Usability of First Molar Teeth Measurements for Age and Sex Estimation in Cone-Beam Computed Tomography Images[*]

Konik Işınlı Bilgisayarlı Tomografi Görüntülerinde Yaş ve Cinsiyet Tahmini için Birinci Molar Diş Ölçümlerinin Kullanılabilirliği

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ABSTRACT

Aim: The morphological changes in tooth structure due to aging gain importance in the adult period. These age-related changes can be used to determine age and sex. The aim of this study was to determine the usability of first molar tooth measurements obtained by cone beam computed tomography (CBCT) in estimating chronological age and sex in Turkish study group.

Materials and methods: Three-dimensional images of 332 patients older than 12 years of age with known chronological age and sex were evaluated by semi-automatic segmentation performed separately by two observers. Pulp volume and tooth volume were measured from maxillary or mandibular molar tooth in each patient. Simple linear regression analysis and discriminant function analysis were performed to estimate age and sex using the measurements. In addition, independent sample t-test was used to compare the measurements according to sex and tooth position.

Results: Sex was estimated by maxillary first molar volume ratio in 76.6% of women and 56.3% of men. Age estimation (AE) with pulp/tooth volume ratio (PTVR) gave more effective results in males and maxillary first molars.

Conclusions: In this study, it was found that maxillary first molar volume ratio gave more accurate results in males AE and in females' sex estimation (SE).

Keywords: Age determination by teeth, Cone beam computed tomography, Dental pulp volume, Molar teeth, Sex determination analysis

ÖZ

Amaç: Yaşlanmaya bağlı olarak diş yapısında meydana gelen morfolojik değişiklikler erişkin dönemde önem kazanmaktadır. Bu yaşa bağlı değişiklikler yaş ve cinsiyeti belirlemek için kullanılabilir. Konik ışınlı bilgisayarlı tomografi (KIBT) ile elde edilen birinci molar diş ölçümlerinin Türk çalışma grubunda kronolojik yaş ve cinsiyet tahmininde kullanılabilirliğini belirlemek bu çalışmanın amacıdır.

Gereç ve yöntem: Kronolojik yaşı ve cinsiyeti bilinen 12 yaşından büyük 332 hastanın KIBT görüntüleri iki gözlemci tarafından ayrı ayrı yapılan yarı otomatik bölümleme ile değerlendirildi. Her hastada maksiller veya mandibular molar dişten pulpa hacmi ve diş hacmi ölçüldü. Ölçümleri kullanarak yaş ve cinsiyeti tahmin etmek için basit doğrusal regresyon analizi ve diskriminant fonksiyon analizi yapıldı. Ayrıca cinsiyet ve diş pozisyonuna göre ölçümleri karşılaştırmak için bağımsız örneklem t testi kullanıldı.

Bulgular: Cinsiyet, kadınların %76.6'sında ve erkeklerin %56.3'ünde maksiller birinci molar hacim oranı ile tahmin edilmiştir. Pulpa/diş hacmi oranı (PDHO) ile yaş tahmini (YT), erkeklerde ve maksiller birinci molarlarda daha etkili sonuçlar vermiştir.

Sonuç: Bu çalışmada maksiller birinci molar dişlerin hacim oranının erkeklerde yaş tahmininde, kadınlarda cinsiyet tahmininde (CT) daha doğru sonuçlar verdiği bulundu.

Anahtar Kelimeler: Azı dişleri, Cinsiyet belirleme analizi, Diş pulpa hacmi, Dişlerle yaş tayini, Konik ışınlı bilgisayarlı tomografi

Introduction

Age estimation (AE) and sex estimation (SE) in forensic dentistry has an important place in both living and dead individuals. Teeth are the structures that are least affected by internal and external factors compared to all structures in the body.[1,2] Therefore, using radiomorphometric analysis of teeth has an important place in forensic medicine.[3-6] Dental AE in adults can be determined from age-related pulp chamber narrowing and occlusal surface abrasions.[1,7-12] It has been stated that tooth development is influenced by sex-linked genes and human permanent tooth structures are sexually dimorphic. For this reason, forensic experts have developed many different techniques to differentiate men from female. However, they mostly preferred canine teeth for SE.[13-15]

To date, panoramic, periapical and bitewing radiographs have been used to determine the age-related changes of teeth and bones and sex determination of societies over the course of history.[1,16] However, these methods cause magnification and distortion and may lead to bias since they are two-dimensional.[1,17,18] Therefore, simultaneous evaluation of mesiodistal and buccolingual dimensions of teeth has been proposed.[5] In recent studies, due to the frequent use of three-dimensional imaging in clinical dentistry applications, potential relationships between chronological age and pulp chamber volume or pulp/tooth volume ratio (PTVR) and radiological wear score (RWS) have been investigated.[1,17,19] The disadvantages of two-dimensional images have disappeared with the introduction of cone beam computed tomography (CBCT).[1,7,20,21] Furthermore, high resolution of CBCT images also allows clear observation of changes in root canal morphology.[1,7]

Since CBCT is also considered accepted as an assessment tool that is easy to apply and gives exact measurements, for the evaluation of PTVR and RWS, and there is no study in the literature focusing on radiomorphometric measurements of the crown and roots of molar teeth using these parameters. The high probability of the first molar teeth to be found in the oral cavity from an early age, and the lack of sufficient comprehensive research investigating the crowns and roots of these teeth prompted our study to conduct research on this topic. The fact that there are not enough studies for Turkish society in determining age and sex shows that there is still a need for alternative techniques. The primary aim of the presented study was to determine the relationship between chronological age and sex, PTVR and RWS in Turkish study group and to determine the ability of first molars to predict the age and sex of individuals with PTVR. In addition, it aimed to validate the regression equations derived on an independent Turkish study group. In this study, the null hypothesis was that there was no significant difference in the relationship between age, sex and PTVR for maxillary and mandibular first molar using CBCT data.

Materials and Methods

This retrospective study was approved by Mersin University Clinical Research Ethics Committee (Approval No. 2019\75) CBCT images of maxillary and mandibular first molar teeth of patients were previously obtained between November 2016 and December 2019 due to various indications of another tooth (implant planning or impacted tooth etc.), and were collected from the archives of Mersin University Faculty of Dentistry Department of Oral and Maxillofacial Radiology. Sample size of scans was calculated with the help of the G*Power test software. Assuming a small effect size of $d = 1.97$, with an alpha level of .05, a target power of 95% and two predictors expected in the final model, the required sample size was found to be 238 scans.

The general information, such as sex, confirmed date of birth and the processing date of CBCTs were collected for all the subjects and have only been used for statistical purposes. Also, the absence of the first molar was considered to be the result of early loss, most likely due to periodontitis or caries. The inclusion

criteria for study population selection were: CBCT scans having informations which were the date of examination completion, patient's date of birth, and sex, and belonging to patients aged 12-69; the presence of at least one healthy one first molar tooth (presence of one maxillary or mandibular first molar tooth) with fully developed root apexes and its crown erupted in the oral cavity, first molars without atypical anatomy, patients without abnormalities that may affect dental development (metabolic diseases, syndromic hereditary disorders and nonsyndromic hereditary disorders etc). CBCT scans containing periapical lesions, decay teeth, dilaceration/rotation in roots, root canal therapy, restorations, excessive tooth wear, orthodontic apparatus or prostheses, root canal pulp calcification, dental trauma/fracture, impacted tooth, some other severe type of malocclusion and periodontitis were excluded from the sample. In addition, low-quality CBCT scans with high artifact formation were also excluded. As a result, a total of 332 CBCT scans (patients) /332 first molar teeth of both sexes, aged 12 to 69 years, with at least one maxillary or mandibular first molar tooth were selected.

All images were taken with a Planmeca 3D Mid (Planmeca, Helsinki, Finland) device with a voxel size of 200 µm and using 85 kVp, 10 mAs and 14s scanning time. Field of view was 15 × 9 cm. Images saved in DICOM (Digital Imaging and Communications in Medicine) data file format was transferred to the three-dimensional semi-automatic segmentation software (ITK-SNAP 2.4) (http://itksnap.org) (Cognitica, Philadelphia, PA) and a three-dimensional image of the pulp volume and tooth volume was generated (*Figure 1*).
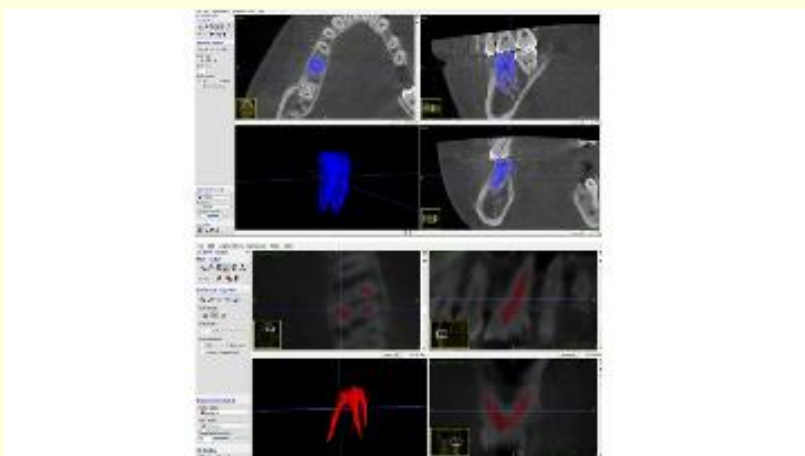

Fig 1. Demonstration of pulp and tooth volume measurements in ITK-SNAP 2.4 segmentation software

Each observer performed their assessments separately in a dimly lit room on a monitor (Dell Ultra Sharp U2711, Dell Computer Corporation, Texas, USA) optimized for radiological study. A specific calibration session by using 20 images/ teeth (maxillary or mandibular first molar) which were not included in the study sample was conducted. Image sets assesments were performed by eight (AO) and 10 (NK) years experienced two dentomaxillofacial radiologists with using their former knowledge of CBCT and experience of ITK-SNAP tools. No time restriction was placed on the observers.

The teeth were examined under two different conditions by evaluating the pulp volumes at 15-day intervals. While the intra-observer agreement was between 0.92 and 1.0, the inter-observer agreement ranged between 0.95 and 0.97. All image analyzes were able to perform due to high agreements.

Tooth and pulp volumes were determined in three steps with the software's semi-automatic segmentation mode. First step, the boundaries of any extension of the tooth to be examined were marked by inspectors in multi-plane reconstructions to define the region of interest (ROI) for segmentation. In the second step, the threshold range was selected with an interactive method according to previous studies. For this

interactive selection, the operator determines the best threshold range for each CBCT scan based on visual analysis of the anatomical limitation between the hard structures of the tooth and the dental pulp. The default density range (range 0 for the lower threshold and 1100 to 1300 for the upper threshold) was set so that the 3D model to be created would only have voxels with gray values in this range. In the third step, seeds-like geometry, (bubble-like formation) were added to the entire pulp extension constrained in multiplane reconstructions, so that the cavity corresponding to the dental pulp was filled according to the predetermined threshold range. Finally, the segmentation process was started gradually by choosing its speed and end. After this procedure, a 3D reconstruction image of the pulp cavity was obtained (***Figure 1***). The volumes of the segmented tooth structures were measured in cubic millimeters (mm³). The volume of the segmented region was saved in a Microsoft Excel worksheet. As a result, measurements of maxillary or mandibular first molar teeth of 332 patients were performed separately by two clinicians in this software.

Smith and Knight's classification index was used to determine the degree of tooth wear, in this study.[9] Smith and Knight explained the evaluation of tooth wear with an index based on the method of scoring zero-four according to the degree of wear in the buccal, lingual, occlusal, incisal and cervical regions of the teeth.[9] Teeth, whose all surface was examined according to the criteria specified in the index, were scored in the corresponding degree. As a result, pulp volume measurement, tooth volume measurement and radiological wear scoring, age and sex information of a first molar (maxillary or mandibular) tooth from each patient were included in the data sets. Three weeks after the completion of all analyzes, 30 randomly selected teeth from the main sample were reassessed for reproducibility.

Statistical analysis

AE was performed by obtaining PTVR measurements with simple linear regression analysis. In addition, independent sample t-test and Mann-Whitney U test were used to compare PTVR and RWS according to sex and tooth position when normality was available and unavailable, respectively. Discriminant function analysis was performed to determine the efficacy of PTVR in SE. Inter- and intra-observer variability were assessed by Intraclass Correlation Coefficient (ICC). *P* <0.05 was considered significant in all statistical tests.

Validation

Another sample group was selected for the validity of the developed formulas, applying the same predetermined inclusion and exclusion criteria. This sample consisted of 60 males and 60 females, a total of 120 teeth/CBCT scans. Equations developed by analysis of the main study group were tested with PTVRs obtained from this sample and age was estimated. The MAE is a useful measure widely used in model evaluations and it was used in the accuracy analysis of the derived equations.[22]

Results

Study group

Mean intra correlation coefficient values for observers first and second were found to be 0.931 and 0.885 for PTVR and RWSs, respectively. These results indicated that inter-rater reliability was very high and there was a perfect agreement between the measurements of the observers. Study sample consisted of 162 (48.80%) females and 170 (51.20%) males. 181 (54.52%) maxillary first molar and 151 (45.48%) mandibular first molar teeth were included in this study. The calculated PTVR of all teeth ranged from 0.06-0.16. The mean PTVR for the maxillary and mandibular first molar teeth was 0.093±0.0249 and 0.096±0.017 respectively, whereas the mean RWS was 1.174±0.867 and 1.354±0.886, respectively. When the effect of PTVR on age was examined according to sex, a negative correlation was found between males and females (***Table 1***).

Table 1. The effect of the PTVR on determining chronological age according to different tooth position and sex

	n	r	R^2	Regression equation	SE
Sex					
Female	162	-0.164	0.027	Age= 30.392 + (-77.198 X PTVR)	36.763
Male	170	-0.399	0.159	Age = 52.882 + (-228.948 X PTVR)	40.639
Tooth position					
Maxillary first molar	181	-0.270	0.073	Age = 42.159 + (-144.199 X PTVR)	38.452
Mandibular first molar	151	-0.134	0.018	Age = 31.535 + (-73.455 X PTVR)	44.340
Total	332	-0.241	0.058	Age = 39.194 + (-131.250 X PTVR)	29.131

SE: standart error; PTVR: pulp/tooth volume ratio; n: refers to sample size; R^2: coefficient of determination; r: correlation coefficient

PTVR decreased in males and females as age increased (***Figure 2***). In females, PTVR accounted for approximately 3% of AE, whereas in males, approximately 16% of age could be estimated by PTVR. AE with PTVR gave more effective results in males (***Figure 2***).
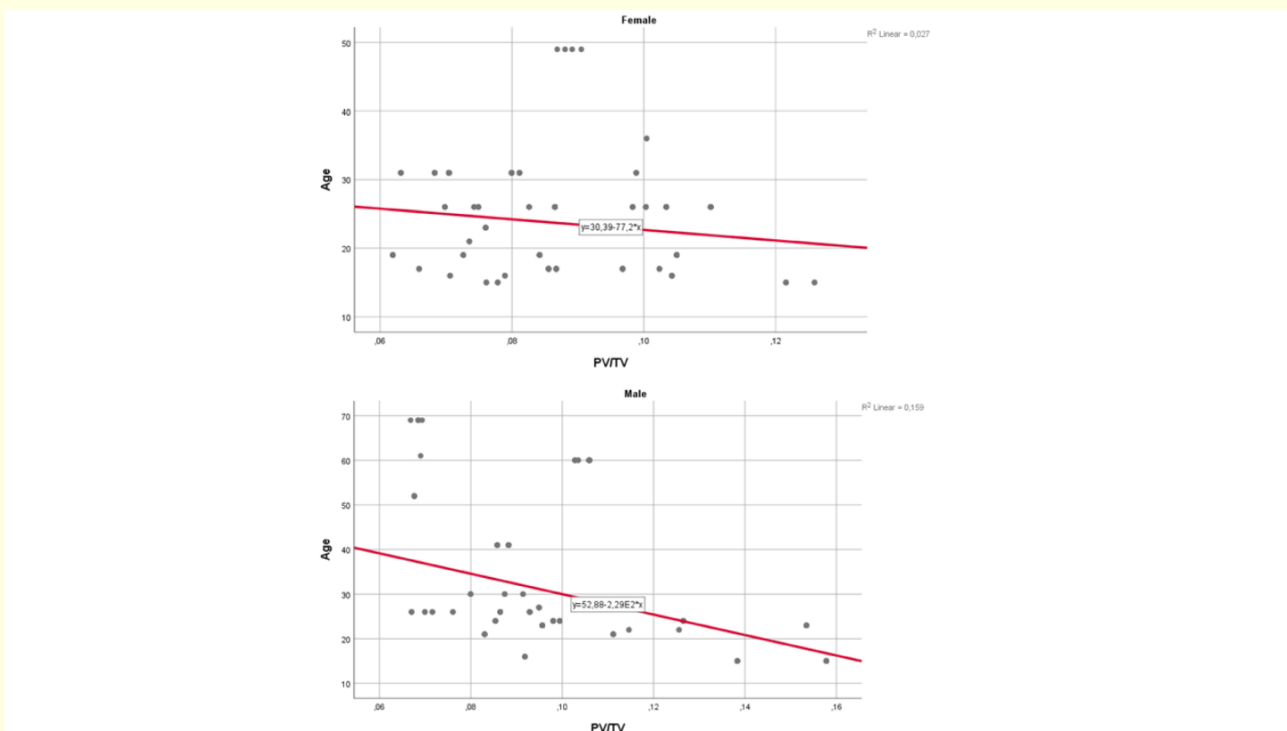
Fig 2. Relationship between PTVR and age according to sex

The effect of PTVR on age was negative in both tooth positions and PTVR decreased as age increased (***Figure 3***). PTVR of the maxillary first molar teeth of the patients accounted for approximately 7% of AE, whereas PTVR of the mandibular first molar teeth accounted for approximately 2% of AE. It was found that maxillary first molar teeth gave more effective results in AE with PTVR (***Figure 3***). In general, there was a negative correlation between PTVR and age, and PTVR decreased as age increased. PTVR of all individuals accounted for approximately 6% of AE (***Figure 4***).
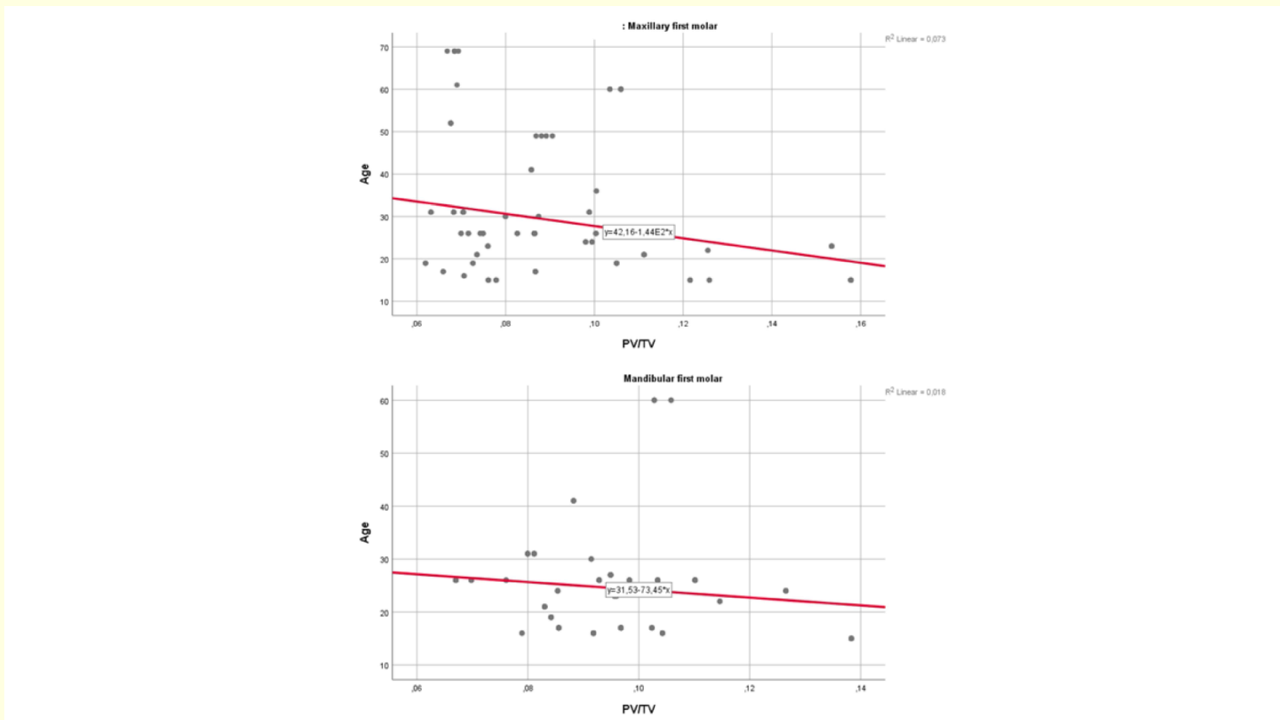
Fig 3. Relationship between PTVR and age according to tooth positions

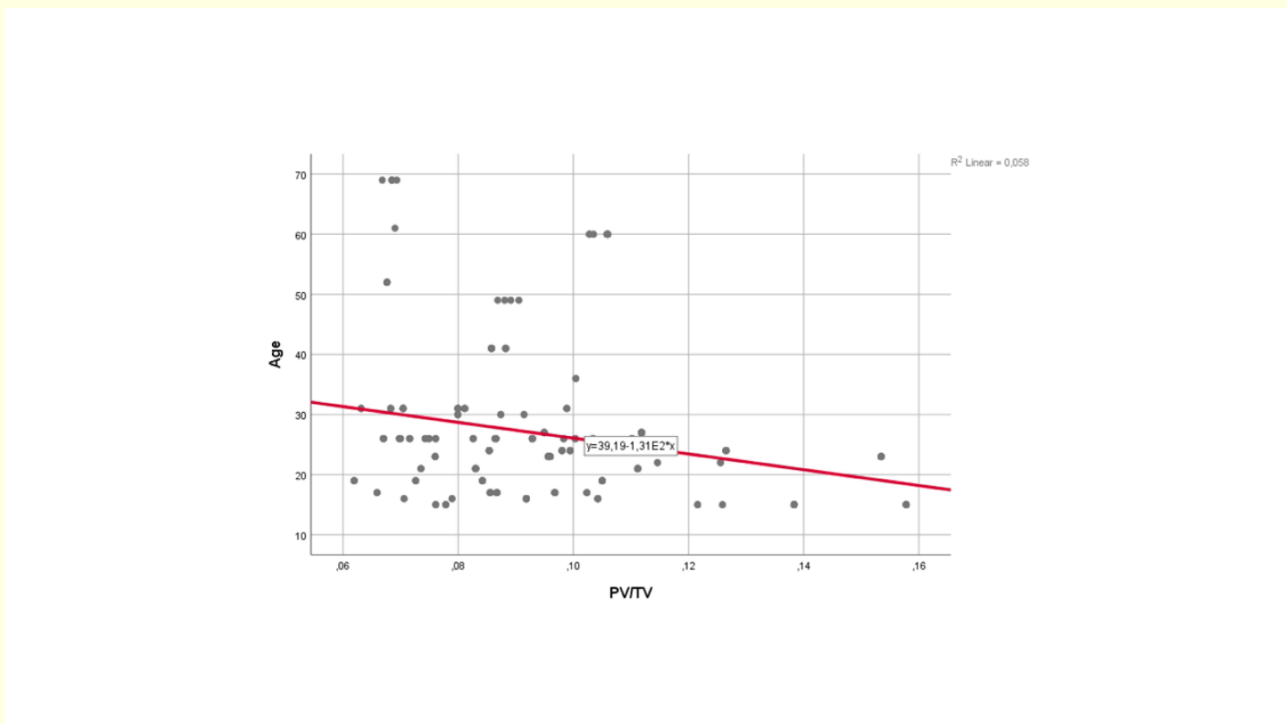**Fig 4.** Relationship between PTVR and age in all first molar teeth

When the correlation between age and PTVR and RWS were evaluated, it was observed that maxillary first molar teeth showed a stronger correlation than mandibular first molar teeth (***Table 2***). In addition, a significant, moderate, positive correlation was found between age and RWS for maxillary first molar teeth (***Table 2***).

Table 2. Correlation coefficients between age, PTVR, tooth position and RWS

	Tooth position			PTVR	RWS
Age	Maxillary first molar		r	-.270**	.585**
			p	<0.001	<0.001
			n	181	181
	Mandibular first molar		r	-0.134	.172*
			p	0.100	0.034
			n	151	151
	Total		r	-.241**	.396**
			p	<0.001	<0.001
			n	332	332

PTVR: pulp/tooth volume ratio; RWS: radiological wear score;   **p<0.001; n: refers to sample size; p-value: the level of significance; r: correlation coefficient

When the results of discriminant function analysis for sex determination were evaluated, the PTVR of maxillary first molar teeth accurately determined sex in 76.6% of females and 56.3% of males, and it was observed that this tooth position gave more accurate results compared to mandibular first molar tooth (***Table 3, 4***). When different tooth positions were compared with respect to sex in terms of PTVR and RWS, it was found that mean PTVR and RWS of men were significantly higher in maxillary first molar teeth (*P <* 0.001). It was found that sex gave more effective results for both PTVR and RWS in maxillary first molar tooth (Cohen d = 0.81-0.63) compared to mandibular first molar tooth (Cohen d = 0.51-0.30) (***Table 5***).

Table 3. Obtaining of discriminant function values according to different tooth position by using PTVR

	PTVR		
Discriminant function values	Maxillary first molar	Mandibular first molar	Total
Eigen values	1.71	0.023	0.097
% of variance	100	100	100
Cumulative	100	100	100
Canonical correlation	0.382	0.15	0.297
Wilks lambda	0.854	0.977	0.912
Chi-square	28.233	3.394	30.494
Significance	<0.001	0.065	<0.001

PTVR: pulp/tooth volume ratio

Table 4. Accuracy rates obtained by using discriminant analysis

			Accuracy rates		Total
Tooth position		Sex	Female	Male	
Maxillary first molar	%	Female	76.6	23.4	100.0
		Male	43.7	56.3	100.0
Mandibular first molar	%	Female	42.6	57.4	100.0
		Male	71.1	28.9	100.0
Total	%	Female	62.3	37.7	100.0
		Male	48.8	51.2	100.0

Table 5. Comparison of PTVR and RWS by sex at different tooth

Tooth position	Variable	Sex	N	Mean	Sd	p	Cohen's d
Maxillary first molar	PTVR	Female	94	0.08	0.02	p<0.001	0.81
		Male	87	0.10	0.03		
	RWS	Female	94	0.93	0.87	p<0.001	0.63
		Male	87	1.44	0.79		
Mandibular first molar	PTVR	Female	68	0.09	0.01	0.053	0.30
		Male	83	0.10	0.02		
	RWS	Female	68	1.11	0.83	0.002	0.51
		Male	83	1.55	0.89		
Total	PTVR	Female	162	0.09	0.01	p<0.001	0.63
		Male	170	0.10	0.03		
	RWS	Female	162	1.00	0.85	p<0.001	0.59
		Male	170	1.50	0.84		

PTVR: pulp/tooth volume ratio; RWS: radiological wear score; Cohen's d: effect size; Sd: standard deviation; Statistically significant difference using the independent sample t test (p < 0.05).

Validation group

Regression equations derived for mandibular molars and maxillary molars were applied on an independent validation group (n=120), which resulted in mean absolute error (MAE) values of 9.79 and 10.98 years respectively. Also, the MAE values were higher in females.

Discussion

In forensic medicine, AE is important not only for dead individuals but also for identification of living individuals. The number of AE methods applicable to living adults decreases drastically as skeletal and dental maturation is completed.[23] The decreases of the PTVR with secondary dentin formation after eruption has become an important AE parameter for adults. This parameter is evaluated via dental radiographs.[17,23] In the study by Cameriere et al., PTVR was shown to be an important indicator for AE.[4,23] In the study by Zhi-phu Ge et al., it was reported that pulp chamber volume of first molars was an important index for AE, and sex and tooth position played an important role in AE.[1] In addition, the use of sex and tooth position-specific AE equations was recommended when using pulp chamber volume of first molars for AE. Different than other studies, the aim of the present study was to evaluate the correlation between chronological age, sex and whole PTVR of first molar teeth by adding root canals to pulp volume.[1,4,23] In addition, our study is very different from similar studies in the literature because it is a multifaceted study that evaluates multiple parameters and the relationships between them for identification purposes AE and SE. In previous studies, AE was made on periapical and panoramic radiographs.[4,23] However, these images are two-dimensional and fail to provide volumetric information in dental structures. Compared to medical tomography, CBCT provides high quality images and low radiation dose. The use of CBCT images in AE provides an objective criterion for PTVR and pulp chamber measurements, and provides significant advantages over other methods as it can be applied to very different samples and does not require interventional procedures such as tooth extraction. With the use of CBCT, magnification and distortion errors in two-dimensional images are eliminated. With the increase of CBCT applications over the years, it has been stated that CBCT has become an important resource for anthropometric studies in revealing societal data.[24] In previous studies with CBCT, AE was made by PTVR of single rooted teeth, and pulp chamber volume measurements of multirooted teeth.[1,5,7,17] In this study, the relationship between

chronological age and PTVR and the RWS of first molars, which change according to age and individual variations, measured in different tooth positions and sexes.

First, observers concluded that measurements performed on sagittal sections were faster compared to other sections, similar to the literature.[25] In their study, Zhi phu ge et al. stated that pulp chamber volume could give more accurate results compared to whole pulp volume due to high image contrast between pulp and dentin.[1] Therefore, the present study measured pulp chamber volume by automatic segmentation and root canal volume was measured manually. In order to obtain whole pulp volume correctly, controlled segmentation of the images was performed in all three sections. In the present study, the strongest correlation between PTVR and age was found in maxillary first molar teeth and males. In addition, it was found that PTVR decreased with age, which was consistent with other studies.[1,7,17] In a study conducted by Someda et al., pulp volume was found to be significantly different between sexes in Japanese adults.[19] In another study most similar to the present study, Zhi-phu Ge et al. reported that both sex and different tooth positions created a significant difference in pulp chamber volume.[1] In our study, when tooth position was taken into consideration, it was found that mean PTVR and RWSs were significantly higher in males and maxillary first molar teeth ($P<0.001$). In mandibular first molar teeth, there was a significant difference in RWS in males but there was no significant difference in PTVR based on sex. When tooth positions were not taken into consideration, mean PTVR and RWSs were found to be significantly higher in males compared to females ($P<0.001$).

In the study conducted by Zhi-phu Ge et al., the R^2 value of the correlation between the first molar pulp chamber volume and age ranged between 0.544-0.684 depending on sex and different tooth position.[1] In our study, R^2 value of the correlation between PTVR and age ranged between 0.018-0.159 depending on sex and different tooth position. Higher values obtained by Zhi-phu Ge et al. compared to our study were attributed to the fact that the increase in secondary dentin accumulation around the pulp chamber with aging was a result of direct interaction between age and pulp chamber.[1] Furthermore, contrary to other studies, in our study, it was found that the correlation between PTVR and age was stronger in males than in females.[1,17,19,26] Based on our findings, our null hypothesis was rejected, as differences clearly existed in the association between chronological age, sex and PTVR for maxillary first molar and mandibular first molar.

In a recent study, it was concluded that there was an increasing tendency of tooth wear directly related with age.[27] For this reason, the relationship between tooth wear over time and chronological age, different tooth positions, and sex were evaluated comparatively in the present study. In a study evaluating the etiology and levels of tooth wear during clinical examination in 570 patients in India, an index similar to the present study was used.[28] The mean age of the patients was 39 and the mean wear score was 0.240.[28] The mean age of 332 patients was 26 and the mean wear score was found to be 0.094 in the present study. It is thought that the young age of our study group and the short exposure time to repetitive behaviors that cause loss of tooth structure in the oral cavity such as eating habits, brushing technique, bruxism, parafunctional habits and vomiting play an effective role on this numerical parameter. Although there are other studies evaluating the relationship between tooth wear and AE similar to our study, our findings should not be compared with other studies since different indexes were used in each.[10-12]

When the literature is reviewed without any sex discrimination, it is stated that morphometric analyses performed on the skeleton provide quick and accurate results. It has been reported that the accuracy rate is increased by 92% when the skull is present, 95% when the pelvis is present, and 98% when both are present.[29] Our study mainly deals with variability in PTVR measurements with respect to age and sex differences in terms of usability in age and SE. According to the results of the discriminant analysis performed for SE from PTVR measurements in molar teeth, maxillary first molar teeth had the highest

accuracy rates with 76.6% in women and 56.3% in men. There are studies in literature that use CBCT or Micro-CT imaging techniques and pulp volume and tooth volume of canine teeth to estimate age or sex because of higher survival rates and less abrasion in canine teeth.[2,30] Contrary to these studies however, our study preferred permanent maxillary and mandibular first molar teeth by evaluating wear in early age, and focused on their usability in age and SE. However, there are no studies in literature estimating sex based on PTVR measurements of molar teeth, therefore our findings cannot be compared with the literature. However, when we compare less than 80% accuracy of our results in SE to higher accuracy rates obtained from other skeletal areas, our findings are noteworthy. In other studies, focusing on the cranium, SE has been made by multiple parameters of the maxillary sinus, foramen magnum and mandibular bone and the accuracy rates obtained are consistent with our findings.[25,31-34] Based on the data obtained from our study, morphometric analysis of molar teeth with PTVR was considered to be an important parameter for sex determination. As in other skeletal areas, increasing the number of measured parameters in the dentomaxillofacial area may also increase the reliability. In our study, the data based on the PTVR of molar teeth provide important information for identification and it is thought that sex determination performed in 1 mm thin sections in CBCT analysis gives effective results on the accuracy of the data.

Age prediction regression models derived for each type of researched teeth were further validated on an independent group (n=120). The MAE value of mandibular molars (9.79) was less than maxillary molars (10.98). MAE values less than 10 years are considered acceptable in forensic adult dental AE.[35] MAE values for maxillary molars and mandibular molars in this study were comparable to the results of a study on first molars in the Chinese population.[1] MAE values for dental AE using PTVR on linear models of mandibular first molars (8.81) and maxillary canines (8.58) were also similar to the mandibular first molars (9.79) in the present study.[1,8] It was also noticed that MAE values in this study were comparatively higher in females, which was differently reported in other studies.[1,20]

There are limited studies investigating the effect of voxel size on AE. In our study, a 0.2 mm^3 voxel size CBCT device was used. However, Adısen et al. reported that voxel size did not have a significant effect on AE in their study.[36]

In future studies performed with the anticipated advances in CBCT technology, an optimized AE method can be developed with more homogeneous distribution of age groups and different modification techniques for measurements. Further investigations are needed to evaluate the differences between tooth positions, measurement techniques and populations in age and SE. In addition, the increase in studies comparing similar parameters by using different tooth types may provide important data to researchers. SE using CBCT scans of the maxillary first molar teeth in the Turkish female study group gave an accuracy of 76.6% and could be used as a complementary method. Since the molar teeth are less affected by external factors than the bone structure in mass deaths or other catastrophic scenarios and they are found in the mouth from the age of six, it is thought that morphometric examination of these teeth with CBCT for sex and AE can be used as a preferable analysis compared to traditional anthropometric methods. Furthermore, since the use of CBCT, DICOM and ITK-SNAP 2.4 program for the morphometric analysis of molar teeth does not require a diagnostic evaluation, it can be easily learned by forensic experts and forensic anthropologists, and its implementation will provide successful results.

Conclusion

In this study, it was found that maxillary first molar teeth volume ratio gave more accurate results in males AE and females SE. It was found that the maxillary first molar teeth RWS showed a higher correlation than PTVR for AE. Also, male's mandibular molars showed less MAE value in the validation group. Using the PTVR of first molars can be a useful index to estimate human age and sex with reasonable accuracy.

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Author contributions

Nazan Koçak-Topbaş: Conceptualization, Methodology, Software, Validation, Investigation, Formal analysis, Data Curation, Writing-Original Draft, Supervision, Project administration, Writing-Review & Editing.
Alime Okkesim: Conceptualization, Software, Data Curation, Validation, Formal analysis, Investigation, Writing - Original Draft, Writing-Review & Editing.

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