ORIGINAL ARTICLE

# Calcifications of the pulp chamber: prevalence and implicated factors

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Received: 21 February 2007 / Accepted: 23 June 2008 / Published online: 30 July 2008 © Springer-Verlag 2008

Abstract The objectives of this study were to describe the prevalence of pulp chamber calcifications in a sample of Turkish dental patients and to report associations between presence of pulp chamber calcifications and dental status, gender, age, and cardiovascular diseases (CVDs). Data were collected through radiographic examination of periapical and bitewing radiographs of 15,326 teeth from 536 dental patients, comprising 270 male and 266 female patients aged between 13 and 65 years. Definite radiopaque focuses inside the radiolucent pulp chamber were defined as pulp chamber calcifications. When the pulp chamber was completely radiolucent, that tooth was scored as tooth without pulp chamber calcification. The dental status was scored as intact, carious, restored, or restored + carious. Pulp chamber calcifications were identified in 204 (38%) patients examined. Of the 15,326 teeth, 747 (4.8%) had pulp chamber calcifications. Gender and dental status were found to be correlated with the presence of pulp chamber calcifications. The high prevalence of pulp chamber calcifications in carious, restored, and restored + carious

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F. K. Cobankara Department of Endodontics, Faculty of Dentistry, Selcuk University, Campus, Konya, Turkey e-mail: k.funda@excite.com teeth support the view that the occurrence of pulp chamber calcifications can be a response to long-standing irritants. However, to report any associations between occurrence of pulp chamber calcifications and different dental or clinical status, further studies are still needed.

Keywords Pulp · Calcification · Prevalence · Etiology

# Introduction

Pulpal calcifications are calcified masses in dental pulps of healthy, diseased, and even unerupted teeth. Their prevalence varies widely from 8% to 95% of the studied population [2, 17, 22, 24]. Since these calcifications usually do not cause pulp disease or subjective symptoms, it is still not clear whether they represent pathology or biological variation [11, 17]. Although the etiological factors for the formation of pulpal calcifications are not well understood, age, gender, various systemic diseases, and long-term irritation such as deep caries and restorations have been proposed as possible implicated factors in the development of pulpal calcifications [7, 13, 14]. On the other hand, there are opposite opinions about these etiological factors in the development of pulpal calcifications in the literature. In addition, in the majority of investigations, only posterior teeth were used and the sample size is limited [5, 20-22].

If the relationship between these factors and the pulpal calcifications can be determined, an answer to the question whether the pulpal calcifications are a systemic or local condition can be found.

The purposes of this study were to describe the prevalence of pulp chamber calcifications in a sample of Turkish dental patients and to report correlations among the presence of pulp chamber calcifications and age, gender,

Table 1 Total teeth number of evaluated patients

Total teeth number in patients	Patient frequency	Percent	
10.00	2	0.4	
11.00	1	0.2	
12.00	3	0.6	
13.00	3	0.6	
15.00	3	0.6	
16.00	2	0.4	
17.00	1	0.2	
18.00	5	0.9	
19.00	6	1.1	
20.00	4	0.7	
21.00	5	0.9	
22.00	7	1.3	
23.00	10	1.9	
24.00	19	3.5	
25.00	18	3.4	
26.00	26	4.9	
27.00	31	5.8	
28.00	63	11.8	
29.00	37	6.9	
30.00	67	12.5	
31.00	51	9.5	
32.00	172	32.1	

dental status, and patient history of cardiovascular diseases (CVDs).

#### Materials and methods

Five hundred thirty-six consecutive patients (266 female and 270 male aged 13–65 years) were examined clinically and radiographically at the Dentistry Faculty of Selcuk University, Konya, Turkey. Radiographs of 15,326 fully erupted posterior and anterior teeth were evaluated. This population was selected randomly, but the number of teeth in the oral cavity (per patient) was taken into account. The patients having a higher number of teeth were preferred.

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Total teeth number and percentage of patients was presented in Table 1. Two patients (0.4%) had ten teeth, and most of the patients (32.1%) had 32 teeth (Table 1). Conventional dental X-ray films (3×4 cm, E speed, Kodak, Stuttgart, Germany) were used in this study. These images were obtained with a constant 70 kVp, 8 mA, and 0.2 s exposure by one clinician for the clinical examination, processed in an automatic processing machine (XR 24; Dürr Dental, Bietigheim-Bissingen, Germany), and with an X-ray viewer under a magnifying lens by two independent investigators. The teeth were categorized into teeth with pulp calcification and teeth without pulp chamber calcification. A pulp chamber calcification was defined as a definite radiopaque mass inside radiolucent pulp chambers. When the pulp chamber was completely radiolucent, the tooth was scored as having no pulp chamber calcification (Figs. 1 and 2). The size and shape of calcifications were not evaluated and scored.

Demographic information and systemic conditions of the patients were determined through both questionnaires and clinical interviews. Angina pectoris, ischemic heart disease, heart surgery, hypertension, congestive heart disease, cerebrovascular accident, hypercholesterolemia, and arrhythmias were recorded as CVDs [7].

The dental status of each tooth was scored as intact, carious, restored, or restored + carious. The presence and depth of caries were determined using radiographs. The presence of restorations was determined through the clinical and radiographic examinations, and the depth of the restoration was determined by radiographs. When the teeth did not present caries and restorations into the dentine, they were accepted as intact. When they showed enamel caries or restorations limited to the enamel (such as fissure sealants), they were also classified as intact. When they did not show restoration material at the dentin level but included primary dentin caries, they were classified as carious. Teeth with restorations reaching the dentin but not showing primary or secondary dentin caries were classified as restored. Restored teeth with primary or secondary dentin caries were classified as restored + carious.

**Fig. 1** Bilateral posterior bitewing radiographs of a man without pulp chamber calcifications



Fig. 2 Radiographic images of pulp chamber calcifications inside the maxillary and mandibular first and second molars bilaterally in a woman



The data were analyzed statistically using the Statistical Package for the Social Sciences (ver. 11.0; SPSS, Chicago, IL, USA). The frequency of distribution was calculated by descriptive statistics. The Spearman's correlation (for age) and the chi-square (for gender, dental status, and CVDs) tests were used to investigate the correlations between the presence of pulp chamber calcifications and gender, age, dental status, and CVDs. The kappa statistic was used to investigate the inter-observer agreement in evaluating pulp chamber calcifications.

## Results

The kappa value of inter-observer agreement in identifying pulp chamber calcifications was 0.98 (almost perfect). In other words, the observers were nearly in full agreement on the identification of pulp chamber calcifications.

Pulp chamber opacities were detected in 747 (4.8%) out of the 15,326 teeth examined. The distribution of teeth with pulp chamber calcifications according to tooth type, location, and patient gender is summarized in Table 2. First molars were the most commonly affected teeth in both arches and genders. There was no significant difference between maxilla and mandible about this issue (p=0.122). Second molars were the second most commonly affected teeth. Lateral incisors were the least commonly affected teeth in both arches and genders. In male patients, it was observed that canines and first premolars did not contain pulp calcification. Maxillary teeth (56%) were more affected than mandibular teeth (44%) in both genders (p= 0.01). Maxillary teeth were affected most commonly, especially in female patients.

Of the 536 subjects, pulp chamber calcifications were observed in 204 (38%) patients: 121 (59%) women and 83 (41%) men. Fifty patients (9%) had only one tooth with a pulp chamber calcification, while 154 patients (29%) had more than one tooth with pulp chamber calcifications. Two persons (0.4%) (one female and one male) had 12 teeth with pulp chamber calcifications (Table 3).

No correlation was detected between patient age and the presence of pulp chamber calcifications (p=0.06). It was found that the presence or absence of pulp chamber calcifications did not change with age. No significant correlation was found between the presence of CVDs and pulp chamber calcifications (p=0.549; Table 4). Of the 204 patients with pulp chamber calcifications, 25 (12%) had CVDs. Of the 315 patients without pulp chamber calcifications, 31 (10%) had CVDs. A significant relationship was observed between gender and presence of pulp chamber calcifications (p=0.02). The prevalence of pulp chamber calcifications was significantly greater in women than men (p=0.02). Table 5 shows the distribution of the numbers and the percentages of persons and teeth with pulp chamber calcifications for both genders. A significant correlation was detected between dental status and the presence of pulp

Teeth	Females		Males	Total	
	Maxilla	Mandible	Maxilla	Mandible	
Central incisor (%)	1 (0.1)	_	3 (0.4)	_	4 (0.5)
Lateral incisor (%)	_	_	1 (0.1)	_	1 (0.1)
Canine (%)	4 (0.5)	4 (0.5)	_	_	8 (1)
First premolar (%)	2 (0.2)	5 (0.7)	-	_	7 (1)
Second premolar (%)	-	14 (1.8)	3 (0.4)	4 (0.5)	21 (3)
First molar (%)	155 (21)	101 (14)	80 (11)	75 (10)	411 (55)
Second molar (%)	103 (14)	69 (9)	60 (8)	43 (6)	276 (37)
Third molar (%)	4 (0.5)	8 (1)	2 (0.2)	5 (0.7)	19 (2.5)
Total (%)	269 (36)	201 (27)	149 (20)	127 (17)	747 (100)

**Table 2** Distribution of pulpchamber calcifications accord-ing to tooth types and arches infemales and males

	The number of individuals having different numbers of teeth with pulp chamber calcifications												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Females (%)	145 (55) 187 (70)	32 (12) 18 (7)	16 (6) 20 (7)	16 (6) 12 (4)	21(8)	9 (3) 6 (2)	4 (2) 7 (3)	10(4) 2(0.8)	8 (3) 6 (2)	2(0.8) 1(0.4)	-	3 (1)	1 (0.4) 1 (0.4)
Total (%)	332 (62)	50 (9)	20 (7) 36 (7)	28 (5)	30 (6)	15 (3)	11 (2)	12 (2)	14 (3)	3 (0.6)	_	3 (0.6)	2 (0.4)

Table 3 The number and percentage of teeth with pulp chamber calcifications in each gender and in total

chamber calcifications (p=0.01). The prevalence of pulp chamber calcifications was greater in carious, restored, and restored + carious teeth than in intact teeth, with restored teeth being more affected (Table 6). A significant correlation was also found between gender and dental status (p=0.00). The prevalence of carious and restored teeth was significantly higher in men (Table 7). A significant relationship was observed between dental status and teeth (p=0.00; Table 8). The prevalence of caries, restorations, and secondary caries was significantly greater in molars, especially first molars. Three hundred twenty-three (44%) of the 892 carious teeth and 790 (59%) of the 1.342 restored teeth were first molars. Of the 292 restored + carious teeth, 171 (59%) were first molars (Table 5). First molars were the teeth most commonly affected teeth in both arches. There were no significant differences between both arches (p=0.786).

#### Discussion

Pulpal calcifications have been investigated by radiographs [1, 5, 7, 18, 22] or histological sections [15]. Small calcified structures (diameter smaller than 200  $\mu$ m) cannot be detected on radiographs. While the radiological studies tend to underreport the incidence of pulpal calcifications, even histological observations may be incomplete in this respect. If only a limited number of sections through a given tooth are made and studied, a significant number of calcified structures will be missed [17]. We evaluated the pulpal calcifications inside the pulp chamber by radiographic examinations. Inter-observer agreement value was

 Table 4
 The corss-tab of pulpal calcification and systemic condition of patients

Systemic Condition	Pulpal Calcification				
	Absence	Presence	Total		
Healthy persons	260	151	411		
Persons with other systemic diseases	41	28	69		
Persons with CVDs	31	25	56		
Total	332	204	536		

almost perfect in determining pulp chamber calcifications in present study. Therefore, the calibration of the observers was good in this study. In recent investigations, radiographs have already been used to detect the pulpal calcifications. In addition, it was stated that bitewing and periapical radiographs did not show significant differences in diagnosis of pulpal calcification [1, 3, 11].

According to reviews of literature, it can be concluded that the ranges of sensitivity and specificity values of diagnostic methods are quite broad in caries diagnosis. Although the sensitivity values of different diagnostic methods such as visual examination, electrical conducting measurement, diagno-dent, and radiography are close, the best specificity value belongs to radiographs in diagnosis of any type of caries [3, 4, 6, 12, 15, 16, 23]. Radiographs were used for the diagnosis of primary and secondary caries in other investigations which showed the correlation between dental status and existence of pulpal calcifications [1, 5, 7, 18, 22]. In this study, dental status was also determined by the combination of radiographic and visual examinations.

The reported ranges in the prevalence of pulp stones are quite broad [2, 20, 22, 24]. This difference results from the variation in sample and sample size in previous studies. Furthermore, the presentations of prevalence were also different in the literature. Some investigations presented the prevalence based on person and teeth numbers, and the others reported only the prevalence based on teeth number [5, 22]. In the present study, the prevalence based on person number is within the reported range. However, our finding based on the number of teeth is much lower than the reported range [1, 5, 18, 22]. This might result from sample variation. We examined both anterior and posterior teeth, whereas only posterior teeth were evaluated and the teeth number is significantly lower in persons examined in other studies [5, 18, 22]. Most pulp chamber calcifications are found in molars [1, 5, 18, 22]. If more molars are examined than anterior teeth or only posterior teeth are considered, the observed prevalence of pulp chamber calcifications seems to be higher than the actual prevalence. However, in determining the prevalence of pulp chamber calcifications, both anterior and posterior teeth should be evaluated and the percentage of each tooth group should be presented

 
 Table 5
 The numbers and
 percentages of pulp chamber calcifications in individuals and teeth

	Individuals	Teeth	Number of persons with pulpal calcifications (%)	Number of teeth with pulpal calcifications (%)
Females	266	7,663	121 (59)	462 (62)
Males	270	7,663	83 (41)	285 (38)
Total	536	15,326	204 (38)	747 (4.8)

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# Table 6 The distribution of pulp chamber calcifications according to dental status

	Dental status						
	Intact	Carious	Restored	Restored + carious	Total		
Teeth with pulp chamber calcifications (%)	547 (74)	52 (7)	122 (16)	23 (3)	744 (100)		
Teeth without pulp chamber calcifications (%)	12,253 (90)	840 (3.2)	1,220 (6.3)	269 (1.05)	14,582 (100)		
Total (%)	12,800 (84)	892 (6)	1,342 (9)	292 (2)	15,326 (100)		

#### Table 7 The distribution of dental status according to gender

	Dental status									
	Intact	Carious	Restored	Restored + carious	Total					
Females (%)	6,590 (86)	315 (4)	648 (9)	110 (1)	7,663 (100)					
Males (%)	6,210 (81)	577 (8)	694 (9)	182 (2)	7,663 (100)					
Total (%)	12,800 (84)	892 (6)	1,342 (9)	292 (2)	15,326 (100)					

## Table 8 The distribution of dental status according to tooth type

	Dental status							
	Intact	Carious	Restored	Restored + carious	Total			
Anterior teeth (%)	4,543 (35)	72 (8)	87 (7)	1 (0.02)	4,703			
Premolar teeth (%)	2,583 (20)	324 (36)	63 (5)	50 (17)	3,020			
Molar teeth (%)	5,674 (45)	496 (56)	1,192 (89)	241 (83)	7,603			
Total (%)	12,800 (100)	892 (100)	1,342 (100)	292 (100)	15,326			

separately. Furthermore, we considered the number of teeth and preferred the patients of whom the number of teeth was higher. We concluded that the more teeth the examined patients had, the more reliable the results would be.

In the present study, we found no correlation between age and pulp chamber calcification, and this finding is in accordance with the literature [1, 2]. Accordingly, it can be suggested that the real causative factor may be chronic irritation, such as deep caries, restorations, or parafunctional habits in time, rather than age of the patients. In addition, the frequency, duration, and intensity of these irritations may also be important. The only reliable way to determine the effect of aging on the formation of pulpal calcifications is to enroll patients into a long-term yearly recall regimen with radiographic follow-up images. New longitudinal studies are necessary in this subject.

In this study, the prevalence of pulp chamber calcifications was significantly greater in women (62%) than in men (38%). This finding is in agreement with the literature [9, 22]. Therefore, the relationship between the presence of pulp calcifications and systemic calcifications should be investigated in both genders. In addition, bruxism can be a longstanding irritation on dentition and its incidence is more prevalent in women. Because of the effect of the bruxism, the prevalence of pulp chamber calcifications is higher in women. This relationship should be investigated in new studies. It was interesting that there was no pulpal calcification in canines and first premolars of male subjects. However, a specific cause of this finding could not be found, and it should be investigated by further studies.

In the present study, we found a significant relationship between pulp chamber calcifications and the status of the teeth. This finding is in accordance with the literature [5, 18]. It has been hypothesized that intracoronal calcifications can indicate an irritated pulp attempting to repair itself [18]. and it has been suggested that the formation of coronal calcifications represents a late response to pulp inflammation [10, 19, 21]. Furthermore, in our study, the prevalence of caries, restorations, and secondary caries was highest in first molars (17%, 43%, and 9%, respectively), and the prevalence of pulp chamber calcifications was also greatest in first molars (55%). In the light of these findings, the greater prevalence of pulp chamber calcifications in first molars may be associated with the greater prevalence of caries and restorations in first molars. In our study, first molars were the teeth most commonly affected in both arches. This finding is in accordance with the literature [1, 5, 18]. This may have occurred because molars are the largest teeth in both arches and have a greater supply of blood to pulp tissues, which may cause the precipitation of calcium in the pulp chamber. Furthermore, higher prevalence of caries and restorations in molars may affect the formation of pulp chamber calcifications. In addition, first molars are the first definitive teeth that show up in the secondary dentition, and therefore, they endure more stress. This could be an important factor. Stress is cumulative, and the first molars are the oldest teeth in secondary dentition.

No relationship was found between pulp chamber calcifications and history of CVDs in our study. This finding differs from the result of Edds et al. [7]. Edds et al. only assessed minimally restored, non-carious molars without radiographically observable periodontal disease, and the difference may have resulted from sample variation. Krell et al. [12] demonstrated lingual artery plaques in atherosclerotic monkeys, although no similar changes are seen in pulpal arterioles. Our findings support the literature [8, 14].

Within the limitations of this study, pulp chamber calcifications were identified in 4.8% of the teeth examined and 38% of the individuals studied. The first molars were teeth most commonly affected in both arches. Gender and long-standing irritants, such as dentine caries and restorations, affected the development of pulp chamber calcifications. Pulp calcifications are not considered a physiological development related to age, but they may be a response to long-standing irritation. The radiographic presence of pulp chamber calcifications is not a reliable indication of CVDs. The pulp chamber calcifications seem to be a local response to longstanding irritants, which are effective on dentition rather than a systemic condition.

**Conflict of interest statement** We have no financial relationship with the organization that sponsored the research and declare that we have no conflict of interest.

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