REVIEW

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A Critical Review of Pulp Stone Etiology and Clinical Significance

Pulpa Taşının Etiyolojisi ve Klinik Önemi Üzerine Eleştirel Bir İnceleme

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ABSTRACT

Pulp stones are discrete nodular, calcified masses that form in the pulp cavity of teeth, including the apical and coronal portions of the pulp. Pulp stones can form in all kinds of teeth, including healthy teeth, diseased teeth and even in impacted or unerupted teeth. They most often form in several teeth and can even form in all the teeth of an individual. Pulp stones can be found either in permanent or deciduous teeth and even in teeth-like structures found in dermoid cysts.

Pulp stones are classified by location as free, embedded, or adherent: free stones are entirely surrounded by pulp tissue and unattached to the pulp cavity walls, making them the most common type; embedded stones are fully enclosed within tertiary dentin, often in the apical pulp; and adherent stones are partially fused to the dentin wall while remaining partly in soft tissue. Due to the difficulty in distinguishing between embedded and adherent types, some researchers group them as “attached” pulp stones, which may later detach and become free within the pulp tissue. Pulp stones are mainly noticed by radiography and appear as lesions or radiopaque structures that can be round or ovoid. In general, there is no clear imaging appearance or uniformity in shape. It can be associated with age, gender, systemic disease, caries, restorative and orthodontic treatments. In principle, pulp stones do not require treatment; however, they may obstruct endodontic procedures and should be removed if they significantly interfere with treatment.

Keywords: *Dental pulp, Pulp calcification, Pulp stone, Pulp chamber.*

ÖZET

Pulpa taşları, dişlerin pulpa boşluğunda, pulpanın koronal ve apikal kısımları da dahil olmak üzere oluşan ayrı nodüler, kalsifiye kitlelerdir. Pulpa taşları, sağlıklı dişler, çürük dişler ve hatta gömülü veya sürmemiş dişler dahil olmak üzere her türlü dişte oluşabilir. Çoğunlukla birkaç dişte oluşurlar veya tüm dişlerde oluşabilirler. Pulpa taşları, daimi dişlerde, süt dişlerinde hatta dermoid kistlerde bulunan diş benzeri yapılarda izlenebilirler. Pulpa taşları, konumlarına göre serbest, gömülü veya yapışık olarak sınıflandırılırlar. Serbest pulpa taşları tamamen pulpa dokusu ile çevrilidir ve pulpa odası duvarlarına bağlı değildir, bu da onları en yaygın tür yapar. Gömülü pulpa taşları tamamen tersiyer dentinin içinde, genellikle apikal kısımda bulunur. Yapışık pulpa taşları ise kısmen yumuşak dokuda kalırken kısmen dentin duvarına yapışmıştır. Gömülü ve yapışık tipleri ayırt etmenin zorluğu nedeniyle, bazı araştırmacılar bunları daha sonra pulpa dokusu içinde ayrılıp serbest hale gelebilen “bağlı” pulpa taşları olarak gruplandırır. Pulpa taşları çoğunlukla radyografide fark edilirler ve yuvarlak veya oval şekilli radyoopak yapılar olarak görünürler. Genel olarak, net bir görünüm veya şekil bakımından tekdüzelik yoktur. Yaş, cinsiyet, sistemik hastalık, çürük, restoratif ve ortodontik tedavilerle ilişkili olabilirler. Prensip olarak, pulpa taşları tedavi gerektirmez; ancak, endodontik prosedürleri engelleyebilirler ve tedaviyi önemli ölçüde etkiliyorlarsa çıkarılmaları gerekir.

Anahtar Kelimeler: *Diş pulpası, Pulpa kalsifikasyonu, Pulpa odası, Pulpa taşı.*

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Introduction

Pulp stones are discrete nodular, calcified masses that form in the pulp cavity of teeth, including the apical and coronal portions of the pulp. Pulp stones can form in all kinds of teeth, including healthy teeth, diseased teeth and even in impacted or unerupted teeth. They most often form in several teeth and can even form in all the teeth of an individual.[1] Pulp stones can be found either in permanent or deciduous teeth and even in teeth-like structures found in dermoid cysts.[2]

Classification of Pulp Stones, Formation Mechanism and Histology

Pulp stones, as a specified categorization, are different from the term “pulp calcification”, which refers to the phenomenon of the general calcification of pulp tissue not necessarily leading to the formation of full, discrete stones. Pulp stones are also called “denticles” or “endoliths” in the literature.[3] Pulp stones can be classified by their location as free, embedded, or adherent: free stones are completely surrounded by pulp tissue without attachment to the pulp cavity walls and represent the most common type; embedded stones are fully encased within tertiary dentin, typically in the apical pulp region and integrated into the canal walls; while adherent stones are partially fused to the dentin wall yet remain partly in contact with soft tissue. Due to the often subtle distinction between embedded and adherent types, some researchers group them collectively as "attached" pulp stones, which may subsequently detach and transition into the free category within the pulp tissue.[4]

Pulp stones can be structurally classified as either "true" or "false" types. True pulp stones consist of dentine surrounded by odontoblasts-neural crest-derived cells located on the pulp's outer surface that resemble peripheral dentine and are responsible for dentine matrix synthesis and mineralization. These odontoblasts are most densely concentrated in the coronal pulp chamber (45,000-65,000 cells per mm^2), with progressively fewer cells in the cervical and in the middle area of the root, explaining why true pulp stones predominantly form in these coronal areas.[5]
True pulp stones, composed of dentine and lined by either true odontoblasts or odontoblast-like cells containing tubules, represent a rare minority among all pulp stones. Their formation may involve cellular products secreted by odontoblasts that facilitate adhesion to the dentine core, which often surrounds a small central cavity of distinct cell remnants. Unlike false pulp stones (to be discussed subsequently), these structures are characterized by their dentine composition and odontoblastic lining, though their development can occur through similar cellular mechanisms despite their relative scarcity.[6]

False pulp stones form through mineralization of degenerating pulp tissue, including not only pulp cells but also blood clots and organic collagen fibers - distinguishing them from true pulp stones which contain only minimal necrotic cell remnants in their central cavity. These false pulp stones demonstrate greater mass of degenerated material, with collagen fibers typically surrounding cores of blood clots and dead cells. Notably, studies have identified epithelial-origin cells resembling Hertwig's epithelial root sheath (HERS) cells within developing false pulp stones, particularly in root areas.[7] Since HERS cells normally guide root formation before transforming into cementoblasts during tooth development, their presence suggests some false pulp stones may arise as natural byproducts of root formation,[8] while others likely form in response to trauma. This HERS-associated subset appears distinct from more generalized trauma-related false pulp stones.[7]

In summary, false pulp stones can be categorized into two distinct types: the more common form, consisting of mineralized blood clots, dead pulp cells, and collagen fibers coalescing around a central nidus, often linked to trauma, and a second type found in the root region, termed "denticles," which have a softer, larger core likely derived from remnants of Hertwig’s epithelial root sheath (HERS) cells and may form naturally during root development. However, the distinction between true and false pulp stones is increasingly debated, with scholars like Torabinejad et al.[5] proposing a classification based on calcification degree rather than origin, as many pulp stones exhibit overlapping features-such as a mix of blood clots, dead cells, and dentine tissue—making clear categorization difficult, particularly in older individuals.[9]

A third classification of pulp stones is based on histology, distinguishing between regular and irregular calcifications. Regular calcifications are smooth, round or ovoid with concentric laminations, often found in the coronal pulp and typically false pulp stones, as their layered growth results from collagen fiber deposition around a central nidus. In contrast, irregular calcifications lack laminations, have rough, rod- or leaf-like shapes, and are mostly located in the apical pulp.[10] A subtype of irregular calcifications, diffuse (or amorphous) pulp stones, forms through dystrophic calcification (abnormal mineralization without systemic mineral imbalance) often near blood vessels. Some researchers classify diffuse pulp stones as a separate category alongside true and false pulp stones (and denticles), even referring to them simply as "dystrophic calcifications" due to their distinct formation process.[11]

Electron probe microanalysis revealed that pulp stones consist primarily of calcium (32.1%) and phosphorus (14.7%), with smaller amounts of fluoride (0.88%), sodium (0.75%), magnesium (0.51%), and trace elements (K, Cl, Mn, Fe, Zn). Immunohistochemical analysis of demineralized free pulp stones showed homogeneous type-I collagen distribution throughout, indicating their role as a dentine matrix component. However, the study found no significant differences in mineral composition between true and false pulp stones.[12]

Pulp stones typically appear on radiographs as round or ovoid radiopacities, varying from single dense masses to multiple tiny opacities, with larger stones sometimes conforming to the pulp chamber's shape.[13 14] While externally invisible, their size ranges from microscopic particles to obstructive masses,[15] though only those >2mm are usually detectable radiographically,[16] with free stones being more visible than embedded ones.[17] They occur most frequently in first molars[18] (particularly maxillary teeth)[19] due to longer exposure to degenerative changes like caries and richer blood supply promoting mineralization,[20] and are predominantly found as free-floating false stones in the coronal pulp region.[21]

Association Between Pulp Stones and Aging: Age-Related Distribution

While the exact etiology of pulp stones remains unclear, potential contributing factors include aging, trauma, occlusal stress, orthodontic forces, and circulatory disturbances, with theories involving nanobacteria gaining little support.[22] Aging demonstrates the strongest correlation, with prevalence markedly increasing with age. Historical data reported pulp stones in 66% (10-30 years), 80% (30-50 years), and 90% (50-70 years) of individuals,[23] while more recent findings showed 14.9% (10-30 years), 44.4% (31-51 years), and 65.1% (52-72 years), confirming an age-dependent pattern, though neither study distinguished between pulp stone types.[24]

Evidence suggests pulp stones predominantly form after the fourth decade, peaking between ages 40–50.[25] Aging reduces pulp space through secondary/tertiary dentine deposition, creating conditions favouring calcification. While trauma (via blood clot formation) and caries/restorative treatments accelerate this process, pulp stone development may also occur independently, implicating intrinsic age-related mechanisms. A study of specimens of teeth obtained from individuals aged between 15-75 shows demonstrate a progressive decline in pulp chamber size and increased calcification, highlighting the interplay between physiological aging and external factors like trauma.[26]

Bernick[27]observed age-related patterns in pulpal calcification: younger individuals exhibit discrete calcifications in nerve endoneurium/perineurium, while advancing age leads to circumferential nerve calcification and eventual nerve tissue destruction. With aging, coronal pulp tissue shows increased collagenous bundles, which -along with fat deposits- serve as nucleation sites for false pulp stones.[26] Concurrently, pulp cell density declines by ~50% between ages 20–70, progressively replaced by these calcification-prone fibrous and fatty deposits.[28]

Association with Systemic Illnesses

Emerging evidence suggests a potential association between pulp stones and cardiovascular disease. While early research found no link with conditions like cholelithiasis or gout, it identified correlations with arteriosclerosis, osteitis deformans, and acromegaly.[29] More recently, Edds et al.[30] demonstrated significantly higher pulp stone prevalence in cardiovascular disease patients compared to healthy individuals, strengthening this connection.

Beyond cardiovascular disease, pulp stones show tentative associations with systemic conditions including late-stage renal failure, Ehlers-Danlos syndrome, calcinosis disorders, Marfan syndrome, and Van der Woude syndrome, though causal relationships remain unproven.[31] A particularly notable connection exists with renal pathology, where individuals with pulp stones in ≥3 teeth exhibit 5.78 times greater likelihood of renal stones.[32,33] Similarly, Kaswan et al.[34] reported a parallel between multiple pulp stones and salivary gland calculi, suggesting a potential shared mineralization mechanism across different organ systems .

Emerging research suggests additional systemic associations for pulp stones, including diabetes.[35] In Marfan syndrome, connective tissue dysplasia may induce pulp arteriole rupture, leading to hemorrhage and subsequent mineralization of blood clots.[36] Other potential correlations include tumoral calcinosis, dentine dysplasia type II, and rare syndromes like Saethre-Chotzen and otodental syndrome, though mechanistic evidence remains limited.[12] The overall trend from the scholarship is that whatever the reasons, there is a causative link between the existence of pulp stones and systemic illnesses. Bains et al.[17] suggest that existence of large numbers of pulp stones can in the future be used as an indicator for different types of systemic disease.

Association with Caries and Restorative Treatment

Evidence suggests chronic pulp irritation from caries or restorative procedures may contribute to pulp stone formation, particularly false pulp stones. Studies indicate that first molars with caries or restorations show higher pulp stone prevalence compared to intact teeth, likely due to defensive calcification responses in the pulpo-dentinal complex. Notably, most observed stones in these cases were of the false type.[15]

While Ranjitkar et al.[37] reported significantly higher pulp stone prevalence in restored/carious teeth (41.7%) versus healthy teeth (28.8%), they did not classify stone type. Conversely, Tamse et al.[38] found no association between pulp stones and crown condition (carious/restored/intact). Similarly, Subay et al.[39] observed no pulp stone formation after short-term (10-40 day) orthodontic extrusion, though longer-term effects remain unexplored.

Possibly the most important cause is local irritants. While the most significant irritant is considered dental caries, other irritants include periodontal disease – especially aggressive periodontitis –, general trauma, healed tooth fractures and treatments including transplantation of teeth, pulp-capping procedures and tooth injury restorations.[40]

Prevalence of Pulp Stones, Distribution in Population and Distribution by Gender

The global prevalence of pulp stones averages 8–9%, though reported rates vary widely across populations—ranging up to 50% in select cohorts.[41] Meta-analyses highlight significant ethnic and geographic disparities, exemplified by a 41.8% prevalence in northern India.[42,43] Much of this variability stems from methodological inconsistencies: studies measuring individuals with ≥1 pulp stone report higher prevalence than those assessing teeth affected.

Gender differences in pulp stone prevalence remain inconsistent across studies. While Stafne and Szabo[29] initially reported higher rates in males, Tamse et al.[38] found contrasting results in adults (20–40 years), with females exhibiting significantly greater prevalence (24.7% vs. 16.9%) in molars and premolars. However, in younger populations (12–13 years), Baghdady et al.[43] observed nearly equal rates (females: 18.8%; males: 19.8%), suggesting age may modulate gender disparities .

Radiographic detection of pulp stones is limited to those >2 mm in diameter, suggesting the true prevalence in the general population is likely underestimated.[44] Additionally, free pulp stones are more easily identified on radiographs compared to embedded or adherent variants, further contributing to detection bias.[45]

Association with Orthodontic Treatment

Orthodontic treatment influences dental pulp through mechanical forces that may alter pulpal blood flow and trigger complications. While Nixon et al.[46] found no permanent pulpal effects, Hamersky et al.[47] reported potential vitality loss due to orthodontic forces. Studies on extrusive and intrusive movements have documented varied pulpal responses, including hyperemia, secondary dentin deposition, internal root resorption, hemorrhage, and necrosis. [48-52]

Studies show that the orthodontic force application may cause pulpal changes like alteration in the pulp, pulpal obliteration by secondary dentin formation, internal root resorption, cyst formation, pulpal necrosis and also pulpal calcifications.[53-56]

Orthodontic treatment may promote pulp stone formation, with studies demonstrating increased prevalence across all tooth groups, particularly in molars. Ertas et al.[42] reported a minimum rise of 1.3% in adolescents (12–14 years), while Korkmaz et al.[57] and Babanour et al.[58] observed more pronounced increases post-treatment, suggesting orthodontic forces alter pulpal calcification metabolism.

Clinical Implications

Pulp stones do not cause pain unless they impinge on nerves. Such an impingement on nerves can often be the cause behind idiopathic pain. They also do not lead to any other sort of discomfort beyond this possibility of nerve impingement and idiopathic pain and are not a cause of pulpitis. As such, they do not have clear clinical implications and do not require treatment. Although pulp stones do not require treatment in principle, they can interfere with endodontic treatment and thus should be removed in cases where this interference is particularly strong. The degree of interference depends on the stones' size and location. Larger pulp stones present in the pulp chamber can cause blockage for root canal openings and impede the movement of dental instruments through the canal. Pulp stones also cause greater blockage if they are located at a curve in the root canal.[59] Embedded and adherent pulp stones have a greater risk of interfering with root canal treatment compared to free pulp stones, based on both their location and size. No distinction has been found in scholarship in this regard between true and false pulp stones.[4]

In general, it can be stated that patients with pulp-related idiopathic pain may have a high presence of pulp stones if examined. However, it is not clear that correlation means causation in this case.[42] To effectively manage pulp stones during root canal treatment, magnification aids (such as dental loupes or operating microscopes) and ultrasonic tips are recommended for their removal. These tools enhance visibility and allow for careful dislodgement of calcifications without damaging the surrounding dentin or compromising canal access.[5, 60]

Conclusion

Pulp stones primarily gain clinical relevance during endodontic treatment, particularly when located in curved root canals where they may obstruct instrumentation. Their removal typically involves burs and ultrasonic devices, often supplemented by sodium hypochlorite due to its enhanced efficacy on false pulp stones (the predominant type). Despite their potential to complicate procedures, research on pulp stones remains limited, with most studies focusing on radiographic prevalence rather than formation mechanisms. While PubMed yields over 400 entries for "pulp stone" and "pulp calcification," the majority address generalized calcifications or clinical management rather than etiological factors. A deeper understanding of pulp stone pathogenesis could ultimately improve endodontic outcomes, highlighting the need for further investigation beyond current radiographic and prevalence-based studies.

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