Guided Endodontics in Calcified Root Canals

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Abstract: *Introduction:* Endoguide is a device that has significantly aids the treatment of calcified root canals. This device involves modern technologies as 3D printing and computed tomography, which increase the accuracy of dental work. Guided endodontics has currently been emphasized because it facilitates more complex endodontic treatments, such as partial or total obliteration of the root canals precluding the conventional endodontic treatment. This method has demonstrated high percentages of safety for both patient and dentist. It is a fast endodontic access system that prevents perforations, unnecessary removal of dentin and tooth structure. This treatment method is more effective than conventional methods for locating calcified root canals due to its accuracy, speed of time and precision of direction.

Objective: To review the current literature on Endoguide in calcified root canals, analyze its practice, advantages, disadvantages, indications and limitations.

Material and Methods: The study was conducted on 20 papers in Portuguese and English from the year 2016 to April 2022, and a classic article from year 1995, searched in the databases PubMed, Google Scholar and Bireme. The following keywords were used: Calcified canal, Guided endodontics, Endodontic access, Endoguide.

Results: This technique showed greater predictability in calcified canals, reducing the risk of perforations and allowing faster and more efficient access, with many advantages, except for its high cost.

Conclusion: Based on this literature review, it can be suggested that the Endoguide technique in calcified canals provides great benefits to both dentist and patient, such as reduction of clinical time, agility and confidence in treatment, reduced risk of accidents and complications such as perforations and unnecessary dentin removal.

Keywords: Calcified canal, Endodontic guide, Endodontic access, Endoguide, Endodontic complications, Guided surgery, Minimally invasive trepanation, Pulp obliteration, Endodontic planning.

1. INTRODUCTION

Guided endodontics, or endoguide, combines cone beam computed tomography (CBCT), intraoral scanning and three-dimensional (3D) printing to endodontic treatment. Using acrylic guides fixed in the dental arch, this technique allows guided cavity access drilling inside the root canal, preventing deviations and unnecessary dentin removal, ensuring excellent access (RIBEIRO, *et al*., 2020).

Over time, the dentin-pulp complex is subject to changes caused by damage, which may lead to root canal calcification. This damage can be caused by several factors as aging, trauma, caries and other aspects that compromise the tooth structure (BUHGREITZ, *et al*., 2016). Teeth with root canal calcification are associated with a high rate of failure of endodontic treatments, since their therapy is more complex. Microguided endodontics is an excellent option for these cases. This technique provides safer access cavities (CONNERT, *et al*., 2019).

The good outcome of endodontic treatment requires a precise understanding of the internal morphology of roots and the root canal system (RCS) and their possible anatomical variations, which directly influence the quality of debridement, disinfection and filling of the root canal system. The root canal system can be complex and difficult to assess, and the lack of location or knowledge of additional and accessory canals can lead to secondary infections (MIRANDA, *et al*., 2020).

It was observed that CBCT (Cone Beam Computed Tomography) is important in endodontic diagnosis, facilitates the verification of anatomical structures, location of root canals, identifies periapical lesions, horizontal root fractures and root resorptions, besides aiding paraendodontic surgeries and the fabrication of endodontic virtual guides (MIRANDA, *et al*., 2020).

With the new technologies, the widespread use of 3D printing technology in endodontics will be available by further research and development. The acquisition of technical knowledge within endodontic practices is a gain for the implementation of safer techniques that allow greater success in endodontic therapy. Increased expertise in the specialty will open the possibilities for a stronger body of evidence that allows endodontists to

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make informed decisions about using high-end technology in clinical practice (ANDERSON; WEALLEANS and RAY, 2018).

Aiming at highlighting the benefits of using the Guided Endodontic Technique in endodontics, this study proposes a systematic review on the subject.

2. METHODOLOGY

This study addresses guided endodontics, in which a literature review was conducted, with a qualitative approach, of a descriptive nature using a literature review methodology. A total of 20 articles in Portuguese and English published after year 2016 were analyzed, including a classic article from 1995 and a MSc dissertation, searched in the databases PubMed, Google Scholar and Bireme. The following key words were used: Calcified canal, Guided endodontics, Endodontic access, Endoguide. As inclusion criteria, the search was refined using the Boolean operator AND between the keywords "Calcified canal" / "Guided endodontics" and "Endodontic access"/ "Endoguide". The study excluded papers without full text and without free access on the databases selected for the study.

3. LITERATURE REVIEW

3.1.1. Calcified Root Canal

Initially, the root canal is a patent space, yet it can be obstructed by a process known as "calcific pulp metamorphosis". This condition may be referred to as pulp canal obliteration, dystrophic calcification, diffuse calcification, and calcific degeneration. These calcium deposits may develop due to several reasons (STEWART *et al*., 1995).

The Calcific Metamorphosis of the Pulp can be clinically diagnosed based on the isolated discoloration of one or two intact teeth. The patient often does not remember any history of dental trauma, but it probably occurred. The root canal obliteration is visualized on the periapical radiograph. Calcifications can obliterate both the coronal and radicular pulp, and they can be diffuse or linear.

When performing root canal therapy in elderly patients or individuals previously submitted to extensive restorative procedures, the professional should be aware of calcareous deposits in the pulp chamber and root canals. Patients with advanced periodontal problems with gingival and bone loss may also have calcification (TODD *et al*., 2020).

3.1.2. Risks

The calcification process usually starts in the coronal portion of the tooth. If the tooth becomes non-vital, it allows contamination of the apical root third, which can perpetuate an infection. When treatment is attempted, misdirected instruments can perforate the root, adding iatrogenic complications. This can lead to tooth loss (TODD *et al*., 2020).

Even when a root canal is found, it often occurs at the expense of substantial loss of tooth structures. Canal calcification is one of the factors that make endodontic treatment challenging and capable of compromising the access of instruments and irrigating solutions throughout the entire root canal length. This precludes the proper disinfection of the RCS (LARA-MENDES *et al*., 2019).

According to the American Association of Endodontists, the treatment of these teeth is classified as having a high degree of difficulty, since in an attempt to find the root canal there may be great tissue loss and deviations, causing perforations in the tooth walls, affecting the prognosis (AAE, 2016).

3.1.3. Causes

The dentin-pulp complex can react to factors as caries, aging and trauma, obliterating the pulp space by dentin deposition. Even though it is a physiological process, in some cases the pulp can become necrotic, leading to the emergence of a periapical pathology, requiring endodontic intervention (RIBEIRO *et al*., 2020).

Considered a pathological response of the pulp to injuries suffered by these teeth, calcifications may be associated with the patient's age, occurrence of trauma or even with the development of caries, with total or partial obliteration of the root canal by mineral tissue deposition (LARA-MENDES *et al*., 2019; RIBEIRO *et al*., 2020).

3.1.4. Intervention

In 2015, the American Association of Endodontists and the American Association of Oral and Maxillofacial Radiology joined to define clinical situations in which cone beam computed tomography (CBCT) should be performed. In this context, one of the indications for its use was the location of calcified root canals.

Recently, three-dimensional models were introduced in Endodontics with promising results for performing guided accesses and locating the calcified root canal. In cases where conventional endodontic treatment is difficult or unviable, we must look for alternatives to perform the intervention (LARA-MENDES *et al*., 2019).

Thus, seeking a new treatment option that might be safer, more practical and cause less damage to the tooth, studies have demonstrated the applicability of another method called "Guided Endodontics" (GE) (ZEHNDER *et al*., 2015; KRASTL *et al*., 2016).

3.2. Guided Endodontics

This method for locating the root canal derives from guides that were created for the placement of dental implants, becoming viable by the technological advancement of computed tomography (CT), intraoral scanners (IS) and 3D printing, which allow visualizing the precise location of the root canal, enabling three-dimensional planning of endodontic access, making it more predictable (ZEHNDER *et al*., 2015; KRASTL *et al*., 2016).

By fixed acrylic guides, thus method allows guided drilling of the cavity access inside the canal, preventing any deviations and unnecessary dentin removal, ensuring excellent access (RIBEIRO *et al*., 2020).

3.2.1. Technique

A study showed a step-by-step process to enable the guide. After diagnosing the need for endodontic intervention, calcification and indication to use the technique, first it is necessary to achieve a computed tomography of the tooth and arch around it (ZEHNDER *et al*., 2015).

3.2.2. Complementary Examinations

Anamnesis, clinical and radiographic examinations are performed to assess the presence of symptoms and/or periradicular alterations. Once severe calcification requiring endodontic intervention has been found, the patient is referred to the radiology center for guided endodontic planning (LARA-MENDES *et al.*, 2019).

3.2.3. Technique's Steps

The CBCT is obtained in high resolution, using a lip retractor as an aid to allow a more detailed view of the dental gingival unit. To guide endodontic access through calcified tissue, a computer-aided design/computer-aided manufacturing (CAD/CAM) approach is used. A 3D model of the arch to be treated is obtained using an R700® scanner (3shape, Holmens Kanal, Copenhagen, Denmark), and the generated image is converted into a Standard Triangle Language (STL) file, a universal file that all 3D printers can read. It is subsequently transferred to a virtual implant planning software.

CBCT is added to this software. Both the CBCT and the model surface scan are superimposed based on radiographically visible structures, such as the patient's soft and hard tissues, highlighted using the Soft Tissue Cone Beam Computed Tomography (ST-CBCT) technique. The Simplant® software (Dentsply Sirona, York, Pennsylvania, USA) is programmed to design a physical hole, used for guided endodontic access, nearly superimposed on the root canal calcification (Figure **1**).

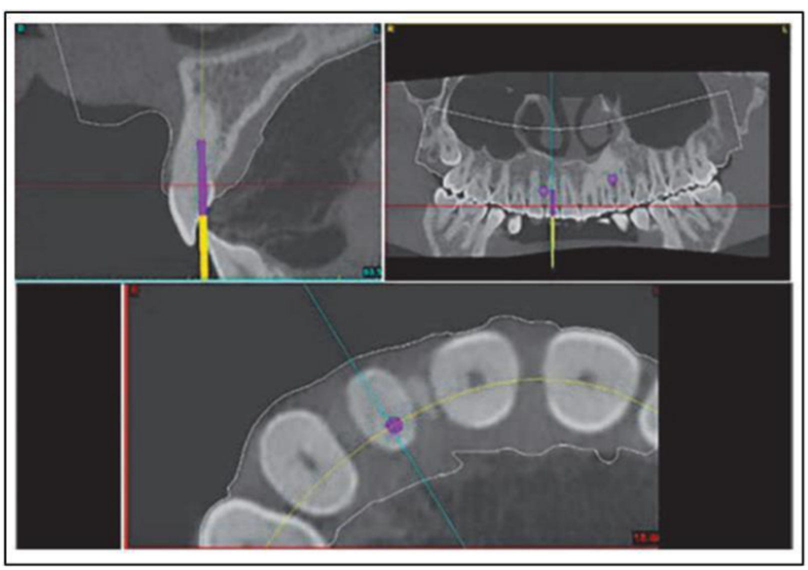

Figure 1: Virtual planning of the access guide.

Source: LARA-MENDES, S. T.; BARBOSA, C. F. M.; MACHADO, V. C. *et al.* Guided endodontics as an alternative for the treatment of severely calcified root canals. **Dental Press Endod**., v. 9, n. 1, p. 15-20, Jan.-April, 2019. Available at: https://docs.bvsalud.org/biblioref/2019/10/1022687/lara-mendes.pdf. Accessed on 22 jan. 2022. DOI: 10.14436/2358-2545.9.1.015-020.sar.

The drill used in this technique has a total length of 20 mm, working length of 12 mm and diameter of 1.3 mm. The virtual drill is tilted, thus preventing wear on the incisal edge, and guides the pathway until the visible lumen of the root canal is reached. Using the previously described drill position, the software automatically creates a virtual model by applying the design tool.

To transfer the accuracy of virtual planning to the surgical procedure, two fixation posts are simulated to stabilize the guide. Once the printed guide is obtained, it is positioned on the patient's arch to check its fitting (Figure **2**).

Osteotomy (bone section) is performed under local anesthesia, guided by the fixation rings. After that, screws are inserted in this trajectory created by the drill, allowing stability without any digital support. Then, guided root access is performed using the same drill guided by the access ring.

To perform these procedures, a rotary engine is used at 1200 rpm and 4 Ncm, under thorough irrigation with saline solution. After that, the guide is removed, and gauze compression is applied to the osteotomy area to promote hemostasis without the need for sutures. After this moment, endodontic treatment is completed conventionally, using rubber dam isolation (LARA-MENDES *et al*., 2019).

3.2.3.1. Utilization of burs

Despite the safety of this technique, it is reported that the high diameter of drills can cause microfractures in the dental roots, since the first works on guided endodontics employed drills with 1.5 mm and 1.2 mm diameters. It also shows that the miniaturization of drills can reduce the chance of creating these microfractures. Therefore, and aiming to use the technique in teeth with narrower roots, such as lower incisors, a study showed that it is feasible to perform guided access with smaller drills, with 0.85 mm diameter, increasing the safety and range of use of guided access (CONNERT *et al*., 2018) (Figure **3**).

Even though the drills used are not ideal for endodontics, some studies show that guided access performed with these drills causes less wear on the tooth structure compared to the attempt to perform conventional access, thus allowing maximum preservation of the tooth structure (KRASTL *et al*., 2016; LARA-MENDES *et al*., 2018).

3.2.4. Advantages

Some articles reported that, due to the safety and predictability of the technique, it is feasible regardless of the operator's experience and can be performed by professionals without expertise in the field of endodontics, also eliminating the need to use a clinical microscope during the procedure (ZEHNDER *et al*., 2015; BUCHGREITZ *et al*., 2015; MAIA *et al*., 2019).

Some studies unanimously report the safety of performing endodontic intervention based on the guide, stating that it is a safe, precise, effective technique that increases the treatment predictability, reducing the risk of accidents and complications of conventional treatment in calcified teeth, such as perforations (CONNERT *et al*., 2018; TAVARES *et al*., 2018; MAIA *et al*., 2019).

Figure 2: Prototyped guide in place and screwed into the maxillary arch.

Source: LARA-MENDES, S. T.; BARBOSA, C. F. M.; MACHADO, V. C. *et al*. Guided endodontics as an alternative for the treatment of severely calcified root canals. Dental Press Endod., v. 9, n. 1, p. 15-20, Jan.-April, 2019. Available at: https://docs.bvsalud.org/biblioref/2019/10/1022687/lara-mendes.pdf. Accessed on 22 jan. 2022. DOI: 10.14436/2358-2545.9.1.015-020.sar.

Figure 3: Root canal access guide.

Source: LARA-MENDES, S. T.; BARBOSA, C. F. M.; MACHADO, V. C. *et al*. Guided endodontics as an alternative for the treatment of severely calcified root canals. Dental Press Endod., v. 9, n. 1, p. 15-20, Jan.-April 2019. Available at: https://docs.bvsalud.org/biblioref/2019/10/1022687/lara-mendes.pdf. Accessed em 22 jan. 2022. DOI: 10.14436/2358-2545.9.1.015-020.sar.

Guided endodontics makes endodontic treatment more predictable and safer in complex situations, besides drastically reducing the procedure time compared to the conventional technique. Also, it does not require a long learning curve and facilitates the accomplishment even by less experienced professionals (LARA-MENDES *et al*., 2019).

3.2.5. Disadvantages

The main disadvantages of endoguide are the high cost and difficulty of placement in the posterior region of the mouth (RIBEIRO *et al*., 2020). Guided Endodontics also has limitations, such as the need for high-tech equipment to manufacture acrylic guides, possibly increasing the treatment cost, which requires the aid of high-standard radiology to intermediate the technological process.

Besides, the diameter of drills used for preparation is not suitable for teeth with thin roots, such as the lower incisors, and the complexity of the procedure can cause fear in the patients or less experienced professionals (RIBEIRO *et al*., 2020).

3.2.6. Efficacy

Torres *et al.* (2018) reported the case of a patient with obliterated left lateral incisor presenting a periapical lesion. After CBCT, an acrylic guide was made, which guided the drill until reaching the target point. With complete access, normal endodontic therapy was performed. After 6 months, the periapical lesion had completely regressed. According to the authors, teeth with obliterations should only be treated if there are any symptoms. The authors concluded that, using endoguide, even in complex cases with calcification, the chances of errors and deviations are minimal (RIBEIRO *et al*., 2020).

Maia *et al*. (2019) reported three clinical cases in which the endoguide was used, with prior tomography, fabrication of guides, selection of drill and endodontic therapy in the same session. After 15 days, all were pain-free, showing complete cure in one year. The authors concluded that, despite the need of detailed planning, endoguide is safe and decisive, thus decreasing mistakes and increasing the chances of success (RIBEIRO *et al*., 2020).

The aforementioned authors also concluded that the endoguide successfully achieved its function, although it should not be used for any case and should not be chosen as first option; if used correctly, it allows quick access even by professionals with less experience, considerably reducing the procedure time compared to conventional endodontic treatment, which is quite exhausting in cases of calcified root canals.

4. DISCUSSION

One manner to achieve success in the treatment of calcified canals, associated with computed technology, is a procedure called endoguide. By acrylic guides fixed in the mouth, this technique allows guiding a cavity access drill inside the canal, preventing deviations and unnecessary dentin removal, ensuring excellent access (RIBEIRO, *et al*., 2020).

After observing severe calcification that requires endodontic intervention, the patient is directed to the radiology center for guided endodontic planning. Studies unanimously report the safety of performing endodontic intervention using the guide. They report that this technique is safe, accurate, effective, and that it makes the treatment more predictable, reducing the chances of accidents and complications of conventional treatment in calcified teeth, such as perforations (CONNERT *et al*., 2018; TAVARES *et al*., 2018; MAIA *et al*., 2019).

The results obtained showed high success rates, placing endoguide not as first choice, but only when necessary, allowing quick and effective access. The technique becomes viable due to the technological advancement of computed tomography, intraoral scanners and 3D printing that allow visualization of the precise root canal location, enabling three-dimensional planning of endodontic access.

With the high level of treatment complexity in calcified canals, guided endodontics reduces the risk of perforation, is easier for the dentist and saves working time. Despite the safety of this technique, it is reported that the large diameter of drills can cause microfractures in the dental roots, such as in lower incisors.

Teeth with pulp canal calcification are related to a high failure rate, since endodontic treatment is complex (CONNERT, *et al*., 2017). Microguided endodontics is an excellent resource for these cases, providing a precise means for creating access cavities.

Connert *et al.* (2019) compared the endoguide and conventional endodontics in relation to the detection of canals, degree of dentin wear and time for performing the procedure. For that purpose, they made six identical sets (three for the mandible and three for the maxilla) containing incisors with calcified canals made in a 3D printer. The models underwent tomography for subsequent manufacture of the acrylic guide. Under simulated clinical conditions, 3 operators with different levels of experience prepared access cavities with the conventional technique and with the endoguide. The sum of structure loss of the three operators in the conventional access was 49 millimeters, compared to only 9 millimeters in endoguide. The procedure duration was 21.8 minutes for the conventional technique and 11 minutes for the guided technique. In the conventional technique, 10 of the 24 canals were accessed, while in guided Endodontics 22 of 24 were accessed.

The authors concluded that, in the evaluated parameters, endoguide proved to be more efficient than the conventional protocol, regardless of the operator's experience, despite presenting limited access in posterior regions, besides generating higher local temperature and not being as effective in thinner roots.

Lower and upper incisors are the best candidates for microguided endodontics for the following reasons: first, the guides are easy to use because the space between the arches usually allows positioning of the guide and drills; second, access to the canal is often straight, as compared to the molars, in which curves are often found. Since the drill is straight and non-deformable, it should only be used in the straight portion of the canal and not beyond the curvature (CONNERT *et al*., 2018; LARA-MENDES *et al*., 2018).

This technique can facilitate the endodontic treatment of calcified root canals even by general practitioners, providing maximum conservation of the coronal and root structures of the tooth, combined to a reduced risk of root perforations and shorter time (KRASTL *et al*., 2016).

Care must be taken to explain to the patient how the operative procedure is performed, the cost-benefit of this approach, especially considering the costs of other complementary resources required when conventional treatment fails and leads to tooth loss (CONNERT *et al*., 2017). The great disadvantage of this technique is its high cost and the need for high-performance technological devices for its accomplishment, making the treatment more expensive. The non-indication of surgical guides in curved and thin canals due to rigidity of the drill is also a disadvantage of this resource.

Considering the literature review performed on the subject, it was noted that the advantages of guided endodontics outweigh its risks and disadvantages. There is a clear need for more studies and publications on the subject, as well as improved access drills. Especially, concerning the comparison of advantages and disadvantages of the technique, few case reports have been published showing success or failure.

However, in the literature review of clinical cases using the technique, some cases were found in which the calcified tooth remained in the mouth (CONNERT *et al*., 2018; LARA-MENDES *et al*., 2018; TORRES, *et al*., 2018; TORRES, *et al*. al., 2018; DEBABECHE, 2020; CHAVES, *et al*., 2022).

5. FINAL CONSIDERATIONS

Based on this literature review, it can be suggested that the endoguide technique in calcified canals, despite presenting higher cost than conventional treatment, brings benefits to the dentist and the patient, such as reduced clinical time, agility and confidence in treatment, reducing the risk of accidents and complications as perforations, unnecessary dentin removal, besides preventing the loss of calcified teeth with unfavorable endodontic prognosis.

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