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ORIGINAL ARTICLE

Radiographic Assessment of the Prevalence of Pulp Stones in a Yemeni Population Sample

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ABSTRACT

Objective: To determine the prevalence and distribution of pulp stones in the posterior teeth of a sample of adult Yemeni dental patients using digital panoramic radiographs.
Methods: In total, 913 panoramic radiographs from patients attending the hospital dental clinics of at University of Sciences and Technology, Sana'a, Yemen, from January 2013 to December 2014 were examined. The occurrence of pulp stones in the posterior teeth of adult subjects was recorded. Associations between pulp stones and gender, age, arch, side and tooth type were studied.
Results: The overall prevalence of pulp stones was 18.6% for individuals (170 out of 913 subjects) and 3.99% for examined teeth (351 out of 8802 teeth). The pulp stone occurrence was significantly higher in the maxilla than in the mandible for each tooth type and location ($P<0.001$). Pulp stones occurred more often on the right side ($P<0.001$). First molars represented 71% of the affected teeth with the maxillary right first molar showing the highest occurrence. Fifty-six percent of the affected subjects had pulp stones in more than one tooth. No significant difference in the occurrence of pulp stones was detected between genders or among age groups ($P>0.05$).
Conclusion: The prevalence of pulp stones is different among populations. Pulp stones were found in approximately one-fifth of subjects in the Yemeni population, where up to 90% of the population have a Qat-chewing habit. This habit usually causes mechanical and chemical irritation and results in pulp calcification.
Keywords: Panoramic radiographs, Prevalence, Pulp stones, Yemeni population

HIGHLIGHTS

- Pulp stones or denticles are discrete calcified aggregates that occur in the dental pulp. They are found in healthy or carious teeth and have been reported in un-erupted teeth.
- Research has shown that the prevalence of pulp stones varies among populations.
- Bitewing radiographs were reported as the best radiographic technique to illustrate pulp stones.
- Pulp stones were found in approximately 19% of subjects and 4% of posterior teeth in the Yemeni population.

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INTRODUCTION

Pulp stones or denticles are discrete calcified aggregates that occur in the dental pulp. They are found in healthy or carious teeth and have been reported in un-erupted teeth (1). They are usually detected during radiographic examination as radiopaque areas of variable sizes and shapes (2). Structurally, pulp stones are classified as true that are made of normal tubular dentine and lined by odontoblasts and as false, wherein pulp stones are formed from degenerating pulp cells that become mineralised. A third type, 'amorphous' pulp stones, is more irregular in shape compared to the false type (3).

According to radiography, pulp stones may be embedded, adherent or free (3). They appear as radiopaque structures within the pulp chamber or inside the root canal. They vary in shape, number and size (4, 5). Pulp stones may be round or oval; they occupy most of the pulp chamber in some cases. They occur in all tooth types but most commonly in molars (6, 7).

TABLE 1. Radiographic studies on the prevalence of pulp stones in several populations

Author	Year	Population	Sample number in subjects	Sample number in teeth	Prevalence in subjects	Prevalence in teeth	Radiographic assessment method
Tamse et al. (15)	1982	Israeli	300 (aged 20-40 years)	1380	Not presented	20.7%	Bitewing and periapical radiographs
Baghdady et al. (9)	1988	Iraqi	515 (teenagers)	6228	Not presented	19.2%	Bitewing radiographs
Al-Nazhan & Al-Shammrani (5)	1991	Saudi	600	8456	Not presented	10.2%	Bitewing radiographs
Al-Hadi Hamasha et al. (8)	1998	Jordanian	814	4573	51.4%	22%	Bitewing and periapical radiographs
Ranjitkar et al. (7)	2002	Australian	217	3296	46.1%	10.1%	Bitewing radiographs
Syrynska et al. (14)	2010	Polish	165	Not presented	51.5%	Not presented	Panoramic radiographs
Al-Ghurabi et al. (4)	2012	Iraqi	390	3758	34.8%	7.3%	Digital panoramic radiographs
Bains et al. (6)	2014	Indian	500	5333 (molars)	41.8%	9.09%	Bitewing radiographs
Kannan et al. (11)	2015	Malaysian	361	1779	44.9%	15.7%	periapical radiographs
Gulsahi et al. (10)	2009	Turkish	519	13474	12%	5%	Periapical radiographs
Şener et al. (12)	2009	Turkish	536	15362	38%	4.8%	Bitewing and periapical radiographs
Colak et al. (17)	2012	Turkish	814	12928	63.6%	27.8%	Bitewing radiographs
Sisman et al. (13)	2012	Turkish	469	6926	57.6%	15%	Bitewing radiographs
Turkal et al. (16)	2013	Turkish	6912	96240	12.7%	2.1%	Digital panoramic radiographs

The prevalence of pulp stones varies among studies. Some studies have presented the prevalence based on subject numbers and teeth number and others have provided the prevalence only based on the number of examined teeth (4-17). An overview of radiographic studies assessing pulp stones prevalence is presented in Table 1.

Some studies have not found any difference in the occurrence of pulp stone between males and females, whereas other studies have found males to have less pulp stones compared to females (13, 16, 17). Aetiological factors implicated include ageing, biological factors, physical factors, chemical factors, genetic pre-disposition and ethnicity (3, 7, 18). Some studies have suggested a possible correlation of cardiovascular disease and occurrence of pulp stone formation (19).

To our knowledge, no published study on the prevalence of pulp stone has involved a Yemeni population. The purpose of this study was to assess the prevalence of pulp stones in a sample of Yemeni dental patients using digital panoramic radiographs and to explore the possible associations between pulp stones and gender, age and tooth type and location.

METHODS

In this retrospective cross-sectional study, 1500 dental records were randomly selected from the records of patients who attended the hospital dental clinics at University of Sciences and Technology, Sana'a, Yemen, for routine dental treatment. These records were registered between 01 January 2013 and 31 December 2014.

For each subject, the digital panoramic radiographs were examined and associated with age and gender.

Radiographs from patients younger than 15 years and those of poor quality were excluded; two expert clinicians made the decision on the poor quality. The remaining radiographs for inclusion and analyses in the study were from 913 patients (344 males and 569 females). For each patient, the variables age, gender, total number of posterior teeth, tooth number and location (side and jaw) were recorded.

In each radiograph, only premolars and molars with complete roots and sound crowns were examined. The third molars and endodontically treated teeth were excluded. A total of 8802 teeth were included and analysed in this study.

The panoramic images were examined by two faculty members in the Department of Endodontics; the examiners had at least 5 years of experience. A tooth was considered to have pulp stone if a clear and definitive mass of opacity was observed in the pulpal space (Figure 1).

The intra-examiners reliability was calculated by re-examining a random sample of 5% (46) of the total radiographs previously examined. A 95% agreement was obtained, indicating that the scoring methods were highly reliable. Inter-examiner reproducibility was determined by calculating the kappa values for the detection of pulp stones. Kappa values were >0.9, indicating a high degree of inter-examiner agreement. In case

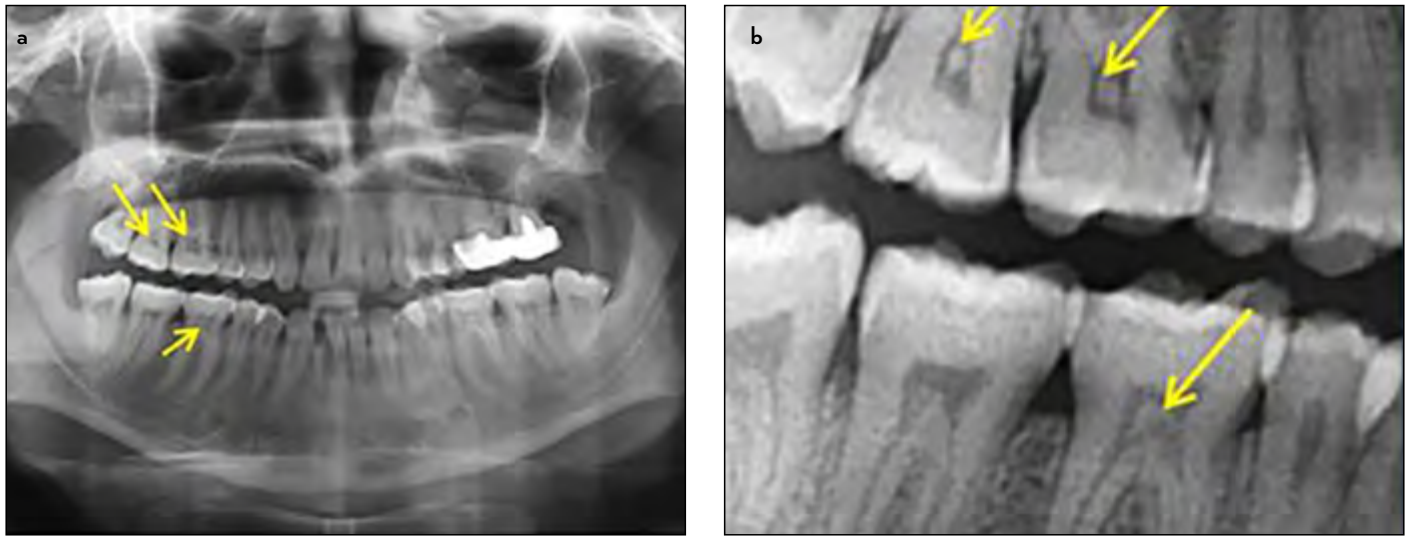

Figure 1. Pulp stones observed inside the pulp chamber in the upper and first molar in the same patient

of disagreement, the two observers came to a consensus. The data were blinded and de-identified prior to analysis (examiner had the X-rays as numbers).

This study has been conducted in full accordance with the World Medical Association Declaration of Helsinki, with an approval from the Ethics Committee in the University of Sciences and Technology, Sana'a, Yemen (MECA No:2015/62).

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) software version 22 (IBM Corp.; Armonk, NY, USA). The Pearson Chi-square test was used to analyse the association between pulp stones and sex, age, tooth type and dental arch according to the above-mentioned criteria.

RESULTS

The results are presented using (a) subject unit; (b) tooth unit and (c) affected teeth unit.

a. Subject unit

In total, 170 subjects from both genders (18.6 %) had at least one pulp stone; 107 female subjects (18.8%) and 63 male subjects (18.3%) had at least one pulp stone (Table 2). The difference between genders was not statistically significant (P=0.853).

The subjects were divided into five age groups, and the distribution of pulp stones according to these groups is shown in Table 3. A lower prevalence (9.19%) was recorded in the youngest subjects (age, 15-20 years) compared to the other age groups. However, the difference was not statistically significant (P=0.33).

Pulp stones were recorded in 108 (11.8%) subjects in the upper jaw only, whereas 16 subjects (1.8%) had pulp stones in the lower jaw only. Forty-six (5%) patients had pulp stones in both jaws (Table 4). These differences were statistically significant (P<0.001).

TABLE 2. Prevalence of pulp stones and the association with gender

Gender	Number of examined subjects	Number of subjects with pulp stones	Percentage of subject with pulp stones
Male	344	63	18.3
Female	569	107	18.8
Total	913	170	18.6

TABLE 3. Association between pulp stones and age

Subject age, years	Number of subjects with pulp stones	Number of examined subjects	Percentage of subjects with pulp stone
15-20	8	87	9.19
21-30	76	334	22.75
31-40	47	256	18.35
41-50	30	178	16.85
51-60	9	58	15.51
Total	170	913	18.61

Seventy-three (44%) subjects had only one tooth with pulp stones, while 97 subjects (56% of the affected subjects) had more than one tooth with pulp stones. In this study, three patients had six teeth with pulp stones, and eight patients had five teeth with pulp stones. The results are shown in Table 5.

b. Tooth unit

In a total of 8802 examined teeth, only 351 (3.99%) teeth with pulp stones were recorded. Pulp stones were detected in 206 of 5478 teeth (3.7%) of female subjects and in 145 of 3324 teeth (4.3%) of male subjects. No significant difference was found between genders (P=0.56, >0.05).

The association of pulp stones occurrence with tooth type, arch and side is presented in Table 6. There was a significant association between pulp stones and dental arches (P<0.001), with more pulp stones found in the maxilla.

In the two arches and in each tooth type, the occurrence of pulp stones was higher in the right side than in the left side (P<0.001; Table 6). The maxillary right first molar showed the highest occurrence (17.35%) followed by the maxillary right second molar (9.96%).

The occurrence of pulp stones in the molars was significantly higher (P<0.001) than that in premolars. Pulp stones were found in only three of a total of 4386 premolars examined. Maxillary premolars did not have pulp stones at all.

TABLE 4. Prevalence of pulp stones by dental arch

	Number	Percentage of all the studied subjects	Percentage of subjects affected with pulp stone
Subjects with pulp stones in the maxillary posteriors only	108	11,8	63,5
Subjects with pulp stones in the mandibular posterior only	16	1,8	9,4
Subjects having pulp stones in both jaws	46	5	27,1
Total	170	18,6	100

TABLE 5. Distribution of number of pulp stones in the affected subjects

Number of teeth with pulp stone	Number of subjects	Percentage of subjects		Percentage of the affected subjects
0	745	81.59		
1	73	7.99		44
2	44	4.81	= 10.4	56
3	28	3.06		
4	12	1.31		
5	8	0.87		
6	3	0.32		
	913	100		100

c. Affected teeth unit

The three premolars with pulp stones constituted only 0.9% of the 351 affected teeth. Among the 351 affected teeth, 250 first molars were recorded (71%) and pulp stones were detected in 98 second molars (28%). Among the affected teeth, the occurrence of pulp stones in the upper jaw (59%; 206 of 351 affected teeth) was significantly greater than that in the lower jaw (41%; 145 of 351 affected teeth). The percentage of pulp stones in the right side was 56% (195 of 351 affected teeth), which was more than that in the left side (44%; 156 of 351 affected teeth). These results are presented in Figure 2.

DISCUSSION

The data for this study were collected from routine digital panoramic radiographs taken for patients attending the hospital dental clinics at University of Sciences and Technology, Sana'a, Yemen. The results reflect the prevalence of pulp stones only in this sample. In this study, the prevalence of pulp stones in adults was examined. The radiographs of children and patients with mixed dentition were excluded.

According to the radiographical examination, the prevalence of pulp stones in teeth ranged from 2% to 27%, and the prevalence in individuals ranged from 12% to 63% (4-17). Histological examinations showed higher percentages (3, 7). In the present study, the prevalence is presented based on both subjects and the examined teeth number.

TABLE 6. Occurrence of pulp stones in association with tooth type, dental arch and side

	Maxilla				Mandible			
	ISO tooth number	Number of examined teeth	Number of teeth with pulp stones	Percentage of teeth with pulp stones	Tooth type	Number of examined teeth	Number of teeth with pulp stones	Percentage of teeth with pulp stones
Right side	14	550	0	0	44	539	0	0
	15	549	0	0	45	560	1	0.17
	16*†∞	559	97	17.35	46	551	27	4.9
	17*†∞	552	55	9.96	47	558	26	4.65
Left side	24	549	0	0	34	541	2	0,36
	25	555	0	0	35	543	0	0
	26*†	544	48	8.82	36	556	23	4.13
	27*†	539	50	9.27	37	557	22	3.94
		4397	250	5.68		4405	101	2.29

*Chi-square test was statistically significant for higher occurrence of pulp stones in the maxilla (P<0.001)
∞Chi-square test was statistically significant for higher occurrence of pulp stones in the right side in each jaw (P<0.001)
†Chi-square test was statistically significant for the occurrence of pulp stones in first and second molars (P<0.001)

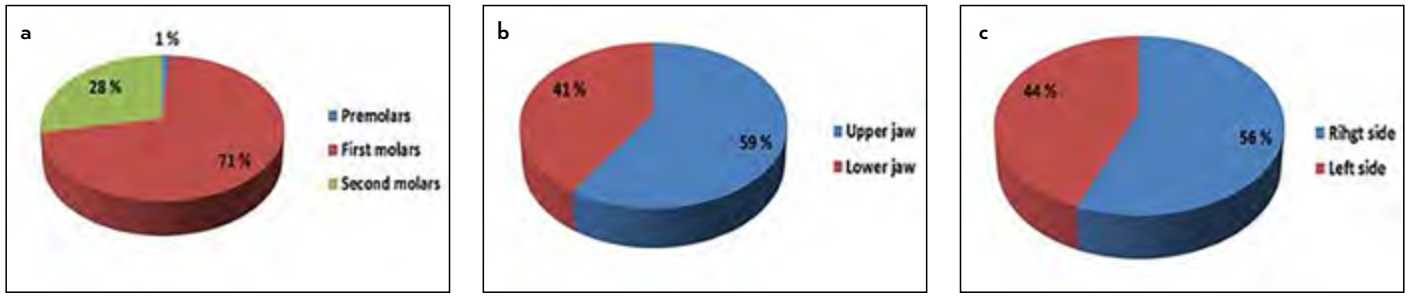

Figure 2. a-c. Distribution of the posterior teeth having pulp stones; percentage of each type of teeth among the affected teeth and (a) distribution of the affected teeth between the two jaws; (b) distribution of the affected teeth between the two sides (c)

The results of the present study showed a prevalence of 18.6% for individuals and 3.99% for the examined teeth. Compared with most previous studies, this prevalence is fairly low but quite similar to the findings in two Turkish populations (Table 1) (10, 16).

Turkal et al. (16) in their study in 2013 used the same radiographical assessment technique (digital panoramic radiography) and reported 12.7% prevalence in individuals and 2.1% prevalence for examined teeth. However, our results are similar to those found by Gulsahi et al. (10). They examined periapical radiographs of 518 Turkish patients and reported pulp stones of 12% in subjects and 5% in teeth.

The difference among these studies may be attributed to the sample difference. Several studies have been conducted to evaluate the prevalence of pulp stone in different populations and in different geographic areas; these studies have revealed different results (4-17). This could be explained by the variation of conditions related to the studied population, such as dental habits, dental care rate or ethnicity. The difference may be also attributed to the difference in sample size.

No significant difference was found between genders. Similar results were found by previous studies (7, 10). Other studies have reported that pulp stones are more common in females than in males (11, 13, 16, 17). Authors reporting that pulp stones are more common in females have speculated that more-prevalent bruxism in women may cause longstanding irritation on dentition and lead to stone formation (12, 13).

Some studies have reported a higher prevalence of pulp stones in old patients (10, 15, 17, 20). In our study, the occurrence of pulp stones was the highest in the 21-30 years age group (22.75%) and the lowest in 15-20 years group (9.19%); however, there was no significant difference between the various age groups ($P>0.05$). A similar result was also found in two previous studies (8, 11). This may be explained by the fact that 74% of the subjects included in this study were under 40 years of age and only 58 patients (6%) were >50 years old; thus, this can be considered a limitation in this study.

The occurrence of pulp stones in this study was significantly higher in the maxilla than in the mandible in each tooth type and location ($P<0.001$). Fifty-nine percent of the affected teeth were detected in the maxilla, and only 41% was detected in the mandible. This is similar to the percentage in several studies (7, 13, 16). However, others have reported no significant difference between the two arches (8, 11).

In our study, most of the pulp stones were found on the right side ($P<0.001$); 56% of the affected teeth were in the right side. Similar result was also reported by Turkal et al. (16) in the Turkish population. However, the study by Sisman et al. (13) on another Turkish population and the study by Ranjitkar et al. (7) on an Australian population showed the opposite (the left side was more affected). The study by Colak et al. (17) on a Turkish population found no significant difference between the two sides.

In all arches and sides and in both genders, the occurrence of pulp stones in molars was higher than that in premolars ($P<0.001$). The upper first molar teeth showed the highest occurrence (17.35% of all teeth and 27.6% of the affected teeth). The occurrence of pulp stones was noticed significantly more often ($P<0.001$) in the first molar (71%) than in the second molar (28%). These findings are in agreement with previous studies (7, 8, 10, 11, 17). This result may be explained by the fact that the molars are the largest teeth in the arch, its pulp is highly supplied with blood and it has the strongest chewing force in the arch. This may lead to greater precipitation for calcification; also, the fact that the first molar is the first erupted tooth led us to think that these teeth will be exposed to degenerative changes for a longer period of time (4, 8).

In this study, 97 subjects (56% of the affected subjects) had more than one tooth affected, and only 73 subjects (44%) had pulp stones in one tooth. This could be presented as an indication of the higher possibility to have ≥1 pulp stones when a subject had already one. In this study, we noticed that the maximum occurrence of pulp stones found in a single patient was six teeth (three cases; Table 5).

Based on radiography, it is only possible to detect pulp stones when its dimension is >200 μm, but radiographic assessment is the only non-invasive method to detect pulp stones (7, 21). Many studies have examined pulp stones using periapical or bitewing radiographs (5-13, 15, 17). Few studies have used digital panoramic radiographs (4, 14, 16, 20).

Bitewing radiographs were reported as the best radiographic technique to illustrate pulp calcification; these radiographs are fairly accurate with only minor distortion or magnification (9, 22). It was considered a limitation that digital panoramic radiographs do not provide a clear image of the posterior teeth with pulp stones (16).

Beside these limitations, panoramic radiographs can display the entire mouth area (all teeth on both arches) by using one X-ray. It is an advantage that panoramic images can screen for pulpal calcifications as all the teeth can be evaluated using the same image (16, 20). Furthermore, digital panoramic images may be examined using an enhancing software that enhances detection. Recently, cone-beam computed tomography (CBCT) has been used to assess the prevalence of pulp stones as this technique provides accurate anatomical details in three dimensions, thereby offering the possibility to view a individual tooth in axial, sagittal and coronal views (23, 24).

The aetiology of pulp stones is still not clearly known. Many controversies exist regarding its aetiological factors. There is evidence that pulp stones are more common in patients with cardiovascular diseases (25, 26). Another study indicated the association between pulpal calcification and coronary atherosclerosis (27). In contrast, Horsley et al. (20) found no significant correlation between pulp stones and carotid calcification.

Many authors have attempted to relate the occurrence of pulp stones to the patient's ethnicity by studying the prevalence in separate ethnic populations. However, as can be observed in Table 1, five different studies in the Turkish population presented different prevalence.

Qat chewing is a popular habit in the Yemeni population. Up to 90% of the population (male and female) and of all age categories, including teenagers, practice this habit (28). Qat chewing may cause a number of changes in the oral mucosa and the dentition. It has been speculated that the mechanical and chemical irritation may result in pulp calcification (28, 29).

The clinical relevance of pulp stones in terms of their effect on root canal treatment has been discussed (3). Their large size in the pulp chamber may block access to canal orifices and alter the internal anatomy. Attached stones may deflect or engage the tip of exploring instruments, preventing their easy passage down the canal. Sometimes, a large pulp stone can be dissected out of an access cavity using burs; however, ultrasonic instrumentation with the use of special tips makes their removal much easier.

CONCLUSION

The prevalence of pulp stones varies among populations. Pulp stones were found in approximately one-fifth of subjects in the Yemeni population, where up to 90% of the population chew Qat. This habit usually causes mechanical and chemical irritation and results in pulp calcification.

Ethics Committee Approval: This study has been conducted in full accordance with the World Medical Association Declaration of Helsinki, with an approval from the Ethics Committee in the University of Sciences and Technology, Sana'a, Yemen (MECA No:2015/62).

Informed Consent: N/A.

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