Detecting calcified pulp stones in patients with periodontal diseases using digital panoramic and periapical radiographies

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Background/purpose: Pulp stones are discrete calcified masses appearing in the dental pulp of healthy, disease and unerupted teeth. They are presented freely within the pulp tissue or attached and embedded in any part of coronal and radicular dentin. Here, the purposes of this study were to identify the presence of pulp stones in periodontal patients using digital panoramic and periapical radiographies, and to determine the association with gender, age, tooth type and dental arch.

Materials and methods: This is a retrospective study on selected records of 465 dental samples obtained between January and December, 2020. Data were collected from patients diagnosed with generalized chronic periodontitis and accepted the full periodontal treatment covered by the Government’s Periodontal Health Care Program. Their digital panoramic (DPR) examination and full mouth periapical radiographic (DPA) examination (including 12 periapical and 4 bitewing images) were performed at the Outpatient Clinics of the Department of Stomatology, Taichung Veterans General Hospital. Patients were segregated into various groups according to their age, gender and tooth locations. All radiographic images were examined by a dental radiologist and two dentists to identify the presence of pulp stone calcifications and their associated factors using the Sirona applications software. Records were analyzed using SPSS version 22.0 based on tests of Pearson Chi-square and McNemar correlation.

Results: From 271 males and 194 females, a total of 465 DPR and 7440 DPA radiographs were studied. Pulp stone calcifications were identified in 270 (58.0%) subjects in DPR images and 348 (74.8%) subjects in DPA images (for 1 or more teeth per subject). We detected calcified opacities in 1031 teeth with DPR images and in 1326 teeth with DPA images from a total of 12,407 teeth. The incidence of pulp stones was similar across genders, but different in tooth locations and dental arch sextant. Moreover, pulp stones were detected more often on maxillary molars...
Introduction

Pulpal calcified structures are fairly common. Such calcification of dental pulp tissue, often known as denticle, pulp stone, or dystrophic calcification, has been studied for over a decade. Pulp stones may occur in any one or multiple teeth, deciduous or permanent, healthy or disease, and even in unerupted or impacted teeth.\(^1\)\(^2\) Pulp stone calcifications vary in number from one or more in a single tooth or in multiple teeth. Their size varies from minute particles to large calcified mass, occluding a part or the entire pulp cavity. Pulp stones are more often seen in coronal pulp although they are also found in radicular areas.\(^2\)\(^3\)\(^5\) These calcifications and/or stones are usually asymptomatic, except when impinging on the nerve or blood vessel.\(^2\) (see Figs. 1 and 2)

Despite a number of microscopic and histochemical studies, the exact causes of pulp calcification remains largely unclear.\(^7\)\(^8\) A host of factors like age, dental trauma, periodontal disease, orthodontic treatment and systemic disease are implicated.\(^7\)\(^9\)\(^16\) The prevalence of pulp stones ranges from 8% to 90%.\(^5\)\(^6\)\(^17\)\(^19\) The detection of pulpal calcifications in human dental pulp, based on radiographic examinations, has been reported to be 2.1%–63.6% across different populations.\(^17\)\(^20\) The occurrence of pulp calcifications are generally believed to be under-estimated. That is mainly because small calcified masses (<200 um) are not easily detected with radiographic imaging.\(^2\) The current digital imaging systems, including periapical, panoramic and cone-beam computed tomography radiography can provide more realistic and accurate images.\(^17\)\(^20\)\(^22\) Hence, visualizing the orientation and dimensions of pulpal structures can be better in replicating and measuring the pulp stone calcifications. However, no such related investigation has been reported regarding two commonly used clinical radiographic techniques on diagnosing pulp tissue disease and occurrence of pulp stone calcifications.

The purpose of this study was: (a) to compare two commonly used digital radiographic techniques, i.e., panoramic and periapical radiography, in detecting pulp stone calcifications at dental pulps of patients with periodontal diseases; (b) to determine the association between

Figure 1  Digital Panoramic radiography is a commonly used clinical tool to quantify the pulpal radiopacities or calcifications (red circle).
the occurrence of pulpal calcifications and related factors like age, gender, tooth type and dental arch sextant.

Materials and methods

Patient selection

Our study protocol was approved by the Institutional Review Board of Research Ethics Committee of Taichung Veterans General Hospital, Taiwan, and complied with guidelines in the Declaration of Helsinki. We retrospectively reviewed and evaluated the radiological records of a total of 465 patients (271 male, 194 female), including 12,407 teeth (7229 male, 5178 female). Patients all received full mouth periodontal treatment under the diagnosis of chronic generalized periodontitis, requiring radiographic examination as part of their oral examination and treatment modality. Periodontal treatment was covered by the Government's Periodontal Health Care Program. Images were taken with digital panoramic radiography (DPR) and full mouth periapical radiography (PAR) (including 12 periapical and 4 bitewing images). Procedures were taken at the Outpatient Clinics of the Department of Stomatology, Taichung Veterans General Hospital between January and December of 2020, before the treatment planning setting. Patients were divided into various groups according to their age, gender and tooth locations. Patients aged between 17 and 99 years old.

Image taking and data record

Radiographic examinations were taken using a digital radiography system (Sirona, Orthophos XG, Bensheim, Germany) under the manufacturer’s recommended exposure settings (8 MA, 69Kvp and 14 s). X-ray images were displayed directly on a 4G monitor at a resolution of 2560 x 1600 pixels. Images measurements were performed with the manufacturer’s software (EBM dental, Taichung, Taiwan). Image contrast and brightness were adjusted using the image-processing tool for optimal visualization. Teeth were scored as having a pulp stone when a definitive radiopaque mass had been observed in the pulp space. The pulp stone was evaluated and identified from both the DPR and PAR images, and confirmed by a senior dental radiologist and two endodontists of our hospital. Intra- or inter-observer variability was determined at the level of <5%.

Statistical analyses

Data were analyzed using the standard statistical software (IBM SPSS version 22.0, New York, USA). Bivariate associations between genders and comparisons of the DPR and the PAR imaging modalities in terms of pulp stone identifications were evaluated using Pearson’s Chi-square test. McNemar correlations test was used to determine the relationship with age, tooth location and dental arch sextants. All statistical analyse were done using SPSS version 22.0 (IBM corporation, Armonk, NY, USA) with a significance P level set at <0.05.

Results

A total of 465 patients (194 females, 271 males) were included in this one year retrospective study. Their mean of age was 48.2 ± 17.7 years (ranged from 17 to 99 years). The tooth missing rate was 16.5% (1030/6208) for females,
and 16.6% (1443/8672) for males (Table 1). Pulp cavity radiopacities were detected in 270 (58.0%) subjects on DPR images and 348 (74.8%) subjects on DPA images in 1 or more teeth, which included 110 (23.6%) in female and 160 (34.4%) in male on DPR images, and 146 (31.3%) in female and 202 (43.4%) in male on DPA images. Of individual teeth, the occurrence of pulp stone calcifications was observed 1031 teeth on the DPR images, and 1326 teeth on the DPA images (Table 1). In those DPR images, pulp stones were identified in the maxillary molar region, and also more often with old ages especially in periodontally involved teeth. Finally, the occurrence of pulp stones was the highest at the maxillary first molar (22.1% in DPR vs 28.7% in DPA), followed by the maxillary second molar (24.9% in DPR vs 19.6% in DPA), and mandibular first molar (15.6% in DPR vs 17.2% in DPA) (P < 0.05). The mandibular incisors were the least affected teeth (0.3% in DPR vs 2.4% in DPA) (Table 2). Overall, 8.3% (1031/12407) of teeth had pulp stones as examined by DPR examination, whereas 10.6% of the teeth (1326/12407) had a pulp stone easily detected in DPA images. We suggested that digital periapical radiography examinations are a great opportunity to observe and identify pulpal calcification prior aggressive dental procedures to be scheduled (Table 1).

Discussion

Pulpal calcifications occur widely in dental pulps of healthy or diseased humans, and even in un-erupted or impacted

| Table 1 Distribution of examined teeth with pulp stone calcification by patient’s characteristics. |
|---|
| **465 subjects (n = 14880 teeth)** | **Full Mouth** | **Panoramic** | **Periapical** |
| | **Missing tooth** | **Pulp stone identified** | **p value** | **Pulp stone identified** | **p value** |
| | | **Yes** | **No** | **%** | | **Yes** | **No** | **%** | |
| **Gender** | | | | | | | | | |
| Female  | 194 | 41.7 | 183 | 39.4 | 11 | 2.4 | | 110 | 23.6 | 84 | 18.1 | 146 | 31.3 | 46 | 9.8 |
| Male  | 271 | 58.2 | 258 | 55.4 | 13 | 2.7 | | 448 | 3.7 | 4730 | 38.1 | 587 | 4.7 | 4591 | 37.0 |
| **Age** | | | | | | | | | |
| 17–20  | 96  | 11.1 | 111 | 8.3 | 14880 | 12407 | 34.2 | | 1326 | 10.6 | 11081 | 98.3 |
| 21–40  | 1664 | 11.6 | 1448 | 11.6 | 118 | 10.6 | 441 | 6.5 | 202 | 15.3 | | 53.5 | 6490 | 52.3 |
| 41–60  | 8288 | 15.1 | 6291 | 12.2 | 6997 | 56.3 | | 739 | 5.9 | 6490 | 52.3 | | 53.5 | 6490 | 52.3 |
| >60  | 4832 | 32.4 | 960 | 38.8 | 3872 | 34.2 | | 353 | 25.9 | 3567 | 31.3 | 415 | 31.2 | 3457 | 31.1 |
| **n** | 14880 | 2473 | 12407 | 83.3 | | | | | | | | | | |

Chi-Square test. * p < 0.05 significantly difference, **p < 0.01 more significantly difference.
Table 2  Distribution of examined teeth with pulp stone calcification by teeth characteristics in different location.

| Pulp stone | Full Mouth | Maxillary | Mandibular | Left | Right |
|------------|------------|-----------|------------|------|-------|
|            | Panoramic | Periapical | Panoramic | Periapical | Panoramic | Periapical | Panoramic | Periapical | Panoramic | Periapical |
|            | n (%)     | p value   | n (%)     | p value   | n (%)     | p value   | n (%)     | p value   | n (%)     | p value   |
| Overall    | 11376 91.6 | 11081 89.3 | 5497 89.2 | 5458 88.7 | 5879 93.8 | 5623 89.7 | 5639 91.3 | 5493 88.9 | 5737 92.0 | 5588 89.6 |
| No         | 1031 8.3   | 1326 10.6 | 644 10.4 | 683 11.1 | 387 6.1 | 643 10.2 | 536 8.6 | 682 11.0 | 495 7.9 | 644 10.3 |
| Yes        | 617 93.0   | 644 97.1 | 255 94.6 | 239 94.8 | 362 95.7 | 369 97.6 | 301 92.9 | 311 95.9 | 316 93.3 | 333 98.2 |
| 3rd molar  | 46 6.9     | 19 2.8   | 30 10.5 | 10 3.5 | 16 4.2 | 9 2.3 | 23 7.0 | 13 4.0 | 23 6.7 | 6 1.8   |
| 2nd molar  | 1198 81.4 | 1238 84.2 | 255 94.6 | 239 94.8 | 362 95.7 | 369 97.6 | 301 92.9 | 311 95.9 | 316 93.3 | 333 98.2 |
| 1st molar  | 1098 75.6 | 1114 76.7 | 255 94.6 | 239 94.8 | 362 95.7 | 369 97.6 | 301 92.9 | 311 95.9 | 316 93.3 | 333 98.2 |
| 2nd premolar | 1547 91.0 | 1456 85.6 | 772 90.7 | 739 88.5 | 775 90.1 | 713 88.2 | 740 90.9 | 733 88.0 | 744 91.1 | 723 88.5 |
| 1st premolar | 152 8.9 | 243 14.3 | 67 96.9 | 94 11.4 | 85 98.4 | 172 86.6 | 77 90.9 | 113 17.3 | 79 8.8 | 126 14.8 |
| Canine     | 1671 94.9 | 1564 88.8 | 825 96.8 | 801 93.2 | 846 93.8 | 763 84.6 | 840 95.5 | 785 89.3 | 831 94.3 | 797 88.4 |
| Yes        | 23 1.3 | 74 7.6 | 34 3.9 | 57 6.7 | 31 3.3 | 60 5.4 | 29 3.3 | 77 8.4 | 34 3.3 | 70 8.4 |
| Lateral incisor | 1747 98.0 | 1689 80.6 | 845 96.5 | 830 94.8 | 902 99.4 | 868 95.7 | 873 97.7 | 857 95.9 | 874 98.3 | 841 94.6 |
| Yes        | 35 1.9 | 84 4.7 | 30 3.4 | 45 5.1 | 5 0.5 | 39 4.2 | 20 2.2 | 36 4.0 | 15 1.6 | 48 5.3 |
| Central incisor | 1732 98.6 | 1681 95.7 | 841 97.6 | 809 94.0 | 891 99.6 | 872 97.5 | 866 98.5 | 843 95.9 | 866 98.8 | 838 95.6 |
| Yes        | 23 1.3 | 74 4.2 | 20 2.3 | 52 5.9 | 3 0.3 | 22 2.4 | 13 1.4 | 36 4.0 | 10 1.1 | 38 4.3 |

McNemar test. *p < 0.05 significantly different, **p < 0.01 more significantly different.
The prevalence of pulpal calcification varies from 8% to 90%.

| Authors             | Population | Study Model          | Samples | Pulp stone (%) | Remark |
|---------------------|------------|----------------------|---------|----------------|--------|
| DPA images          | DPR images |                     |         |                |        |
| Hamasha et al. (1998) | Jordanian  | Periapical/Bitewing | 814     | 51.4           | Molar  |
| Ranjitkar et al. (2002) | Australians | Bitewing           | 217     | 46.1           | Max molar |
| Gulsahi et al. (2009) | Turkish    | Periapical           | 519     | 12.0           | Molar  |
| Sener et al. (2009)  | Turkish    | Periapical/Bitewing | 536     | 38.0           |        |
| Al-Nazhan (2011)     | Saudi Arabia | Bitewing      | 600     | 10.2           |        |
| Al-Ghurabi (2012)    | Iraqi      | Panoramic           | 390     | 34.8           | Molar  |
| Colak et al. (2012)  | Turkish    | Bitewing           | 814     | 63.6           | Max molar |
| Sisman et al. (2012) | Turkish    | Bitewing           | 469     | 57.6           | Max molar |
| Turkal et al. (2013) | Turkish    | Panoramic           | 6912    | 12.7           | Max    |
| Kannan et al. (2015) | Malaysian  | Periapical          | 361     | 44.9           | Molar  |
| Kumar et al. (2015)  | India      | Periapical          | 240     | 55.0           |        |
| Jayam et al. (2017)  | Nepal      | Panoramic           | 1000    | 51.4           | Max molar |
| Kalaji et al. (2017) | Yemini     | Panoramic           | 913     | 18.6           | Max    |
| Hassanabadi et al. (2018) | Iranian    | Panoramic          | 493     | 15.2           | Max    |
| Kuzekanani et al. (2018) | Iranian    | Periapical         | 412     | 31.5           | Max molar |
| Sandhu et al. (2018) | Indian     | Periapical          | 500     | 26.0           | Max molar |
| Yousuf et al. (2018) | South Indian | Panoramic   | 374     | 14.4           | Max    |
| Alawjali (2019)      | Libyan     | Panoramic           | 1200    | 30.2           | Max    |
| Sadoon et al. (2019) | Saudi Arabia | Periapical      | 298     | 28.0           | Molar  |
| SriVarsha (2019)     | Chennai    | Panoramic           | 100     | 58.0           | Max molar |
| Chen et al. (present study) | Taiwanese | Panoramic       | 465     | 58.0           | Max molar |

The consensus is the occurrence of such calcification mostly is due to dystrophy or degeneration of dental pulp tissues. Therefore, dystrophic calcification is a physiological and/or pathological manifestation. The occurrence of pulp stone calcifications we found in this present study is 58% of personal subjects (270/465) in DPR images and 74.8% (348/465) in DPA images. Such findings are similar to those reported earlier by Colak et al. (2012), Sisman et al. (2012), Kumar et al. (2015), and SriVarsha (2019). Regarding individual teeth, we found the occurrence of pulpal radiopacities being 8.3% (1031/12047) in DPR images, and 10.6% (1326/12407) in DPA images. This finding is also similar with those reports by Ranjitkar et al. (2002), AlNazhan & Sl-Shamrani (2011), Jayam et al. (2017), Kuzekanani et al. (2018). The findings supported a significant difference between two assessed radiographic techniques (Table 1) (P < 0.01).

Robertson et al., in 1997 and Holan in 1998 analyzed the incidence of calcific metamorphosis using radiographic techniques and they found a significant correlation between calcification and dental trauma. Other researchers reported the incidence of calcified bodies in the dental pulp increased with age. Our results are in line with their findings. In our study population including four age groups (from 17 to >60 years of age) and results indicated the occurrence of pulp stone calcifications in the dental pulps of periodontal disease increased with old age.
groups, particularly those aged >40 years (Table 1). Over 90.6% (935/1031) in DPR images, and 89.7% (1192/1326) in DPA images had pulp stone calcifications identified in those older age groups (p < 0.001). Studies of Hillmann & Geurtsen (1997), Fetami et al. (2012) and Chen & Huang (2016) reported higher rate pulpal calcifications in elderly patients with periodontal disease.7,12,13 These authors also suggested that the frequency, duration and intensity of chronic irritations being causative factors for such calcifications. Consistent with that, we found a high incidence of pulp stone calcifications in periodontally involved teeth up to 58.0%–78.8% respectively (p < 0.006).

In this study, we found no correlation between gender and pulp cavity calcification (p > 0.05). Our finding is in line with the work of Sayegh & Reed (1968) and Stroner & Van Cura (1984).1,4 Furthermore, the tendency we found for a higher chance of pulp calcifications in molar teeth also agrees with the most recent studies.19,32,33,35,40–42 We confirmed the higher prevalence of calcifications in molar teeth (65.1% in DPA and 44.1% in DPA) compared with bicuspids (23.3% in DPA and 33.1% in DPA) and incisors (11.4% in DPR and 22.4% in DPA) (Table 1). The underlying cause may be related to their large pulp chamber and space in the dentition, and hence greater chance to be injured and damaged during daily mastication, leading to formation of calcified stones.

In conclusion, our results are in support of pulpal calcifications commonly occurring in human dental pulp tissue. Other findings are the prevalence of pulp stone calcifications in a group of periodontal patients in Taiwan Chinese population was 58.0% with digital panoramic examination, and 74.8% with digital periapical radiographic examination. Both prevalence rates were higher than other populations such as Libyan (Alawjali 2019), Indian (Yousuf et al., 2018; Sandhu et al., 2018), Iranian (Hasanabadi et al., 2018; Kuzekanani et al., 2018), Nepal (Jayam et al., 2017), Turkish (Turkal et al., 2013; Gulsahi et al., 2009), Saudi Arabia (AlNazhan & Sl-Shamrani 2011; Sadoon et al., 2019), and Iraqi (Al-Ghurabi & Najm 2009),26,28,29,32–35,37,38,43,44 As pulp stone calcifications are likely dystrophic and degenerative manifestations, and may develop in different patterns and number and/or size due to chronic local irritation such as aging, periodontal disease, and dental trauma. In addition, we found pulpal calcifications in maxillary molar teeth being more common than in bicuspids and incisors (Table 1). Our findings of incidence of pulp calcification associated with chronic tissue inflammation (e.g., periodontal disease) which likely plays a key role in the formation of pulpal calcification. Since conflicting reports in the literature exist regarding the association between pulp calcification and systemic disturbances. Further studies on longitudinal data of larger samples would help to clarify potential correlation between systemic and medical disorders such as coronary artery disease, diabetes mellitus and renal dysfunction.

Declaration of competing interest

The authors gave no conflicts of interest relevant to this article.

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