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Radiographic examination of pulp stones in children and adolescents in the Southeastern Anatolia Region of Türkiye: A retrospective cross-sectional study

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Purpose: This study aims to contribute to endodontic applications and the literature by radiographically examining the frequency and distribution of pulp stones in the permanent teeth of children and adolescents aged 9-16 in Türkiye's Southeastern Anatolia Region.

Methods: In our retrospective cross-sectional study, panoramic radiographs of 5006 individuals who presented to Dicle University Faculty of Dentistry between 2018 and 2023 were evaluated. The data were analyzed based on age, gender, tooth type, and the dental arch where the tooth was located. For categorical variables, IBM SPSS V23 software was used, and the data were analyzed using Chi-square, Fisher's Exact, and McNemar tests, with a statistical significance level set at $p < 0.05$.

Results: In our study, pulp stones were observed in 8.1% of the individuals and 1.22% of the teeth examined, most frequently in the maxillary permanent first molars. A significant relationship was found between age and the presence of pulp stones, where each unit increase in age raised the risk of pulp stones by 1.198 times in the univariate model and by 1.196 times in the multiple model ($p < 0.001$). While no significant difference was found in the frequency of pulp stones between genders, more pulp stones were observed in the maxillary arch compared to the mandibulary arch.

Conclusion: It was determined that pulp stones in children and adolescents are concentrated in the maxillary permanent first molars and increase with age. Early detection of pulp stones through appropriate preoperative radiographs is critically important for improving endodontic treatment outcomes and preventing complications, thereby underscoring their impact on clinical success.

Keywords: Children; endodontic treatment; panoramic radiography; pulp stone; retrospective cross-sectional study.

Introduction

Pulp stones are known as calcified formations located within the dental pulp, either localized in the pulp tissue or integrated with or into the dentin (1). While the precise causes of pulp stone formation remain unclear, several factors are thought to play a role in this process, such as pulp calcification, orthodontic movements, aging, periodontal issues, deep dentin decay, bacterial infections, systemic illnesses, restorations, and genetic factors (2,3). In addi-

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tion, research in the literature has identified a notable link between pulp stones and systemic conditions, including diabetes, heart disease, gallstones, and kidney stones (4).

The effect of age on the formation of pulp stones is debatable. Scientific studies suggest no direct relationship between age and the presence of pulp stones. Instead, it is highlighted that factors associated with pulp stone formation may be more closely linked to the duration, severity, and frequency of irritant factors (5,6). Although they are more commonly observed in adults, pulp stones have also been reported in younger patients (7).

In a study conducted within the pediatric age group, an increase in pulp stone prevalence was observed with advancing age. This study suggests that pulp stone formation in pediatric individuals might be related to age, emphasizing the need for long-term and more extensive research to understand age-related changes in detail (8).

Identification of pulp stones is possible through histological analysis and radiographic imaging methods (8). On radiographic examination, pulp stones are defined as round or oval opacities within the pulp, appearing as a single dense mass or multiple small opacities in different shapes and sizes as radiopaque structures (9,10). Pulp stones are commonly examined using panoramic and bitewing radiographs, as well as cone-beam computed tomography (8). Panoramic radiographs are reported to be an effective method for detecting pulp stones as they allow the evaluation of the entire jaw and teeth in a single image (11).

Literature research indicates that while pulp stones can be present in the radicular pulp, they are more frequently found in the coronal area (12). The presence of pulp stones in the apical third of the root is known to obstruct root canals, making endodontic treatment procedures more challenging (13). The presence of pulp stones during root canal treatment may result in perforations, loss of tooth structure and working length, or even treatment failure, thereby raising the risk of complications (14,15).

The aim of this retrospective cross-sectional study is to radiographically examine the frequency and distribution of pulp stones in the permanent teeth of children and adolescents in Türkiye's Southeastern Anatolia Region. With the findings obtained, this study aims to contribute to the prevention of complications that may be encountered during dental practices, especially in endodontic procedures.

Materials and Methods

This study received ethical approval from the Local Ethics Committee of Dicle University Faculty of Dentistry in accordance with the Declaration of Helsinki (No: 2023-51, Date: 29/11/2023).

Sample Size Calculation

Between December 2018 and December 2023, a total of 139,162 individuals presented to the Department of Pediatric Dentistry at Dicle University Faculty of Dentistry for dental treatment. Using OpenEpi's sample size calculator (https://www.openepi.com/SampleSize/SSPropor.htm), and setting a 95% confidence level with a 5% margin of error, the sample size was calculated. These parameters indicated a minimum required sample size of 384.

Study Group

The sample for our study consists of panoramic radiographs obtained from individuals who presented to the Department of Pediatric Dentistry at Dicle University Faculty of Dentistry for dental treatment between December 2018 and December 2023. Written consent was obtained for all radiographic records (panoramic radiography, cone-beam computed tomography, wrist radiographs, lateral cephalometric radiographs, etc.) to be used in scientific studies as part of patients' diagnostic and treatment processes. The archival records of periapical and bitewing radiographs for the permanent teeth to be examined were found to be insufficient, and the CBCT archival data for children and adolescents were limited due to adherence to the ALARA principle (16). Since our study is retrospective in nature, only existing records were analyzed, and it was not possible to obtain additional radiographs. For these reasons, our study was conducted based on panoramic radiographs.

Radiographic Evaluation

All digital panoramic radiographs (Progeny, Midmark Company, USA) were taken using a panoramic X-ray device with 0.5 mm focal point, 3.2 mm filtration, 70 kVp, 10 mA, and 15.9 seconds scanning parameters. The scans were performed using the standard panoramic module of the device. All data were evaluated by two expert dentists (YP and ECT) together under optimum ambient lighting conditions on an HP Envy 13-ah1xxx laptop with a 13.3-inch screen, 1920x1080 pixel resolution, and an Intel Core i7 processor. Data were reviewed simultaneously by two expert dentists on the same computer without calculating the interobserver correlation coefficient, and the final classification and radiographic confirmation of the findings were determined by consensus between the observers. Radiographic examinations were limited to the 9-16 age range, and the data were grouped and analyzed based on age, gender, tooth type, and the dental arch in which the tooth was located.

Inclusion Criteria

Participants included in the study had normal skeletal and dental development characteristics, with no craniofacial syndromes, cleft lip or palate, malformations, cysts, lesions, anomalies detectable on radiographs, history of trauma, or orthodontic treatment. Our study is based on archival data derived from patients' self-reported medical and systemic health conditions, and individuals with such conditions were excluded from the scope of the study. Radiographs obtained from patients aged 9-16 within the specified time frame had to be free of artifacts or distortions, with sufficient clarity for evaluation. The reason for determining the 9–16 age range as the inclusion criterion in our study is that the completion of apical development in the permanent teeth to be examined was taken as the basis. Additionally, only permanent teeth in the mixed and/or permanent dentition period that showed radiopaque masses identified as pulp stones in the pulp chamber, and that had no decay, restorations, or fractures except for third molars, were included in the evaluation. However, since dentin-embedded pulp stones could not be detected, only free pulp stones were included in the study, and the inclusion criterion focused on those clearly and distinctly visible on panoramic radiographs. Based on these criteria, 5006 panoramic radiographic images were included in the study.

Statistical Analysis

Data were analyzed using IBM SPSS V23 software. Relationships between categorical variables were evaluated with Chi-square and Fisher's Exact tests. McNemar's test was applied for comparing the right and left sides within gender groups. The effect of independent variables on the presence of pulp stones was examined using binary logistic regression analysis. A statistical significance level of $p < 0.05$ was accepted.

Results

The data presented in Table 1 show the occurrence rates of pulp stones in the individuals and teeth examined. Pulp stones were detected in 8.1% of the 5006 individuals studied. Among the total 80,096 teeth examined, the rate of teeth with detected pulp stones was found to be 1.22%. The occurrence rate of pulp stones was 0.83% in maxillary teeth, while this rate was 0.39% in mandibulary teeth (Table 1).

When examining the gender distribution of patients aged 9-16 included in the study, it was determined that there were 2455 boys (49%) and 2551 girls (51%). The median age was calculated as 12, while the median number of teeth with pulp stones per individual was 0 (Table 2).

There was no statistically significant association between gender and the presence of pulp stones in the maxillary permanent left first premolar ($p = 0.500$), left second premolar ($p = 1.000$), maxillary permanent right first molar ($p = 0.072$), maxillary permanent left first molar ($p = 0.883$),

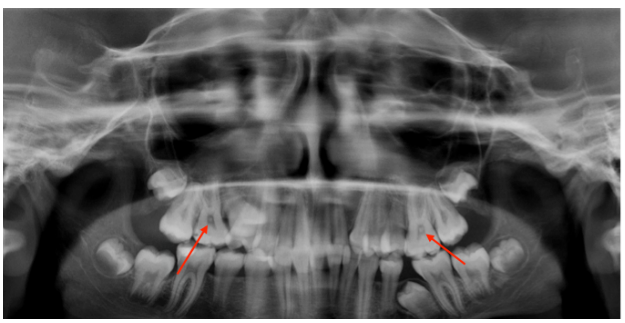

Fig. 1. Image of pulp stones in the maxillary right and left first molar teeth in the panoramic radiograph of a 13-year-old boy.

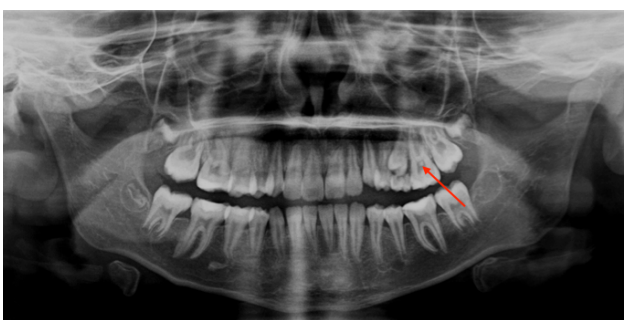

Fig. 2. Image of a pulp stone in the maxillary left first molar tooth in the panoramic radiograph of a 12-year-old girl.

Table 1. The mean, standard deviation, and p values of the amount of removed dentin thickness in experimental groups (%)

	Number (n)	Percentage (%)
Total number of individuals examined	5006	100
Individuals with detected pulp stones	405	8.1
Total number of teeth examined	80096	100
Maxillary teeth with detected pulp stones	663	0.83
Mandibulary teeth with detected pulp stones	313	0.39
Total number of teeth with detected pulp stones	976	1.22

Table 2. Descriptive statistics of variables

Variables	Mean ± SD	Median (min-max)
Age	12.2 ± 2.3	12 (9-16)
Number of teeth with pulp stones per individual	0.19 ± 0.82	0 (0-11)
	Frequency	**Percentage**
Gender		
Boys	2455	49
Girls	2551	51
Presence of pulp stones		
Absent	4600	91.9
Present	406	8.1
Maxillary right 1st premolar		
Absent	5006	100
Maxillary right 2nd premolar		
Absent	5006	100
Maxillary right 1st molar		
Absent	4749	94.9
Present	257	5.1
Maxillary right 2nd molar		
Absent	4910	98.1
Present	96	1.9
Maxillary left 1st premolar		
Absent	5004	99.9
Present	2	0.1
Maxillary left 2nd premolar		
Absent	5003	99.9
Present	3	0.1
Maxillary left 1st molar		
Absent	4792	95.7
Present	214	4.3
Maxillary left 2nd molar		
Absent	4915	98.2
Present	91	1.8
Mandibular left 1st premolar		
Absent	5004	99.9
Present	2	0.1
Mandibular left 2nd premolar		
Absent	5003	99.9
Present	3	0.1
Mandibular left 1st molar		
Absent	4901	97.9
Present	105	2.1
Mandibular left 2nd molar		
Absent	4961	99.1
Present	45	0.9
Mandibular right 1st premolar		
Absent	5001	99.9
Present	5	0.1
Mandibular right 2nd premolar		
Absent	5004	99.9
Present	2	0.1
Mandibular right 1st molar		
Absent	4897	97.8
Present	109	2.2
Mandibular right 2nd molar		
Absent	4964	99.2
Present	42	0.8

All the mentioned teeth are permanent teeth

Table 3. Relationship between gender and the presence of pulp stones in permanent maxillary teeth and comparison of pulp stone presence in right and left maxillary permanent teeth within each gender group

		Gender			Test Statistic	p
		Boys (n = 2455)	Girls (n = 2551)	Total (n = 5006)		
	Pulp stone	n / %	n / %	n / %		
Maxillary right 1st Premolar	Absent	2455 (100)	2551 (100)	5006 (100)	-	0.500**
Maxillary left 1st Premolar	Absent	2455 (100)	2549 (99.92)	5004 (99.96)	-	
	Present	0 (0)	2 (0.08)	2 (0.04)		
p		-	-			
Maxillary right 2nd Premolar	Absent	2455 (100)	2551 (100)	5006 (100)	-	1.000**
Maxillary left 2nd Premolar	Absent	2454 (99.96)	2549 (99.92)	5003 (99.94)	-	
	Present	1 (0.04)	2 (0.08)	3 (0.06)		
p		-	-			
Maxillary right 1st molar	Absent	2343 (95.44)	2406 (94.32)	4749 (94.87)	3.233	0.072*
	Present	112 (4.56)	145 (5.68)	257 (5.13)		
Maxillary left 1st molar	Absent	2349 (95.68)	2443 (95.77)	4792 (95.73)	0.022	0.883*
	Present	106 (4.32)	108 (4.23)	214 (4.27)		
p***		0.497	< 0.001			
Maxillary right 2nd molar	Absent	2407 (98.04)	2503 (98.12)	4910 (98.08)	0.036	0.849*
	Present	48 (1.96)	48 (1.88)	96 (1.92)		
Maxillary left 2nd molar	Absent	2412 (98.25)	2503 (98.12)	4915 (98.18)	0.119	0.731*
	Present	43 (1.75)	48 (1.88)	91 (1.82)		
p***		0.424	1.000			

*Pearson Chi-square Test **Fisher's Exact Test ***McNemar Test, Frequency (Percentage). All the mentioned teeth are permanent teeth.

left first premolars ($p < 0.001$), with a pulp stone rate of 0.04% in the right first premolar and 0% in the left. Similarly, in girls, a significant relationship was noted between the mandibular permanent right and left first premolars for pulp stone presence ($p < 0.001$), with rates of 0.16% in the right first premolar and 0.08% in the left. No statistically significant difference was found between the mandibular permanent right and left second premolar teeth in boys and girls (boys: $p = 1.000$; girls: $p = 1.000$) regarding the presence of pulp stones. Similarly, no significant relationship was found between the mandibular permanent right and left first molar teeth (boys: $p = 1.000$; girls: $p = 0.761$). For the mandibular permanent right and left second molar teeth, no statistically significant difference was found in either boys ($p = 0.804$) or girls ($p = 1.000$) (Table 4).

As a result of examining the effect of age and gender on the presence of pulp stones using binary logistic regression analysis, it was found that each one-unit increase in age increased the likelihood of pulp stone presence by 1.198 times in the univariate model ($p < 0.001$). In the multiple model, age was found to increase the presence of pulp stones by 1.196 times ($p < 0.001$). However, gender did not have a statistically significant effect on the presence of maxillary permanent right second molar ($p = 0.849$), and left second molar ($p = 0.731$) ($p > 0.05$). While no significant relationship was observed in boys between the presence of pulp stones in the maxillary right and left first molars ($p = 0.497$), a significant relationship was found in girls ($p = 0.001$). In girls, the presence of pulp stones was identified in 5.7% of the maxillary permanent right first molars and 4.2% of the maxillary permanent left first molars. No significant relationship was found between the maxillary permanent right and left second molars in either boys ($p = 0.424$) or girls ($p = 1.000$) (Table 3).

Pulp stones detected in the maxillary permanent right and left first molars of a 13-year-old boy are shown in Figure 1. The pulp stone observed in the maxillary left first molar of a 12-year-old girl is illustrated in Figure 2.

There was no statistically significant relationship between gender and the presence of pulp stones in the mandibular permanent right first premolar ($p = 0.375$), left first premolar ($p = 0.500$), right second premolar ($p = 1.000$), left second premolar ($p = 1.000$), right first molar ($p = 0.778$), left first molar ($p = 0.922$), right second molar ($p = 0.901$), and left second molar ($p = 0.780$) ($p > 0.05$). A significant association was found in boys regarding the presence of pulp stones in the mandibular right and

Table 4. Relationship between gender and the presence of pulp stones in permanent maxillary teeth and comparison of pulp stone presence in right and left maxillary permanent teeth within each gender group

		Gender			Test Statistic	p
		Boys (n = 2455)	Girls (n = 2551)	Total (n = 5006)		
	Pulp stone	n / %	n / %	n / %		
Mandibular right 1st Premolar						
	Absent	2454 (99.96)	2547 (99.84)	5001 (99.9)	-	0.375**
	Present	1 (0.04)	4 (0.16)	5 (0.1)		
Mandibular left 1st Premolar						
	Absent	2455 (100)	2549 (99.92)	5004 (99.96)	-	0.500**
	Present	0 (0)	2 (0.08)	2 (0.04)		
p***		< 0.001	< 0.001			
Mandibular right 2nd Premolar						
	Absent	2454 (99.96)	2550 (99.96)	5004 (99.96)	-	1.000**
	Present	1 (0.04)	1 (0.04)	2 (0.04)		
Mandibular left 2nd Premolar						
	Absent	2454 (99.96)	2549 (99.92)	5003 (99.94)	-	1.000**
	Present	1 (0.04)	2 (0.08)	3 (0.06)		
p***		1.000	1.000			
Mandibular right 1st molar						
	Absent	2403 (97.88)	2494 (97.77)	4897 (97.82)	0.079	0.778*
	Present	52 (2.12)	57 (2.23)	109 (2.18)		
Mandibular left 1st molar						
	Absent	2404 (97.92)	2497 (97.88)	4901 (97.9)	0.009	0.922*
	Present	51 (2.08)	54 (2.12)	105 (2.1)		
p***		1.000	0.761			
Mandibular right 2nd molar						
	Absent	2434 (99.14)	2530 (99.18)	4964 (99.16)	0.016	0.901*
	Present	21 (0.86)	21 (0.82)	42 (0.84)		
Mandibular left 2nd molar						
	Absent	2432 (99.06)	2529 (99.14)	4961 (99.1)	0.78	0.780*
	Present	23 (0.94)	22 (0.86)	45 (0.9)		
p***		0.804	1.000			

*Pearson Chi-square Test **Fisher's Exact Test ***McNemar Test, Frequency (Percentage) All the mentioned teeth are permanent teeth

Table 5. Evaluation of the effect of age and gender on the presence of pulp stones using binary logistic regression analysis

	Univariate		Multiple	
	OR (95% I)	p	OR (95% I)	p
Age	1.198 (1.145 - 1.253)	< 0.001	1.196 (1.144 - 1.251)	< 0.001
*Gender	1.139 (0.929 - 1.396)	0.210	1.086 (0.884 - 1.333)	0.431

* Reference: Male

pulp stones in either the univariate model (p = 0.210) or the multiple model (p = 0.431) (Table 5).

Discussion

Pulp stones are calcified structures located in the dental pulp of primary and permanent teeth, which can be found in teeth with or without pathology, and even in unerupted teeth (7). Pulp stones or sclerosis are mostly detected incidentally in radiographs (17). It is known that pulp stones larger than 200 µm can be observed in radiographs such as panoramic, periapical, and bitewing images (18). Due to the limited availability of CBCT archival data for children

and adolescents in accordance with the ALARA principle (16), and the retrospective design of our study, additional radiographs could not be obtained. Therefore, the detection of pulp stones was performed using panoramic radiographs.

While pulp stones do not entirely obstruct endodontic procedures, larger stones can block the canal, complicating access and increasing the risk of instrument fractures. Consequently, it is advisable to obtain appropriate preoperative radiographs when pulp stones are detected. Additionally, in some patients, unexplained dental pain may occur due to the pressure of pulp stones on dental nerves (19).

Our retrospective cross-sectional study aims to investigate the frequency and distribution of pulp stones in the permanent teeth of children and adolescents in the Southeastern Anatolia Region of Türkiye, using panoramic radiographs. Panoramic radiography was chosen due to its increased safety for pediatric populations, given its low radiation dose, and its ability to offer a rapid solution as a broad screening tool. With the findings obtained from our study, we aim to contribute to the literature and help prevent complications that may arise, particularly during endodontic procedures.

When examining studies on the incidence of pulp stones, it has been reported that the occurrence in individuals ranges from 3.5% to 83.3% (17,20-22), while in teeth, it varies from 0.5% to 57.5% (5, 22-25). According to a recent study conducted in the pediatric population, pulp stones were found in 6.5% of individuals aged 9-18 and in 0.96% of the teeth evaluated (8). In our study, pulp stones were detected in 8.1% of individuals aged 9-16 and in 1.22% of permanent teeth. The findings of our study are consistent with the literature data.

In studies from the literature, it has been reported that the majority of observed pulp stones were detected in the maxillary arch, particularly in the first molar teeth (10,17,20,21,26). Another study reported a higher incidence of pulp stones in the maxillary first and second molars compared to those in the mandible (8). However, some studies have indicated a greater incidence in the mandible (27,28). In our study, pulp stones were more frequently found in the maxilla than in the mandible, with the maxillary permanent right and left first molars most commonly affected. Our findings align with several literature reports (10,17,20,21,26).

Studies have shown that pulp stones may vary in distribution across different sides of the jaws. In one study on this topic, no statistically significant difference was reported regarding whether the teeth with pulp stones in both jaws were located on the right or left side (8). Some studies, however, have reported a higher frequency of pulp stones on the right side compared to the left (9,10). In our study, no statistically significant difference was found between the right and left sides of maxillary and mandibular teeth in terms of the presence of pulp stones.

While there are studies in the literature reporting that pulp stones are observed at a higher rate in boys (21, 22,29), other research indicates that the incidence of pulp stones is significantly higher in girls compared to boys (8,9). In some studies, no significant difference was found in the incidence of pulp stones among adolescents aged 12-19 across genders (18,25-27,30). Studies in Türkiye by Şişman et al. (17) in Central Anatolia and Karadaş et al. (31) in northeastern regions both reported a significantly higher prevalence of pulp stones in females compared to males, suggesting a potential gender influence. In the study conducted by Kannan et al. (18) on the Malaysian population, it was reported that there was no statistically significant relationship between the prevalence of pulp stones and gender. In our study, the effect of gender on the presence of pulp stones was examined using binary logistic regression analysis, which revealed no significant difference between genders, indicating that gender does not affect the presence of pulp stones. These variations are thought to arise from factors such as population characteristics, hormonal differences, genetics, and environmental factors.

In studies on the incidence of pulp stones, it has been reported that there is no significant difference between age groups (22,32), while some research indicates that the incidence of pulp stones increases with age and that there are significant differences between age groups (8,9,20,27). In the binary logistic regression analysis conducted in our study, the univariate model showed that an increase of 1 unit in age increased the presence of pulp stones by 1.198 times ($p < 0.001$). In the multiple model, it was found that age increased the presence of pulp stones by 1.196 times ($p < 0.001$). These findings are quite valuable as they indicate that age is a significant risk factor in the formation of pulp stones.

Limitations

The study's sample, drawn exclusively from individuals in Türkiye's Southeastern Anatolia Region, limits the generalizability of the findings to other geographic areas. The primary limitation of this study is the inability to perform a detailed evaluation using CBCT due to its retrospective design and the limited availability of CBCT records, particularly for the pediatric and adolescent population. The absence of advanced imaging methods, such as cone-beam computed tomography, may have hindered the detection

of small or early-stage pulp stones, potentially negatively impacting diagnostic accuracy. Due to the retrospective nature of the study, a comprehensive analysis of hormonal, genetic, and environmental factors that could influence the incidence of pulp stones could not be conducted.

Conclusion

In our study, pulp stones were most frequently observed in the maxillary permanent first molar teeth. A significant relationship was found between increasing age and the presence of pulp stones, while no significant difference in pulp stone incidence was found between genders. Large pulp stones can obstruct root canals, leading to complications such as instrument fracture and perforation during root canal treatment. Therefore, the early detection of pulp stones through appropriate preoperative radiographs is essential to enhance the success of endodontic treatment. The data obtained in our study regarding pulp stones are valuable in terms of their potential impact on endodontic treatment and in preventing complications. We believe that further studies utilizing advanced imaging methods, such as cone-beam computed tomography, and AI-supported software will contribute even more to the literature.

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