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# GUIDED ENDODONTICS IN THE TREATMENT OF CALCIFIED ROOT CANALS: A LITERATURE REVIEW

**Jader Oliva JORGE**
**Universidade Federal de Minas Gerais (UFMG)**
**E-mail: Jader.oj@gmail.com**
**ORCID: http://orcid.org/0000-0002-0294-895X**

**Rafaela Regina LIMA**
**Universidade Federal de Minas Gerais (UFMG)**
**E-mail: rafaelardlima@gmail.com**
**ORCID: http://orcid.org/0009-0000-6008-4347**



**Kelly Oliva JORGE**
**Pontifícia Universidade Católica de Minas Gerais (PUC Minas)**
**E-mail: Kellyoliva@yahoo.com.br**
**ORCID: http://orcid.org/0000-0001-6829-6029**

**ABSTRACT**

This study was developed through a literature review aiming to discuss the use of guided endodontics in calcified canals. Articles were retrieved from the databases Portal Capes, Medline, Lilacs, Embase, ISI, and PubMed between September 2019 and March 2020. In cases of pulp calcification, preparing an adequate access cavity and locating the canal orifice represents a clinical challenge and may lead to unnecessary loss of tooth structure. Furthermore, it often impairs instrumentation and the internal penetration of irrigating solutions into the root canal, hindering proper disinfection. A proposed technique for the treatment of calcified canals is guided endodontics, which uses a preplanned guide to direct drills along a specific path. Existing approaches to designing endodontic guides are based on visual analysis and cone-beam computed tomography (CBCT) scans of the teeth. It can be concluded that the guided endodontic technique is predictable, effective, and feasible for the treatment of teeth with pulp calcification. It represents a safe technological innovation for working in straight portions of root canals, reducing treatment time, radiation exposure, and the risk of iatrogenic damage.

**Keywords:** Guided endodontics. Calcification. Cone-beam computed tomography.

## INTRODUCTION

Endodontics is a meticulous and delicate procedure that requires extensive knowledge and skill from the professional. However, certain difficulties and challenges frequently arise in clinical practice. One of the most common challenges during endodontic treatment is root canal calcification, which may prevent adequate instrumentation of the canal (Hargreaves & Berman, 2016).

Pulpal calcifications are commonly found in the pulp chamber or root canals of a tooth and can be defined as the obliteration of pulpal spaces in response to physical, chemical, or biological agents. It is the most prevalent response of the pulp tissue to external aggressors. Pulp calcification may also occur due to physiological stimuli, such as the aging process, or environmental factors like trauma, dental caries, or parafunctional habits. Endodontic treatment should be considered for teeth with pulpal calcification when they present negative responses to vitality tests (Medeiros, 2017).



In cases involving unusual dental morphology, such as calcified root canals, guided endodontic treatment is recommended. For this purpose, a guide that directs drills according to a pre-planned path is used. Current approaches for designing endodontic guides are based on visual observation and analysis of computed tomography scans (Nayak, 2018).

These guides are three-dimensionally printed based on cone-beam computed tomography (CBCT), which enables precise planning and execution of endodontic procedures. The use of a CBCT-based endodontic guide is considered the most accurate method to access the apical portion of the root during guided endodontics, compared to the approximate freehand technique (Ackerman, 2019).

The study of guided endodontics has high clinical relevance, considering that approximately 25% of teeth requiring endodontic treatment exhibit some degree of calcification. Given the difficulty of locating the root canal in such cases, conventional endodontic treatment often leads to excessive loss of tooth structure and the occurrence of perforations, compromising the preservation and function of the dental element (Paquete, 2019).

Guided endodontics therefore emerges as a technique to translate virtual planning into the clinical deobstruction of calcified root canals, reducing clinical time and contributing to the success of endodontic therapy (Lara-Mendes et al, 2019).

Accordingly, the present study aims to contribute to the knowledge of dental professionals and students by presenting the features and benefits of this contemporary technique in the field of endodontics.

Thus, the objective of this literature review is to discuss guided endodontics as a treatment approach for calcified root canals.

## METHODOLOGY

This study was condh0ucted through a literature review, with an active search for articles in the following databases: Portal Capes, Medline, Lilacs, Embase, ISI, and PubMed, covering the period from September 2019 to March 2020. The keywords used were "endodontia guiada" and "calcificação", as well as their English equivalents: "guided endodontics" and "calcification," used in combination.



Inclusion criteria comprised articles published in Portuguese and English, within the time frame from 1998 to March 2020. Studies were included if they presented the concept of guided endodontics and evaluated the technique's functionality, accuracy, and performance.

The studies were selected based on title and abstract screening by three independent researchers. After a thorough full-text reading, articles that did not align with the research topic or that addressed the use of guides for other dental specialties (such as implantology or oral and maxillofacial surgery) were excluded. As a result, the final sample consisted of 33 articles.

## THEORETICAL FRAMEWORK

### Concept of Endodontic Treatment

Endodontic therapy aims to disinfect and instrument the root canal system by reducing the microbial load and eliminating the byproducts of microbial activity. Its goal is to ensure effective sealing of the root canal system, thereby eliminating infection and preventing or treating periapical pathologies (Pereira, Silva & Coutinho-Filho, 2012).

Imaging exams are essential before any endodontic procedure. When periapical radiographs are inconclusive, cone-beam computed tomography (CBCT) is recommended. In 2015, CBCT was endorsed by the American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiology as a diagnostic and planning tool for endodontic treatment, due to its ability to reveal detailed dental morphology (Lara-Mendes, 2018).

CBCT is a fundamental tool in endodontics, assisting in the diagnosis of periapical pathologies, root morphology, pulp calcifications, root resorptions, among others. Moreover, this diagnostic technique has improved endodontic treatment success rates through optimized treatment planning (Maia et al, 2019).

## Concept of Pulp Calcification



Pulp calcification can occur due to several factors, including patient age, since lifelong dentin deposition is a known phenomenon. In younger patients, partial or total canal calcification may be a consequence of dental trauma (Lara-Mendes et al, 2019).

Canal obliteration can be classified as total or partial. In total obliteration, both the pulp chamber and canal are radiographically invisible, whereas in partial obliteration, the canal is still visible, although significantly narrowed (Holan, 1998).

In cases of pulp calcification, creating an adequate access cavity and locating the canal orifice poses a challenge and may lead to unnecessary loss of tooth structure. Additionally, it often impairs instrumentation and the internal delivery of irrigating solutions, making proper canal disinfection difficult (Zehnder, 2015).

A minimally invasive, preplanned and guided access cavity can help preserve tooth structure and avoid iatrogenic errors, improving the long-term prognosis of the treated tooth (Zehnder, 2015; Lara-Mendes et al, 2019).

## Guided Endodontics

In teeth with completely obliterated canals, deobstruction and obturation become significantly more complex. Therefore, a novel method—guided endodontics—has been proposed. This approach aims to facilitate canal access while maximizing the preservation of dental structure (Paquete, 2019).

Guided endodontics may also be indicated to prevent further deterioration in cases where conventional treatment has failed, even with the use of surgical microscopes (Buchgreitz, Buchgreitz & Bjørndal, 2019).

According to Paquete et al. (2017), guided endodontics is indicated when there are clinical signs of pulp devitalization (negative response to vitality tests), with or without a history of trauma, and/or when periapical radiolucent lesions are present, indicating root canal therapy. After informing the patient about the lower success probability of conventional treatment, guided endodontics may be chosen as a favorable alternative. This method uses 3D printed models for guided canal access and in vitro accuracy assessment.

According to Buchgreitz et al. (2016), the use of guides reduces the risk of iatrogenic damage to the dental element and increases the likelihood of locating the root canal.

Guided endodontics resembles guided implant surgery. The technique consists of locating and accessing severely calcified canals through digital planning based on tomography (Theodorakou, 2012).



This technique involves the fusion of CBCT images and optical scans of the teeth to create a surgical guide that directs the drill into the calcified canal. After accessing the pulp chamber and placing a rubber stop on the drill (commonly used in implantology) to limit its working length, a glide path is created for canal deobstruction (Buchgreitz, Buchgreitz & Bjørndal, 2019).

According to Antunes et al. (2017), CBCT provides highly accurate 3D images of the maxillomandibular bone complex. CBCT data, when processed through specialized software, enable dynamic analysis of the target area by simultaneously scanning axial, coronal, or sagittal planes, revealing structures not visible on conventional two-dimensional radiographs.

To develop the endodontic guide, CBCT data are uploaded into virtual planning software originally designed for guided implant surgery. This enables virtual planning for the fabrication of a 3D-printed guide that directs a customized drill toward the apical third of the root canal (Connert, 2017).

The process begins with either elastomeric impressions or digital intraoral scans to obtain a study model of the target teeth. Combined with CBCT imaging, the anatomy and particularities of the dental structure are assessed. The study model is scanned using a high-resolution optical scanner. The combined data—CBCT and digitized model—are imported into software. A digital copy of the drill is overlaid onto the CBCT image and virtually aligned to avoid excessive wear of the incisal portion, guiding it toward the canal lumen (Maia et al, 2019; Lara-Mendes et al, 2019).

According to Lara-Mendes et al. (2019), the software automatically generates a virtual model. To ensure accurate transfer of the digital plan to the clinical procedure, two simulated fixation rings are added for guide stabilization, along with one ring to direct the drill toward the visible lumen of the root canal. The generated guide model is exported as a digital file and sent to a 3D printer.

The 3D-printed guides follow recommended protocols for endodontic treatment. They can also be customized based on the patient's oral conditions, being supported by teeth, mucosa, or a combination of both (Strbac, 2017). A straight-line path is created from the crown to the canal apex to guide the drill. The guide features a cylindrical corridor for the drill and external visual alignment lines for intraoperative orientation (Torres, 2019).



According to Maia et al. (2018), the drill diameter is chosen based on canal width as determined by CBCT data.

The guided endodontic technique shortens clinical time and can be performed by less experienced or non-specialist practitioners, making it a valuable alternative in complex cases (Theodorakou et al, 2012). However, Strbac et al. (2017) note that 3D planning still involves high costs and longer fabrication times compared to conventional techniques.

**DISCUSSION**

According to Campos et al. (2016), conventional endodontic treatment involves a sequence of procedures aimed at removing infected or necrotic pulp tissue from the root canal system. The canal is then prepared using mechanical instrumentation combined with chemical preparation, followed by filling with a biocompatible material capable of sealing the entire canal. This process aims to eliminate microorganisms and restore the health of tissues adjacent to the root surface. Thus, the success of endodontic therapy depends on three key procedures: cleaning, shaping, and obturation.

However, several factors can lead to the failure of endodontic treatment, many of which depend on the condition of the tooth being treated. Among these are root canal calcifications, which can alter canal anatomy and hinder proper instrumentation and subsequent obturation. Such complications may result in inadequate sealing, with obturation falling short of the apical foramen, which can lead to pathological recurrences or the development of periapical lesions that were not initially present (Hollan, 1998).

Although conventional root canal treatment has a high success rate in both simple and complex cases, calcification that obstructs canal access significantly increases the risk of treatment failure (Cohen & Hargreaves, 2011; Sardahara et al, 2016).

Lara-Mendes et al. (2019) emphasized that pulp calcification is one of the main factors complicating endodontic procedures, as it limits the access of instruments and irrigants throughout the canal system.

Root canal calcification may result from physiological aging or external aggressions such as trauma, caries, friction, or even iatrogenic damage caused by restorative procedures (Andreasen, 2012).



Supporting this view, the American Association of Endodontists (AAE, 2016) defines pulp calcification as a defensive response of the pulp tissue to injury, characterized by rapid deposition of hard tissue inside the root canal. Although histologically, radiolucent zones of pulp tissue may still be present, radiographically the canal may appear completely obliterated.

Clinically, pulp calcification may cause crown discoloration, typically turning yellow due to reduced dentin translucency (Hollan, 1998; Torres, 2019).

According to McCabe et al. (2012), Ogginni (2009), and Paquete (2019), tooth discoloration is often the most apparent consequence of pulp calcification. Despite the esthetic impact, many of these teeth remain healthy and functional, without radiographic evidence of bone lesions. However, between 7% and 27% of traumatized and subsequently calcified teeth exhibit clinical and radiographic signs compatible with pulp necrosis. Therefore, endodontic treatment should be considered in these cases.

There is a general consensus in the literature that root canal treatment is only indicated in calcified teeth if acute symptoms or apical periodontitis are present. Even the most experienced clinicians may face difficulties in such cases, and root perforations or canal deviations are commonly reported complications (Tavares, 2016; Krastl et al, 2016).

For teeth with pulp calcification, the AAE (2018) classifies treatment as highly complex, as even the initial access cavity preparation can lead to excessive tooth structure loss, compromising long-term tooth stability. Consequently, a new therapeutic approach—guided endodontics—has been proposed. This technique has a dual objective: to improve orientation for canal access and to maximize preservation of tooth structure.

Guided endodontics is indicated for root canals with mild to severe calcification, especially when there is periodontal ligament thickening or clinical and radiographic signs of periapical lesions (Ogginni, 2009).

According to Maia et al. (2019), the guided technique facilitates the endodontic treatment of calcified canals even by inexperienced professionals, allowing for maximum preservation of coronal and radicular structure, reduced risk of root perforation, and shorter clinical time compared to conventional methods.

However, as noted by Tavares (2018), guided endodontics can only be performed in straight roots or the straight portion of curved roots. The technique is limited in teeth with severely curved roots or in posterior teeth due to restricted working space in the oral cavity. Additionally, it requires a linear path to the target point—the apical region. Connert et al. (2017) also warn of the potential for dentinal microcracks and increased temperature due to drill friction. Nonetheless, Lara-Mendes et al. (2018) demonstrated that guided endodontics is feasible in posterior teeth, though careful case selection is essential in patients with limited mouth opening, which may be considered a contraindication.



Another limitation is the lack of dedicated endodontic drills. Implant drills are typically used in guided endodontics, but they are not suitable for cutting through enamel. This necessitates an additional access step using carbide burs, which may affect the procedure's precision. Moreover, the need for a specific motor for these drills may require endodontists to acquire equipment not typically used in their specialty (Elias, 2019).

When planning the fabrication of a guided endodontic guide, three-dimensional imaging is required. Cone-beam computed tomography (CBCT) is a non-invasive imaging modality capable of rendering detailed representations of dental structures in all planes. It is widely used in dentistry and has proven essential for evaluating new diagnostic and therapeutic procedures. CBCT provides highly accurate, life-size images of the target anatomy, enabling visualization of pulp calcifications and detailed root morphology. This is especially important since the guide must be securely attached to the patient's dentition to ensure accurate access by the drill (Torres, 2019; Lara-Mendes, 2018; Maia, 2019).

Furthermore, Maia et al. (2019) highlight that CBCT reduces the need for multiple radiographs during the localization of the canal system, increasing procedural predictability.

According to Torres et al. (2018), guided endodontics allows for a minimally invasive access with minimal dentin loss during drill orientation. This enhances safety during instrumentation and facilitates obturation, promoting a more predictable apical seal and aiding in the resolution of apical pathologies.

In agreement, Loureiro (2019) found that guided access, when compared to conventional access, preserved a greater volume of tooth structure. Thus, guides allow for controlled removal of dental tissue. On the other hand, ultra-conservative access may compromise canal and chamber debridement.



Teles and Gomes-Cornélio (2019) observed that the total time required for planning, imaging, and 3D printing is similar to the time spent in conventional treatment.

However, Tavares et al. (2018) and Paquete et al. (2019) report that conventional treatment in calcified canals tends to take longer, carries a higher risk of root perforations and excessive dentin wear, and subjects patients to more radiographic exposure when compared to the guided technique. Teles and Gomes-Cornélio (2019) further state that guided endodontics in calcified teeth is an effective and stable approach, reducing the risk of accidents and increasing treatment predictability.

## CONCLUSION

Based on the analysis of the advantages and limitations of the guided endodontics technique, it can be concluded that it is a predictable, effective, and feasible method for the treatment of teeth with pulp canal calcification. Guided endodontics represents a safe technological innovation for managing straight portions of root canals. It offers advantages such as reduced chair time, lower radiation exposure for the patient, and minimized risk of iatrogenic damage.

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