Table 1**).

The relationship between chronological age and pulp cavity size was statistically significant. Maxillary central incisor and mandibular first molar showed a strong relationship between chronological age and pulp cavity size. A significant relationship between age and pulp cavity size of the tooth was observed (►**Table 2**).

Discussion

The results of this study showed that maxillary central incisor showed strongest relationship between pulp cavity size and age. The similar results were observed in the previous studies.[4,10,12] However, the method used for their study differ from the present one because they have considered measuring pulp cavity to tooth volume ratio for age estimation, while in this study changes taking place in the

Table 1 Agreement between right and left side in both maxillary central incisor and mandibular first molar pulp cavity size of the tooth

Symmetric measures						
Side			**Value**	**Asymp. std. error**	**Approx. T[b]**	**Approx. sig.**
Right central incisor	Interval by interval	Pearson's R	−1.000	0.000	−394.621	0.000[c]
	Ordinal by ordinal	Spearman correlation	−1.000	0.000	−312.330	0.000[c]
	No of valid cases	52				
Left central incisor	Interval by interval	Pearson's R	−1.000	0.000	−352.248	0.000[c]
	Ordinal by ordinal	Spearman correlation	−1.000	0.000	−291.040	0.000[c]
	No of calid cases	48				
Right molar	Interval by interval	Pearson's R	−1.000	0.000	−331.104	0.000[c]
	Ordinal by ordinal	Spearman correlation	−1.000	0.000	−288.534	0.000[c]
	No of valid cases	50				
Left molar	Interval by interval	Pearson's R	−1.000	0.000	−342.132	0.000[c]
	Ordinal by ordinal	Spearman correlation	−1.000	0.000	−288.534	0.000[c]
	No of valid cases	50				
Total	Interval by interval	Pearson's R	−0.216	0.066	−3.105	0.002[c]
	Ordinal by ordinal	Spearman correlation	−0.477	0.062	−7.629	0.000[c]
	No of valid cases	200				

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.
c. Based on normal approximation.

pulp cavity size due to secondary dentin deposition with age were determined using CBCT.[11]

The main purpose of choosing pulp cavity is because changes happening in the pulp cavity size is directly related to the age. On the other hand, the tooth volume can be increased or decreased by different factors. Pulp cavity size measurement is easy and more accurate as compared with measurement of whole tooth volume.[11]

In the forensic field, age estimation is vital for living and nonliving. It is an integral part of every identification process, especially in those conditions where the information related to the deceased is unavailable.[4] The number of methods for age determination is remarkably reduced in adults. In such a situation, the teeth can be used for age estimation because they are the hardest structures resistant to external factors.[11]

Table 2 Maxillary central incisor and mandibular first molar present a statistically significant relationship between age and pulp cavity size of the tooth

Symmetric measures						
Tooth side			**Value**	**Asymp. std. error**	**Approx. T[b]**	**Approx. sig.**
Incisor	Interval by interval	Pearson's R	−1.000	0.000	−446.626	0.000[c]
	Ordinal by ordinal	Spearman correlation	−1.000	0.000	−435.635	0.000[c]
	No of valid vases	100				
Molars	Interval by interval	Pearson's R	−1.000	0.000	−404.290	0.000[c]
	Ordinal by ordinal	Spearman correlation	−1.000	0.000	−435.635	0.000[c]
	No of valid cases	100				
Total	Interval by interval	Pearson's R	−0.216	0.066	−3.105	0.002[c]
	Ordinal by ordinal	Spearman correlation	−0.477	0.062	−7.629	0.000[c]
	No of valid cases	200				

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.
c. Based on normal approximation.

The deposition of secondary dentin is a slow, continuous process and is not affected by other external factors; when the individual age increases, the size of the pulp cavity decreases because of secondary dentin deposition.[4,12] The changes in the pulp cavity size with age because of secondary dentin deposition can be measured by dental radiographs and considered for age estimation.[8]

Panoramic and periapical radiographs describe changes in the pulp cavity size due to secondary dentin deposition with age. These radiographs are 2D and fail to provide an accurate measurement. They also do not represent the 3D image of the changes happening in the pulp cavity.[13] In this study, changes in the pulp cavity size with age were assessed using CBCT. It is a newly developed device that gives a 3D image of the structure and more accurate measurement than 2D radiographs.[14]

Numerous studies have considered measuring the pulp cavity-to-tooth volume ratio for age estimation. In contrast, in this study, changes in the pulp cavity size due to secondary dentin deposition with age were determined using CBCT.[15] The primary purpose of choosing a pulp cavity is because changes in the pulp cavity size are directly related to age. On the other hand, the tooth volume can be increased or decreased by different factors. Pulp cavity size measurement is easier and more accurate than a whole tooth volume measurement.[11]

Ge et al suggested that the first molar should be considered for age estimation. The results of this study are concurring with the above research findings which showed that the mandibular first molar shows a statistically significant relationship between age and pulp cavity size.[16] Also, our findings are similar to a previous study that revealed that the maxillary central incisor strongly correlates with pulp cavity size and age.[17] However, in this study, we estimated individual age by measuring pulp cavity size of maxillary central incisor and mandibular first molar using CBCT. Both of them showed a significant relationship with age.

This study has some noteworthy limitation such as conducted by one examiner, limited area, and small sample size.

Conclusions

- The relationship between age and pulp cavity size of maxillary central incisor and mandibular first molar is statistically significant as a result both can be used for age estimation.
- Relationship between right and left side was strong as a result one can choose either right or left maxillary central incisor and mandibular first molar for age estimation.

Further studies must be conducted by more than one examiner, advanced techniques must be used, and large sample size selection, multiple types of teeth from different population, and both genders must be involved to improve the accuracy of the study

Authors' Contributions

All named authors contributed to the conceptualization of study, data collection and analysis, and drafting and revision of the manuscript. They all take responsibility for all the contents and conclusions.

Compliance with Ethical Principles

The study was approved by the research ethical committee of Sardar Begum Dental College, Gandhara University Peshawar in its 19th meeting held on May 2, 2019. Informed consent (verbal/written) was obtained.

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Conflict of Interest

None declared.

References

1 Vaidya S, Ahuja N, Bajaj P, Kapoor C, Sabarwal R, Rajpal K. Objective measurement of shade color in age estimation. J Forensic Dent Sci 2015;7(03):171–174
2 Method R, Naik P, Naik S. Enamel shade: a bright future in age estimation. J Forensics Res 2015;6(05):1
3 Arora J, Talwar I, Sahni D, et al. Secondary dentine as a sole parameter for age estimation: comparison and reliability of qualitative and quantitative methods among North-Western adult Indians. Egypt J Forensic Sci 2016;6(02):170–178
4 Gulsahi A, Kulah CK, Bakirarar B, Gulen O, Kamburoglu K. Age estimation based on pulp/tooth volume ratio measured on cone-beam CT images. Dentomaxillofac Radiol 2018;47(01): 20170239
5 Cameriere R, Cunha E, Wasterlain SN, et al. Age estimation by pulp/tooth ratio in lateral and central incisors by peri-apical X-ray. J Forensic Leg Med 2013;20(05):530–536
6 Star H, Thevissen P, Jacobs R, Fieuws S, Solheim T, Willems G. Human dental age estimation by calculation of pulp-tooth volume ratios yielded on clinically acquired cone beam computed tomography images of monoradicular teeth. J Forensic Sci 2011;56 (Suppl 1):S77–S82
7 Mittal S, Nagendrareddy SG, Sharma ML, Agnihotri P, Chaudhary S, Dhillon M. Age estimation based on Kvaal's technique using digital panoramic radiographs. J Forensic Dent Sci 2016;8(02): 115
8 Ge ZP, Ma RH, Li G, Zhang JZ, Ma XC. Age estimation based on pulp chamber volume of first molars from cone-beam computed tomography images. Forensic Sci Int 2015;253:133. e1–133.e7
9 Ge ZP, Yang P, Li G, Zhang JZ, Ma XC. Age estimation based on pulp cavity/chamber volume of 13 types of tooth from cone beam computed tomography images. Int J Legal Med 2016;130(04): 1159–1167
10 Biuki N, Razi T, Faramarzi M. Relationship between pulp-tooth volume ratios and chronological age in different anterior teeth on CBCT. J Clin Exp Dent 2017;9(05):e688–e693
11 Pradella F, Baldinotti C. Age estimation based on a 3D CBCT study of the pulp cavity and hard tissues of the teeth for forensic purposes. J Forensic Odontostomatol 2016;5(04):54–57
12 Haghanifar S, Ghobadi F, Vahdani N, Bijani A. Age estimation by pulp/tooth area ratio in anterior teeth using cone-beam computed tomography: comparison of four teeth. J Appl Oral Sci 2019;27: e20180722
13 Rastogi M, Logani A, Shah N, Kumar A, Arora S. Age estimation of living Indian individuals based on aspartic acid racemization from tooth biopsy specimen. J Forensic Dent Sci 2017;9(02): 83–90

14 G U. The age of criminal responsibility. Austral Instit Criminol 2017;6(02):11–18
15 Panchbhai AS. Dental radiographic indicators, a key to age estimation. Dentomaxillofac Radiol 2011;40(04):199–212
16 Jananee DDR. Age changes of enamel, dentin, pulp and cementum. Int J Sci Res 2015;8(03):16–6
17 Sivapathasundharam B. Tumors of the Salivary Glands. Shafer's Textbook of Oral Pathology E-book; 2020;276

