Guided Endodontics in Calcified Canals: Literature Review

Frujeri Maria de Lourdes Vieira[2], Oliveira Gabriela Macedo[1] and Rocha Ana Júlia Pereira[1]

[1]*Undergraduate Dentistry students of Centro Universitário Euro-Americano de Brasília- Unieuro*

[2]*PhD in Health Sciences by UnB and Professor of Dentistry at Centro Universitário Euro-Americano de Brasília- Unieuro*

Abstract: Endodontic treatment controls the root canal microbiota by shaping, disinfecting and filling the canals to promote periapical healing. The calcification process is linked to pulp alterations, usually caused by an inflammatory process due to caries, loss of tooth surface, trauma or pulp exposure. This study aimed to emphasize the influence of computed tomography-guided endodontics on the accuracy and efficacy of endodontic treatments compared to conventional techniques. Articles were selected from PubMed, SCIELO and BVS databases using the descriptors "endodontics OR root canal treatment AND dental calcification AND pulp cavity AND cone beam computed tomography". The study included articles published from 2013 to 2023. After analyzing the inclusion and exclusion criteria, 20 articles were selected. Endodontic treatment of calcified teeth is challenging and can result in failures in root canal instrumentation and disinfection. Also, it leads to complications such as perforation and weakening of the tooth structure due to excessive wear. Thus, minimally invasive endodontics is gaining prominence in contemporary endodontics. New techniques, such as guided endodontics, are emerging and have helped to reduce the risk of root perforation.

Keywords: Endodontics, Dental calcification, Cone beam computed tomography, Pulp cavity, Root canal treatment.

1. INTRODUCTION

Endodontic treatment aims at controlling the root canal microbiota by adequate root canal shaping, disinfection and obturation to achieve periapical healing. Root obliteration can compromise the access and complicate endodontic treatment, complicating this treatment. According to the American Endodontic Association, guided surgery emerged in an attempt to solve complications faced when accessing and treating more complex calcified canals [1].

The calcification process is called obliteration or calcific metamorphosis and is associated with pulp alterations. Pulp injury is commonly caused by an inflammatory process, which may be caused by caries, loss of tooth surface, dentoalveolar trauma, extensive restorations, physiological changes in elderly patients, excessive orthodontics or pulp exposure [2]. Obliteration does not necessarily lead to pulp necrosis; however, the treatment is impaired due to the complication [3].

In most cases, calcification is severe in the coronal section, extending towards the apex, and the dental professional may feel unsure to continue the treatment, which may cause complications as perforation and loss of tooth structure [3].

The use of cone beam computed tomography and intraoral scanning enables the creation of access guides, which are useful in cases of calcified root canals with unfavorable prognosis, and guided access is the most recommended [4]. Cone beam computed tomography (CBCT) is a reliable and noninvasive imaging and measurement tool. It can show teeth in all spatial planes to explore the root canal anatomy and can aid in the assessment of pulp canal obliteration (PCO). CBCT can also be used to identify periapical lesions, horizontal root fractures and root resorptions, besides assisting in paraendodontic surgeries [5].

Radiation doses are often considerably low. This can aid the specialist in establishing a personalized strategy for root canal assessment before treatment, possibly reducing the treatment time [6]. Guided endodontics acts as an access tool in cases of root canal obliteration, with endodontic access guides, also allowing the efficient and safe removal of fiberglass posts, avoiding cracks, fractures and excessive wear when removing the posts with drills. However, guided endodontics has some limitations related to the high cost of materials for fabrication of acrylic guides and the high-tech equipment to make them. The drills used in this preparation are not recommended for teeth with thin roots, which can complicate the procedure [7]. The chances of iatrogenesis as root perforations are reduced when using a 3D printed guide, enhancing the identification of root canals, reducing damage and treatment time [6].

2. METHODOLOGY

This study highlights an exploratory investigation, by a literature review, with qualitative approach, with

Address correspondence to this author at the PhD in Health Sciences by UnB and Professor of Dentistry at Centro Universitário Euro-americano de Brasília-Unieuro; E-mail: frujeri@terra.com.br

the subject "Guided endodontics in calcified canals: literature review". Above all, it aims to elucidate the following guiding question: **How does the use of computed tomography-guided endodontics influence the accuracy and effectiveness of endodontic treatments compared to conventional techniques in the endodontic treatment of calcified canals?**

The papers were identified and selected by research in the following databases: PUBMED, SCIELO and BVS. Publications from 2013 to 2023 were considered, with data collection including descriptors in Portuguese and English from the descriptors in health sciences (DECS); namely: "*Endodontia*", "*Calcificação de dente*", "*Tomografia computadorizada de feixe cônico*", "*Cavidade pulpar*", "*Tratamento do Canal Radicular*"; and "*Endodontics*", "Tooth calcification", "Cone-beam computed tomography", "Dental pulp cavity", "Root Canal Therapy" adding AND and OR as Boolean signals, which initially retrieved 73 papers.

The initial screening was followed by a strict inclusion and exclusion process. The 38 papers whose titles were directly related to the study objective were excluded. The remaining 32 papers were submitted to detailed reading of the abstracts, with special attention to those that directly compared guided endodontics with the conventional techniques in calcified canals. To ensure the relevance and applicability of studies, additional exclusion criteria were applied, excluding those that did not directly address the topic or literature reviews. Thus, 20 articles were selected to compose the theoretical basis of the research. In the data extraction process, each article was carefully analyzed to identify key variables, such as treatment methods, clinical outcomes observed, imaging techniques applied, and any complications reported. These data were organized into comparative tables to facilitate a critical and detailed analysis of guided versus conventional endodontic approaches. Also, the analysis included identification of potential methodological biases and limitations inherent to the studies, ensuring a rigorous and evidence-based interpretation.

To further enrich the analysis, a temporal comparison of technological advances described in the selected studies was performed, observing how the evolution of cone beam computed tomography (CBCT) techniques and the development of personalized endodontic guides impacted the clinical outcomes over the years. This approach allowed not only to evaluate the effectiveness of interventions, but also to understand the practical and clinical implications of technological innovations in contemporary endodontics.

The review considered the diversity of clinical scenarios presented in the studies, analyzing specific cases as severely calcified molars and incisors with thin roots, to better understand the limitations and opportunities of guided endodontics. This considered factors as treatment cost, learning curve required for the application of new technologies, and the ethical and economic implications of adopting such methods in daily clinical practice.

The methodology was complemented by discussion of the identified research gaps, suggesting directions for future studies that might deepen the knowledge on the effectiveness of guided endodontics and its potential to replace or complement conventional techniques, especially in scenarios of high endodontic complexity.

3. LITERATURE REVIEW

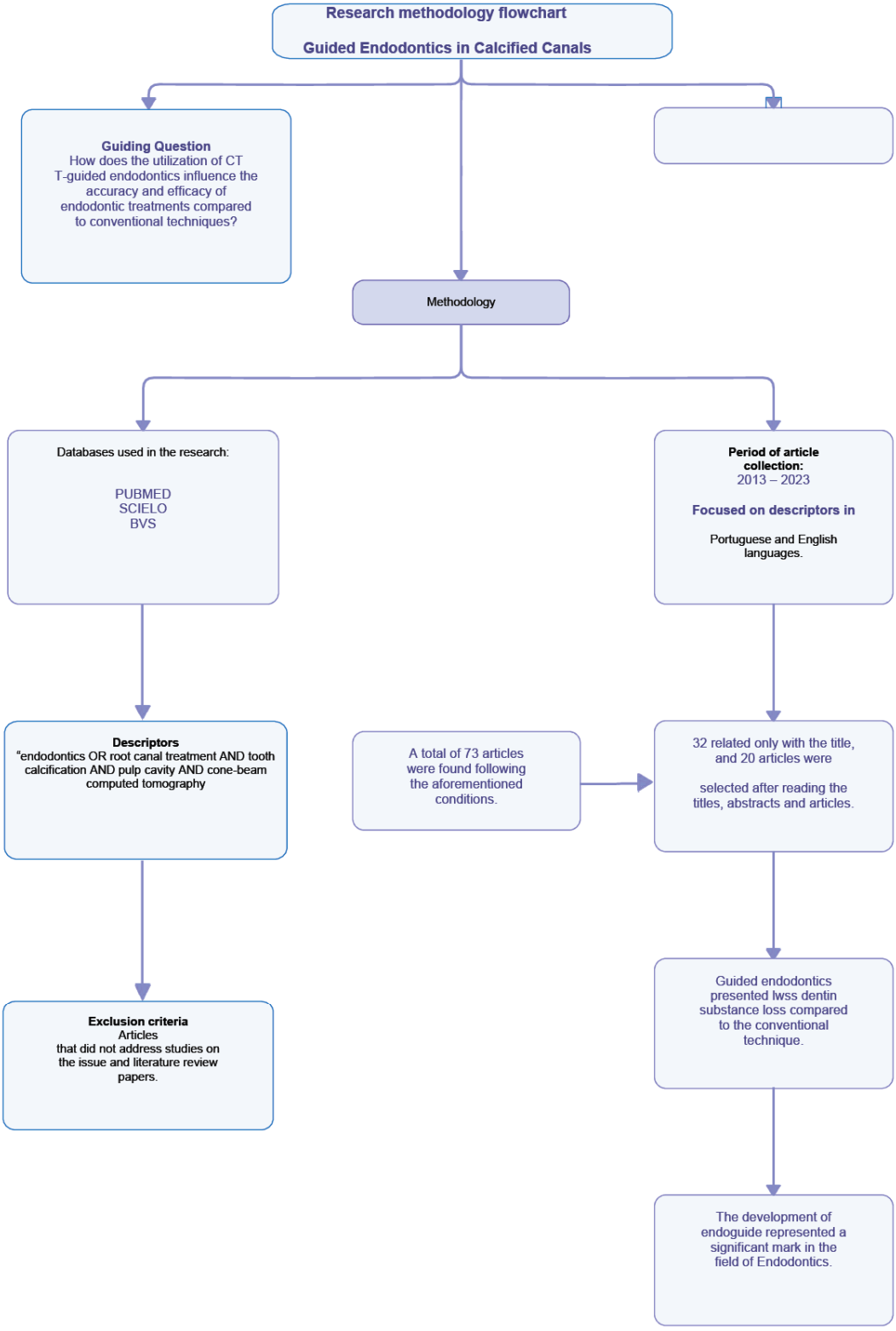
3.1. Definition and Classification of Calcified Canals

Pulp obliterations or calcifications are characterized by the apparent loss of pulp space and yellowish crown discoloration, making the root canal treatment questionable, since calcification complicates the root canal disinfection [1]. Calcific metamorphosis (CM) is a term also addressed in studies on the subject and is defined as a pulp response to trauma, with rapid destruction of hard tissue and deposition of tertiary dentin in the root canal [8].

According to Krug *et al*. (2020) [9], endodontic treatment of calcified teeth is difficult. This complication can cause failure in root canal instrumentation and disinfection and can also cause problems as perforation and weakening of the remaining tooth structure due to excessive wear [8]. Diagnosis of these cases can be even more difficult to identify when there is no response to thermal and electrical pulp tests [6].

3.2. Diagnosis of Calcified Canals

A presumptive diagnosis is based on clinical examination and imaging by =an initial periapical



radiograph, which shows partial or total root canal calcification and signs of previous endodontic access. It is also possible to reach a diagnosis by computed tomography and wear measurements, which detect root perforation and calcification in the periapical third [10].

In this scenario of root canal obliteration and the emergence of guided endodontics, it is important to emphasize the technological advances in cone beam computed tomography, intraoral scanners, CAD-CAM software and stereoscopic 3D printing that allow the implementation of the concept of guided endodontic

treatment. Based on this fidelity of CBCT images, endodontic diagnoses have become more accurate [11].

3.3. Techniques for Calcified Canals Preparation

Some treatment options have been indicated in the literature, such as ultrasonic instrumentation and methylene blue dye to locate the root canal orifice in the event of enlargement. Conversely, with the highlight on minimally invasive endodontics in contemporary endodontics, new techniques as guided endodontics are spreading to minimize the risk of root perforation [1].

According to Tavares *et. al*. (2020) [12], not all cases of pulp space obliteration can be solved by endodontic treatment. These authors state that, in cases of pulp canal calcification, endodontic treatment is only indicated in cases of apical periodontitis or in the presence of pulp symptoms. Although many approaches have been described for treating calcified canals, even the most experienced endodontists may have difficulty in achieving patency and performing adequate cleaning and shaping [13].

Cone beam computed tomography is an innovative endodontic option for treating obliterated canals. This technology allows more accurate planning and treatment and stands out compared to the conventional approach, which has disadvantages related to access opening causing aggressive loss of tooth structure and the possible errors, making the prognosis unfavorable [4].

3.4. Surgical Guides and Navigation Systems

The term “guided endodontics” was first used by Krastl *et al*. to associate the minimally invasive access cavity planned and guided virtually with the recommendation of more conservative treatment [1].

According to Ribeiro *et al*. (2020) [14], the endodontic guide allows drill access guided by the tooth structure, preventing unnecessary wear and deviations. Thus, teeth previously considered almost impossible to access now have a treatment option [14]. For some authors, adoption of the endodontic guide proved to be accurate and significantly reduced the operative time. Since then, guided endodontics has been developing and expanding its indications, mainly for cases with PCO [11].

In guided endodontics, a digital impression is obtained from the patient and recorded in the CBCT data. A path is then created for the drill to the root canal site on the CBCT. Finally, using computer-aided design software, the drill guide to be used during treatment is designed and printed on a 3D printer [15].

Guided endodontics has few disadvantages, such as the high cost of the procedure related to the need of last-generation equipment to produce acrylic guides [14]. Also, it cannot be used in emergency procedures,

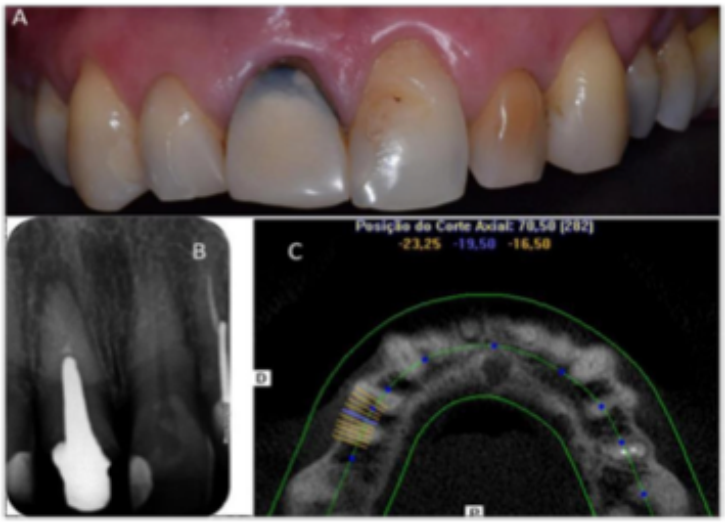


Figure 1: A) Intraoral clinical image of anterior teeth; **B**) Initial periapical radiograph of tooth 11; **C**) Cone beam computed tomography (CBCT) of the sagittal section evidencing the relationship of the lesion with the apex of the upper right central incisor.

Source: FLORES OROZCO *et al*. Guided endodontic access of severe calcified tooth without incisal edge - case report. Braz. dent. sci, 2022:; 25 (3) : 1-8 .

due to the need of prior intraoral examinations and computed tomography [11]. Additionally, the use of drills for preparation of lower incisor teeth with thin roots is not appropriate, since the drill diameter is not adequate [14].

3.5. Case Reports

Flores Orozco *et al*. (2022) [1] described the case of a patient with a highly calcified root canal system in tooth 11, accompanied by symptomatic periapical periodontitis, using a poorly adapted full crown, besides tooth discoloration and gingival inflammation. In the first session, the ceramic crown was removed with an FG metal grinding drill and the metal post was removed by ultrasonic vibration. Using cone beam computed tomography and intraoral scanning, guided endodontic access was planned to allow precise drilling. Obturation was performed in the same session, followed by preparation of the full ceramic crown. After twelve months of follow-up, two sessions were scheduled for evaluation, which revealed new bone formation in the periapical lesion without signs or symptoms of discomfort to the patient. Intraoral clinical

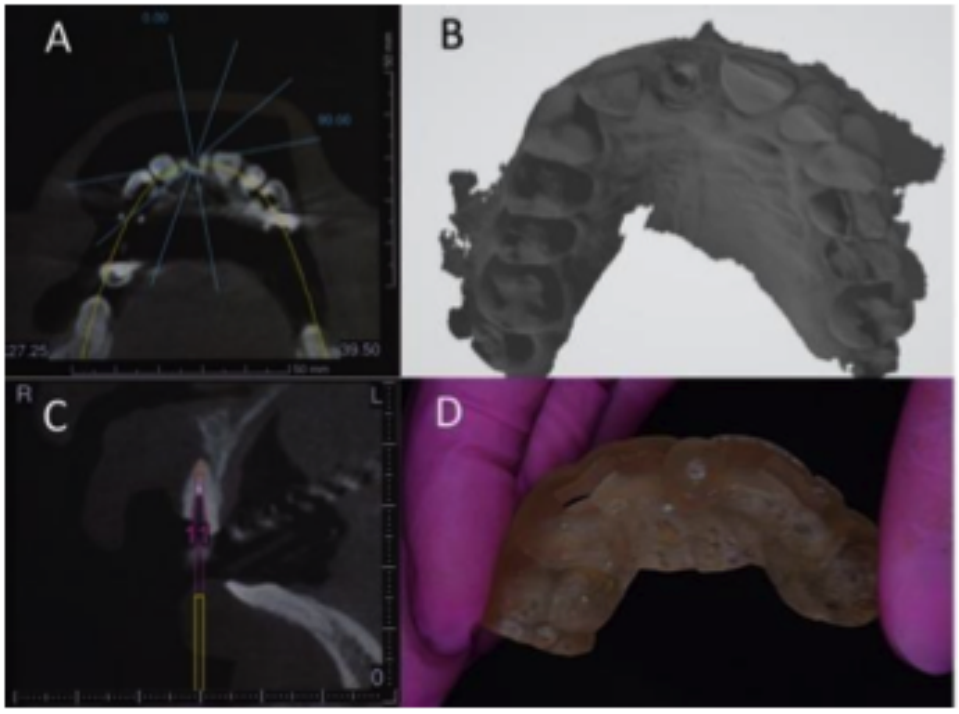


Figure 2: A) and **C**) Virtual planning of the guided endodontic model in CBCT images in axial section; **B**) intraoral impression; **D**) model after impression.

Source: FLORES OROZCO *et al.* Guided endodontic access of severe calcified tooth without incisal edge - case report. Braz. dent. sci, 2022; 25(3): 1-8.

Figure 3: A) Use of Neodent drill for cavity access; **B**) testing the guide insertion and adaptation in the mouth and accomplishment with low-speed handpiece; **C**) Periapical radiograph for length checking.

Source: FLORES OROZCO *et al.* Guided endodontic access of severe calcified tooth without incisal edge - case report. Braz. dent. sci, 2022; 25 (3): 1-8.

examination showed well-adapted crown, without gingival inflammation or tooth discoloration. The authors concluded that guided endodontics is recommended to access root canals with severe calcification.

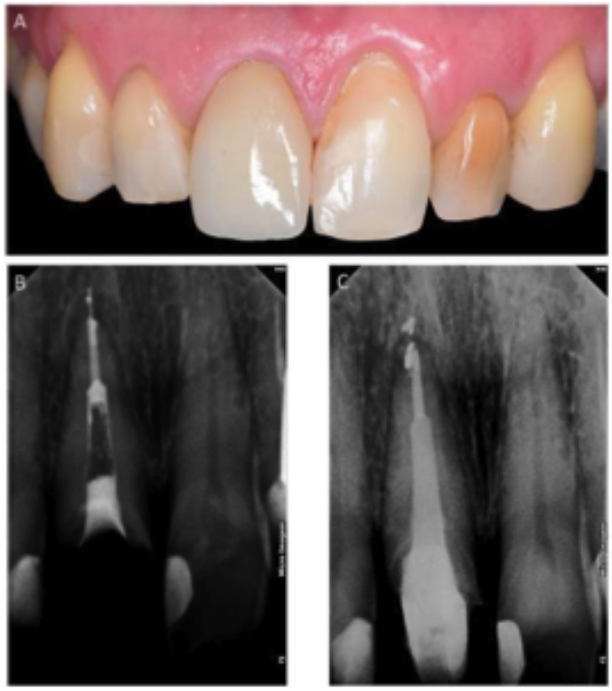


Figure 4: **A**) Intraoral image immediately after crown cementation; **B**) Periapical radiograph immediately after obturation; **C**) Periapical radiograph at the one-year follow-up.

Source: FLORES OROZCO *et al.* Guided endodontic access of severe calcified tooth without incisal edge - case report. Braz. dent. sci, 2022; 25 (3): 1-8.

Lima *et al*. (2021) [16] reported the case of a 40-year-old female with complaint of tooth darkening. During clinical examination, an alteration in the crown color of the upper left central incisor was observed, and radiographic examination revealed a calcified root canal with a periapical lesion. Cone beam computed tomography revealed a faint lumen of the root canal along the root length, periapical lesion, and significant wear in the cervical portion, without evidence of perforation; thus, a 3D endodontic guide was designed for safe access to the root canal. For stabilization, it was necessary to perform bone grinding at two points in the maxilla. After positioning the guide, drilling was performed with a specific drill followed by conventional root canal preparation and obturation. The authors highlighted the advantages of guided endodontics, including reduced working time, safety and accuracy, yet emphasized the need for more randomized clinical trials and systematic reviews.

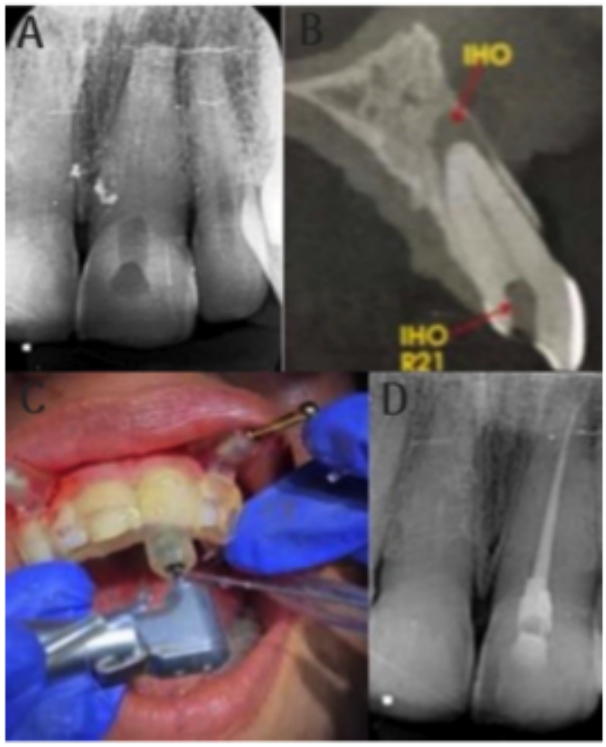


Figure 5: A) Initial radiograph of tooth 21 indicating calcified root canal; **B**) Sagittal section of tooth 21 indicating the presence of a faint root canal lumen; **C**) Bur penetration to the length indicated by the stop; **D**) Final radiograph.

Source: LIMA, T. *et al.* Aplicação de endodontia guiada na localização do canal radicular calcificado com lesão periapical: relato de caso**.** Pesquisa, Sociedade e Desenvolvimento, 2021; 10 (16):1-8. [17]

Tavares *et al*. (2020) [12] published a case series that illustrated the use of guided endodontics in complex molars with symptoms. The last case involved a 42-year-old patient with acute apical periodontitis in the upper right first molar, whose canals were completely obliterated on the radiographs. The first attempt using an endodontic microscope failed, thus the use of an Endodontic Guide (EG) based on the CBCT was suggested, requiring the construction of three different templates for each canal. After the instrumentation and irrigation protocol, the root canals were filled with calcium hydroxide and sealed with GIC for 10 days. On the second session, the intracanal medication was removed with sodium hypochlorite irrigation, followed by filling the canals with gutta-percha and bioceramic cement. The tooth was restored with composite resin. At follow-up visits after 1 week and 12 months, the patient remained asymptomatic. The authors suggest that guided endodontics is a reliable and effective option for treating calcifications in molars.

Nabavi *et al*. (2022) [8] reported the case of a 58-year-old man referred for root canal treatment on teeth

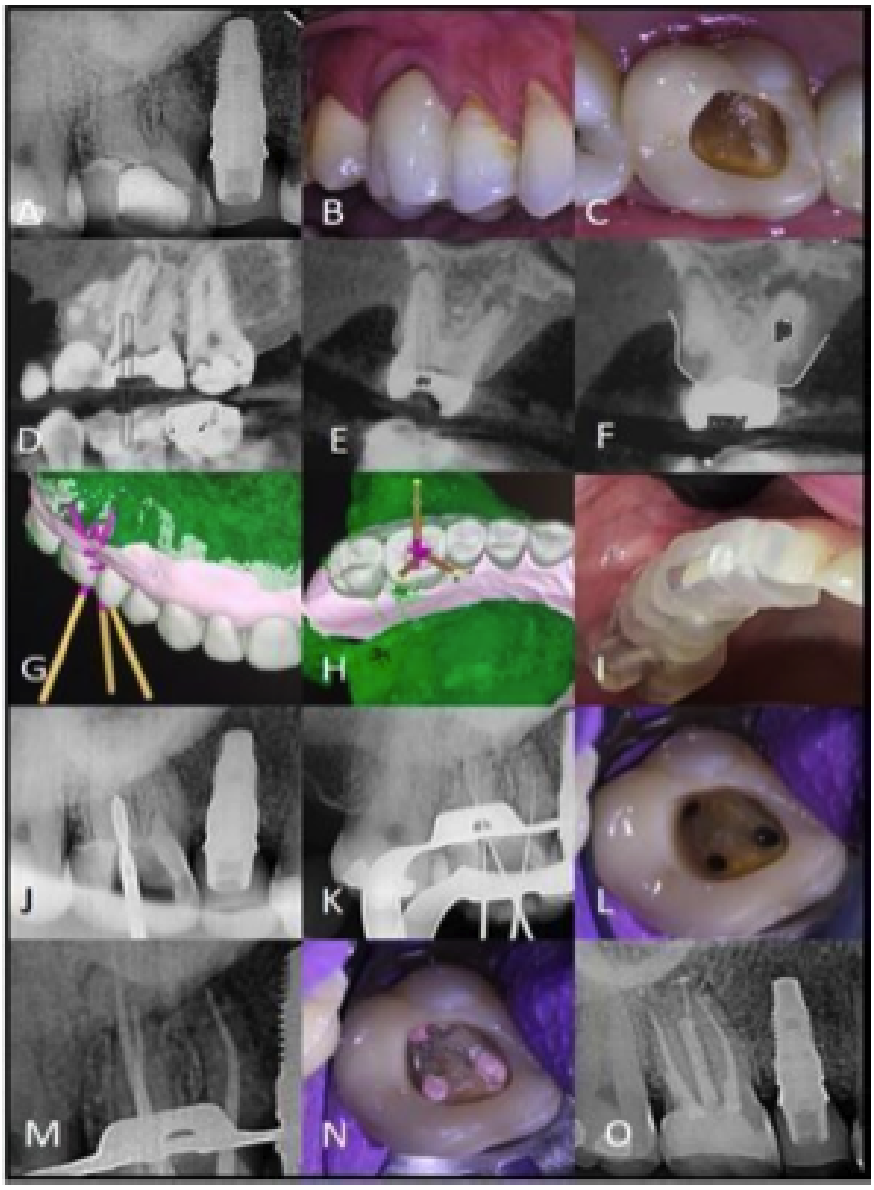


Figure 6: AC) Radiographic and clinical aspects of root canal obliteration; **DH**) Digital planning of guided endodontics; **I**) Evaluation of 3D template in the mouth; **J**) Perforation of the palatal canal; **K**) Radiographic determination of working length; **L**) Clinical aspect after root canal instrumentation; **M**) Evaluation of master points; N) Root canal obturation; **O**) One-month follow-up.

Source: FONSECA TAVARES *et al.* Guided Endodontics in Complex Scenarios of Calcified Molars. Iran Endod J, 2020; 15(1): 50-56.

24, 25 and 26 due to prosthetic needs. Pulp necrosis was diagnosed due to partial obstruction of the canals of anterior teeth. To avoid complications, a 3D printed guide was used during the procedure, whose stability and accuracy were verified with alginate impression and a plaster model. During the clinical session, the guide was positioned, and the root canals were successfully accessed. After detecting two canals in tooth 26 on the CBCT image, the access cavity was manually expanded in buccolingual direction to find the lingual canal, after locating the main canal. The procedure included irrigation with NaOCl, preparation using rotary files, final rinsing with EDTA and root canal obturation followed by sealing with temporary restorative material. The patient was referred to the prosthetics department for complete restorative treatment. After 6 months of follow-up, the teeth were asymptomatic and in normal function.

3.6. Limitations and Challenges of Guided Endodontics

Although guided endodontics allowed a significant advance in precision and safety of the treatment of

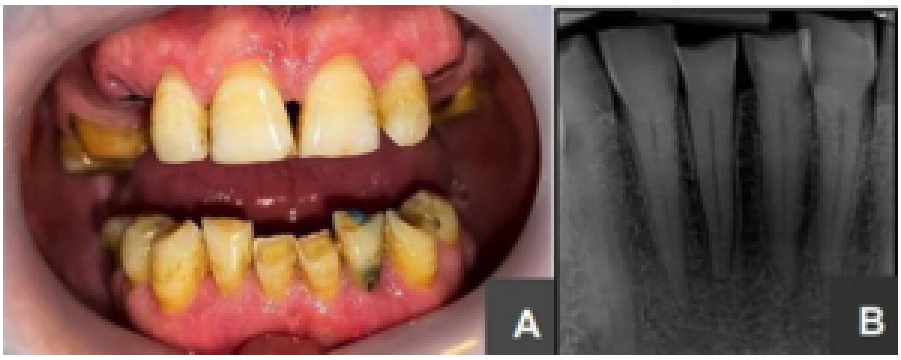


Figure 7: A) Clinical aspect; **B**) Periapical radiograph, anterior teeth with attrition and partial calcifications in the root canal system.

Source: NABAVI, S.; NAVABI, S.; MOHAMMADI, S. M. Management of Pulp Canal Obliteration in Mandibular Incisors with Guided Endodontic Treatment: A Case Report. Iran Endod J, 2002; 17(4): 216-219.

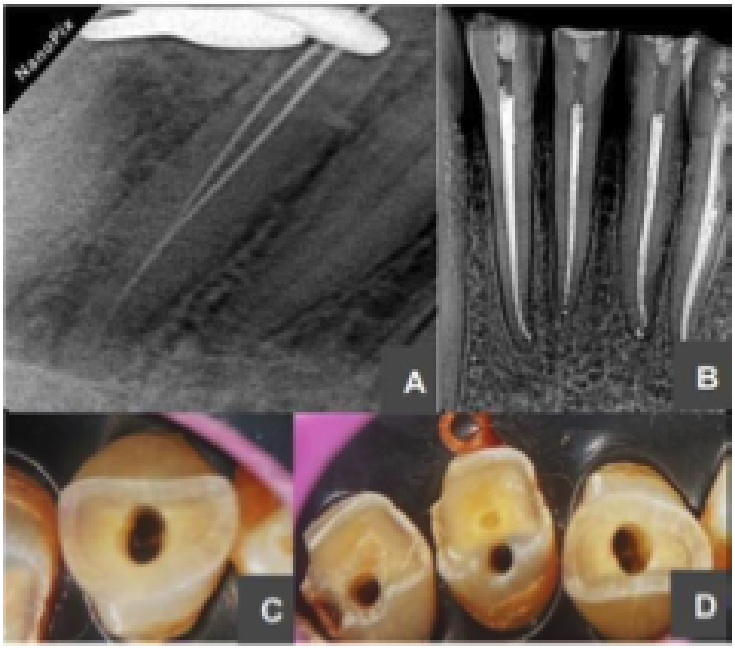


Figure 8: A) Presence of two canals in tooth 26; **B**) Post-obturation radiograph; **C**) and **D**) Enlarged view of the bur tip.

Source: NABAVI, S.; NAVABI, S.; MOHAMMADI, S. M. Management of Pulp Canal Obliteration in MandibularIncisors with Guided Endodontic Treatment: A Case Report. Iran Endod J, 2022; 17 (4) :16-219.

calcified root canals, it has several limitations that require detailed analysis. One of the main challenges is the high cost associated with this technology. The use of cone beam computed tomography (CBCT) and the production of customized acrylic guides require state-of-the-art equipment, such as intraoral scanners and 3D printers. These high costs not only make the treatment less accessible to many patients, but also limit its adoption in clinics with less technological infrastructure. As highlighted by Fonseca Tavares *et al*. (2020) (12), the high cost of the equipment required for guided endodontics can make it unaffordable, especially in regions with less economic development.

Another critical aspect is the learning curve associated with the technique. Guided endodontics requires professionals to be experienced with traditional endodontic practices, and also to be familiar with new technologies and digital planning software. This can become a barrier for many dentists who, without adequate training, may have difficulty implementing the technique with the necessary effectiveness. Santiago *et al*. (2022) (11) mentioned that guided endodontics, though promising, requires significant adaptation of professionals, which may delay its large-scale implementation. Clinical cases also reveal practical limitations of guided endodontics,

especially if the root anatomy is complex. For example, in teeth with thin roots, such as lower incisors, the drills used in guided endodontics may be inadequate, increasing the risk of perforations or root fractures. A study by Nabavi *et al*. (2022) (8) highlighted a case in which the use of guided endodontics resulted in complication due to inadequate drills, requiring an additional intervention to correct the problem. This highlights the importance of careful planning and assessment of tooth anatomy before indicating this technique.

Guided endodontics depends on detailed planning and prior examinations, which makes it less viable in emergency situations. If time is a critical factor, the need to perform a CT scan and create custom guides can significantly delay treatment. As pointed out by Loureiro *et al*. (2021) (10), the need for detailed prior examinations limits the applicability of guided endodontics in emergency cases, which require rapid interventions.

It is crucial to consider that, despite the advantages offered by guided endodontics, the technique still depends largely on the accuracy of imaging exams and the quality of guide manufacture. Any inaccuracy in these steps can compromise the treatment success, resulting in failure to access the root canal or undesirable deviations. The literature suggests that future research should focus on improving the technologies involved, to minimize these risks and make guided endodontics a safer and more accessible option for a large variety of clinical cases.

4. DISCUSSION

Fonseca Tavares *et al*. (2020) [12] suggest that endodontic treatment is only necessary in cases of pulp canal calcification in the presence of apical periodontitis or pulp symptoms. Flores Orozco *et al*. corroborate this statement, highlighting that pulp calcification is not an endodontic disease, and clinical intervention is recommended when calcification hinders treatment, prognosis or outcome, especially in teeth with periapical lesions, which require more intensive disinfection is necessary using specific techniques.

Krug *et al*., 2020 [9]; Santiago *et al*., 2022 [11]; Ribeiro *et al*., 2020 [14] and Jain *et al*., 2020 [18]agree that endodontic treatment of calcified canals is a high risk procedure due to the association with iatrogenesis and extensive hard tissue wear.

According to Ribeiro *et al*. (2020) [14], it is indisputable that the emergence of guided endodontics has facilitated the treatment of pulp necrosis and periodontitis, with the association of cone beam computed tomography, software, acrylic models made on 3D printers, and previously designed drills [14].

It should be mentioned that Krug *et al*. (2020) [9] emphasizes that, in severely curved canals, guided endodontics may fail in the apical root canal curvature; therefore, in cases of sharply curved canals, the most appropriate technique is apicoectomy.

SANTIAGO *et al*., 2022 [11] mentioned that the treatment of obliterated canals is especially difficult in posterior teeth, requiring more elaborate planning in the CAD phase due to the anatomical diversity. The roots of lower molars are usually narrow, curved and have two very close canals, further complicating the endodontic access. The author also emphasized that, like all techniques, guided endodontics requires a steep learning curve for professionals who will perform the surgical technique.

RIBEIRO *et al*., 2020 [14] mentions as one limitation the need for technology to make the acrylic guides, increasing the treatment cost. It is important to highlight that some drills used for this preparation are not suitable for teeth with thin roots, such as the lower incisors.

SANTIAGO *et al*., 2022 [11] validated the disadvantages of this technique and also highlighted the impossibility of emergency procedures using this technique, because it requires previous cone beam computed tomography and intraoral scanning. The literature review that, despite the limitations still existing in guided endodontics, when compared to the conventional endodontic approach, it has shown significantly smaller dentin loss [19]. Also, the success of the guided approach is not influenced by the operator's experience, since the operator has a guide to support and direct the work. This can minimize deviations from the calcified anatomical root canal path and iatrogenesis, which are common in the conventional endodontic approach [20].

A fundamental aspect that requires further investigation is the cost-benefit analysis of guided endodontics compared to conventional techniques. Although guided endodontics offers improved precision and reduced risk of complications, the initial investment

in equipment as cone beam computed tomography (CBCT) and 3D printers can be prohibitive. Studies that analyze the return on investment, considering not only the financial costs but also the long-term clinical benefits, such as reduced treatment time and greater preservation of tooth structure, are fundamental. According to Connert *et al*. (2019) [19], economic evaluation is essential to determine the feasibility of widespread adoption of guided endodontics, especially in countries with limited resources.

There is an urgent need to develop new technologies to reduce the current limitations of guided endodontics. Specifically, the development of thinner and more flexible burs that can be safely used on thin and curved roots would be a significant advance. Investigations on biomaterials for the production of more affordable and sustainable endodontic guides could also make guided endodontics more economically viable. Zehnder *et al*. (2015) [20] highlight the importance of continuing innovation of tools and techniques to expand the indications for guided endodontics and overcome the challenges presented by complex root anatomies.

Randomized clinical trials are crucial to validate the efficacy of guided endodontics compared to conventional methods. These studies should focus not only on immediate outcomes, such as treatment success and incidence of complications, but also the long-term results, such as restoration durability and patient satisfaction. According to Van Der Meer *et al*. (2016) [3], the lack of high-quality data on the long-term efficacy of guided endodontics prevents a complete assessment of its clinical utility. Therefore, encouraging and supporting the performance of such studies will significantly contribute to improve the clinical guidelines and allow broader adoption of the technique.

5. CONCLUSION

The development of endoguide represented a significant milestone in the field of endodontics. This innovative tool has ensured substantial improvements in efficiency, preservation of tooth structure and optimization of clinical time in the treatment of complex cases without solution by conventional therapy. To further improve this method of clinical intervention, new laboratory research, technological tests aimed at improving the technique and long-term case follow-up are essential.

CONFLICTS OF INTEREST

The author declared no conflicts of interest.

REFERENCES

[1] Flores Orozco EI, Abu Hasna A, Andrade GSd, Machado VdC, Manhães Junior LRC, Saavedra GdSFA. Guided endodontic access of severe calcified tooth without incisal edge - case report. Braz dent sci. 2022; 25(3): 1-8. https://doi.org/10.4322/bds.2022.e3145

[2] De alcantara ED. Tratamento endodôntico em dente com canal calcificado: relato de caso. Monografia, Especialização em Endodontia, Faculdade Sete Lagoas - FACSETE, set., 2021, 21p. Disponível em: https: //faculdadefacsete.edu.br/monografia/files/original/a140b5a2 2d5f025f47b66d 72060b2c1b.pdf, Acesso em: 03 de junho de 2024.

[3] Van Der Meer WJ, Vissink A, Ng YL, Gulabivala K. 3D Computer aided treatment planning in endodontics. Journal of dentistry. 2016; 45: 67-72. https://doi.org/10.1016/j.jdent.2015.11.007

[4] Lara-Mendes STO, Barbosa CFM, Machado VC, Santa-Rosa CC. A New Approach for Minimally Invasive Access to Severely Calcified Anterior Teeth Using the Guided Endodontics Technique. J Endod. 2018; 44(10): 1578-82. https://doi.org/10.1016/j.joen.2018.07.006

[5] Miranda JKT, de Moraes MEP, Padilha EMF, de Oliveira Rocha A, dos Santos DDD, de Oliveira ALP, *et al*. Tomografia computadorizada em endodontia: revisão de literatura. Revista Eletrônica Acervo Saúde. 2020(50): e3238-e. https://doi.org/10.25248/reas.e3238.2020

[6] Torres A, Shaheen E, Lambrechts P, Politis C, Jacobs R. Microguided Endodontics: a case report of a maxillary lateral incisor with pulp canal obliteration and apical periodontitis. Int Endod J. 2019; 52(4): 540-9. https://doi.org/10.1111/iej.13031

[7] Chaves HGdS, Assis ST, Macedo IFA, Figueiredo B, Casadei BdA, Valadares ACT. The use of guided endodontics for fiberglass pin removal: clinical case report. 2022.

[8] Nabavi S, Navabi S, Mohammadi SM. Management of Pulp Canal Obliteration in Mandibular Incisors with Guided Endodontic Treatment: A Case Report. Iran Endod J. 2022; 17(4): 216-9.

[9] Krug. Guided endodontic treatment of multiple teeth with dentin dysplasia: a case report. Head Face Med. 2020; 16(1): 27. https://doi.org/10.1186/s13005-020-00240-4

[10] Loureiro MAZ, Silva JA, Chaves GS, Capeletti LR, Estrela C, Decurcio DA. Guided endodontics: The impact of new technologies on complex case solution. Aust Endod J. 2021; 47(3): 664-71. https://doi.org/10.1111/aej.12498

[11] Santiago. Guided endodontic treatment in a region of limited mouth opening: a case report of mandibular molar mesial root canals with dystrophic calcification. BMC Oral Health. 2022; 22(1): 37. https://doi.org/10.1186/s12903-022-02067-8

[12] Fonseca Tavares WL, de Carvalho Machado V, Oliveira Fonseca F, Canal Vasconcellos B, Cruz Guimarães L, Diniz Viana AC, *et al*. Guided Endodontics in Complex Scenarios of Calcified Molars. Iran Endod J. 2020; 15(1): 50-6.

[13] Veloso ACR. Abordagem clínica a canais radiculares calcificados e/ou atresiados.(2017). FCS (DCM)-Dissertações de Mestrado Disponível em: https: //bdigital ufp pt/handle/10284/6108 Acesso em: 03 de junho de 2022.

[14] Ribeiro. Aspectos atuais da Endodontia guiada. HU revista. 2020; 46: 1-7. https://doi.org/10.34019/1982-8047.2020.v46.29153

[15] Da Rocha BMDL, Melo LHB, Frujeri MLV. Guided Endodontics in Calcified Root Canals.

[16] Gonçalves WF, Garcia LdFR, Vieira-Schuldt DP, Bortoluzzi EA, Dias-Júnior LCdL, Teixeira CdS. Guided endodontics in root canals with complex access: two case reports. Brazilian Dental Journal. 2021; 32: 115-23. https://doi.org/10.1590/0103-6440202104537

[17] Lima TO, Rocha AdO, Anjos LMd, Santos RdMdA, Meneses Júnior NS, Melo AESd, *et al*. Application of Guided Endodontics to locate the calcified root canal with periapical lesion: case report. 2021.

[18] Jain. Dynamically Navigated versus Freehand Access Cavity Preparation: A Comparative Study on Substance Loss Using Simulated Calcified Canals. J Endod. 2020; 46(11): 1745-51. https://doi.org/10.1016/j.joen.2020.07.032

[19] Connert T, Krug R, Eggmann F, Emsermann I, ElAyouti A, Weiger R, *et al*. Guided Endodontics versus Conventional Access Cavity Preparation: A Comparative Study on Substance Loss Using 3-dimensional-printed Teeth. J Endod. 2019; 45(3): 327-31. https://doi.org/10.1016/j.joen.2018.11.006

[20] Zehnder M, Connert T, Weiger R, Krastl G, Kühl S. Guided endodontics: accuracy of a novel method for guided access cavity preparation and root canal location. Int Endod J 2015; 49(10): 966-72. https://doi.org/10.1111/iej.12544

Received on 06-07-2024 Accepted on 27-08-2024 Published on 08-10-2024

https://doi.org/10.12974/2311-8695.2024.12.04