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. 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.

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.

According to radiography, pulp stones may be embedded, adherent or free. They appear as radiopaque structures within the pulp chamber or inside the root canal. They vary in shape, number and size. 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.

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 aging, 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.

**MATERIALS AND METHODS**

The present study complied with the rules and demands of the Research Ethics committee of Federal University of Juiz de Fora (Protocol 173.290). The 60 canines with similar coronal and radicular (diameter) measurements used in the study were donated by Federal University of Juiz de Fora.

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 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.

**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                |
| Ranjitkak et al. (7)    | 2002 | Australian | 217                        | 3296                   | 46.1%                  | 10.1%             | Bitewing and periapical 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                      |
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.

**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.

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

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**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                  | 100                                 |
| 1                               | 73                 | 7.99                   | 44                                  |
| 2                               | 44                 | 4.81                   | 10.4                                |
| 3                               | 28                 | 3.06                   | 56                                  |
| 4                               | 12                 | 1.31                   |                                     |
| 5                               | 8                  | 0.87                   |                                     |
| 6                               | 3                  | 0.32                   |                                     |
| Total                           | 913                | 100                    | 100                                 |

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

| 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       |                          |                                 |                                     |            |                          |                                  |                                     |
| Maxilla          | 14                       | 550                             | 0                                  | 0          | 44                       | 539                              | 0                                  |
|                  | 15                       | 549                             | 0                                  | 0          | 45                       | 560                              | 1                                  |
|                  | 16<sup>SI</sup>          | 559                             | 97                                 | 17.35      | 46                       | 551                              | 27                                 | 4.9                                |
|                  | 17<sup>SI</sup>          | 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<sup>II</sup>          | 544                             | 48                                 | 8.82       | 36                       | 556                              | 23                                 | 4.13                               |
|                  | 27<sup>II</sup>          | 539                             | 50                                 | 9.27       | 37                       | 557                              | 22                                 | 3.94                               |
|                  | Total                    | 4397                            | 250                                | 5.68       |                          | 4405                             | 101                                | 2.29                               |

<sup>SI</sup>Chi-square test was statistically significant for higher occurrence of pulp stones in the maxilla (P<0.001)
<sup>II</sup>Chi-square test was statistically significant for higher occurrence of pulp stones in the right side in each jaw (P<0.001)
<sup>III</sup>Chi-square test was statistically significant for the occurrence of pulp stones in first and second molars (P<0.001)
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 pulp 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 an 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.

Disclosures

Confict of Interest: No conflict of interest was declared by the authors.

Ethical 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).

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