European Annals of Dental Sciences
Official Publication of Ankara University, Faculty of Dentistry

EADS, 2022, 49 (1), 5–9

e-ISSN : 2757-6744
doi : 10.52037/eads.2022.0002

Article Received : October, 13 2021
Article Accepted : March, 26 2022

ORIGINAL RESEARCH ARTICLE

Pulp Dimensions As An Indicator of Age In Turkish Subpopulation

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Abstract

Purpose: Age prediction is an important factor in the legal process in forensic medicine. The present study aims to assess the impact of pulp height and width on dental age prediction.

Materials & Methods: This study consisted of 1000 patients (11-77 years, 500 females and males). The mandibular first molar was assessed on panoramic radiography. Two age estimation models were applied. Model 1 included measurements of pulp length and crown length whereas parameters of model 2 were crown width and pulp width. Patients were divided into 4 age groups: Group 1 (between 11 and 18 years), Group 2 (between 19 and 29 years), Group 3 (between 30 and 50 years), Group 4 (between 51 and 77 years). Radiographs were evaluated by two observers. Multiple linear regression models were performed to predict the chronological age for each indicator. Pearson correlation coefficient was used to assess the relationship between chronological age and predicted dental age.

Results: Coefficients of models 1 and 2 were 0.461 and 0.523, respectively. Pearson correlation analysis showed a negative relationship between chronological age and, pulp height and width ratio. The difference between sex was not statistically significant. Group 3 showed the highest accuracy, whereas Group 4 showed the lowest among age groups.

Conclusion: The parameters based on width and length provided similar reliability on dental age estimation. The age between 30 to 59 years showed the highest accuracy of the pulp width and the pulp height in dental age prediction.

Key words: age estimation; forensic odontology; pulp height; pulp width; secondary dentin

Introduction

Dental age estimation is a crucial factor for identification and criminal processes in forensic medicine. Dental and skeletal age estimation methods have been used to estimate chronological age.[1] The stages of tooth development and the maturation processes are controlled by genetic factors and less affected by environmental and hormonal factors compared to bone development. Since tooth development is minimally affected by mechanical and chemical factors, dental age estimation methods are very valuable in forensic medicine.[2] Thus, understanding the correlation between dental indicators and chronological age is essential for forensic odontology.

Various age estimation methods using different indicators have been described by the researchers.[1,3,4] The stages of dental development, the quantity of calcification, and eruption are examined for age determination in children. Researchers used different methods based on various tooth development stages observed on orthopantomography.[2,5,6] In adults, secondary dentin deposition is the most important determinant with the highest correlation for chronological age prediction.[7] Secondary dentin accumulated slowly on the walls of the pulp chamber and canal space and is directly associated with the aging process.[8] The accumulation of secondary dentin originates in the periphery of the pulp chamber. This process causes the pulp recession and is increased with the age of the individual. However, its accumulation pattern is asymmetric, and it is seen prominently on the roof and floor of the pulp chamber compared to the lateral walls of the pulp.[9] Cameriere et al.[10] and Kvaal et al.[6] used the pulp/tooth ratio based on secondary dentin deposition for chronological age determination and reported it was correlated with age.

Methods based on biochemical and histological examinations for dental age determination are invasive and require tooth extraction. However, radiographic methods are easy and non-destructive for chronological age prediction.[11] Orthopantomography have been recommended to estimate chronological age by the Forensic Anthropology Society of Europe and Study Group on Forensic Age Diagnostics and American Board of Forensic Odontology (ABFO).[12]

The aim of the present study was to evaluate the reliability of

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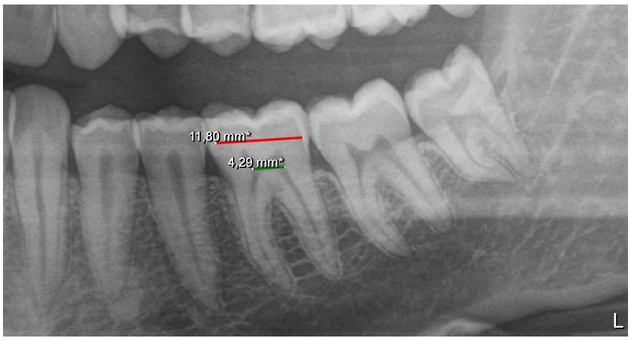

Figure 1. Mandibular first molar measurements on panoramic radiography. Crown width was measured from the midline of the crown without including enamel (red line). Pulp width was measured from the midline of the pulp chamber (green line).

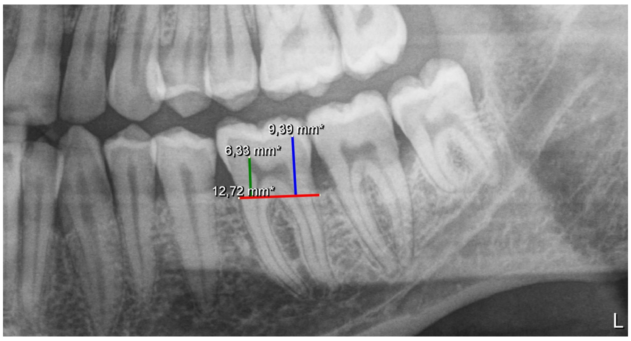

Figure 2. Mandibular first molar measurements on panoramic radiography. Crown height was measured from furcation line to the highest dentin point (green line). Pulp horn was measured from the furcation line (red line) to the tip of the pulp horn (blue line).

pulp width and pulp height for dental age estimation and the correlation between the age and the dimensions of the pulp chambers in the Turkish subpopulation. Our null hypothesis of the present study was formulated as the pulp height has a more precise correlation with age compared to the pulp width.

Materials and Methods

Study Sample

This retrospective study consisted of 1000 patients (11-77 years, 500 females, and 500 males) who were referred to the university clinic between January 2019 and May 2020. This study was approved by the ethics committee and designed in accordance with the Declaration of Helsinki. The mandibular first molars with complete root formation on panoramic images were selected for the study. Mandibular first molars with decayed, fillings, prosthetic or restorative treatment, endodontic treatment were excluded. Patients who had a metabolic bone disease such as osteogenesis imperfecta, rickets, dentinogenesis imperfecta were also excluded from our study. Panoramic radiographs of patients were obtained from Orthophos (Sirona Dental Systems, Bensheim, Germany). Images with metal artifacts in the interested region, blurred, distorted, or low-quality ones were removed. All samples were divided into 4 age groups; Group 1; patients between 11 and 18 years old (mean age 14.22), Group 2; patients between 19 and 29 years old (mean age 23.49), Group 3; patients between 30 and 50 years old (mean age 38.17), Group 4; patients between 51 and 77 years old (mean age 58.08). Descriptive data of the patients were recorded. Samples were evaluated by the oral maxillofacial radiologist (five years experienced) and the endodontist (five years experienced) who blinded the data of the patients to prevent bias. Observers re-evaluated measurements of all samples after 2 weeks to report inter-observer variability.

Radiographic Examination

The two age prediction models based on the length and width of the pulp were investigated in our study. The first model consisted of two indicators; pulp height (PH) was measured from the furcation line to the tip of the pulp horn and crown height (CH) was measured from the furcation line to the highest dentin point. The second model consisted of two indicators; pulp width (PW) was measured from the midline of the pulp chamber, crown width (CW) was measured from the midline of the crown without including enamel Figure 1-2.

Statistical analysis

Descriptive analysis of our data was recorded as range, quartiles, mean, standard deviation (SD) to summarize the study group. Pearson correlation coefficient was performed to assess the relationship between chronological age and estimated age. Multiple linear regression models were performed to predict the chronological age of each indicator. Intraclass correlation coefficient (ICC) and Durbin-Watson analysis were used to assess the reliability of indicators. Intraobserver and interobserver agreements were evaluated using ICC.

Results

Descriptive analysis of our data was summarized in Table 1. The difference between the genders was not statistically significant. For re-evaluated measurements, intra-observer and inter-observer agreement were found 0.881 and 0.801, respectively which showed high reliability of our database.

As shown in Table 2., the coefficient of determination of model 2 (R2=0.523) was stronger than model 1 (R2=0.461). ICC analysis showed that the parameters of model 2 were more predictive values for reliable outcomes. Prediction errors of Model 1 and 2 were 14.29 and 12.44, respectively. Group 2 (between 30-50 years) has the most accurate values among age subgroups for each model (Table 3.).

Age prediction outcome of model 1 was formulated;

The Estimated Age=39.82+(-0.165) x Gender(Male=1 and Female=0)+(-7.603)*PH+(3.942) x CH

The age estimation formula of model 2 was;

The Estimated Age=43.998+(0.258) x Gender(Male=1 and Female=0)+(-9.246) x PW+(2.325) xCW

Based on the Pearson correlation; the coefficients of PH/CH and PW/CW were -0.447 and -0.451, respectively. This result indicated a negative moderate relationship for the ratio of width and height. Figure 3 shows changes in height and width ratios of pulp/crown with age.

Discussion

Dental age estimation methods are used to determine chronological age in living individuals as well as deceased individuals. The age estimation of living individuals is important in cases of determining criminal responsibility, child labor, asylum seekers, refugees, rape, kidnapping, human trafficking.[13] Therefore, non-destructive methods based on dental radiographs for age determination are crucial. Our study evaluated the correlation between the dimensions of the pulp observed on panoramic radiography and chronologi-

Table 1. Descriptive Analysis For The Study Population. Difference between the Estimated Age (EA) and Chronological Age (CA)

	Gender	n	Mean	Median	Minimum	Maximum	SD	p
Model 1	Female	500	0,0028	-2,17	-31,48	35,8	12,8	
	Male	500	0,003	-2,48	-52,1	36,28	13,06	0,971
	Total	1000	0,0029	-2,32	-52,1	36,28	12,92	
Model 2	Female	500	0,0018	-2,53	-27,35	57,22	12,58	
	Male	500	0,0021	-2,75	-28,67	57,91	12,24	0,864
	Total	1000	0,002	-2,6	-28,67	57,91	12,41	

Table 2. Relationship Between Explanatory Variables And Response Variable And Reliability Analysis Of Observed Data

Model	Parameters	B	p	R	Durbin Watson	ICC
1	(Constant)	39.820	0.000	0.461	1.695	0.518
	gender	-.165	.841			
	pulp horn	-7.603	0.000			
	crown height	3.942	0.001			
2	(Constant)	43.998	.000	0.523	1.651	0.601
	gender	.258	.743			
	pulp width	-9.246	.000			
	crown width	2.325	.000			

Table 3. Accuracy Of Two Age Prediction Models For Each Age Subgroups

	Age Groups	n	Mean	Minimum	Maximum	ss
Model 1 PH CH	Group 1	127	-15,12	-50,53	15,88	9,99
	Group 2	322	-9,2	-48,8	14,62	10,17
	Group 3	387	1,3	-30,62	27,8	10,74
	Group 4	164	15,59	-6,35	41,54	11,12
	Total	1000	-1,82	-50,53	41,54	14,29
Model 2 PW CW	Group 1	127	-11,79	-32,17	19,21	7,72
	Group 2	322	-8,87	-25,95	19,82	6,09
	Group 3	387	0,28	-24,55	26,57	7,59
	Group 4	164	18,3	-3,4	58,01	10,1
	Total	1000	-1,24	-32,17	58,01	12,44

cal age. The changes in the pulp width and height with age were accepted as an indirect indicator of secondary dentin deposition. Since the dimensions of the pulp are dependent on the dimension of the crown, the correlation with chronological age was evaluated by the pulp/crown ratio. Our results showed that the pulp width and height have a similar correlation with chronological age. According to this result, the null hypothesis that the pulp width has a more precise correlation with age compared to the pulp height was rejected. Contrary to the result of this study, a previous study stated that the recession in the pulp height is greater compared to the pulp width due to secondary dentin formation.[14] This difference can be explained by racial or methodological factors.

In our study, crown height and width were measured without including enamel, which is supported by the previous studies.[15,16] The enamel is more affected by age-independent pathological processes like bruxism. Above all, when the enamel formation is completed, ameloblasts which are enamel-producing cells undergo apoptosis and the enamel thickness does not change except for pathological processes.[17] Moreover, in our study, pulp height was measured from the tip of the pulp horn. Since secondary dentin secretion starts in the peripheral pulp, age-related changes can be observed clearly in this region.[9] In our study, the "furcation line" that passed through the furcation was used to measure the height of the pulp instead of the cementoenamel junction. The furcation line was considered a preciser point that was less affected by radiographic errors like the burnout phenomenon.

The type of teeth is an effective factor in the correlation between the dimension of the pulp and chronological age. In a previous study that evaluate the correlations of the pulp widths of incisors, canines, and premolars, the lowest correlation was reported in premolars.[18] This may be related to the common anatomical variations in premolar teeth. In our study, mandibular first molars were investigated, and second molars were excluded due to the anatomical variations such as c-canals in mandibular second molars.[19]

The present study demonstrated that there's no significant difference in sex for both models. Similar to the results of our study, a previous study that assessed total tooth and pulp width at cementoenamel junction reported that the relationship between sex and the deposition of secondary dentin was not statistically significant.[18] A possible explanation of this result may be that a similar methodology. Enamel was not included in measurements in these studies. Enamel formation is regulated by the amelogenin gene that is used as a sex prediction biomarker due to mostly expressed on X chromosomes.[20] As enamel was not included in our study, no significant difference was found between genders.

In our study, Groups 2 and 3 have the most accurate values among age subgroups. We concluded that ages between 18-50 years are strongly correlated with ages according to the regression formulae in this study. A possible explanation of being low accuracy under the age of 18 can be related to the secondary dentin formation is beginning after the occlusion of the teeth.[9] Therefore, the deposition of secondary dentin is not adequate for reliable assessment. For this reason, we do not recommend using these models to determine the age of children for legal procedures. Group 4 (between 50 and 77 years) has the lowest accuracy in the age subgroups in our study. This can be explained by the fact that the deposition of tertiary dentin is higher than secondary dentin in old ages.[9] In our study, correlations of model 1 and model 2 were found to be 0.461 and 0.523, respectively. Several studies are investigating the correlation between chronological age and pulp height.[21,22] In the literature, the estimated error was ranged from ± 5 years to 11.45 years whereas the R coefficient was found to between 0.58 and

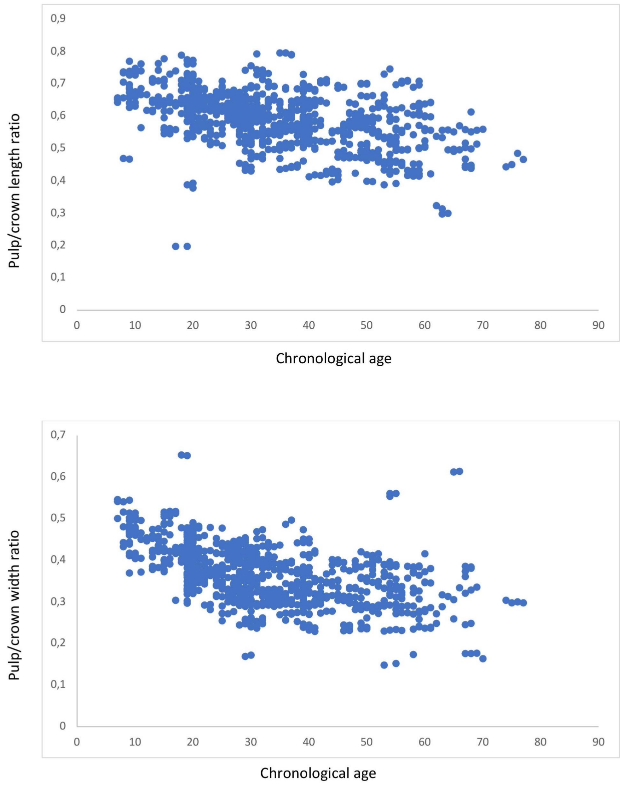

Figure 3. Relationship between chronological age and pulp/crown height ratio(left) and pulp/crown width ratio (right).

0.85.[21–23] In a previous study, the correlation coefficient between pulp height and chronological age was found to be R=0.61.[21] Likewise, in a study examining pulp and root height using CBCT, the standard error of estimated age was found to be 11.45 years, whereas R=0.58.[15] Results of this study were similar to our study. This can be explained by the fact that these studies have similar parameters of their methodologies. Besides, this outcome shows analysis based on panoramic radiography provides adequate consequences for age prediction.

Two-dimensional imaging techniques such as periapical radiography and panoramic radiography have been used for dental age determination.[7] Besides, three-dimensional data obtained from modalities including CT, CBCT, and micro-CT can be used by examining the volume of the pulp/tooth ratio.[22] In our study, the correlation of dental indicators with age was investigated on panoramic radiography, as it is easy to access and provides the image of all teeth.

The limitations of these indicators are that the pulp is more affected by the pathological processes. Dental treatments including fillings, root canal treatment, and crown prosthesis hamper the use of the dimensions of the pulp for dental age estimation.[18] Besides, tertiary dentin formation occurs due to pathological processes including caries, attrition, chronic trauma, or bruxism.[9] However, tertiary dentin cannot be distinguished from secondary dentin on dental radiographs. Therefore, tertiary dentin decreases the accuracy of dental age estimation methods based on secondary dentin deposition.

Maintaining pulp vitality leads to the continued formation of secondary dentin.[9] However, due to various reasons, the pulp tissue can be necrosis, and the secondary dentin formation does not continue. In a necrotic tooth scenario, when the noninfected sterile necrotic pulp (no bacterial load) exists in the root canal, no or mild reaction occurs on the periapical bone tissue.[24] It becomes impossible to find evidence of necrosis of the tooth by panoramic radiography. Therefore, the correlation of dental age estimation methods based on secondary dentin deposition with age is negatively affected by this scenario.

The limitation of this study is that the correlation of the dimension of pulp with age was examined only in the first mandibular molars. In a previous study, the highest prevalence of caries was demonstrated on mandibular and maxillary molars in the Turkish population.[25] Therefore, the use of mandibular molars in adults for dental age estimation can be compromised due to filling, root canal treatment, or other dental treatment presence.

Conclusion

Within the limitations of this study, the pulp width and the pulp height can be useful dental age indicators in adults. Group 3 (between 30 and 50 years) and Group 4 (between 51 and 77 years) showed the highest accuracy of the pulp width and the pulp height in dental age prediction. No statistically significant difference was found between sex.

Author Contributions

D.Y.: Conceptualization, Methodolgy, Investigation, Formal Analysis. S.O.: Conceptualization, Writing-Original Draft prepapation, Visualization

Conflict of Interest

The authors of the present study have not declared any conflict of interest.

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