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Pulpal Calcification and Stone Formation: Literature Review

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Abstract

Pulp stones are detected as calcified, nodular masses that are found in the root or coronal portions. They are formed due to the aggregation of calcifications in the tooth pulp of various types. These include the embedded, attached, and freestones, based on the site and true, false and diffuse stones. Furthermore, it can be based on the structure or on the presence and absence of lamination. Many factors have been reported to be associated with pulp stones such as age, genetic factors, orthodontic tooth movements and other systemic disorders. The prevalence rate of pulp stones is greatly variable due to the method of investigation for detecting the lesion, and the difference in patients' demographics and associated factors. The clinical significance of pulp stones remains debatable, however, it can result in severe pain and may be considered a marker for many systemic disorders as reported. Therefore, pulp stones should be dealt with in a clinical constructive manner to decrease morbidity.

Keywords: *Pulp Stones; Calcification; Prevalence; Etiology; Review; Dentin*

Introduction

Pulp stones are detected as calcified, nodular masses that are found in the root or coronal portions. They are formed due to the aggregation of calcifications in the tooth pulp. Dental pulp calcification can occur discretely as calcific stones or diffusely. Moreover, it can occur as a free calcific material within the dental pulp or can be found embedded in or attached to the pulp dentin [1]. Additionally, these stones have been differentiated microscopically into true and false calcification forms. According to their microscopic nature, pulp stones are usually asymptomatic, however, symptoms can occur secondary to irritation or compression of the related nerves or blood vessels [2]. It has been found that pulpal calcification usually occurs in apparently-normal teeth, but can also occur in all conditions even unerupted teeth [3].

Pulp stones can either be a single or multiple stones affecting teeth with variable shapes and sizes. A previous study showed that a range of 1 - 12 stones can be detected in a single tooth and that the size of these masses is hugely variable varying from microscopic

lesions to macroscopic, relatively-large masses that can cause pulp space occlusion [4]. These lesions can be detected radiographically, however, it is considered bery challenging to be detected clinically. Radiologically, pulp stones are detected as radiopaque lesions residing in the pulp root or chamber. While they can be found as oval or round structures, some of them may be large enough to take the shape of the containing pulp [5]. Moreover, their sizes are hugely variable and can even reach up to 2 - 3 mm in diameter in some cases. Meanwhile, not every radiological modality have the capability of detecting small stones, hence the importance of early detection.

Calcific pulp stones may be found in all teeth types, however, they are most frequently found in the molars [5]. It has been estimated that around 50% of all young men and many individuals over 50 years of age have pulp stones in their teeth that can be detected [5]. Many factors have been associated with the formation of calcific pulp stones. These include idiopathic factors, age, pulp circulatory disturbances and degeneration, abnormal inductive interactions between the epithelium and pulp tissue, bacterial infections, excess fluoride supplementation, orthodontic tooth movements, genetic factors, and Marfan syndrome [1,2,6,7]. Moreover, other factors such as dental caries, which can induce chronic irritation, has been suggested to induce calcific pulp stones secondary to irritation for self-regeneration, chronic inflammatory disorders, and previous deep fillings have been also related to pulp stones formation [1]. Many studies have been published investigating the aforementioned information, however, there is still a lot of information to investigate and analyze. In this study, we aim to review the different aspects of pulp calcification and stone formation from previous studies published on the same topic.

Methods

We performed an extensive literature search of the Medline, Cochrane, and EMBASE databases on 26th October 2020 using the medical subject headings (MeSH) or a combination of all possible related terms. Papers discussing the different aspects of pulp calcification and stone formation were screened for relevant information. We did not pose any limits on date, language, age of participants or publication type.

Histopathology and classification of pulp stones

Many factors have been proposed for the development of calcification and stone formation. Early studies showed that experimental intrusion induced the aggregation of islands of cells, which are thought to be from an epithelial origin, mainly [8-12]. These cells were observed within the main bulk of the pulp stones. The process of calcification has been usually associated with the development of false stones. Goga., *et al*. [13] reviewed all the published mechanisms that can eventually lead to pulp stone formation and provided a discussion for all the possible explanations. Moreover, based on previous studies in the literature, the process of calcification was usually associated with age as an increased number of calcification increases with the advancement in age [14-16]. This fact was indicated by previous studies which showed that increased prevalence rates of pulp stones were associated with elderly patients [17,18]. This is logical because, with aging, deposited materials increase, and blood supply decrease which induces ischemia and decreased sensations allowing more materials to accumulate, and therefore, dystrophic calcification is usually frequent, although they might have variable degrees [14-16]. Moreover, with aging, the number of cells decrease which reduces the chances of tissue regeneration, and patients are more prone to the deposition of many materials [19,20]. Therefore, care and advice should be offered for older patients to maintain good oral health and prevent any complications.

Many classification systems have been proposed to generate types of pulp stones. A structural classification of the pulp stones was proposed by Seltzer., *et al*. [21] which classified stones based on their location into true, false, and amorphous or diffuse pulp stones. The latter type was proposed by Mjor., *et al*. [22] in 1973 and illustrated that these diffuse lesions have irregular shapes and tend to occur near the blood vessels. The difference between true and false pulp stones is that the first ones are formed from dentine structures that are surrounded by odontoblasts while the latter ones are formed from mineralized materials in the pulp structure that usually occurs secondary to tissue degeneration [4]. Pulp stones have been also classified according to their location into adherent, free, and embedded. Both adherent and embedded forms are found to be attached to the underlying dentine, however, embedded stones are more attached

than the adherent and they are usually present in the apical part of the root with peripheral odontoblasts and calcification [4]. Another classification was also proposed based on the presence and absence of distinct laminations. Non-laminated stones are usually rough and small, unlike the laminated ones. Pashley., *et al*. [23] demonstrated that on a histological basis and reported that laminated stones are oval or round in shape with smooth surfaces while non-laminated stones are not; having rough outer surfaces, and with no particular shapes.

Etiology and associated factors with pulp stones

The exact etiology of various types of pulp stones is still vague, however, many factors have been reported to be associated with the development of calcification and subsequent stone formation. For instance, previous studies estimated that age and gender are important risk factors that can significantly affect the prevalence rates of pulp stones. Moreover, it was suggested that bacterial infections are the reason for pulp calcification and stone formation. Sofou., *et al*. [24] reported that the culture of the extracted pulp stone showed that streptococci were present on the surfaces of these stones. However, these claims are not of any significance as these stones were obtained from healthy teeth, and therefore, these bacteria may have been introduced on the stones during the process of dental extraction. Additionally, the relationship between pulp stone formation and other systemic disorders such as gout, atherosclerosis, acromegaly, osteitis deformans, renal stones, cholelithiasis, and torus mandibularis or palatinus have been investigated. Cardiovascular disorders may be the most prevalent disorders that are associated with dental pulp stones [25]. Sundell., *et al*. [12] investigated the association between the incidence of pulp stones formation and pulp provocation by restorative materials and cutting procedures. The authors found no significant association with the thickness of the remaining dentin after the cutting, the amount and time of preparations beneath the cavity, and trauma-induced by the operative procedure. Other theories related to thrombosis and vessel-wall injury which may impact the nourishment of the pulp tissue and increase calcification. Another theory that shows that pulp cells may be induced by the process of including the remnants of the epithelial sheath into the pulp root to differentiate into odontoblasts which may form the mass-like lesions that are idintified as pulp stones [26].

Prevalence of pulp stones

The prevalence of pulp stones is hugely variable and depends on many factors regarding the investigated population and country. Bains., *et al*. [25] reported that among 500 routine dental check-ups in India, the prevalence of pulp stones was 41.8%. Moreover, the most common sites reported by the authors were the maxilla followed by the mandible, on the left side more than the right one, and in the first molar than the others. Ravanshad., *et al*. [27] conducted a radiological assessment study on 652 patients from Iran and found that the prevalence rate of pulp stones in one or more teeth was 46.9%. Moreover, prevalence according to the site was similar to that reported by Bains., *et al* [25]. Another study in India was conducted by Jena., *et al*. [28] to analyze the effect of orthodontic treatment on pulp stones formation. The authors reported that the prevalence rate was 15.5% among patients with pulp stones. Moreover, orthodontic treatment was responsible for a 4% increase in the rate from before and after installation, which was statistically significant. In an 814 Turkish population, Colak., *et al*. [29] conducted a retrospective study and found that the prevalence rate of pulp stones was 63.6% in the examined subjects and 27.8% in the examined teeth. Kanna., *et al*. [30] from Malaysia also studied the prevalence of pulp stones in 361 patients and found that the rate was 44.9% among the patients that were concluded and 15.7% among the teeth that were investigated. In Australia, the rate was not much different as reported by Ranjitkar., *et al*. [1] which investigated the radiographic assessment of 217 undergraduate students and found that the rate was 46.1% among them and 10.1% among the investigated teeth. Significant occurrence rates of pulp stones were found in the first maxillary molars. The significantly higher rates in the molars, among other teeth, are probably due to the better blood supply reaching the pulp tissue which can precipitate calcification [31]. A systematic review conducted by Jannati., *et al*. [32], which included 16 studies with 14,093 patients, estimated that the pooled prevalence rate for all of these patients was found to be 36.53%. Moreover, prevalence by tooth was also estimated as the authors reported a prevalence rate of 9.57% of pulp stones found in 193,687 teeth investigated. These relatively low rates are probably due to the radiographic basis of these studies, and by which many small stones are assumed to be missed in the calculation process. Huang., *et al*. [33] investigated the prevalence rate of pulp stones on a

histological level was 62% while the prevalnece on a radiographical level was 30%. A similar rate of 66% was also reported by Hill., *et al* [34]. These rates indicate the fact that the prevalence of pulp stones is still underestimated due to the large number of radiographic studies that may be unable to detect a huge number of minute calcification stones, and therefore, histologic examinations are preferred for this purpose.

Clinical significance and associated systemic disorders

The clinical significance of many pulp stones is still doubtful as some of them are subclinical and can rarely cause symptoms and inflammation as these lesions have been previously reported in unerupted teeth. However, pain due to pulp stones are one of the most common symptoms associated with the condition and can vary from mild to severe pain [6,12,35]. Moreover, it has been suggested that pain of unknown etiologies may result from pulp stones formation as they can easily compress and irritate the nerve roots causing inflammation and pain [36]. Martin., *et al*. [37] also compared pulp, gall bladder, and kidney stones, however, the incidence and occurrence of pulp pain are probably much higher due to the high prevalence of pulp calcification and stones [38]. Moreover, it has been reported that these stones can affect the surgical instruments and deflect them preventing them from the easy passage into the root canal [39] and therefore, may intervene against many diagnostic and therapeutic approaches.

Previous studies also showed that pulp stones are associated with different systemic disorders. Bains., *et al*. [25] reported that cardiovascular and atherosclerotic disorders followed by renal stones and cholelithiasis were the most frequent complications that were associated with pulp stones in their population. Carotid artery calcifications (CACs) were also prevalent in 2% of patients with pulp stones in a Saudi population [40]. Yeluri., *et al*. [41] also reported a rate of 91% and 92% for CACs and renal calcification. However, the sample size of this study was very small (n = 50). Many studies have established an association between pulp stones and CACs and renal stones [42-44]. It was also found that the prevalence of pulp stones was high in patients with coronary artery disease [45]. On the other hand, Patil., *et al*. [46] investigated these clinical outcomes in end-stage renal disease patients and reported that the prevalence of pulp stones in these patients was 33.92% while CACs were not seen in any of the included patients. Therefore, the authors concluded that no significant association was found between the occurrence of CACs and neither of hemodialysis patients nor pulp stones formation. Similar results, where the prevalence of CACs was very low to be significant, were also reported by other studies [47,48]. Despite the low prevalence rates in these studies, these events should be considered and patients should be carefully monitored for perfect prevention and management of any complications associated with the disorder.

Conclusion

The prevalence rate of pulp stones is high and underestimated due to the microscopic sizes of many pulp stones that are hard to be detected microscopically. Moreover, higher prevalence rates are noticed in association with advanced ages and many mechanisms have been proposed. Moreover, the etiology of pulp stones formation is still controversial, however, we could obtain a considerable number of associated factors that can increase the prevalence of pulp stones. Besides, pulp stones can be asymptomatic because many of these lesions are too minute to induce any clinical significance, however, pain can be the only presenting manifestation and can be variable from mild to very severe. Pulp stones can be also used for the prediction of other systemic disorders and improve the morbidity and prognosis.

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