



ISSN: 0975-833X

Available online at <http://www.journalcra.com>

International Journal of Current Research
Vol. 15, Issue, 01, pp.23217-23220, January, 2023
DOI: <https://doi.org/10.24941/ijcr.44550.01.2023>

INTERNATIONAL JOURNAL
OF CURRENT RESEARCH

RESEARCH ARTICLE

GUIDED ENDODONTICS FOR CALCIFIED ROOT CANALS- A REVIEW

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ARTICLE INFO

Article History:

Received 16th October, 2022
Received in revised form
19th November, 2022
Accepted 15th December, 2022
Published online 20th January, 2023

Key words:

Calcified, Dynamic Guided Endodontics, Guided Endodontics, Obliterated Canal, Pulp Canal Obliteration, Static Guided Endodontics.

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Citation: Renuka Nagarale, Mandar Todkar, Fatima Shaikh, Najiya Shaikh, Kanshini Waghmare and Sanaya Ahmed, A. 2023. "Guided Endodontics For Calcified Root Canals- A Review". *International Journal of Current Research*, 15, (01), 23217-23220.

ABSTRACT

Introduction: The 'guided endodontics' technique was introduced in 2017 as a substitute for the conventional access cavity preparation for teeth with canal obliteration, apical pathosis or irreversible pulpitis. With the help of cone-beam computed tomography and a digital surface scan, an optimal access to the calcified root canal orifice can be planned virtually with suitable software. **AIM:** The aim of this review was to provide with an update on the application of guided endodontics for calcified root canals. **Materials and Methods:** A search of the particular literature was performed on four electronic databases PubMed, Scopus, Science Direct, and Web of Science until October 2022. Studies that answered the research question were included (i) application of guided endodontics for calcified canals, (ii) case reports and (iii) in vitro or ex vivo studies assessing types, advantages, disadvantages, and outcomes of its use and the accuracy as well as limitations of guided endodontics for calcified canals. The exclusion criteria were as follows: (i) Articles in any language other than English, (ii) Articles before the year 2017 (iii) experts' opinion and (iv) guideline reports. The researchers reviewed the complete list of articles and selected the articles that were potentially relevant. Later, full-text screening was performed and articles that did not meet the inclusion criteria were excluded. The articles those dealt with a topic other than that of interest to this literature review were also excluded. **Conclusion:** GE seems to be extremely promising. Favorable laboratory-based results regarding the accuracy of guided endodontic access cavities for both static and dynamic navigation provided better insight towards it being more accurate and safer.

INTRODUCTION

Pulp canal obliteration (PCO) can result due to luxative injuries and other stimulants. It is radiographically characterized as evidence of increased dentine production, primarily as a response to trauma. Depending on the extent of Pulp canal Obliteration, root canal treatment can prove to be challenging even for experienced and well-equipped endodontic specialists. The treatment can be extremely time-consuming and carries an increased risk of perforation. They occur in 15%–40% of cases followed by luxation injuries (Andreasen, 1987; Nikoui, 2003). Calcific metamorphosis caused due to trauma, produces a pulp response leading to rapid deposition of hard tissue in the pulp space (Bastos, 2018; Spinaz, 2021; Mass, 2011; Fleig, 2017). Pulp Obliteration may be total (the pulp chamber and root canals are difficult to visualize or not visible) or partial (the pulp chamber is indistinguishable and root canals are significantly narrow but visible) (Kristerson, 1985).

The pulp indirectly is considered vital due to apposition of dentine, but is frequently encountered with a negative response to sensitivity testing. Although Pulp Obliteration is a reparative response, it can lead to pulp necrosis (PN), which is closely related to the degree of root development. Establishing a treatment plan for these teeth is complicated. Some authors have advocated for a prophylactic endodontic treatment upon the diagnosis of Pulp Obliteration, since it is believed that the risk of necrosis increases upon new trauma or after therapeutic treatments such as orthodontics and dental restorations (Robertson, 1996; Vinagre, 2021). At the moment there is consensus, that root canal treatment is not indicated unless there is clinical symptomatology and radiological evidence of pulpal or periapical involvement (ESE, 2021; Krastl, 2021). However, in these teeth periodontitis results over time, leading to a need for root canal treatment. This is to be expected in up to 27% of the examined teeth with Pulp canal Obliteration after a longer observation period (Oginni, 2009).

Table 1.

Authors	Objective of the study	Type of Teeth	Adjuncts used	Conclusion
X.Shi et al (2017) ^[16]	Guided endodontics for treating a molar with pulp canal calcification and apical pathology	Mandibular right first molar	CBCT Intra oral scan	Guided endodontics appears to be a safe and clinically useful method for treating teeth with pulp canal calcification and apical pathology. The use of 3D printed templates may facilitate the localization of the canal and allow for a more predictable approach.
Tavares et al. (2019) ^[17]	Guided endodontics in complex symptomatic cases with calcified root canals.	two mandibular molars, and one case of a maxillary molar	CBCT	The use of guided endodontics in cases of calcification in molars was demonstrated to be a viable and reliable alternative treatment
Bordone et al.(2020) ^[18]	Endodontic treatments of obliterated teeth using a static guided endodontic (GE) technique.	Mandibular right canine, right central incisor, mandibular left canine, maxillary right canine.	Pulp Vitality Tests CBCT	Static GE assists endodontists in the management of complex cases by enabling centered drilling of the canal with minimum risk of deviating from the virtually planned path. The novel choice of a small-diameter drill (0.75 mm) helps maximize the preservation of the dental tissues.
DrKhyathi Shah (2020) ^[19]	Using microguided endodontics for negotiating a root canal.	Right Central Incisor	Periapical radiograph CBCT Intraoral surface scan microscope	The Microguided endodontics approach seems to be a safe, clinically feasible method for locating root canals and preventing iatrogenic errors in teeth with pulp canal calcification that cannot be predictably accessed via traditional endodontic methods.
Thomas Connert et al. (2018) ^[20]	To present a novel miniaturized and minimally invasive treatment approach for root canal localization in mandibular incisors with pulp canal calcification and apical periodontitis.	Mandibular left and right central incisors.	Periapical radiograph CBCT intra-oral surface scan	Preparation of minimally invasive access cavities to the apical third of the root in mandibular incisors is feasible with the presented Microguided Endodontics technique using miniaturized instruments.
Fonseca Tavares et al.(2018) ^[21]	Using guided endodontics in calcified anterior teeth and discusses the applicability of this approach	Maxillary right central incisors.	CBCT Intraoral surface scan	The conventional opening access programming of guided endodontics in cases of PCC in anterior teeth with apical periodontitis has been shown to be very reliable and permits proper root canal disinfection.
Lara-Mendes et al.(2018) ^[22]	Minimally invasive approach that leads to no tooth damage at the incisal edge.	Maxillary left central incisor	CBCT Intra oral scan	The guided endodontic therapy provided a conservative access with no tooth damage at the incisal edge in a safe and predictable way despite the presence of a severely calcified root canal.
Maia et al. (2019) ^[23]	Using guided endodontics for the treatment of complex calcified root canals	1 molar and 2 premolar	Periapical radiograph CBCT	Execution is relatively fast and safe even in the case of the upper molar

Throughout the endodontic treatment of obliterated teeth, a number of complications arise that can hinder both the treatment and the prognosis of the affected tooth. A retrospective study conducted four decades ago, assessed the frequency of technical failures and the 4-year success rates of root canal treatments in incisors with post-traumatically reduced pulpal lumen and periapical pathologies. In teeth with total obliteration, technical failures such as root perforation, fracture of a file or inaccessible root canals occurred in one third of the cases, which led to significantly reduced success rates after root canal treatment (Cvek, 1982). In order to minimize the risk of technical errors and to reduce the treatment time, a minimally invasive computer-assisted approach was developed to localize calcified root canals, and that was termed as 'Guided Endodontics' (Krastrl, 2016; Zehnder, 2016). At the moment, there are two different types of guided endodontics: static guided endodontics (SGE) and dynamic guided endodontics (DGE). Hence the purpose of this review was to provide with an update on the application of Guided Endodontics for calcified root canals.

MATERIALS AND METHODS

A search of the particular literature was performed on four electronic databases PubMed, Scopus, Science Direct, and Web of Science until October 2022. Studies that answered the research question were included (i) application of guided endodontics for calcified canals, (ii) case reports and (iii) in vitro or ex vivo studies assessing types, advantages, disadvantages, and outcomes of its use and the accuracy as well as limitations of guided endodontics for calcified canals. The exclusion criteria were as follows: (i) Articles in any language other than English, (ii) Articles before the year 2017 (iii) experts' opinion and (iv) guideline reports. The researchers reviewed the complete list of articles and selected the articles that were potentially relevant. Later, full-text screening was performed and articles that did not meet the inclusion criteria were excluded. The articles those dealt with a topic other than that of interest to this literature review were also excluded.

RESULTS

Once the search of the evidence in PubMed, Scopus, Science Direct, and Web of Science were found. The total sum of 50 articles was stored in a reference manager software in order to ease the organization and storage, as well as to discard duplicates. 26 articles were selected by title and abstract that seemed to be related to the main search topic. Finally, the remaining articles were read entirely, resulting in the 13 studies that were included in this literature review. The year of publication ranges from 2017 to 2022.

STUDY CHARACTERISTICS: From the selected 13 studies, 8 of them were case reports of guided endodontics used for the treatment of obliterated canals (Table 1). From the 13 research studies, 3 studies compared between conventional treatment approach and guided endodontics, all showing excellent results (Ali, 2021; Loureiro, 2020; Jain, 2021). Only one study compared two different software used for guided approach and one study was done (Krug, 2020)

DISCUSSION

It is agreeable that the most common treatment performed by guided endodontics is of calcified canals. Jain A, Nikhade P (2021) aimed to locate calcified canals by performing minimally invasive cavities using conventional method and guided endodontics. It was found that the manual treatment accumulated several errors that resulted in perforations and a greater amount of dental tissue removal. Using high-speed drills entails less operation time compared to low-speed drills used in conjunction with 3D guides in static guided endodontic. This was also concluded in the study by Loureiro MA (2020). In the study by Ali A, Arslan H (Ali, 2021) it was confirmed that even an inexperienced and novice operator could have similar success to an

endodontic specialist with respect to locating calcified canals, removing a minimal amount of dental tissue, and completing the treatment in similar time. The Static Guided-access significantly preserved the fracture resistance of the teeth as compared with the control group ($P < 0.05$). There was a significant difference between the groups in terms of failure. Preparation path to maintain straight line access through the Mineral Trioxide Aggregate (MTA) was easier with guided endodontics. Non-restorable failure was the more frequent type of failure in the control group as compared with the Static Guided-access group. The access cavities located with guided endodontics, specifically Static Guided Endodontic (SGE), are limited to a linear access, and they cannot be performed in curved canals or in teeth with an abnormal morphology. In the case of straight canals in the same tooth, several guides would have to be designed in the case of Dynamic Guided Endodontic (DGE) depending on root or depending on where the canals are located. A single guide with several accesses could be considered in cases of multiple root canals in adjacent teeth, e.g., several incisors, or one seating Dynamic Guided Endodontic (DGE) treatment could be planned to perform these root canals (Krug, 2020). In recent times, with the advancement in technology, magnifying glasses, microscopes, and Cone Beam Computed Tomography (CBCT) can be utilized for better guidance. But at the same time, it can be difficult for the operator to interpret the Cone Beam Computed Tomography (CBCT) images, create a mental guide, and perform the treatment manually all together. In a study, all root canals could be detected, full working length could be established in 90% of the cases using a microscope and a success rate of 80% could be achieved after 3 years post treatment (Kiefner, 2017). However, up to one hour was needed to negotiate the root canals. Substantial loss of hard tissue particularly in the cervical region was noticed in association with negotiating root canals, which is prone to root fracture. This can lead to reduced stability and favorable long-term prognosis of the tooth (Lang, 2006). Intraoral scanner and its accuracy have an added value when used with guided endodontic, it helps reducing the number of steps (Fonseca Tavares, 2018). However, the clinical cases showed that it is not important to attain positive result. It has been reported that the digital impression technique is clinically better than the optical scanning of a gypsum cast compared to scanning natural teeth directly (Albdour, 2018). However, the optimal error value for clinical and digital impression acquisition for guided endodontics has not yet been described. Considering the limitations of guided endodontics, it can be observed that this technique is promising method for the endodontic or surgical treatment of complex cases. The use of a guide eases the work of the clinician, reducing the working time and results in a more reliable outcome (Albdour, 2018)

CONCLUSION

Guided endodontics using static or dynamic navigation appears to be a safe, accurate and minimally invasive method for detecting calcified root canals. It has great potential for further development.

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