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## REVIEW ARTICLE

# A systematic review assessing the dental pulp stone prevalence in the Saudi Arabian population

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**Abstract** This Systematic Review (SR) was to report on the prevalence of pulp stones in the Saudi Arabian (KSA) population. The electronic databases were searched for scientific research articles during May 2021. The data search was performed in electronic search engines like PubMed, Scopus, Web of science, and Saudi Digital Library, and 6 original research articles which fulfilled the eligibility criteria were assessed for qualitative data. The prevalence of pulp stones among the KSA population ranged from 4.6% to 50.93% among the study participants and it ranged between 10.2%–13.34% in the teeth assessed. The pulp stones were more frequently reported in decayed teeth, periodontal diseases, attrition, teeth with dental restorations, and higher in the molar teeth in comparison with the premolar teeth. The data on the prevalence of pulp stones among the Saudi population will be helpful for clinicians in planning endodontic procedures.

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## 1. Introduction

Pulp Stones (PS) found within the pulpal tissues of a tooth, which are either attached or can be found embedded within the dentine of the tooth (Kaswan et al., 2014; Ozkalayci et al., 2011). Pulp stones is usually found in the coronal as well as the radicular pulp and may vary from microscopic to macroscopic in their dimensions. Based on their histological features they have been classified as true and false pulpal stones. The true pulp stones is made up of irregular dentine (Patil and Sinha, 2013). Pulp stones usually appears on a radiograph with a round or oval shape (Ertas et al., 2017). They may appear as single large opacity or may even appear as small opacities with the pulp chamber (Kansu et al., 2009). The number of pulp stones within the pulp chamber of a single tooth may vary from one to twelve or even more in number (Bevelander and Johnson, 1956; Ranjitkar et al., 2002). The etiology behind the formation of the pulp stones is still unclear. There have been several factors that have been correlated with their occurrence. Several predisposing factors like aging, the presence of long-standing dental caries, wasting diseases like attrition and abrasion, reduced blood supply to the pulpal tissues, dental operative procedures, and orthodontic therapy are considered as the alterations that could lead to the formation of pulp stones that are nothing but calcifications around blood thrombi, collagen fibers or degenerating cells (Berès et al., 2016; Goga et al., 2008; Jain et al., 2014; Patil and Sinha, 2013). The chronic pathological irritation caused by the microbial process within the long-standing dental caries leads to vascular injury within the pulpal tissues which eventually results in the deposition of calcium salts and resulting in the formation of pulp stones (Baghdady et al., 1988). Studies that have assessed the prevalence of pulp stones in different

populations have reported that the frequency of occurrence of pulp stones may increase with the growing age and it is different between sex (al-Hadi Hamasha and Darwazeh, 1998; Hill, 1934; Sayegh and Reed, 1968; Sundell et al., 1968). Other prevalence studies have also reported that females experience a higher occurrence of pulp stones when compared with the male population (Sisman et al., 2012; Tamse et al., 1982). The frequency of the occurrence of pulp stones is very important for clinicians especially the one performing the endodontic treatment, the pulp stones which are located within the pulp chamber or the root canals often narrow and even lead to the obstruction of access to the apical end of the root canal. This could eventually result in increased difficulty in performing the endodontic treatment and in a greater amount of stress on the NiTi rotary instrument used (Gambarini et al., 2020; Zeng et al., 2011). Hence this Systematic Review was taken up to report on the prevalence of pulp stones among the KSA populations by adhering to PRISMA guidelines.(See Tables 1 and 2)

## 2. Materials and methods

### 2.1. Protocol and Registration

The international prospective register of systematic reviews (PROSPERO) database was searched for registered protocols on reporting the prevalence of pulp stones in the Saudi Arabian Population and no registered protocol was found. Hence the present Systematic Review (SR) was taken up after reviewing the guidelines for Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2009). This protocol was registered in the PROSPERO with Reg. No 243908.

**Table 1** Shows the details of the characteristics of cross-sectional studies that were included in this systematic review.

Serial Number	Authors	Year of Publication	Study Region	Study Objective	Examination technique/ Radiographic technique	Gender	Number of patients examined and prevalence	Number of teeth examined and prevalence	Risk of Bias
1	S Al-Nazhan et al ( <a href="#">Saad Al-Nazhan and Saleh Al-Shamrani, 2011</a> )	2011	Riyadh	To determine the prevalence of pulp stones in a group of Saudi Arabian population using radiographs.	Bitewing radiograph	M = 319 F = 281	N = 600 Prevalence = 46.8%	N = 8456 Prevalence = 10.2%	Moderate
2	S R. Patil et al ( <a href="#">Patil et al., 2018a</a> )	2018	Aljouf	To determine the prevalence of pulp stones using cone beam computed tomography among Saudi Arabian population	CBCT Images	M = 236 F = 192	N = 428 Prevalence = 50.93%	N = 2982 Prevalence = 13.34%	Moderate
3	S R. Patil et al ( <a href="#">Patil et al., 2018b</a> )	2018	Aljouf	To assess the prevalence of pulp stones using Cone Beam Computed Tomography (CBCT) in a Saudi Arabian adolescent population.	CBCT Images	M = 148 F = 89	N = 237 Prevalence = 50.02%	N = 1018 Prevalence = 10.06%	Moderate
4	Alsweed A et al ( <a href="#">Alsweed et al., 2019</a> )	2019	Qassim	To determine the prevalence of carotid artery calcifications (CACs) and pulp stones detected on panoramic radiographs (PRs) among Saudi Arabian subpopulation	Panoramic radiographs	M = 1212 F = 801	N = 2013 Prevalence = 4.6%	Not mentioned in the article	Moderate
5	Sadoon et al ( <a href="#">Sadoon et al., 2019</a> )	2019	Hail	To study the prevalence of pulp stones among Saudi subpopulation using periapical radiographs	Intra oral periapical radiograph	M = 153 F = 145	N = 298 Prevalence = 28%	N = 1306 Prevalence = 12%	Moderate
6.	Srivastava et al	2020	Sakaka	To evaluate the the prevalence pulp stones in the Saudi Arabian population with cardiovascular diseases, diabetes mellitus and healthy	CBCT images	M = 231 F = 238	N = 229 Prevalence = 22.27%	N = 4807 Prevalence = 9.75%	Moderate

**Table 2** Risk of Bias Assessment of the selected studies.

First authors name/Year of publication	S. No	1. Was the sample frame appropriate to address the target population?	2. Were study participants sampled in an appropriate way?	3. Was the sample size adequate?	4. Were the study subjects and the setting described in detail?	5. Was the data analysis conducted with sufficient coverage of the identified sample?	6. Were valid methods used for the identification of the condition?	7. Was the condition measured in a standard, reliable way for all participants?	8. Was there appropriate statistical analysis?	9. Was the response rate adequate, and if not, was the low response rate managed appropriately	Overall risk of bias
Al-Nazhan/2011(Saad Al-Nazhan and Saleh Al-Shamrani, 2011)	1	No	No	No	Yes	Yes	Yes	Yes	Yes	Not applicable	Moderate
Patil et al / 2018 (Patil et al., 2018a)	2	No	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Moderate
Patil et al/ 2018 (Patil et al., n.d.)	3	No	No	No	Yes	Yes	Yes	Yes	Yes	Not applicable	Moderate
Alsweed A et al /2019 (Alsweed et al., 2019)	4	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Not applicable	Moderate
Sadoon et al / 2019 (Sadoon et al., 2019)	5	No	No	No	Yes	Yes	Yes	Yes	Yes	Not applicable	Moderate
Srivastava et al / 2020 (Srivastava et al., 2020)	6	No	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	Not applicable	Moderate

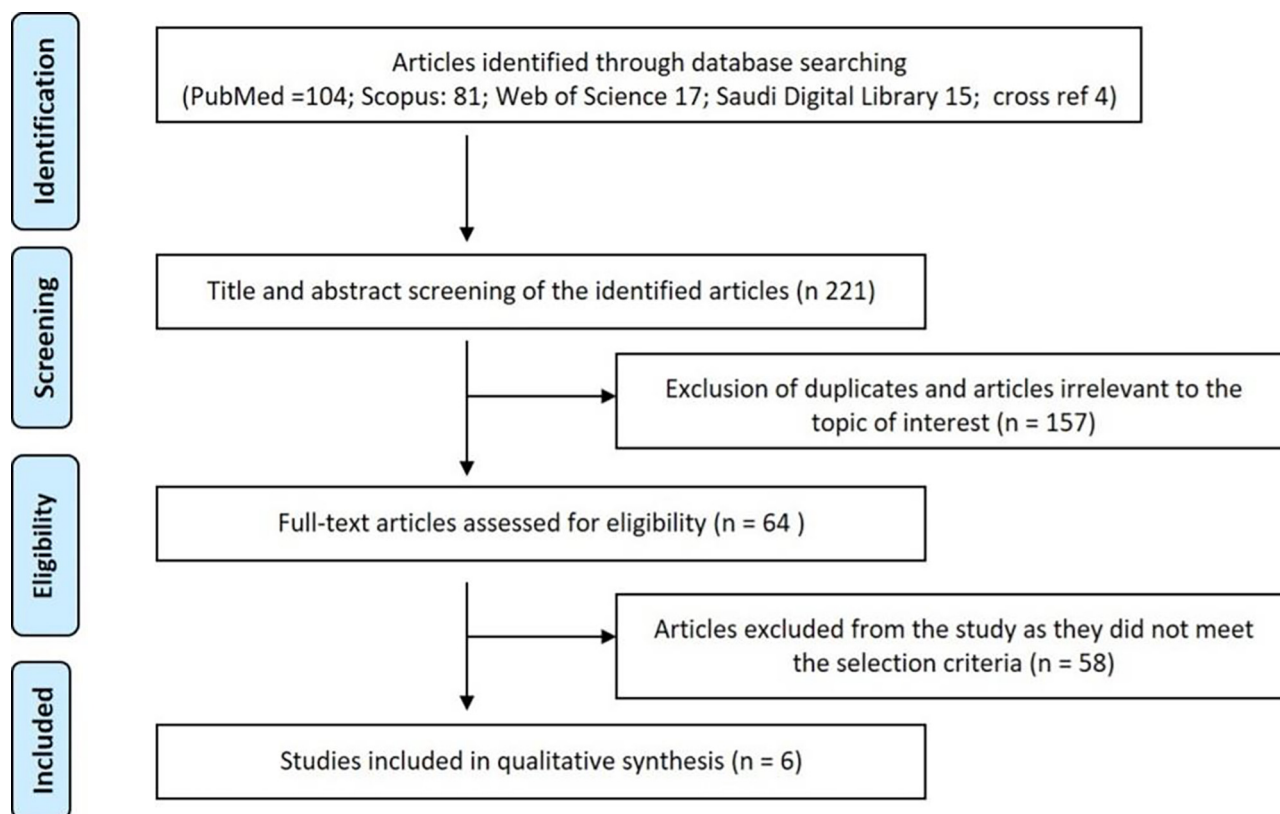


Fig. 1 Pulp stone article.

## 2.2. Search Strategy

Two independent researchers performed the search of articles in the electronic databases. The electronic databases were searched for scientific research articles during May 2021. Key-words combinations such as “prevalence of pulp stones and Saudi Arabia” and “prevalence of pulp calcifications” with Boolean operators such as AND electronically searched the available databases such as PubMed, Web of Science, Scopus, and Saudi Digital Library for identification of potential articles. The English language was used as a filter to select the articles for the present SR. In addition, the authors manually searched the reference lists of the included studies to ensure comprehensive literature search. The title and abstract of each article were screened for the initial selection to identify relevant articles. The preliminary search yielded 221 articles that were related to our research topic. Out of these 157 articles had to be eliminated to avoid the duplication of data and the research topic was not related to the prevalence of pulp stones. After this elimination process, a total of 64 articles were left for evaluation in the next stage. In the next stage, these articles were screened by applying the selection criteria.

## 2.3. Selection criteria

### 2.3.1. Inclusion criteria

In this systematic review cross-sectional observational studies that estimated the prevalence of **pulp stones** among the KSA population were included. There was no age limit for the study population in the inclusion criteria.

### 2.3.2. Exclusion Criteria

Conference papers, research papers with only abstracts, case reports, and review articles were excluded.

### 2.3.3. Focus question

This systematic review aimed to address the potential focus question based on the following criteria: Population (P): Saudi Arabian Population; Study design (S): Observational studies, cross-sectional studies, cohort studies, case-control studies; Outcome (O): Prevalence of pulp stones (Järbrink et al., 2016). Focus question: What is the prevalence of **pulp stones** in the Saudi Arabian (KSA) population?

### 2.3.4. Study selection

Finally, the 6 articles which met the selection criteria were considered in this SR for quality synthesis (Fig. 1).

## 2.4. Risk of bias assessment of the selected studies:c

The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for studies reporting prevalence data (last amended in 2017) was used to assess the risk of bias of all the 5 included articles. The parameters assessed included appropriateness of sample frame, sample method, adequacy of sample size, description of study setting and participants, the conduct of data analysis with adequate coverage of the identified sample, methodology used for identification of the condition, reliability of the measurement of condition for all participants, statistical analysis, and adjustment of non-response rate (Joanna Briggs Institute., n.d.; Ma et al., 2020).



### 3. Results

#### 3.1. Search results

In the present SR totally 5 original research articles which had met the eligibility criteria were assessed for qualitative data. All 5 selected studies were cross-sectional studies and were conducted in different parts of Saudi Arabia over the last 10 years. The sample size in the included studies ranged between 237 and 2013 study subjects and the total number of teeth assessed for the presence of **pulp stones** ranged between 1018 and 8456 teeth. The prevalence of **pulp stones** among the KSA population ranged from 4.6% to 50.93% and in the teeth assessed it ranged between 10.2%–13.34%.

#### 3.2. Data extraction and qualitative synthesis

These studies were conducted in different regions of KSA. One study was conducted in Riyadh, two studies in Aljoud and two other studies respectively in Qassim and Hail, and one in Sakaka (Alsweed et al., 2019; Patil et al., 2018b, 2018a; Saad Al-Nazhan and Saleh Al-Shamrani, 2011; Sadoon et al., 2019; Srivastava et al., 2020). There was mention of sample size estimation in only one of the selected studies (Patil et al., 2018a). The sample size of the study population in the included studies varied from 237 to 2013 study subjects. The radiographic evaluation techniques used for assessing the presence of pulp stones in the included studies in this systematic review were done using Bitewing radiographs; Cone-beam computed tomography (CBCT) images, Orthopantomogram (OPG), and Intraoral Periapical Radiograph (IOPAR).

All the included studies had a moderate risk of bias (Alsweed et al., 2019; Patil et al., 2018a, 2018b; Saad Al-Nazhan and Saleh Al-Shamrani, 2011; Sadoon et al., 2019; Srivastava et al., 2020).

A study conducted by Al-Nazhan et al. assessed the prevalence of pulp stones in a group of KSA population using bitewing radiographs (Saad Al-Nazhan and Saleh Al-Shamrani, 2011). The authors reported examining the radiographs of 600 study subjects which comprised of 8456 teeth. The prevalence of pulp stones among the 600 study participants was 46.8% and the prevalence in the 8456 included teeth was 10.2%. The authors also reported that the prevalence of pulp stones was more in the molars in comparison with premolars, which was statistically significant. The teeth with attrition and the aged patients had a higher frequency of pulp stones and were statistically significant. Patil et al. assessed the prevalence of pulp stones among the KSA population using CBCT images (Patil et al., 2018a). A total of 428 study subjects comprising of 2982 teeth were assessed for the presence of pulp stones. The prevalence of pulp stones was 50.93% among the study subjects and 13.34% among the included teeth. The prevalence of pulp stones was higher among the male subjects in comparison with the female subjects and was statistically significant. The presence of pulp stones was higher in the teeth affected with dental caries, teeth with attrition and the teeth affected with periodontal diseases in comparison with intact teeth and the difference were statistically significant. Patil et al. in another study assessed the prevalence of pulp stones among the KSA adolescent population using CBCT images (Patil et al., 2018b). A total of 237 study subjects comprising of

1018 teeth were assessed for the presence of pulp stones. The prevalence of pulp stones was 50.02% among the study subjects and 10.06% among the included teeth. There was no significant difference in the frequency of pulp stones when compared with gender, dental arches, and sides of the jaws. The presence of pulp stones was higher in the teeth affected with dental caries and teeth with dental restorations. Alsweed et al. in their study assessed the prevalence of pulp stones and correlated it with the prevalence of carotid artery calcifications (Alsweed et al., 2019). The authors reported assessing panoramic radiographs of 2013 study subjects. The prevalence of P pulp stones was 4.6%. The prevalence of pulp stones was higher among the younger population in comparison with older study subjects and the difference was statistically significant. There was no significant difference in comparison with gender. Abdulmjeed et al. assessed the prevalence of pulp stones among the Saudi Arabia subpopulations using intraoral periapical radiographs (Sadoon et al., 2019). A total of 298 study subjects which comprised 1306 teeth were screened for the presence of pulp stones. The prevalence of pulp stones was 28% among the study subjects and 12% in the included teeth. The authors also reported that the presence of pulp stones was higher in the teeth affected with dental caries and teeth with restorations. The prevalence was also noted to be higher among the aged subjects in comparison with the young subjects. Srivastava et al. (Srivastava et al., 2020). reported the prevalence of pulp stones among Saudi Arabian subpopulations using cone-beam computed tomography (CBCT). In their study among 229 individuals, 22.27% had pulp stones and among 4807 teeth 9.75% had pulp stones. They reported that both pulp stones was more prevalent in patients with cardiovascular disease followed by diabetics and least in the control group. they also reported that patients with cardiovascular disease had 2.94 times more risk and patients with diabetes had 8 times more risk of pulp stones. Among the teeth first molar had a 2.20 times higher risk for pulp stones in comparison with other teeth.

### 4. Discussion

The current data on the prevalence of pulp stones has a wide range from 8% to 90% which has been attributed to the difference in the method used for assessment of the presence of pulp stones such as intra oral periapical radiograph, bite wing radiograph and histology. The sensitivity and specificity of each method is different hence there may be variations in identification of the pathology (Moss-Salentijn and Hendricks-Klyvert, 1988). Conventional radiographic techniques which mainly include intraoral periapical radiographs, bitewing radiographs, and panoramic radiography are the most used techniques for assessing the presence of pulp stones due to the ease of operation and cost effectiveness. With the advancement in radiographic techniques like the CBCT diagnostic tools, which provide high resolution and three-dimensional imaging have the advantage of providing more accurate anatomic details in comparison with the conventional radiographic techniques. Studies that have reported on the prevalence of pulp stones also underlined that histological exams provide an enhanced report on pulp stones and can demonstrate higher numbers, but its invasive technique is one of its major limitations (Kannan et al., 2015; Rodrigues

et al., 2014). In this SR articles have reported on the prevalence of pulp stone used intraoral periapical radiographs, bitewing radiographs, panoramic radiographs, and CBCT imaging techniques (Alsweed et al., 2019; Patil et al., 2018a, 2018b; Saad Al-Nazhan and Saleh Al-Shamrani, 2011; Sadoon et al., 2019). One of the major limitations of using radiographic techniques for accessing the prevalence of pulp stones is that the diameter of these calcified bodies has to be more than 200um to be detected through radiographic technique as projectional radiographic method requires particular size of calcification to depict radio opacity and the rays can pass through calcifications that are less than 200 um (Moss-Salentine and Klyvert, 1983). In comparison, a microscopic method is considered more accurate in reporting the actual prevalence of pulp stones (Goga et al., 2008; Kansu et al., 2009) which could be attributed to the fact that histological sections could detect smaller size of pulp stones that are not visible radiographically. Studies conducted by Patil et al. (Patil et al., 2018b) and Alsweed et al. and Srivastava et al (Srivastava et al., 2020) mentioned that there was no difference in the prevalence of pulp stones concerning gender (Alsweed et al., 2019). A study conducted by Patil et al. reported that the prevalence was higher among the male participants in comparison with the female participants, which is contrary to the studies reported in the literature that says there is a female prevalence as previously described (Saad Al-Nazhan and Saleh Al-Shamrani, 2011). Several studies have reported that the frequency of pulp stones is higher among female participants in comparison with the male participants (Baghdady et al., 1988; Satheeshkumar et al., 2013; Sener et al., 2009; Sisman et al., 2012; Turkal et al., 2013). The higher prevalence of pulp stones among the female population could be due to the larger frequency of bruxism among females that has been reported in literature and this chronic irritation could initiate calcifications (Sener et al., 2009). In the present SR, studies conducted by S Al-Nazhan et al., S Abdulmejed et al., and Srivastava et al. (Srivastava et al., 2020) reported that the prevalence of pulp stones was higher among the aged participants in comparison with the younger participants (Saad Al-Nazhan and Saleh Al-Shamrani, 2011; Sadoon et al., 2019). These findings were under the findings reported from other studies (Hekmatian and Shokrgozar, 2015; Javadzadeh et al., 2014; Kazemizadeh, 2011). These findings could be explained by the age-related changes that occur within the tooth, where there are atherosclerotic changes and hypoperfusion of pulp, followed by secondary dentin deposition with a subsequent increase in the amount of connective tissue (Alsweed et al., 2019). A study conducted by Alsweed et al. reported that the prevalence of pulp stones was higher among the younger participants in comparison with the older participants (Patil et al., 2018b). These findings were contrary to the studies reported in the literature that could be attributed to the sample size and sample population selected in the study. In the present SR, a study conducted by Al-Nazhan et al. and Srivastava et al. (Srivastava et al., 2020) reported that the prevalence of pulp stones was higher in the molar teeth in comparison with the premolar teeth, these findings were following the findings reported in the literature (Baghdady et al., 1988; Saad Al-Nazhan and Saleh Al-Shamrani, 2011; Sisman et al., 2012). These variations among the tooth could be due to the early eruption of the first molar in comparison with other teeth, which could be the reason for longer exposure with the oral cavity that could be exposed to chronic irritation

due to mastication speech etc. (Alsweed et al., 2019). In the present systematic review, the studies conducted by Al-Nazhan et al. and Patil et al. reported that the prevalence of pulp stones was higher with the teeth affected by wasting diseases like attrition, dental caries, and periodontal diseases (Patil et al., 2018a; Saad Al-Nazhan and Saleh Al-Shamrani, 2011). This could be attributed to the fact that wasting diseases of the teeth are associated with chronic inflammation that could initiate calcification. Studies conducted by Patil et al. (Patil et al., 2018b) and Alsweed et al. (Alsweed et al., 2019) reported that the prevalence of pulp stones was higher with the teeth affected with dental caries and the teeth that were having dental restorations when compared with the intact teeth. These findings were the following studies reported in the literature and could be attributed to the chronic irritation and stimulation from dental caries process (Kannan et al., 2015; Ranjitkar et al., 2002; Sener et al., 2009). The association of periodontal diseases and dental caries is related to inflammatory changes and then circulatory interference (Patil et al., 2018b). Considering systemic diseases, Srivastava et al reported that patients with cardiovascular diseases and diabetes mellitus had a higher risk of developing pulp stones in comparison with the control group. It has been reported that the presence of pulp stones has an increased risk for cardiovascular disease (Ezoddini-Ardakani et al., 2015; Srivastava et al., 2020). This could be correlated with the calcification of atherosclerotic plaques as a predisposing factor for cardiovascular disease. The increased prevalence of pulp stones in diabetic individuals could be attributed to obliterative endarteritis as a result of aging. Pulp is more prone to calcification as there is no collateral vascularization for the pulp tissue (Nayak et al., 2010). The clinical importance of detecting pulp stones is to avoid the difficulties that could be encountered during endodontic procedures pulp stones could interrupt the access to the canal orifices during the endodontic procedures and could prevent the easy passage of the endodontic instruments into the root canals. The knowledge of these situations before starting the endodontic treatment can avoid the development of high stress and high level of operative torque which can probably lead to intracanal instrument separation (Seracchiani et al., 2021). The presence of pulp stones does not prevent the use of rotary instruments, but their management is more complex: it is recommended to use lubricants and frequent canal washing with different irrigants to avoid instrument separation or other iatrogenic errors (Mazzoni et al., 2020). The limitations of this paper are that only cross-sectional observational reporting on the prevalence of pulp stones were included as there were no data available on the prospective assessing the prevalence of pulp stones which would be more reliable. Further prospective studies need to be conducted in the future to know the incidence of pulp stones, which could provide more information on the factors associated with the occurrence of pulp stones. In all the included studies the sample frame was not representative of the population and was confined to the patients visiting a single hospital or a few selected hospitals. Also, the sample size calculation was adequate only in one study. The prevalence of pulp stones in the included studies was low, hence meta-analysis comparing the gender and geographic variations would have minimal clinical significance. Hence the present SR was confined only to systematic review and meta-analysis was not performed. Future studies with adequate sample

frames, sampling methods, and sample size have to be carried out to determine the prevalence of pulp stones among the Saudi Arabian population.

## 5. Conclusions

The prevalence of pulp stones among the included studies in this SR ranged from 4.6% to 50.93% among the study participants and it ranged between 10.2%–13.34% in the teeth assessed. The pulp stones were more frequently reported in teeth affected with dental caries, periodontal diseases attrition, and teeth with dental restorations. The prevalence of pulp stones was found to be higher in the molar teeth in comparison with the premolar teeth. Aging is associated with an increase in the prevalence of pulp stones. These findings will be helpful for clinicians in planning endodontic procedure as pulp stones in pulp chamber or the root canals often narrow and even lead to the obstruction of access to the apical end of the root canal and give greater amount of stress on the NiTi rotary instrument used.

## Ethical statement

Not applicable.

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## CRediT authorship contribution statement

**Sandeepa Nuchlakath Chalikkandy:** Conceptualization, Formal analysis, Project administration, Writing – review & editing. **Shilpa Bhandi:** Formal analysis, Software, Supervision, Writing – review & editing. **Hamed Ahmed Ali Al Shawkani:** Formal analysis, Software, Visualization, Writing – review & editing. **Mohammed Hussain Dafer Al Wadei:** Data curation, Project administration, Validation, Writing – review & editing. **M. Mohammed Abdul Kader:** Investigation, Software, Writing – review & editing. **Atfal Hassan Hussain Jaafari:** Data curation, Methodology, Validation, Writing – original draft. **Thilla Sekar Vinothkumar:** Data curation, Methodology, Visualization, Writing – original draft. **Saranya Varadarajan:** Conceptualization, Investigation, Resources, Writing – original draft. **Luca Testarelli:** Conceptualization, Investigation, Writing – original draft. **Shankargouda Patil:** Resources, Supervision, Visualization, Writing – original draft.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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