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A CONCISE REVIEW ON CALCIFIED CANALS - A REVIEW

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Running Title: A concise review on calcified canals.

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ABSTRACT:

A calcified canal is a root canal system complication due to hard tissue deposition which makes the canal narrower. Calcification is uncontrolled due to enzyme failure that could result in reduced blood supply to the tissue. Canal calcification is usually termed as an obliteration of the pulp canal. Pulp canal obliteration (PCO) or calcific metamorphosis as sequelae of dental trauma may also occur as sequelae of aging, dental caries, tooth loss or critical pulp therapy, orthodontic care. Extreme physiologic PCO in geriatric patients can arise from secondary or tertiary dentine apposition. Despite the application of high-magnification and cone-beam computed tomographic (CBCT) imaging, access cavity preparation for such cases is prone to procedural errors that may result in substantial loss of dentin structure, thus reducing the long-term prognosis. With the aid of advanced technology, early detection of canal obliteration will save a lot of frustrations. Early intervention as a prophylactic measure may not be reasonable, due to the low incidence of such teeth developing periapical pathosis. Hence, it is important to explain prophylactic action, if intended. Upon failure of other treatment modalities surgical intervention may be a possibility. Given the difficulty in its management, it is recommended that teeth showing signs of obliteration be referred to an Endodontist who can handle such cases with minimal errors in conjunction with specialist training, magnification, proper equipment, and detailed knowledge of dental anatomy, thereby providing a better prognosis. This analysis assists in information about the calcified canals about their etiology, possible modes of growth, diagnosis, and management, thereby helping to provide better treatment quality.

Keywords: *calcified canals, negotiation, blood supply, failure of an enzyme, access opening, management.*

I. INTRODUCTION:

To all dental practitioners, calcification of the canals is a perplexing problem. Healthy, ill, and even unerupted teeth may suffer from problems with pulpal calcifications. Calcified canal negotiation is a challenge and requires patience; good magnification, illumination, and proper armamentarium [1]. Calcification is a process involving the reduction in the size of the intra-dental cavities resulting from the formation of hard tissue by the vital pulp cells. As a result of dentin deposition inside the tooth, it may end in complete calcification. The prevalence of these varies widely. Even if the etiological factors remain unclear [2].

The causes of calcifications could be trauma, aging, and various systemic diseases such as cardiovascular diseases. There are certain analyses that claim that there is a relation between calcified canals and also linked with systemic diseases [3]. Furthermore, Long-term discomfort such as deep caries and restorations with close proximity to the pulp were suggested as possible factors involved in the production of pulpal calcifications [4].

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Calcification which is uncontrolled due to pyrophosphatase enzyme failure, capillary permeability reduction, and blood supply induces calcifications. Root canal in teeth where calcific deposits block access to the canals is often hampered by treatment efforts. An attempt to locate the residual canal may extract significant quantities of dentin, and the possibility of root fracture and perforation could be present. Calcific Metamorphosis or pulp canal obliteration may be described as "a pulpal reaction to trauma characterized by rapid deposition of hard tissue within the canal space." This is also known as pulp canal obliteration, dystrophic calcification, diffuse calcification, and calcific degeneration [5]**.** Calcified pulp chamber deposits cause darker hue, loss of translucency, and yellowish appearance of the crown of the tooth. It is characterized by the deposition of hard tissue inside the space of the root canal, and clinical crown yellow discoloration [6].

The exact mechanism of canal obliteration is unclear but it is believed to be linked to damage to the pulp's neurovascular supply during trauma. Such incidents and their clinical treatment that provide the odontologist with considerable challenges; because the sequel can occur several years after the incident, proper medical and dental history, as well as a comprehensive history of the dental trauma, a thorough clinical review can assist the dental practitioner in formulating a correct diagnosis and, consequently, sufficient care [7].

It is generally accepted that the frequency of obliteration from the pulp canal depends on the extent of the luxation injury and the root formation stage. Canal calcification can be basically classified as Partial Obliteration – the chamber of the pulp is not visible, and the canal is clearly narrowed but visible. Total Obliteration – the chamber and channel of pulp is hardly visible or not visible [8].

There are two distinct types of calcification that occur in the pulp, according to Kronfeld and Boyle: calcification that is more frequent in the radicular pulp is generally referred to as diffuse or linear calcifications, whereas pulp stones (denticles) are more commonly found in the coronal region [9].

They can be categorized into embedded, interstitial, adherent, and free denticles. according to their position. Furthermore, the degree of pulp obliteration may be categorized as absolute obliteration, in which the pulp chamber and root canal are hardly or fully unseen, and partial obliteration, in which the pulp chamber is not discernible and the root canal is distinctly narrowed but clearly visible [10].

There's yet another pulp obliteration classification — localized and generalized. The etiologic agent is most commonly trauma in the localized form and this condition has been described relatively frequently following the crown and root fractures, tooth luxation, jaw fractures, tooth replantation, and endodontic procedures. The generalized form is part of the aging process and is usually seen in older people. In most teeth, the pulp chamber may be totally obliterated or hairline thin which is often accompanied by attrition [11].

Treating a calcified canal can be challenging because the pulp chamber and pulp canal are narrowed. The narrowing of the pulp chamber will lead to the difficulty in locating the canal's access and will also cause considerable difficulties during cleaning and shaping. It can lead to the breakage of the instrument during cleaning and shaping, due to the calcification of canals. Enlargement of the orifice of the channels is important for easy access to the canal. Obturation quality lies in proper cleaning and shaping [12].

If the calcified tooth is asymptomatic then it is of little concern but endodontic treatment must be performed in a tooth with periapical pathosis. There are many ways the canals can exhibit calcification such as pulp stones or calcific metamorphosis. These conditions will also cause the coronal part of the teeth to become discolored. Calcification is usually associated with tooth trauma that will stop blood supply and diminish the vascularity over time leading to calcification. Because of the canal calcification, this can often lead to a root canal treatment failure due to the difficulty in locating the canal and gaining access channel [13].

Calcification may be due to a variety of physical factors such as aging, idiopathic factors, fluoride supplementation, hypervitaminosis D, or genetic predisposition, such as imperfect dentinogenesis and dentinal dysplasia, which may even occur in unerupted teeth [14].

The main purpose of this study is to explore calcified canals in order to better understand them for improved treatment.

II. MATERIALS AND METHODS:

The review was done by collecting 49 articles using search engines such as PubMed, Google Scholar, Scopus, Cochrane, etc. The level of relevant information was analyzed, which was included in this review. Reports on the concept of calcified canals, etiology, pathogenesis, diagnosis, and management.Quality research was performed on the basis of health evidence – a quality assurance method for gathering review papers (Table 1) [15]. The findings of this study are based on previous studies conducted by respected scholars.

Table 1: Representation of Quality analysis for the articles collected.

SERIAL NUMBER	AUTHOR	YEAR	LEVEL	QUALITY OF RESEARCH
1	*Siddiqui SH et al*	2016	Level 1	Weak
2	*Patterson SS et al*	1965	Level 1	Weak
3	*Fonseca JM et al*	2015	Level 2	Moderate
4	*Hussainy SN et al*	2018	Level 1	Moderate
5	*Fonseca T et al*	2018	Level 1	Moderate
6	*AlDaiji MT et al*	2018	Level 3	Strong
7	*Moradi Majd N et al*	2014	Level 3	Moderate
8	*NGeow et al*	1998	Level 2	Strong
9	*De Touves KMS et al*	2017	Level 1	Weak
10	*Huang Y-F et al*	2004	Level 2	Strong
11	*Geethapriya N et al*	2019	Level 1	Moderate
12	*Teja KV et al*	2019	Level 1	Weak
13	*Stewart JJ et al*	1995	Level 2	Strong
14	*McCabe PS et al*	2012	Level 2	Strong

15	*Dabuleanu et al*	2020	Level 2	Moderate
16	*Schafer KG et al*	1996	Level 1	Weak
17	*Siskos GJ et al*	1990	Level 3	Strong
18	*Mahajan P et al*	2016	Level 3	Moderate
19	*Malhotra N et al*	2013	Level 3	Strong
20	*Kumar D et al*	2018	Level 1	Weak
21	*Zhao JJ et al*	2016	Level 1	Weak
22	*Jose J et al*	2020	Level 2	Moderate
23	*Bauss O et al*	2008	Level 1	Weak
24	*Delivanis HP et al*	1982	Level 1	Weak
25	*Rajendran R et al*	2019	Level 3	Weak
26	*Kulsum u et al*	2011	Level 3	Moderate
27	*Manohar MP et al*	2018	Level 2	Moderate
28	*Teja KV et al*	2018	Level 1	Strong
29	*Kiefner P et al*	2017	Level 2	Weak

30	*Ramamoorthi S et al*	2015	Level 2	Strong
31	*Kansu O et al*	2009	Level 2	Strong
32	*Ravinthar K et al*	2018	Level 3	Moderate
33	*Garg N et al*	2014	Level 3	Strong
34	*Rajakeerthi RR et al*	2019	Level 1	Weak
35	*Janani K et al*	2020	Level 3	Weak
36	*Amir FA et al*	2001	Level 1	Moderate
37	*Gopikrishna V et al*	2004	Level 2	Strong
38	*Nandakumar M et al*	2018	Level 2	Weak
39	*Johnson PL et al*	1956	Level 1	Moderate
40	*Noor SSE et al*	2016	Level 3	Strong
41	*Queiroz AF et al*	2019	Level 3	Strong
42	*Verutti E et al*	2009	Level 3	Moderate
43	*Siddique R et al*	2019	Level 3	Strong
44	*Moiseiwitsch JRD et al*	1998	Level 1	Strong

45	*Ramanathan S et al*	2015	Level 2	Strong
46	*Yang YM et al*	2016	Level 1	Weak
47	*Jain SD et al*	2020	Level 1	Strong
48	*Rivera ME et al*	2019	Level 3	Weak
49	*Floratos S et al*	2017	Level 3	Strong

III. CALCIFICATION OF PULP:

The calcified structure can be classified according to the Kronfield structure which is most commonly used. True denticles (composed of tubular dentine), False denticles composed of concentrated layers, not dentin-like calcified material), Diffuse calcifications (Small calcified deposits scattered throughout the pulp tissue).

Though these structures resemble the same but differ in their mode of development (i.e., true denticles develop as a result of epithelio-mesenchymal interactions, whereas false denticles form on a calcified Nidus). No such strict relationship exists, as shown below [16]. Second, most pulpal calcifications are conglomerates of different tissues: orthodentine, normal, and irregular calcified material, so that a distinction is almost impossible [17].

IV. Orthodentin, tubular dentin may present in pulp stone and denticles:

Denticles

Formed as a result of epithelio-mesenchymal interactions are made up of tubular dentin at the earliest stage of their development, but as the calcified bodies increase, most or all of the odontoblasts decrease in height and disappear.

Pulp stones

These are initially developed as an amorphous calcified nidus. It was suggested that all dental papilla cells undergo initial induction by odontogenic epithelium and by differentiation into odontoblasts and dentin production. But this may not happen when there is a presence of pulp stone that can lead to canal calcification [18].

Regular calcified material found in the peripheral region:

Pulp stones increase in size through the gradual deposition on the surface of the irregularly calcified nidus core of layers of regular calcified material. The most striking feature of the calcified body resulting is that it appears to be microscopically laminated light. A laminated pulp stone consists of layers of concentrated collagen fibers, an interfibrillar material into which mineral hydroxyapatite has been deposited [19].

V. Irregular calcified material

These can be found in the core of most pulp stones, but also sometimes on the surface of a laminated pulp stone or even on a denticular surface. This type of material consists of diffuse calcifications. Irregular calcified deposits consist of an irregular matrix of collagen fibers and interfibrillar, electron-dense material into which crystallites of hydroxyapatite have been placed. The collagen fibers apparently form part of the pulp tissue 's natural intercellular matrix. These calcified bodies have an irregular periphery, and they are larger in size. They grow to lie matrix fibers by adding minerals [20].

VI. ETIOLOGY OF CALCIFIED CANALS:

The etiological factors which result in the obliteration of the pulp canal are prolonged trauma, the natural aging process, gender, various systemic diseases, non-vital tooth without endodontic treatment, long-term irritation such as dental restorations and crowns which exert a constant force on the tooth [21].

Changes in age result in reduced size of the pulp due to secondary dentin deposition, occurring during life contributing to a decrease in canal length and width. Blood supply also decreases with age. The pulp horns and the pulp chamber floor and roof in molars can be reduced to a flat disk in the elderly due to attrition from a large rectangular cavern in the young [22].

Deposition at roots is always concentrated toward the center of the dentine mass. Reactionary and reparative dentine, which is used to minimize the porosity of dentinal tubules exposed to caries, trauma, or dental treatment or to heal pulpal exposures, further decreases the pulp volume [23]. Generalized pulp obliteration was also observed but in some diseases such as Marfan syndrome and renal osteodystrophy and atherosclerosis, it was not experimentally developed. It is also stated that orthodontic treatment may cause blood vessel compression, which can cause calcification of the canal [24].

Pulp canal obliteration has been found in all luxation categories and it has been observed that blood vessels are constricted in teeth with closed apices that lead to pulpal necrosis, whereas if the apices are open, the tooth will react with increased sclerotic dentine deposition. Restorative materials may also have an effect on the underlying pulp leading to odontoblastic injury resulting in pulp calcification [25].

VII. V. POSSIBLE MODES OF DEVELOPMENT:

Due to uncontrollable mineralization due to the failure of the normal functioning of the self-limiting pyrophosphatase enzyme, can develop canal calcification. A loss of parasympathetic inhibition may lead to a reduction in the supply of pulpal blood which could lead to cellular respiratory depression, leading to pathological mineralization of the pulp, some studies hypothesized that the deposition of hard tissue is a consequence of stimulation of pre-existing odontoblast. This also makes the tooth unable for remineralization in which calcium phosphate and fluoride ions are deposited in the demineralized part of the teeth [26]. It has been reported that in humans the average rate of reparative dentin formation is 2.8 microns for deciduous teeth and 1.5 microns for permanent teeth. But in the case of calcified canals, this varies [27]. Two different modes of pulpal calcification production were generally proposed: calcification of tissue components and epithelial-mesenchymal interaction

VIII. Calcification Of Tissue Components

The initial calcification of a component of pulp tissue (ground substance, necrotic cell residues, collagen fibril), which is served as a nidus on which calcified material is eventually deposited, is present in various calcification promoters and inhibitors, either in concentrated lamellar or in a radial fashion, in any connective tissue. These nidus or bacterial colonies can be avoided by giving intracanal medicament (Ledermix) in early-stage to avoid initiation of calcification [28]. In a normally non-calcifying tissue, such as the pulp, calcification may occur when the balance between the two is disturbed; for example, the local breakdown of inhibitors (e.g., proteoglycan complexes) [29]. Local metabolic dysfunction "is the precipitating factor for nidus development. A close spatial relationship exists between calcified structures and the pulp's blood vessels and/or nerves [30].

Occasionally these nidi (or foci) occur in neurovascular bundles, mostly during shedding in the pulps of the deciduous teeth. While in the latter the calcifications likely associated with the degeneration of the nerves themselves, the observed relationship between calcifications and neurovascular bundles may be coincidental due to the richness of the pulp's neurovascular supply, making the calcified structure almost impossible [31]Some researchers suggested that pulpal calcifications may be associated with certain systemic conditions such as arteriosclerosis. While incidence in normal individuals was 46 percent, in patients with arteriosclerosis (53 percent), osteitis deformans (55.7 percent), and acromegaly (57.1 percent), this was somewhat but not significantly higher [32]**.**

IX. Epithelio-Mesenchymal Interactions

During the development of a tooth, the epithelial strands are separated from the enamel tissue. Subsequently, these strands become isolated in the dental papilla where they interact with the mesenchyme papilla, resulting in normal differentiation of odontoblasts around the strands [33]**.**

The undifferentiated ectomesenchymal cells of dental papilla are to differentiate into two daughter cells during the development of a tooth. Under the epithelial effect, the first daughter cell differentiates into odontoblasts and lays down dentin whereas the 2nd daughter cell that is not subjected to epithelial effect survives as a sub odontoblast cell that differentiates into odontoblast as cells and deposits dentine as hard tissue under other influences. These are

found in multi-rooted teeth furcation zones, where epithelial extensions subdivide the enamel organ cervical opening [34].

X. DIAGNOSIS OF CALCIFIED CANALS:

Clinical findings

Color

Pulpal obliteration of the tooth revealed yellow discoloration. These pulp obliteration teeth are darker in hue than the neighboring teeth and have a dark yellow color due to a reduction in translucency due to a higher dentin thickness under the enamel. More than two-thirds of teeth with pulpal obliteration have also been found to be asymptomatic [35].

Pulp sensibility testing

Teeth with partial pulpal obliteration were also reported to be more responsive to electric pulp testing than compared to those that were totally obliterated. The pulse oximeter is a non-invasive oxygen saturation monitoring device that is commonly used in clinical practice to measure blood oxygen saturation levels during intravenous anesthesia administration [36]. It is generally accepted that the absence of a positive response to the electric pulp test does not automatically imply that there is pulp necrosis [37].

Radiographic findings

The calcified canal radiograph appears either as partial or total obliteration of the pulp canal space per apical pathosis, with or without associated. Total radiographic obliteration of the pulp space does not mean the absence of the pulp canal space; a pulp space with pulp tissue is present in the majority of these cases, but the sensitivity of traditional radiographs is too low to enable the capture of their images [38].

Histopathology

The pulp status of pulpal canal obliterated teeth has failed to show any symptoms of pathological process inflammation[39]. Previous studies described pulpal obliteration as a highly irregular, tertiary dentine reaction to trauma in pattern and calcification. In traumatized primary teeth it was found that dentine-like, bone-like, or fibrotic tissues occluding the pulpal lumen were in nature [40].

Differential Diagnosis

Canal calcifications are not usually of pathological origin; they may be the result of natural pulp aging. Moderate to extreme periodontal diseases show diffuse calcification [41]. Certain factors, such as alkaline pH of calcium hydroxide bases, unset composite monomers, hand or mechanical condensation pressure, thermal conductivity, and micro-leakage may also stimulate localized reparative dentin deposition leading to the eventual obliteration of the pulp canals. In chronic pulpitis, the pulp tends to become obliterated by the root canal processing of reparative dentin [42].

XI. MANAGEMENT OF CALCIFIED CANALS:

Krasner and Rankow have laid down other laws that are especially useful in finding calcified orifices for canals. The DG-16 explorer (SybronEndo) is the most important orifice positioning instrument. Number 6 K- file is used for channel negotiation but is very good and lacks rigidity. Channel pathfinder such as canal Pathfinder or instrument with higher shaft resistance, such as pathfinder CS (Kerr), can be used as an alternative [43].

Many practitioners likewise prefer the use of magnification in the form of enhanced glasses or a microscope. Examining highly magnified color changes on the floor will help to locate the orifice of the canal. Chelating agents can be useful in channel irrigation with 2.5 percent-5.25 percent sodium hypochlorite, which increases organic debris dissolution [44].

The penetration of calcified canals can be made easier by using chelating pastes or solutions. Ultrasonic instruments aids to loosen debris in the canal orifices located in the pulp chamber. For the calcified canals, the flaring is one in crown-down fashion to avoid complications. Endodontic microsurgery is an option in the treatment of calcified canals because it provides a direct approach to the root apex [45].

Cone-beam computed tomography (CBCT) generates three-dimensional dentition scans, the maxillofacial skeleton, and anatomical structural relationships. CBCT's endodontic applications include diagnosing periapical bone defects,

assessing internal and external root resorption, detecting vertical root fractures, visualizing and locating perforations, identifying root canals, and treatment planning for surgical and complex cases such as invaginated teeth [46].

CBCT analysis plays a vital role in detecting the calcification depth by means of gutta-percha points. The benefits of CBCT areas are as follows: Accurate reproduction and measurement in 2D and 3D, Image accuracy, Rapid scans, and Limited Area Sensitive Scanning CT scanners are simpler, less complicated, and less expensive [47].

3- Dimensional navigation technology also helps to locate apertures which require a minimally invasive procedure. New dynamic navigation technology with high-speed drills has the ability to achieve minimally intrusive access cavities by finding extremely complex calcified canals. New improvements to dynamic navigation technology promote clinical viability in non-operative drilling to reduce iatrogenic errors [48].

XII. LIMITATIONS:

Locating the orifices with ultrasonic tips can cause teeth damage sometimes [49]. Calcified canal diagnosis still does not have a universal method to follow [50].

XIII. FUTURE SCOPE:

This analysis will lead researchers to find innovative ways to access calcified canals. Additionally, any advance will lead to the early detection of calcified canals. This review provided a concise understanding of calcified canals that could serve better treatment and management.

XIV. CONCLUSION:

The calcification of root canals is a challenge for the dentist and causes a lot of difficulty in instrumentation even though it can be challenging to negotiate and manage calcified canals, they can be managed if a proper protocol is followed. The skill, patience, and proper armamentarium of the operator are necessary to overcome the difficulties of delivering a successful treatment. However, these difficulties can be managed through the use of different instruments to negotiate the canal. By understanding all aspects of the calcified canal, appropriate treatment can be provided by acquiring adequate knowledge about calcified canals, thus leading to successful treatment.

REFERENCES:

[1] Siddiqui SH, Mohamed AN. Calcific Metamorphosis: A Review. Int J Health Sci 2016;10:437–42.
[2] Patterson SS, Mitchell DF. Calcific metamorphosis of the dental pulp. Oral Surgery, Oral Medicine, Oral Pathology 1965;20:94–101. https://doi.org/10.1016/0030-4220(65)90272-0.
[3] Fonseca GM, Fonseca MM. Calcific Metamorphosis with Pathological Root Resorption in Permanent Teeth: Morphohistometric Evaluation of Two Cases. International Journal of Morphology 2015;33:712–8. https://doi.org/10.4067/s0717-95022015000200047.
[4] Hussainy SN, Nasim I, Thomas T, Ranjan M. Clinical performance of resin-modified glass ionomer cement, flowable composite, and polyacid-modified resin composite in noncarious cervical lesions: One-year follow-up. J Conserv Dent 2018;21:510–5.
[5] Fonseca Tavares WL, Diniz Viana AC, de Carvalho Machado V, Feitosa Henriques LC, Ribeiro Sobrinho AP. Guided Endodontic Access of Calcified Anterior Teeth. J Endod 2018;44:1195–9.
[6] AlDaiji MT, Alsahaly L. Aesthetic management of complete calcific metamorphosis: a case report. International Journal of Research in Medical Sciences 2018;6:3782. https://doi.org/10.18203/2320-6012.ijrms20184264.
[7] Moradi Majd N, Arvin A, Darvish A, Aflaki S, Homayouni H. Treatment of necrotic calcified tooth using intentional replantation procedure. Case Rep Dent 2014;2014:793892.
[8] Ngeow, Ngeow, Thong. Gaining access through a calcified pulp chamber: a clinical challenge. International Endodontic Journal 1998;31:367–71. https://doi.org/10.1046/j.1365-2591.1998.00176.x.
[9] de Toubes KMS, de Oliveira PAD, Machado SN, Pelosi V, Nunes E, Silveira FF. Clinical Approach to Pulp Canal Obliteration: A Case Series. Iran Endod J 2017;12:527–33.
[10] [Huang Y-F, Zhu Y-Q. [Advances in investigation of calcified root canal therapy]. Shanghai Kou Qiang Yi Xue 2004;13:141–3.
[11] Geethapriya N, Subbiya A, Newbegin Selvakumar Gold, Venkatesh A. Successful Management of Calcified Canal with Perforation—A Case Report with Six Months Follow Up. Indian Journal of Public Health Research & Development 2019;10:3014. https://doi.org/10.5958/0976-5506.2019.04367.5.
[12] Teja KV, Ramesh S. Shape optimal and clean more. Saudi Endodontic Journal 2019;9:235.
[13] Stewart GG. Gaining access to calcified canals. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology,

and Endodontology 1995;79:764–8. https://doi.org/10.1016/s1079-2104(05)80314-2.
[14] McCabe PS, Dummer PMH. Pulp canal obliteration: an endodontic diagnosis and treatment challenge. Int Endod J 2012;45:177–97.
[15] Health Evidence - Quality Assessment Tool 2016. https://www.healthevidence.org/documents/our-appraisal-tools/QA_Tool&Dictionary_10Nov16.pdf (accessed June 17, 2020).
[16] Cleaning and Shaping Calcified Canals | jcda n.d. https://jcda.ca/article/b38 (accessed June 5, 2020).
[17] Schafer KG. Treatment of calcified root canals. Ont Dent 1996;73:21–3.
[18] Siskos GJ, Georgopoulou M. Unusual case of general pulp calcification (pulp stones) in a young Greek girl. Dental Traumatology 1990;6:282–4. https://doi.org/10.1111/j.1600-9657.1990.tb00433.x.
[19] Mahajan P, Grover R, Bhandari SB, Monga P, Keshav V. Management of Mandibular Lateral Incisor with Two Roots: a Case Report. International Journal of Medical and Dental Sciences 2016;5:1093. https://doi.org/10.19056/ijmdsjssmes/2016/v5i1/83583.
[20] Malhotra N, Mala K. Calcific metamorphosis. literature review and clinical strategies. Dental Update 2013;40:48–60. https://doi.org/10.12968/denu.2013.40.1.48.
[21] Kumar D, Delphine Priscilla Antony S. Calcified Canal and Negotiation-A Review. Research Journal of Pharmacy and Technology 2018;11:3727. https://doi.org/10.5958/0974-360x.2018.00683.2.
[22] Zhao J-J, Zhou Z-J, Han J-L, Zhu Y-Q. [Clinical management of calcified root canal with Mtwo NiTi files]. Shanghai Kou Qiang Yi Xue 2016;25:204–7.
[23] Jose J, P. A, Subbaiyan H. Different Treatment Modalities followed by Dental Practitioners for Ellis Class 2 Fracture – A Questionnaire-based Survey. The Open Dentistry Journal 2020;14:59–65. https://doi.org/10.2174/1874210602014010059.
[24] Bauss O, Neter D, Rahman A. Prevalence of pulp calcifications in patients with Marfan syndrome. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106:e56–61.
[25] Delivanis HP, Sauer GJ. Incidence of canal calcification in the orthodontic patient. Am J Orthod 1982;82:58–61.
[26] Rajendran R, Kunjusankaran RN, Sandhya R, Anilkumar A, Santhosh R, Patil SR. Comparative Evaluation of Remineralizing Potential of a Paste Containing Bioactive Glass and a Topical Cream Containing Casein Phosphopeptide-Amorphous Calcium Phosphate: An in Vitro Study. Pesquisa Brasileira Em Odontopediatria E Clínica Integrada 2019;19:1–10. https://doi.org/10.4034/pboci.2019.191.61.
[27] Kulsum U, Farzana F. Surgical Management of Calcific Metamorphosis of Pulp: A Case Report. BIRDEM Medical Journal 2011;1:46–50.
[28] Manohar MP, Sharma S. A survey of the knowledge, attitude, and awareness about the principal choice of intracanal medicaments among the general dental practitioners and nonendodontic specialists. Indian J Dent Res 2018;29:716–20.
[29] Teja KV, Ramesh S, Priya V. Regulation of matrix metalloproteinase-3 gene expression in inflammation: A molecular study. J Conserv Dent 2018;21:592–6.
[30] Kiefner P, Connert T, ElAyouti A, Weiger R. Treatment of calcified root canals in elderly people: a clinical study about the accessibility, the time needed and the outcome with a three-year follow-up. Gerodontology 2017;34:164–70. https://doi.org/10.1111/ger.12238.
[31] Ramamoorthi S, Nivedhitha MS, Divyanand MJ. Comparative evaluation of postoperative pain after using endodontic needle and EndoActivator during root canal irrigation: A randomised controlled trial. Aust Endod J 2015;41:78–87.
[32] Kansu O, Ozbek M, Avcu N, Aslan U, Kansu H, Gençtoy G. Can dental pulp calcification serve as a diagnostic marker for carotid artery calcification in patients with renal diseases? Dentomaxillofac Radiol 2009;38:542–5.
[33] Ravinthar K, Jayalakshmi. Recent Advancements in Laminates and Veneers in Dentistry. Research Journal of Pharmacy and Technology 2018;11:785. https://doi.org/10.5958/0974-360x.2018.00148.8.
[34] Garg N, Garg A. Cleaning and Shaping of Root Canal System. Textbook of Endodontics 2014:246–246. https://doi.org/10.5005/jp/books/12108_18.
[35] R R, Rajakeerthi R, Ms N. Natural Product as the Storage medium for an avulsed tooth – A Systematic Review. Cumhuriyet Dental Journal 2019;22:249–56. https://doi.org/10.7126/cumudj.525182.
[36] Janani K, Palanivelu A, Sandhya R. Diagnostic accuracy of dental pulse oximeter with customized sensor holder, thermal test and electric pulp test for the evaluation of pulp vitality - An in vivo study. Brazilian Dental Science 2020;23. https://doi.org/10.14295/bds.2020.v23i1.1805.
[37] Amir FA, Gutmann JL, Witherspoon DE. Calcific metamorphosis: a challenge in endodontic diagnosis and treatment. Quintessence Int 2001;32:447–55.
[38] Gopikrishna V, Parameswaran A, Kandaswamy D. Criteria for management of calcific metamorphosis: review with a case report. Indian J Dent Res 2004;15:54–7.
[39] Nandakumar M, Nasim I. Comparative evaluation of grape seed and cranberry extracts in preventing enamel

erosion: An optical emission spectrometric analysis. J Conserv Dent 2018;21:516–20.
[40] Johnson PL, Bevelander G. Histogenesis and Histochemistry of Pulpal Calcification. Journal of Dental Research 1956;35:714–22. https://doi.org/10.1177/00220345560350050901.
[41] Noor SSSE, S Syed Shihaab, Pradeep. Chlorhexidine: Its properties and effects. Research Journal of Pharmacy and Technology 2016;9:1755. https://doi.org/10.5958/0974-360x.2016.00353.x.
[42] Queiroz AF, Hidalgo MM, Consolaro A, Panzarini SR, França AB, Pires WR, et al. Calcific metamorphosis of pulp after extrusive luxation. Dent Traumatol 2019;35:87–94.
[43] Berutti E, Cantatore G, Castellucci A, Chiandussi G, Pera F, Migliaretti G, et al. Use of nickel-titanium rotary PathFile to create the glide path: comparison with manual preflaring in simulated root canals. J Endod 2009;35:408–12.
[44] Siddique R, Sureshbabu NM, Somasundaram J, Jacob B, Selvam D. Qualitative and quantitative analysis of precipitate formation following interaction of chlorhexidine with sodium hypochlorite, neem, and tulsi. J Conserv Dent 2019;22:40–7.
[45] Moiseiwitsch JRD, Trope M. Nonsurgical root canal therapy treatment with apparent indications for root-end surgery. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology 1998;86:335–40. https://doi.org/10.1016/s1079-2104(98)90182-2.
[46] Ramanathan S, Solete P. Cone-beam Computed Tomography Evaluation of Root Canal Preparation using Various Rotary Instruments: An in vitro Study. The Journal of Contemporary Dental Practice 2015;16:869–72. https://doi.org/10.5005/jp-journals-10024-1773.
[47] Yang Y-M, Guo B, Guo L-Y, Yang Y, Hong X, Pan H-Y, et al. CBCT-Aided Microscopic and Ultrasonic Treatment for Upper or Middle Thirds Calcified Root Canals. Biomed Res Int 2016;2016:4793146.
[48] Jain SD, Carrico CK, Bermanis I. 3-Dimensional Accuracy of Dynamic Navigation Technology in Locating Calcified Canals. Journal of Endodontics 2020;46:839–45. https://doi.org/10.1016/j.joen.2020.03.014.
[49] Rivera-Peña ME, Duarte MAH, Alcalde MP, Furlan RD, Só MVR, Vivan RR. Ultrasonic tips as an auxiliary method for the instrumentation of oval-shaped root canals. Brazilian Oral Research 2019;33. https://doi.org/10.1590/1807-3107bor-2019.vol33.0011.
[50] Floratos S, Miltiadous M-E. Intraoperative Use of CBCT for Identification and Localization of Calcified Canals: A Clinical Technique. Case Reports in Dentistry 2017;2017:1–6. https://doi.org/10.1155/2017/1265701.