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Pulp stone: A literature review

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In Partial Fulfillment for the Bachelor of Dental Surgery

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Certification of the Supervisor

I certify that this project entitled **"Pulp stone: A Literature Review"** was prepared by fifth year student **Teba ayad sadik** under my supervision at the College of Dentistry / University of Baghdad in partial fulfillment of the graduation requirements for the bachelor degree in dentistry.

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Dedication

To my dear parents, sisters and brother for their support and encouragement.

Teba

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Primarily I would like to thank the supreme power the Almighty God for everything in my life, for being able to complete this project with success.

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List of abbreviations

Abbreviation	Phrase
PS	Pulp stone
CNPs	Calcifying nanoparticles
CAD	Coronary artery disease

Introduction

Pulp stones (or denticles) are defined as calcified foci that are observed in the coronal pulp or, less frequently, radicular pulp cavity. They are found in the dental pulp of the teeth in primary and permanent dentition. These calcified structures can be detected in the pulp of healthy, infected, and even impacted teeth **(Pietrzycka *et al*., 2020).**

Pulp stones are classified according to their structure into true denticles, false denticles and diffuse calcification. True denticles are made up of localized masses of calcified tissue that resemble dentin because of their tubular nature, while false denticles do not exhibit tubules and finally diffuse calcification appears as calcific deposits. **(Vibhute *et al*., 2016).**

Other classification were proposed based on their size, pulp stone have been divided into fine and diffuse mineralization, based on their location, pulp stones may be embedded that are entirely surrounded by dentin, attached to dentin walls or free within the pulp tissue and based on their shape, pulp stones have been divided into stones with regular calcifications and stones with irregular calcifications **(Mahajan *et al*., 2010; Louis *et al*., 2020).**

The exact etiology of pulp stone formation still remains unclear. Some factors that have been implicated in pulp stone formation include pulp degeneration, epithelial tissue in pulp, aging, orthodontic tooth movement, periodontal disease, genetic predisposition, Irritants (bacterial infection, deep caries, restorations), trauma, surgical procedures and calcifying nanoparticles **(Bains *et al*., 2014; da Silva *et al*., 2017).**

Chapter one

Review of literature

Review of literature

1.1 Dental pulp

Dental pulp can be defined as a richly vascularized, innervated and unminerlized connective tissue enclosed by dentin with communication to the periodontal ligament by apical foramen and accessory canals. The embryonic origin of dental pulp from dental papilla which originates from neural crest cells **(Kumar, 2015).**

Typically the center area of each tooth occupies by the dental pulp and mainly consists of delicate connective tissue. Generally the location of the pulp is the pulp chamber of the crown and the root canal of the tooth. In the crown in which part of the pulp is located it is named by the coronal pulp as well as the pulp that present in the root is termed by the radicular pulp**(Goldberg, 2014).**

During histological examination, four unique zones can be distinguished: **Odontoblastic zones**: it is representing the peripheral aspect of pulp, which contains the odontoblast cells body. **Cell-free zone or zone of Weil**: This zone contains many bundles of fibers, numerous capillaries and nerves but does not contain any cells. **Cell-rich zone**: it contains several fibroblasts which represent the predominant cells type of pulp and also contains undifferentiated mesenchymal cells which can be differentiated into different pulp cells. **Pulp core**: This zone mainly contains the main blood vessels in the pulp and Raschkow plexus of nerves **(Figure 1.1) (Kumar, 2015; Alwafi, 2018).**

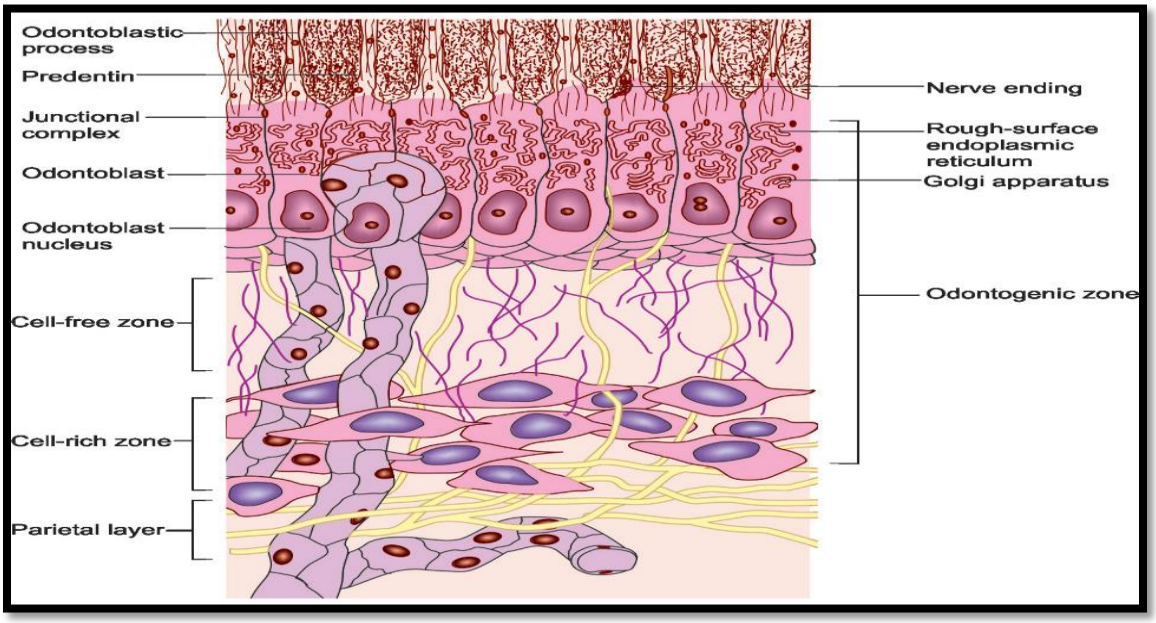


Figure (1.1): Diagram illustrating odontoblast, cell-free, cell-rich zone, and parietal layer (pulp core) with blood vessels and nonmyelinated nerves among odontoblasts **(Kumar, 2015)**

1.2 Pulp stones

Pulp stones (PS), or denticles, frequently are found in pulp tissue. As their name implies, they are discrete calcified masses that have calcium-phosphorus ratios comparable to that of dentin. They may be singular or multiple in any tooth and are found more frequently at the orifice of the pulp chamber and or within the root canal **(Figure 1.2) (Tomczyk *et al*., 2017).** Histologically, they usually consist of concentric layers of mineralized tissue formed around blood thrombi, dying or dead cells, or collagen fibers**(Figure 1.3) (Goga *et al*., 2008; Nanci, 2018).**

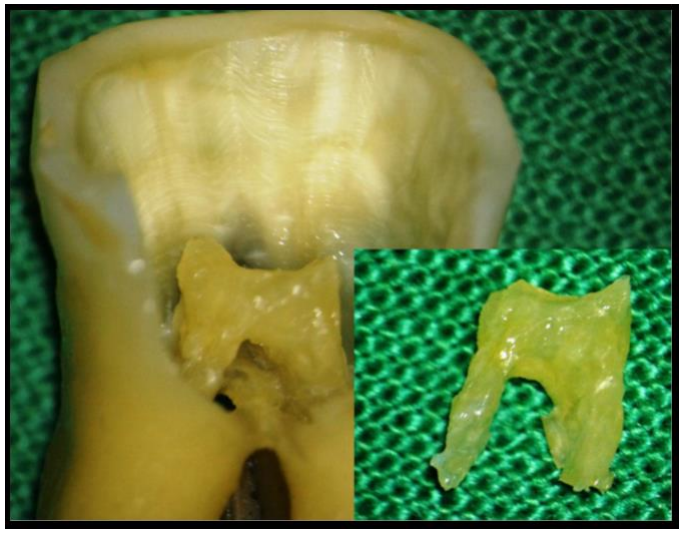


Figure (1.2): First left lower molar with visible pulp stone. **(Tomczyk *et al*., 2017)**

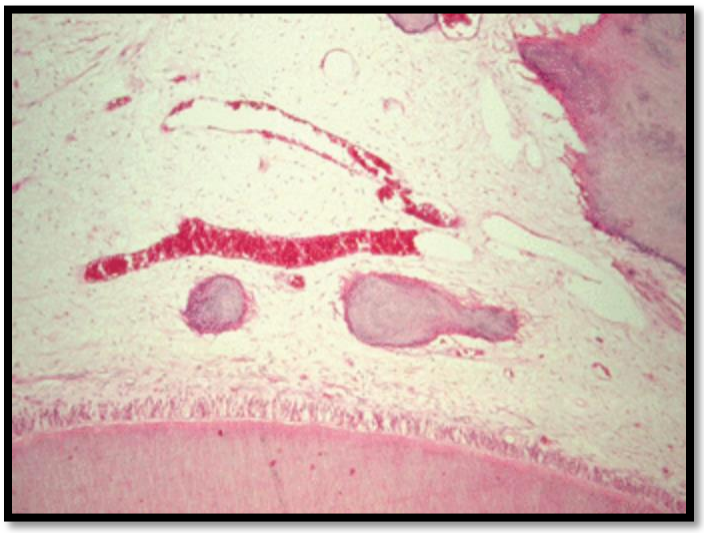


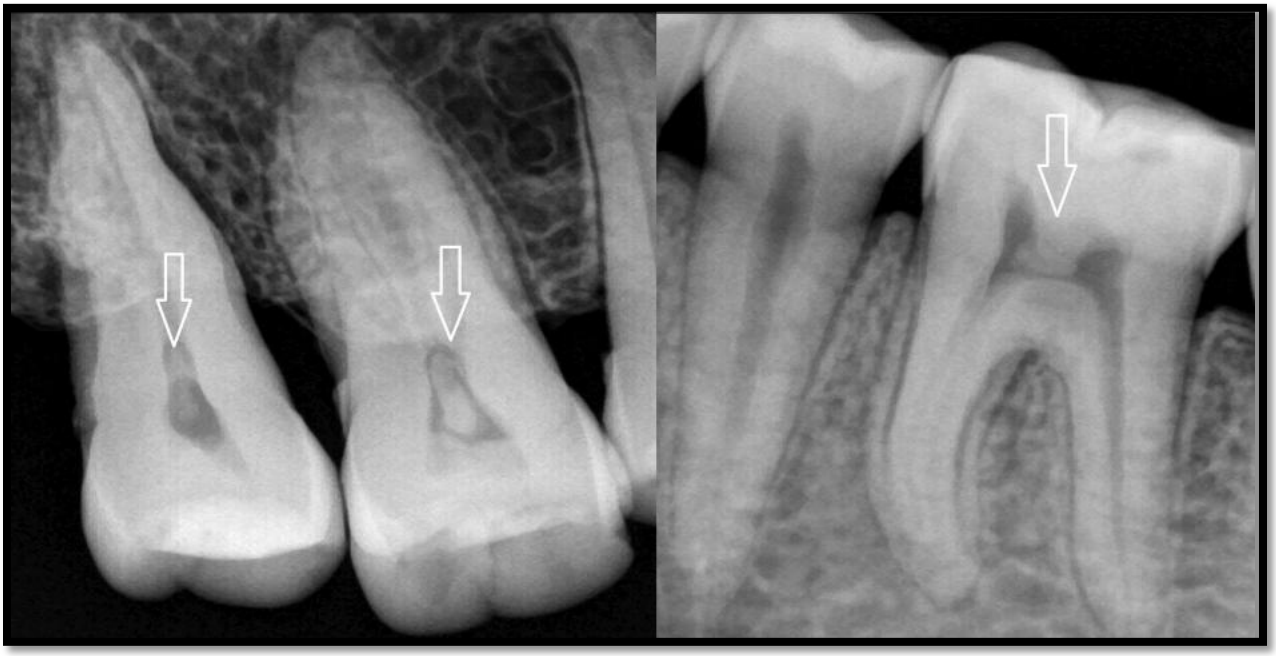
Figure (1.3): Histological views of Pulp stones of variable size within the dental pulp **(goga *et al*., 2008)**

1.3 Radiographical features of pulp stones

The imaging appearance of pulp stones is quite variable. They may be seen as radiopaque structures within pulp chambers or root canals, or they may extend from the pulp chamber into the root canals. No uniform shape or number exists. They may occur as a single dense mass or as several small radiopacities **(White**

and Pharoah, 2014). They may be round or oval, and some pulp stones that potentially occupy most of the pulp chamber conform to its shape. Their outline likewise varies from sharply defined to a more diffuse margin **(Figure 1.4)(Tomczyk *et al*., 2017).**

The pulp stones vary in size ranging from microscopic particles to larger masses that almost completely obliterate the pulp chamber. Among them, only the larger pulp stones are radiographically apparent, while those are small in size or relatively less calcified and in the initial stages of calcification are not detected by the conventional radiographs and can be detected by histological examination **(Babu *et al*., 2020).**



Figure(1.4): Radiographical view of posterior teeth with visible pulp stones **(Tomczyk *et al*., 2017).**

1.4 Prevalence of pulp stones

Radiographic studies have reported the prevalence of pulp stones with varying percentages from 8% to 90%, depending on the type of study, the design and the radiographic technique used **(Udoye and Sede, 2010; Moudi *et al*., 2015; Srivastava *et al*., 2020).** Studies conducted by **Al-Nazhan *et al*. (2011) and Hekmatian *et al*. (2013)** reported significantly higher rates of pulp stones among subjects aged over 50. In general, senile changes in the dental structure is predictable which occurs following second dentin deposition, atherosclerotic changes, and pulp destruction during ageing **(Gulsahi *et al*., 2009).**

Many previous studies found that pulp stones in first molars was higher than other teeth **(Sisman *et al*., 2011; Bains *et al*., 2014; Moudi *et al*., 2015).** The early eruption of the first molar, which leads to its exposure for long periods of time and also high masticatory forces, can be possible explanations for it **(Sisman *et al*., 2011; Bains *et al*., 2014).**

Malhorta *et al*. (2012) reported significantly higher percentages of pulp stones were found in the left arch than in the right arch, while **Moudi *et al*. (2015)** found that there were no significant differences in the percentages of pulp stones between the left and right arches. Regarding the maxillary and mandibular arch many previous studies was conducted a significantly high percentage of teeth with pulp stones were detected in maxillary teeth compared to mandibular teeth **(Malhorta *et al*., 2012; Turkal *et al*., 2013).**

Considering gender, more than half of the primary studies reported higher prevalences of pulp stones among women (**Sener *et al*., 2009; Çolak *et al*., 2012;**

Satheeshkumar *et al*., 2013; Bains *et al*., 2014). **Sener *et al.* (2009)** reported that higher frequency of bruxism among women is responsible for the higher rate of pulp stones.

1.5 Etiology of pulp stones

The etiological factors for pulp stone formation are not well understood, however namy factors have been implicated for stone formation they include:

1)Aging: Continued formation of secondary dentin throughout life gradually reduces the size of the pulp chamber and root canals, although the width of the cementodentinal junction appears to stay relatively the same**(Vertucci *et al*., 2005).**

In addition, certain regressive changes in the pulp appear to be related to the aging process. There is a gradual decrease in the cellularity and a concomitant increase in the number and thickness of collagen fibers and fats, particularly in the radicular pulp. These deposits may serve as foci for pulpal calcification **(Figur1.5) (Byers *et al*., 2011; Udoye and Sede, 2011; Nanci, 2018).**

2) Irritants and trauma: The formation of pulp stone may be associated with long standing irritants such as caries, deep fillings, and chronic inflammation. occlusal load, and dental wear are amongst etiological factors for pulp mineralization . They tend to break down pulp connective tissue homeostasis and provoke blood circulation disturbances, degenerative processes and small areas of pulp necrosis **(Bains *et al.*, 2014)**. Suggesting that pulp stones are a feature of an irritated pulp, attempting to repair itself. The incidence of the calcification in the carious teeth of children and young adults was reported to be 5 times greater than that in the non-carious teeth pulp stone are also caused by thermal injuries. Those

injuries lead to the necrosis of tissues that are surrounded by the pulp to encapsulate and calcify in order to separate the necrotic tissue from healthy tissue **(Figure 1.5B)(da Silva *et al*., 2017; Nanci, 2018).**

3) Orthodontic tooth movements: During the orthodontic tooth movement a complex series of tissue reaction occurs. Previous study concluded that orthodontic treatment may trigger the formation of dental pulp stones, however, further studies are required to determine the relationship between the pulp stone formation and orthodontic treatment **(Ertas *et al*., 2017).**

Numerous studies showed that the forces formed through orthodontic tooth movement may cause pulpal blood flow changes that induce pulpal changes and complications like alteration in pulpal respiration rate, pulpal obliteration by secondary dentin formation, internal root resorption, cyst formation, pulpal necrosis and also pulpal calcifications **(Ramazanzadeh *et al*., 2009; Javed *et al*., 2015; Korkmaz *et al*., 2019).**

4) Epithelial rest in pulp tissue: Pulp stones may also form around epithelial cells such as remnants of Hertwig's epithelial root sheath. It is presumed that epithelial remnants are able to induce adjacent pulp cells to differentiate into odontoblasts that proposed to form true pulp stones **(Chaini and Georgopoulou, 2016).**

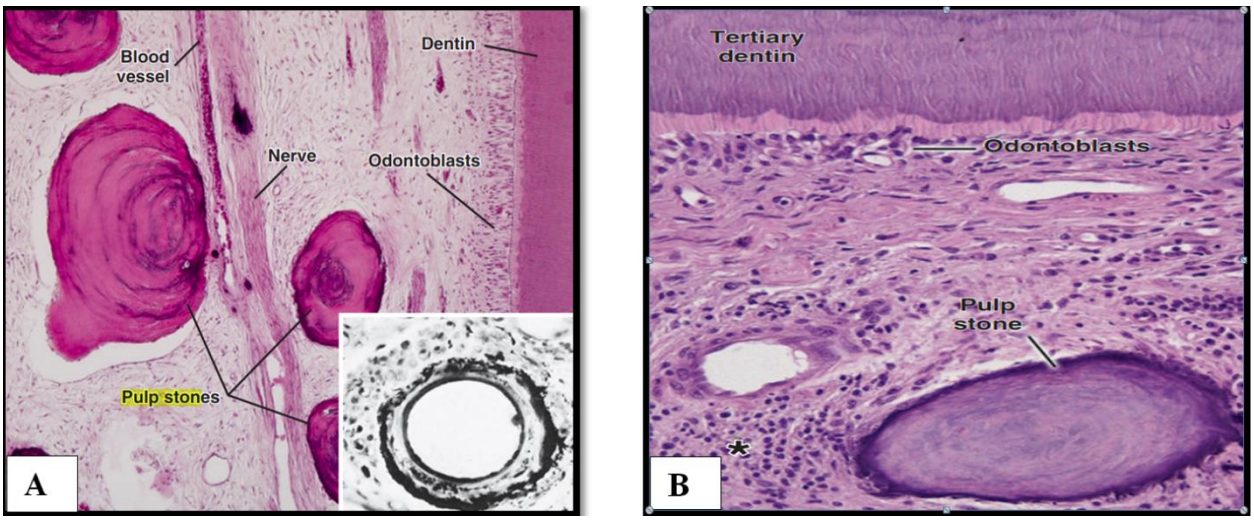
5) Pulp degeneration: Pulp degeneration is usually present in teeth of old people. It may also result in persistent, mild irritation in the teeth of young patients. Part of the pulp tissue is replaced by calcific material i.e., stone or denticles. It may occur in root canal or pulp chamber **(Patil and Sinha, 2013).**

6) Genetic predisposition: several genetic diseases that result in pulp chamber calcification, including pulpal dysplasia, radicular dentin dysplasia (dentin

dysplasia type I, or DDI), coronal dentin dysplasia (dentin dysplasia type II, or DDII), and dentinogenesis imperfect. Calcifications are often visible on radiographs in the pulp chambers of individual teeth. In patients with certain systemic or genetic diseases, the pulp chamber calcifications are occasionally found throughout the dentition **(Al-Ghurabi and Najm, 2012).**

7) Surgical procedure: The reduction of blood supply and nutrition to the pulp as a result of surgical procedures is causing a decrease in cellular elements and an increase in calcification and formation of pulp stones **(Kisiel *et al*., 2015)**

8) Calcifying nanoparticles(CNPs) : Also referred to as nanobacteria, CNPs first appeared as self-propagating calcifying macromolecular complexes found in bovine and human blood and blood products. These nanoparticles could produce biogenic carbonate apatite on their cell envelope at all growth phases, which resulted in white biofilm and mineral aggregates closely resembling those found in tissue calcification in the human body. Pulp stones are the characteristic manifestation of physiological or pathological calcification of the human body reflected in the dental pulp tissue. It could be hypothesized that CNPs are involved in the calcification of the dental pulp tissue **(Zeng *et al*., 2011).**



Figure(1.5): A- Multiple stones in an aged pulp. Dystrophic calcification is beginning in a vessel wall (inset).**B-**The presence of tertiary dentin and a strong mononuclear inflammatory cell infiltrate are indicative of a carious lesion **(Nanci, 2018).**

1.6 Classification of pulp stones

Based on their structure, there are **true, false and diffuse pulp stones**

1.6.1 True pulp stones

They are similar in structure to dentin in that they have dental tubules and surround by odontoblasts . True denticles are comparatively rare and are usually located close to the apical foramen. A theory has been advanced that the development of the true denticle is caused by the inclusion of remnants of the epithelial root sheath within the pulp. These epithelial remnants induce the cells of the pulp to differentiate into odontoblasts, which then form the dentin masses called true pulp stones **(Figure 1.6A) (kumar, 2015).**

1.6.2 False pulp stones

These stones do not exhibit dentinal tubules but appear instead as concentric layers of calcified tissue. In some cases these calcification sites appear within a bundle of collagen fibers. False pulp stones are formed from degenerating cells of pulp tissue that mineralize. Such mineralization occur in stages ,initially cell nests become enclosed by concentrally arranged fibers which then become impregnated with mineral salts then calcified incremints are added **(Figure 1.6B)(Garg *et al.*, 2019).**

1.6.3 Diffuse Calcifications

They appear as an irregular calcific deposits in the pulp tissue, usually following collagenous fiber bundles or blood vessels. Sometimes they develop into larger masses but usually persist as fine calcified spicules. The pulp organ may appear quite normal in its coronal portion without signs of inflammation or other pathologic changes but may exhibit these calcifications in the roots. Diffuse calcifications are usually found in the root canal and less often in the coronal area **(Figure 1.6C)(kumar, 2015).**

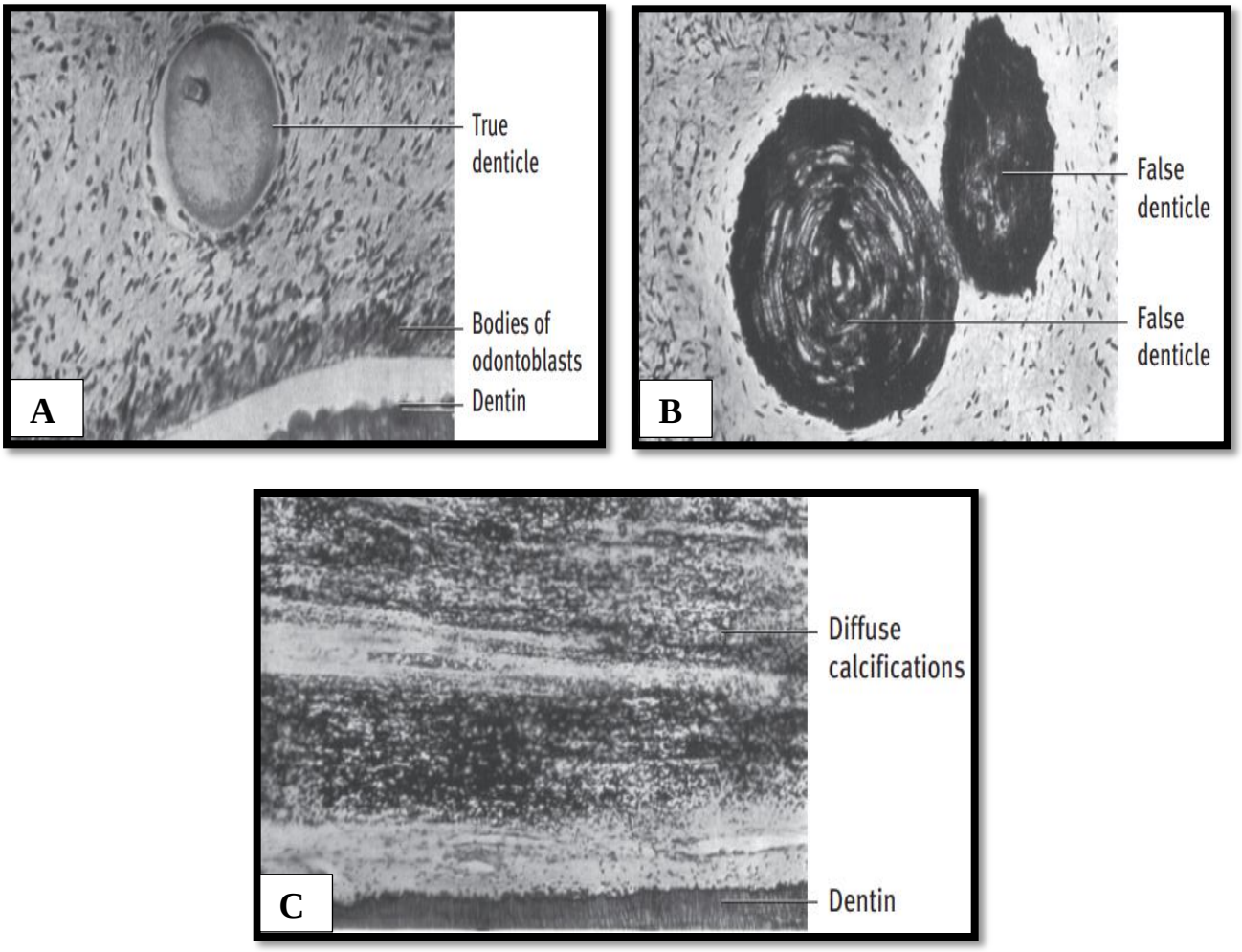


Figure (1.6): Calcification in the pulp A-True denticle **B**-False denticle **C**-Diffuse calcifications **(kumar, 2015).**

Based on their location, pulp stones can be classified as **embedded, attached and free:**

1-Embedded pulp stones are formed in the pulp but with ongoing physiological dentine formation they become entirely surround by dentine. They are found most frequently in the apical portion of the root **(bains *et al*., 2014).**

2-Attached pulp stones are in intimacy with dentine walls(partly fused with dentin), while embedded stones are incorporated into dentinal mass during dentinogenesis **(Berès *et al*., 2016).**

3-Free pulp stones are found within the pulp tissue proper and are the most commonly seen type on radiographs. They are very common and vary in size from 50μm in diameter to several millimetres when they may occlude the entire pulp chamber **(Figure 1.7)(goga *et al*., 2008; Kumar, 2015).**

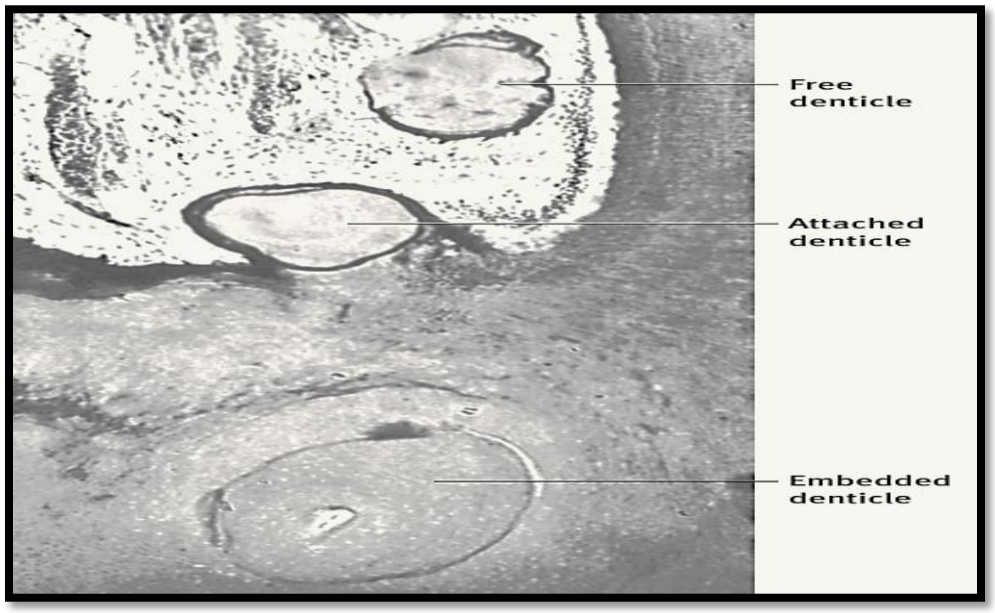


Figure (1.7): Examples of the typical appearance of pulp stones as free, attached, and embedded **(goga *et al*., 2008).**

Histologically, there are two types of stones: (1) stones with regular calcifications (2) stones with irregular calcifications. For regular calcification, the pulp stones are smooth, round or ovoid with concentric laminations. It is commonly found in the coronal pulp. As for irregular calcifications without laminations, pulp stones may have the shape of rods or leaves and the surface is rough. It is more common in the radicular pulp. Pulp stones with regular

calcification grow in size by addition of collagen fibrils to their surface, whereas the irregular type of pulp stones are formed by calcification of pre-existing collagen fibers **(Louis *et al*., 2020).**

1.7 Pulp stone in primary teeth

Previous study examined 120 primary teeth and found that only 6.7% of the teeth had pulp stones, with 11.7% having some diffuse calcification. Given that the size of the pulp stones ranged from 0.05 to 3.3 mm, it is likely that the radiographic prevalence of pulp stones would be very low **(Vibhute *et al*., 2016).**

Pulp calcification also occurs as sequelae to trauma to the primary dentition . In cases with repeated traumatic injuries, the chances of pulp calcification are doubled compared to single trauma. It is a common finding associated with the healing process following traumatic injuries while other cases it may be suggested that the pulp stones were of idiopathic origin **(Figure 1.8) (Marwaha *et al*., 2012).**

Other study found a correlation between extensive pulp calcification and post-natally initiated fluoride prophylaxis, although the duration of tablet fluoridation (1-10 years) had no statistically significant influence on pulp calcification. Thus even though there are contrasting findings regarding occurrence of pulpal calcifications in primary teeth, the dominant results conclude that the prevalence and complexity of pulpal calcification increases with age and has a large physiological component **(Holtgrave *et al*., 2001).**

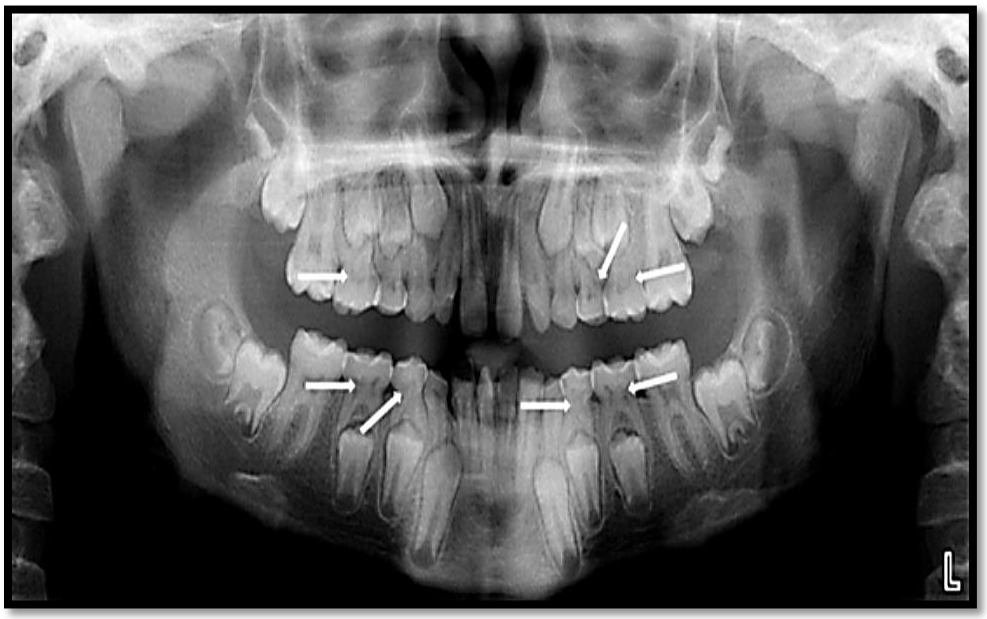


Figure (1.8): OPG revealing pulp stones in all primary molars **(Marwaha *et al*., 2012).**

1.8 Clinical consideration

The clinical significance of pulpal calcification is not completely understood. It has been reported upon numerous occasions that pulp stones are a cause of pain, varying from mild to severe excruciating pain. The consensus is that though denticles may seem to impinge on the nerves of the pulp, they probably do not. Therefore the extraction of teeth with radiographically demonstrable pulp stones in the hope of pain relief cannot be defended **(Figure1.9)(Shafer *et al*., 2009; Kumar, 2015).**

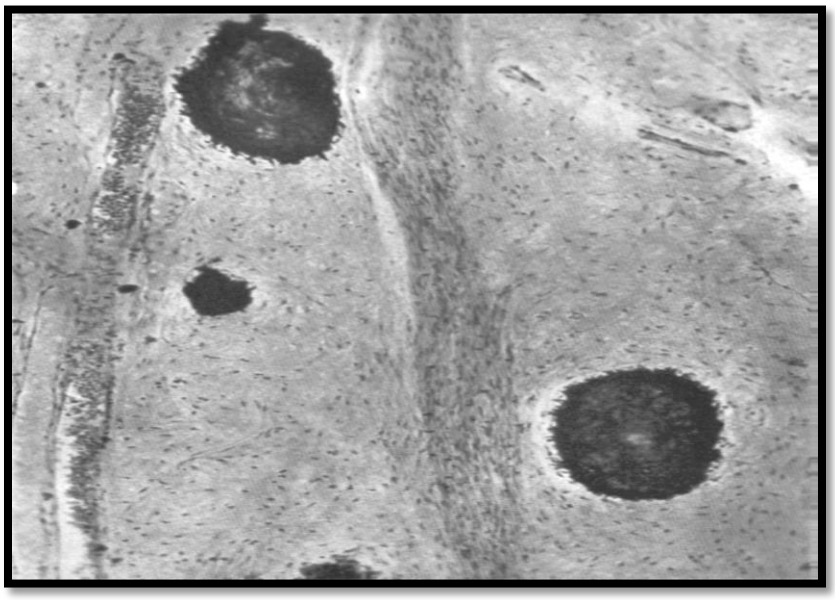


Figure (1.9): Pulp stones in proximity to nerve (**Kumar, 2015)**.

Pulp stones usually grow as layers of mineralized tissue, formed by accumulation around dead or degenerating cells, collagen fibers, or blood thrombi. A tooth may have single or multiple stones of fluctuating sizes (from minute to large), which can result in occlusion of pulpal space . These stones are known to offer difficulty in endodontic access to root canals and their shaping while root canal treatment **(Shabbir *et al*., 2021)**

1.9 Endodontic treatment and pulp stone

The removal of pulp calcification (pulp stones) is present another challenge in endodontic treatment, as they block the access to the root canals. The best treatment for this condition is the combination of magnification and ultrasonic tips. The presence of pulp stone may alter the internal anatomy and confuse the operator by obscuring, but not totally blocking the orifice of the canal. Attached denticles may deflect or engage the tip of exploring instruments in the canals, thus preventing their easy passage down the canal**(Figure 1.10)(Jain *et al*., 2014).**

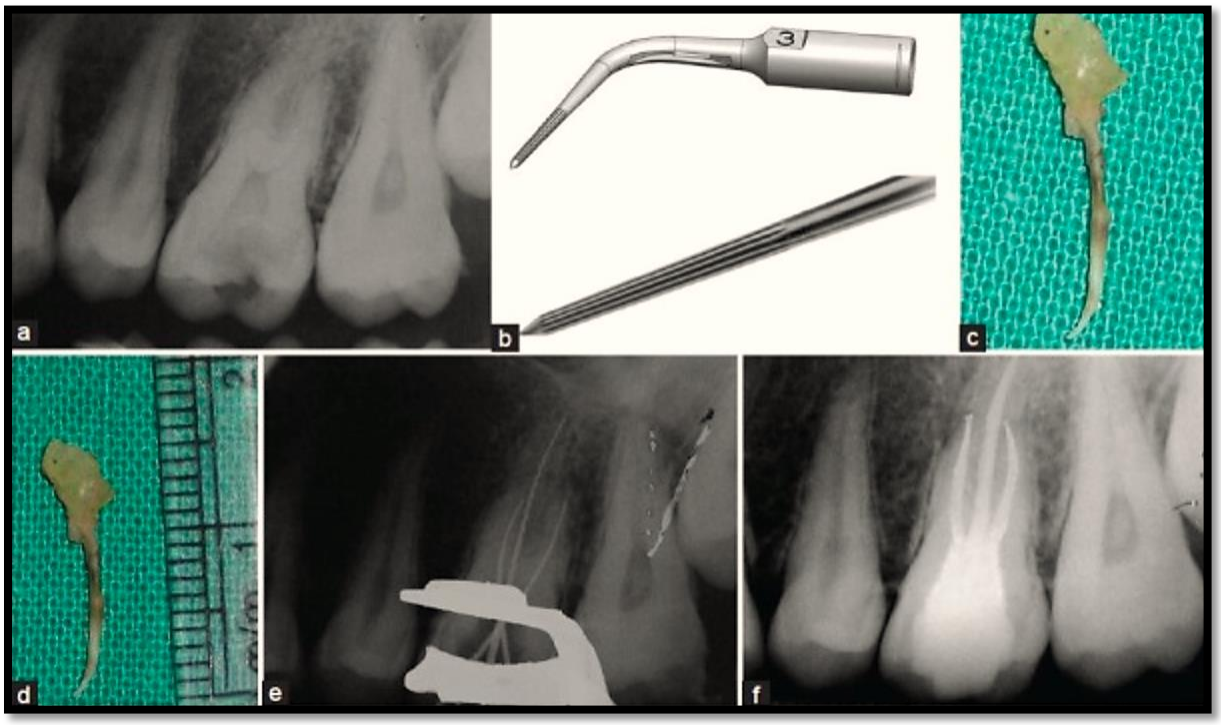


Figure (1.10): (a) Preoperative radiograph showing diffused radio opacities throughout the pulp chamber and in the palatal root canal.**(b)** ultrasonic tip for calcified canal scouting. **c)** Photograph of partially calcified pulp tissue.**(d)** Length of the partially calcified pulp tissue was measured to be 16 mm long.**(e)** Working length radiograph **(f)** Post-obturation radiograph **(Jain *et al*.,2014).**

Sometimes a large pulp stone can be dissected out of an access cavity using burs, but ultrasonic instrumentation with the use of special tips makes their removal easier. Ultrasonic instruments can be used for removal of pulp stones. In teeth with narrow canals, sodium hypochlorite or EDTA can be used as a dissolving agent in addition to the ultra-sonic instrumentation. Proper instrumentation, access opening, and magnification are necessary to overcome the hindrance posed by pulp stones while performing root canal treatment **(Figure 1.11)(Alaajam *et al*., 2021).**

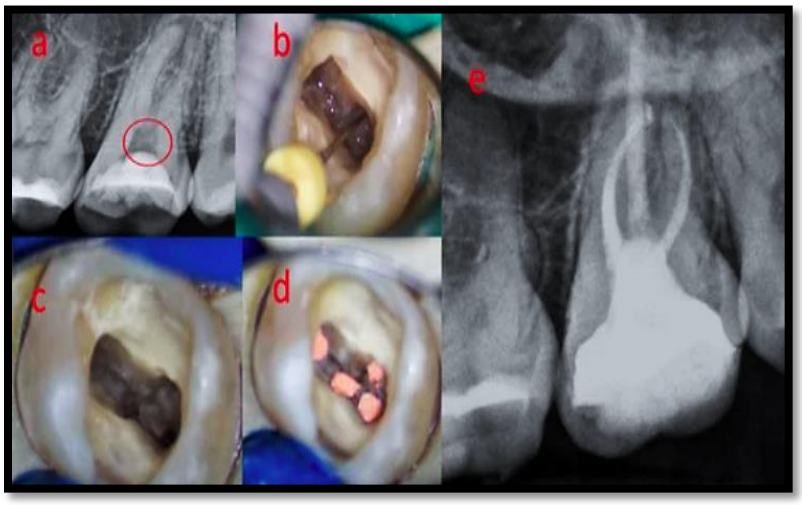


Figure (1.11): Removal of pulp mineralization followed by endodontic treatment: (**a**) Preoperative radiograph; (**b**) Identification of canal orifices; (**c**) The pulp chamber after the pulp stone removal; (**d**) Tooth after the endodontic treatment; (**e**) Postoperative radiograph **(Alaajam WH *et al*., 2021).**

1.10 Associated systemic disease

Generalized pulp calcifications might be associated with systemic disease. A higher than normal association has been made between pulp stones and several systemic conditions including cardiovascular disorders, Diabetes mellitus and renal stones **(Rawat *et al*., 2020).**

Previous study indicated that a significant higher number of patients with pre-existing cardiovascular disorders had detectable pulp stones compared to a control group. They suggested that it may be helpful to use a radiographic presence of pulp stones as a screening tool for cardiovascular disorders**(Khojastepour *et al*., 2013).**

The patients with coronary artery disease (CAD) have high chance of being affected with pulp stones. Higher prevalence of this entity in multiple teeth may warrant such an individual, in the presence of other compounding risk factors, as a candidate for CAD to be ruled out **(Babu *et al*., 2020).**

Some studies have suggested that the presence of pulp stones may be a manifestation of some serious disease, which leads to other pathologic calcifications like kidney stones **(Malhotra *et al*., 2012; Sisman *et al*., 2011).**While other studies reported that CNPs (calcifying nanoparticles) can produce nucleate hydroxyapatite; therefore, they can be considered an etiologic factor for calcifications, including kidney stones, gall stones, atherosclerosis and pulp stones **(Ciftcioglu and Mackay *et al*., 2010; Zeng *et al*., 2011).** In recent immunohistochemical study showed that osteopontin is localized in pulp stones and also in atherosclerotic plagues and urinary stones,, in which a correlation was found between the presence of pulp stones, kidney stones and cardiovascular disorders **(Srivastava *et al*., 2020).**

Previous study found that type II diabetics and pulp stones were have a higher than usual prevalence. The dental pulp of diabetics tends to age readily due to obliterative endarteritis and because of its limited or no collateral blood circulation in fully developed teeth **(Rawat *et al*., 2020).** Other study concluded that patients with diabetes mellitus were found to be more prone to form chamber calcifications, due to the increase in glucose present in the blood which activates osteopontin**(Araya *et al*., 2020).**

Chapter two

conclusion

Conclusion

It would appear that pulp stones are primarily a physiological manifestation and may increase in number and/or size due to local or systemic pathology. The aetiological factors involved in their formation are still not fully apparent. Their primary clinical relevance remains in the area of endodontic treatment.

The removal of pulp calcification (pulp stones) is present another challenge in endodontic treatment, as they block the access to the root canals. The best treatment for this condition is the combination of magnification and ultrasonic tips. Knowledge of root canal morphology, use of proper armamentarium and operator's skill are critical for successful retrieval of pulp stones. Attention should be paid to the presence of pulp stones and the treatment problems associated with them.

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