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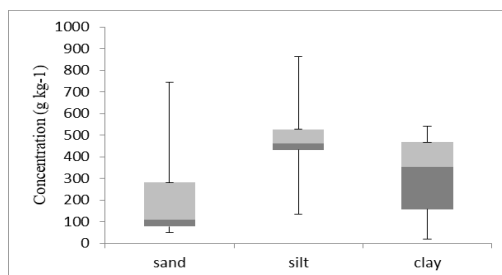
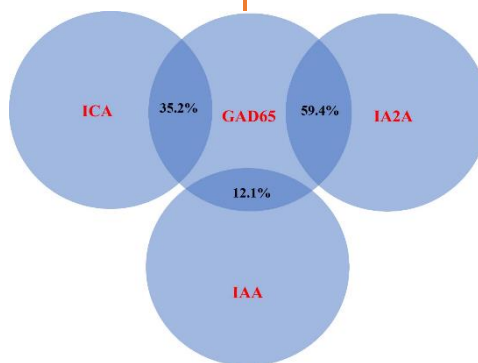
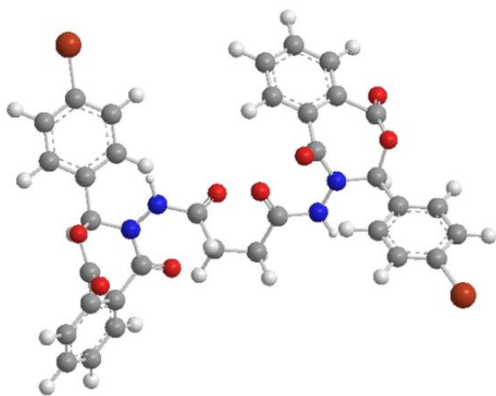
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The prevalence of pulp stones in the Kurdish population as a diagnostic tool in endodontic prognosis using Digital Orthopantomograph

Azhar Ghanim Ahmed^{1*}, Ranj Adil Jalal², Mohammed Abdalla Mahmood¹, Rukhosh Hasan Abdalrahim¹

1 Dental Basic Sciences Department, College of Dentistry, University of Sulaimani, Sulaimaniyah, Iraq

2 Oral Diagnosis Department, College of Dentistry, University of Sulaimani, Sulaimaniyah, Iraq

*Corresponding author: azhar.ahmed@univsul.edu.iq

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Abstract

Background: Pulp stones (PSs) are calcified masses, found commonly in dental pulps of healthy, diseased, and even unerupted teeth. **Objectives:** Our study aims to determine the prevalence of PS in Kurdish adults using an orthopantomograph (OPG) and investigate the relationships between PSs with sex, age, tooth type, and dental arch/side. **Patients and Methods:** We examined 1,170 digital OPGs from Kurdish patients at the private Maxillofacial Radiology Center in Sulaimaniyah City, Iraq, were taken for various purposes between January and July 2023. A total of 31,598 teeth were examined to identify PSs. We collected patient data and determined correlations between the presence of PSs and various patient variables. **Results:** About 242 (20.68%) patients and 471 (1.49%) teeth had at least one stone. The prevalence of PS in the Kurdish population was 20.68% based on the total number of patients examined and it was 1.49% based on the total teeth examined. The PS frequently was found in those aged 45 years and more (50%) and the PS prevalence was higher in females (61%) than males (39%). The maxillary dental arches and molar teeth had the highest frequency of PS ($p=0.000$). **Conclusions:** In the Kurdish population, the prevalence of PSs was moderately high, particularly among females. PSs were most frequent in the maxillary arch and first molars, with incidence increasing with age.

Introduction

Dental pulp can develop pulp stones (PS), which are nodular calcified structures, found in both in the coronal or radicular portions of the tooth. PS can affect both primary and permanent teeth whether the pulp is healthy or unhealthy, and can even occur in unerupted teeth [1]. The prevalence of these calcifications in the population varies geographically and racially [2]. PSs often formed by either aggregation of calcified material around a nucleus which is called false stone, or odontoblast-like cells are forming a calcified tissue inside the dental pulp which is called true stone and it resembles dentin [3].

Some PS greatly resemble dentin in terms of their structure and chemical properties (true stones), while some are aggregations of calcified materials only (false stones). Variations in morphology are common among pulp stones. They share similarities with dentin in terms of radio-opacity and density, with crucial chemical components including calcium and phosphorus. Additionally, fluorine, magnesium, potassium, sodium, zinc, iron, and copper may be present in PS [4,5]. Based on the location, PS may be free or attached to the dentin within the dental pulp [6].

In addition, the size of PSs can vary widely, ranging from microns to millimeters. Notably, the coronal pulp is more prone to developing PSs when compared to the radicular pulp [7]. The precise cause of PS's occurrence

is not fully known. Pulp irritation, interactions between epithelial and pulp tissue, ageing, circulation issues (low), genetics, and orthodontic force might be related to PS formation [8] that could be caused by several factors, including bruxism, iatrogenic factors such as trauma, and ongoing pulp irritation [9].

Digital orthopantomograph (OPG) serves as a cost-effective screening method for identifying dental diseases, making it an excellent initial step in investigating PS [10]. Impacted teeth may be related to PSs. The first molars are most frequently linked to PSs, then the second molars on the mandible and maxilla [11, 12]. Incisors and canines are least frequently linked to PSs [11]. Due to the occlusion of the root canal orifices caused by PSs, it may be challenging to detect root canals and there may be a higher risk of instrument fractures during endodontic therapy [13]. Hence, the primary objective of this study was to assess the prevalence of PSs in Kurdish adults using OPGs and explore potential relationships between PSs and factors such as sex, age, tooth type, and dental arch/side.

Materials and Methods

Patients and study setting

A total of 1170 OPGs of Kurdish populations who visited the private Maxillofacial Radiology Center, Sulaimaniyah City, Iraq, to take panoramic radiographs for different purposes between January to July 2023 were involved in present study. Radiographs were taken by a Pax-I 3D machine (Vatech, Korea, 2019) and images were viewed and examined with EzDent-I software by a maxillofacial radiologist. To ensure accuracy, all radiographs were examined by two independent examiners. A total of 31598 teeth were examined, once a distinct mass of opacity was seen in the pulpal area, it was scored as present, and the tooth was considered to have PS.

Sample size calculation

G*Power calculation of the sample size was 1150 subjects when the effect size was set at 0.1, the alpha level was 0.05, and the power level was set at 0.8. Then, the correlation between the availability of PS and different variables was determined.

Inclusion criteria

This study included Kurdish individuals aged between 17 and 70 years who had high-resolution Orthopantomograph free from artefacts, irrespective of gender.

Exclusion criteria

Patients with endodontically treated teeth, teeth-filled with pulpotec, a tooth with an artificial crown over it (abutment), a tooth with an orthodontic brace or band attached to it, teeth with fractured crown involving the pulp chamber, or retained root were excluded from the study.

Ethical considerations

Appropriate guidelines and regulations belonging to the Declaration of Helsinki were followed to conduct this study. The Scientific and Ethics Committees of the College of Dentistry, University of Sulaimani, Sulaimaniyah, Iraq, revised and approved the study protocol (No. 179/23-2023/UoS). Before collecting data, formal authorization was obtained from government authorities.

Statistical analysis

Statistical Package for Social Sciences (SPSS, Chicago, USA, version 26) was used to analyze the data. The distribution of the data was evaluated for normality using the Shapiro-Wilk (W) goodness-of-fit test and a p-value of ≤ 0.05 was considered significant.

Results

Out of a total of 1,170 patients' OPGs, 572 were from males (49%), and 598 were from females (51%). The patients' ages were categorized into five groups with 10 year intervals. Notably, the age group of 35 to 45 years had the highest number of patients with PS, accounting for 42.9% (60 patients) of cases.

Among the 31,598 teeth examined, 1.49% showed signs of PS. This equated to 471 teeth affected in 242 patients (20.68%). When examining the affected teeth with PS, it was observed that the first molars in all quadrants were significantly affected, with 110 cases in the upper right side, 99 in the upper left side, 33 in the lower left side, and 28 in the lower right side. Conversely, the least commonly affected tooth was the upper lateral incisor (1 case), followed by the second premolars in all quadrants (one case in each quadrant), except in the upper left quadrant, where 2 cases exhibited PS (Figures 1-3).

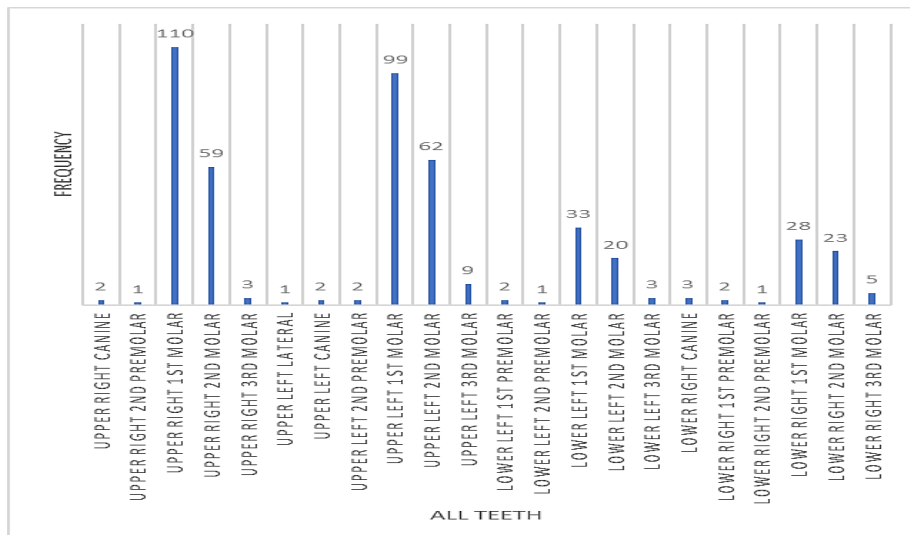


Figure 1: Pulp stone distribution among the teeth.

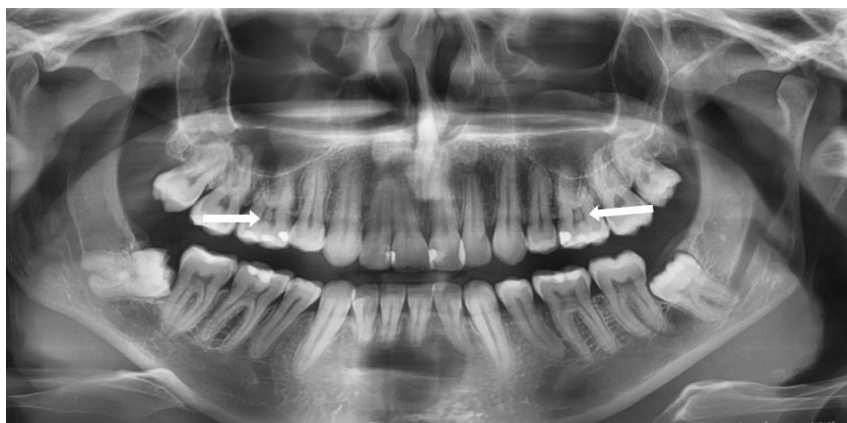


Figure 2: Coronal pulp stone of upper right and left first molars (white arrows).



Figure 3: Multiple coronal pulp stones of upper and lower molar teeth.

The distribution of PS according to gender and its relation to the quadrant is summarized in Table 1. Among females, the upper right 1st molar reported the highest incidence of PS (62.6%), followed by the lower left 1st molar (61%), the upper left 1st molar (55.2%), and the lower right 1st molar (50%). Overall, females exhibited a higher prevalence of PS compared to males

Table 1: Distribution of pulp stones according to sex and jaw quadrant

Gender	Pulp stone (Number, Percentage)					
	Upper right canine	Upper right 2nd premolar	Upper right 1st molar	Upper right 2nd molar	Upper right 3rd molar	
Male	0.0 (0.0)	1.0 (1.9)	32 (61.5)	18 (34.6)	1.0 (1.9)	
Female	2.0 (1.6)	0.0 (0.0)	77 (62.6)	42 (34.1)	2.0 (1.6)	
Total	2.0 (1.1)	1.0 (0.6)	109 (62.3)	60 (34.3)	3.0 (1.7)	
	Upper Left lateral incisor	Upper left canine	Upper left 2nd premolar	Upper left 1st molar	Upper left 2nd molar	Upper left 3rd molar
Male	1.0 (2.0)	0.0 (0.0)	2.0 (4.0)	29 (58)	15 (30)	3.0 (6.0)
Female	0.0 (0.0)	2.0 (1.6)	0.0 (0.0)	69 (55.2)	48 (38.4)	6.0 (4.8)
Total	1.0 (0.6)	2.0 (1.1)	2.0 (1.1)	98 (56)	63 (36)	9.0 (5.1)
	Lower right canine	Lower right 1st premolar	Lower right 2nd premolar	Lower right 1st molar	Lower right 2nd molar	Lower right 3rd molar
Male	0.0 (0.0)	0.0 (0.0)	1.0 (5.0)	7.0 (35)	10 (50)	2.0 (10)
Female	3.0 (7.1)	2.0 (4.8)	0.0 (0.0)	21 (50)	13 (31)	3.0 (7.1)
Total	3.0 (4.8)	2.0 (3.2)	1.0 (1.6)	28 (45.2)	23(37.1)	5.0 (8.1)
	Lower left 1st premolar	Lower left 2nd premolar	Lower left 1st molar	Lower left 2nd molar	Lower left 3rd molar	
Male	1.0 (5.6)	1.0 (5.6)	8.0 (44.4)	7.0 (38.9)	1.0 (5.6)	
Female	1.0 (2.4)	0.0 (0.0)	25 (61)	13 (31.7)	2.0 (4.9)	
Total	2.0 (3.4)	1.0 (1.7)	33 (55.9)	20 (33.9)	3.0 (5.1)	

Further analysis of the data using the Chi-square test for Goodness of Fit revealed a highly significant difference between maxillary and mandibular teeth ($p=0.000$). PS was more frequently detected in maxillary teeth (199 cases) compared to mandibular teeth (61 cases) (Table 2).

Table 2: Chi-square test, showing the differences between upper and lower teeth.

Arch	Pulp stone	Expected number	Residual	Chi-square test for Goodness of Fit
Maxillary teeth	350	235.5	114.5	value= 111.34 df=1 p=0.000*
Mandibular teeth	121	235.5	-114.5	
Total	471			

*: Highly significant difference using the Chi-square test

Regarding the correlation between gender and PS occurrence, females (61%) had more PS than males (39%) without a significant difference between them (p=0.447) (Table 3).

Table 3: The chi-square test, for Goodness of Fit shows the differences between sexes.

Sex	Frequency	Pulp stone	Expected number	Residual	Chi-square test for Goodness of Fit
	Number, Percentage				
Male	572 (49)	186 (39)	585	-13.0	value= 0.578 df= 1 p=0.447
Female	598 (51)	285 (61)	585	13.0	
Total	1170 (100)	471 (100)			

Table 4

shows a highly significant difference between all age groups about the presence of PS (p=0.000).

Table4: The chi-square test, the goodness of Fit, shows the differences among age groups.

Age group (Years)	With pulp stone	Without pulp stone	Total	p-value
	Number, Percentage			
15-25	230 (38)	375 (62)	605 (100)	0.000*
25-35	147 (41.2)	210 (58.8)	357 (100)	
35-45	60 (42.9)	80 (57.1)	140 (100)	
45-55	22 (50)	22 (50)	44 (100)	
≥55	12 (50)	12 (50)	24 (100)	

*Highly significant difference using the Chi-square test

Discussion

Pulp stone detection has been examined in histologic or radiographic studies. The radiographs underestimate the actual prevalence as they can only detect pulpal calcifications of <200 µm, but it is the only tool that can be employed in clinical studies [11,14].

In our study of the Kurdish population in Sulaimaniyah City, Iraq, the prevalence of PS was 20.68%, with 242 cases. When calculated based on the number of teeth examined, it was found to be 1.49%. Comparatively, the prevalence of PS in our study was lower than in other studies conducted on different populations, such as Taiwan (58%) [15], Pondicherry, India (54%) [10], Turkey (52%) [16], and Tirupati, Andhra Pradesh, India (51.4%) [17]. In a Saudi subpopulation, PS was found in 28% of the sample, while it was 12% when considering the number of teeth examined [18]. Other studies reported a lower prevalence rate, as 18.6% in the Yemeni population [19], 12.7% in the Turkish population [20], and 15.21% in the Iranian population and the prevalence based on the number of teeth examined was found to be 5.37% teeth [21]. In addition, Ajmal et al. [24] reported that 7.5% of 1000 subjects experienced PS, with a rate of 1.45% out of 27,184 teeth [22]. These variations in prevalence rates can be attributed to differences in sample size, research methodology (including imaging techniques), as well as the heterogeneity in the study populations. Factors such as ethnicity, dental habits, geographical variations, and oral care practices [23] all contribute to these differences.

In the current study, females had a greater PS prevalence than males (61% vs. 39%); which might be related to women being more sensitive to higher stress levels and, consequently, the higher prevalence of bruxism which can lead to long-term irritation of the teeth [8,24]; however, there was no significant difference with

males. This result is consistent with the findings of previous studies in different countries [1,20,24-27]. In contrast, several studies reported that the prevalence of PS was higher in males than females [13,28,29].

Many studies in the literature have reported pulp calcifications as an age-related phenomenon. In this study, the presence of PS was highest in the age group of ≥ 45 (50%) and lowest in the age group of 15 to 25 years (38%). This observation aligns with findings other studies [29,30], whereas Sezgin et al. [27] and Rodrigues et al. [31] noted an increased prevalence in a younger age group (31-40 years). On the other hand, Turkal et al. [20] and Hamasha and Darwazeh [28] reported no correlation between age and the occurrence of PS.

In comparison the mandibular arch, the maxillary arch had a higher prevalence of PS, with the highest incidence observed in the right maxillary molars. This result is similar to earlier research [9,13,15,20,27]. While some studies have reported that the incidence of PS in the maxilla and mandible is almost equal [16,29], others have found a higher incidence of PS in the mandible than in the maxilla [32]. These discrepancies in outcomes might be attributed to differences in the number of teeth per quadrant.

The first molars are among the first permanent teeth to erupt and have a larger surface area, making them more susceptible to occlusal stresses and potentially leading to early degenerative alterations and an increase in PS incidence. The maxillary first molar is also the largest tooth in the maxillary arch, with a large pulp chamber volume, superior load-bearing ability due to the presence of three roots, and a better blood supply, all of which may play a role in the circumstances that favour calcifications [19].

Our study is limited by the radiographic assessment technique that was utilized. It is possible that panoramic radiographs do not depict PS in the anterior teeth. Bitewings are preferred because they provide a clearer image with a greater definition of the pulp chamber, but one of the primary benefits of panoramic radiography is that it can display both jaws on a single radiographic image with a lower radiation dose than a full mouth series of periapical or bitewing radiographs. We could retrospectively examine the entire teeth for PS using a panoramic scan without re-exposing the patient to bitewing radiation. It would be an ideal radiograph for pulpal calcification screening [33].

Conclusions

The prevalence of PS in the Kurdish population of Sulaimaniyah City, Iraq, was moderately high when assessed based on the total number of patients examined but low when based on the total teeth examined. A significant association was detected in the prevalence of PS with age and dental arch. Notably, females were more prone to PS than males. Furthermore, the frequency of PS was significantly higher in the upper first molars. The presence of PS can be a significant concern, often detected incidentally. It's important to note that PS is not a rare condition, and caution should be exercised during endodontic treatment, as these stones can interfere with procedures and necessitate adjustments to the treatment plan.

Conflict of interest

The authors confirm that they are not affiliated with or involved in any organization or entity with financial interests.

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