Clinical and Experimental Health Sciences

Investigation of the Relationship Between the Pulp Area and Chronological Age in Patients that Received and Not Received Orthodontic Treatment

Zeliha Ugur Aydin [1], Tulin Dogan [1], Duygu Goller Bulut [2], Yasemin Nur Korkmaz [3]

[1] Bolu Abant Izzet Baysal University, Faculty of Dentistry, Department of Endodontics, Bolu, Turkey.
[2] Bolu Abant Izzet Baysal University, Faculty of Dentistry, Department of Oral Diagnosis and Radiology, Bolu, Turkey.
[3] Bolu Abant Izzet Baysal University, Faculty of Dentistry, Department of Orthodontics, Bolu, Turkey.

Correspondence Author: Tulin Dogan
E-mail: dt.tulin153@gmail.com
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ABSTRACT

Objective: In this study, it was aimed to evaluate the relationship between chronological ages and pulp areas of mandibular canine teeth of patients that received and not received orthodontic treatment.

Methods: 102 patients that completed fixed orthodontic treatment and between the ages of 13-24, and 102 age and sex-matched control group subjects were included in the study. A total of 204 dental panoramic radiographs taken with the same procedures and with the same device (Soredex; Cranex Novus, Tuusula, Finland) were evaluated in this study. The pulp areas of the mandibular canine teeth were measured using the Image J software (US National Institutes of Health, Bethesda, MD). Data were analyzed statistically.

Results: In both the orthodontic group (r = -0,511) and the control group (r = -0,592), there was a negative correlation between chronological age and pulp area. There was no significant difference between the groups in terms of the pulp area and gender (p >0.05).

Conclusion: Orthodontic treatment did not result in a significant difference in the correlation between the pulp area and the chronological age.

Keywords: Age estimation, orthodontic treatment, pulp area.

1. INTRODUCTION

Age determination is a frequently applied procedure in forensic and archaeological sciences due to criminal liability, marriage law, illegal migration and mass disasters (1,2). Many tissues are used for age determination (3). Skeletal structures and teeth are the most commonly used tissues for age determination in both dead and living individuals (4,5). The teeth are more preferred biomarkers in age determination than skeletal structures in both dead and living individuals, as teeth are resistant to thermal, chemical and mechanical factors and therefore can protect their existence after death (6,7).

In the literature, it has been reported that parameters of the teeth such as translucency, root resorption, secondary dentin accumulation, dentin rings, cement apposition, retzius lines, and amino acid reamination can be used in age determination (1,2,6,8-10). Using these parameters of dental structures, it has been reported that the age determination is accurately calculated in many methods such as Gustafson's parameters, Johanson's classification, methods based on dental nuclear tests and Demirjian technique (11-13). Secondary dentin accumulation, which is one of these parameters, is a progressive process with age and, is therefore, a dental structure that is frequently used in determining age (8,14). After teeth eruption, the mean increase rates of secondary dentin accumulation around the pulp cavity were reported as 6.5 mm/year for the crown and 10 mm/year for the root. Based on this information, Kvaal et al. (15) revealed a method associated with secondary dentin accumulation and age determination on radiography in 1995. Afterward, Cameriere et al. (10,14) reported a high correlation between the pulp area and the chronological age in determination of age using the pulp area.

Radiographs of dental structures are widely used due to their advantages such as the fact that they do not require an invasive procedure and can be used in both living and dead individuals for age estimation (6). Micro-computed tomography (Micro-CT) allows for the 3-dimensional quantitative analysis of dental structures, but it is an unsuitable method for the prediction of age in living individuals. Cone Beam Computed Tomography (CBCT) is used frequently in age estimation methods and allows the 3D (dimensional) evaluation of dental structures without superposition and distortion (1,5,16-22). However, periapical and panoramic radiography techniques that give a 2D image provide more limited imaging compared

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to CBCT, but it allows the living individuals to be exposed to less ionized radiation (1).

It has been reported that secondary dentin accumulation has increased in patients that received orthodontic treatment (23). Therefore, it can be thought that the correlation between secondary dentine accumulation and chronological age in these treated patients can be affected. In other words, in patients that received orthodontic treatment, age determination based on secondary dentine accumulation may lead to incorrect evaluations.

In our comprehensive literature review, it was found that limited study investigating the relationship between pulp area and chronological age in patients that received orthodontic treatment exists. Therefore, in this study, it was aimed to evaluate the relationship between pulp area and chronological age using panoramic radiographs in patients that received and not received orthodontic treatment.

2. METHODS

A total of 204 panoramic radiographs obtained using the same panoramic X-ray device (Soredex, CranexNovus, Tuusula, Finland, 70kVp, 10 mA, 8-sec exposure parameters) of 102 patients that received fixed orthodontic treatment (mean±standard deviation [SD] age: 17±0.7 years, 45 females, 57 males) and 102 patients that not received orthodontic treatment (mean±SD age: 21±0.3 years, 59 female, 43 male) were included in the study. For the current study, the patients that received orthodontic treatment were treated with only fixed orthodontic brackets and bands and never used any other fixed or removable orthodontic appliance. The mean ±SD duration of treatment for the orthodontic treatment group was 22.5±1.8 months. Radiographs with poor image quality and magnification and distortion in the mandibular canine teeth were excluded from the study. After obtaining the radiographs, the images were recorded in equal dimensions in high-resolution JPEG format (Joint Photographic Experts Group). Subsequently, the images were converted to the image file format (TIFF) and were transferred to Image J version1.3 (National Institutes of Health, Bethesda, MD, USA). The area of the mandibular canine teeth was measured on the radiographs obtained using Image J software (Fig. 1). All measurements were performed by a maxillofacial radiologist with 5 years of experience. To test intra-observational reliability, 40 images were reanalyzed after 10 days the measurements were completed (correlation coefficient= 0.89). Correlation between chronological age and pulp area measurements was analyzed.

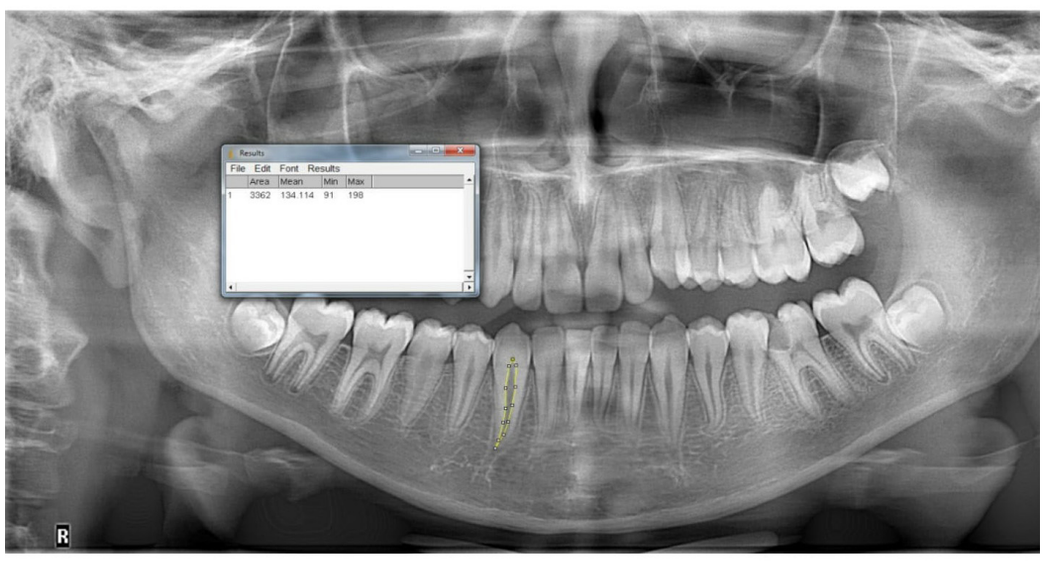

Figure 1. *Measurements of Pulp Area on the Radiograph*

2.1. Statistical Analysis

The independent t-test was used to assess the difference between the pulp area of males and females. The relationship between age and pulp area was analyzed using Pearson's rank correlation test. The coefficient of estimation (R^2) from the analyses was calculated to evaluate the relationship between age and pulp area of mandibular canines. All analyses were performed using SPSS version 21.0 (IBM Statistical Package for the Social Sciences Statistics; New York, ABD). The level of significance was set at $p < 0.05$.

3. RESULTS

There was no significant difference according to gender in the pulp area ($p > 0.05$) (Table 1). In both the orthodontic treatment group (y=21.28+-2.12E-3*x($R^{2=}$ -0.511, p= 0.000); Fig. 2) and the control group (y=22.99+-2.51E-3*x(R^2= -0.592, p= 0.000); Fig. 3), there was a negative correlation between the pulp area and the chronological age. No significant difference was found in the age estimation with pulp area among the individuals who received and who did not receive orthodontic treatment ($p > 0.05$) (Table 2).

Table 1. *Comparison of the Pulp Area (mm²) of Male and Female Subjects between Groups (mean ± SD / SE)*

	Male	Female	t value	P value
Orthodontic group	1743.79± 836.12/ 155.26	1754.90± 494.27/ 105.37	-0.05	0.956
Control group	1887.46±597.49/ 163.21	2385.72±638.99/ 184.35	-2.83	0.928

SD: standard deviation; SE: standard error

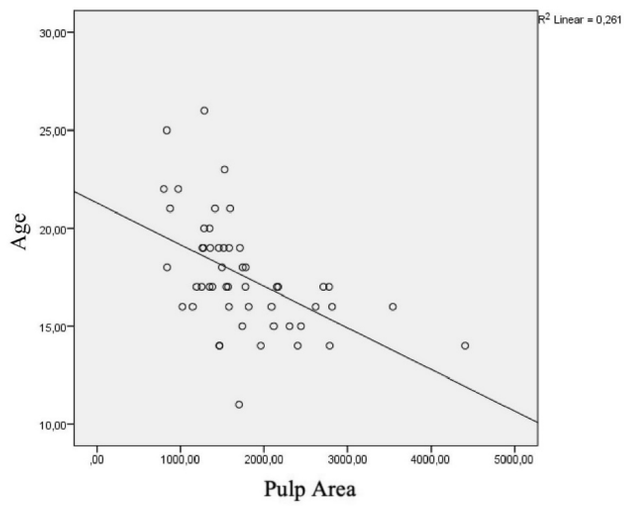

Figure 2. *The Relationship between Chronological Age and Pulp area in the Control Group*

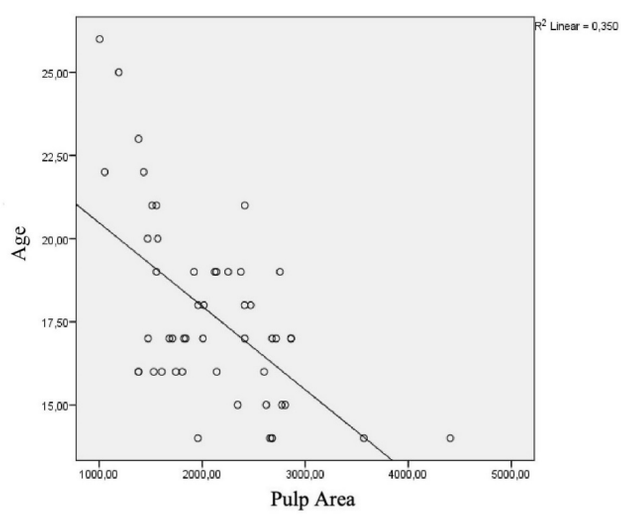

Figure 3. *The Relationship between Chronological Age and Pulp Area in the Orthodontic Group*

Table 2. *Comparison of the Pulp Area (mm2) between Groups (mean ± SD/ SE).*

	Orthodontic group	Control group	P value
Mean ±SD	1748.91± 328.67/ 157.81	2136.602.16/ 171.48	> 0.05

SD: standard deviation; SE: standard error

4. DISCUSSION

Today, age estimation is used in many areas for different reasons. Therefore, there is an increasing interest in the development of age estimation methods which are non-invasive, accurate, cost-effective and simple to implement (24). In the current study, the relationship between the chronological age and the pulp area was investigated based on the accumulation of secondary dentine over time in patients that received and did not receive orthodontic treatment.

It is known that secondary dentin formation is a physiological process that develops with age (15). Therefore, this study was performed on two groups with the same age range to avoid any bias in the study design. Secondary dentin accumulation is an important indicator of age estimation on dental radiography. Many studies on dental radiographs have found a relationship between chronological age and secondary dentin accumulation (15,23,26,27). Orthodontic treatment causes mechanical trauma in the periodontal ligament and induces pulp reactions (28). Histological studies have shown that secondary dentin formation increases after tooth movement (29). Therefore, the size of the pulp chamber decreases due to secondary dentin formation (21). In the light of this information, this study aims to evaluate the effect of orthodontic treatment on the pulp area and age estimation.

In many studies, age estimation was performed on different tooth groups. It has been reported that the complex anatomy of molar teeth may cause difficulties in determining the boundaries of the pulp area and may cause inconsistencies in the measurements (11). Similarly, because of the small pulp volume of the lower incisors and variations in the root canal anatomy, it has been reported that the pulp area can be measured incorrectly using the 2D radiographs (10). For this reason, this study was performed on radiographs of canine teeth which have the largest pulp volume among single-rooted teeth and the longest functional survival rate in the mouth, which is relatively less exposed to occlusal wear and stresses compared to posterior and other anterior teeth (14,25). In this study, the teeth were selected from the left or right side. It has been reported that, there was no significant morphological difference between the permanent teeth on the left or right side of the jaw (15).

In our comprehensive literature review, only one study investigating the effect of orthodontic treatment on age estimation was found. Penaloza et al. (23) showed that using Kvaal method orthodontic treatment did not have a significant effect on age estimation on panoramic radiographs. Similarly, in our study, it was determined that orthodontic treatment did not cause a significant difference in the correlation between the pulp area and the chronological age. The different age estimation methods, the similarity in the results of the study despite the different populations and the different teeth group shows that the secondary dentin accumulation induced after orthodontic treatment does not cause a significant change in the pulp

area. Besides, the results of the study showed that gender had no significant effect on the pulp area of canine teeth. Similarly, Jeevan et al. (30), Singaraju et al. (31) and Dehghani et al. (32) were reported that gender has no significant effect on morphological variables.

5. CONCLUSION

The results of the present study showed that orthodontic treatment did not affect the relationship between chronological age and pulp area. To obtain more detailed data on the effect of orthodontic treatment on age estimation, we think new studies with larger sample sizes on different populations and comparison with other age determination methods are necessary.

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