

Guided endodontics. Advantages disadvantages and future prospects. An overview

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Abstract

Guided endodontics is an advanced technique that can be considered as an alternate to conventional method. It is used in a variety of procedures, particularly in microsurgical endodontics, accessing and locating root canals in teeth with pulp canal obliteration, and removing glass fiber posts in endodontic retreatments. Additionally, it is unaffected by an operator's level of experience and requires less treatment time for the patients and is more precise and safer than conventional endodontics. The main aim of this research is to conduct an updated review of the literature on guided endodontics based on the most recent scientific research to identify and describe its advantages, and its disadvantages and to identify what the future holds for it. Literature search was conducted using four electronic databases: PubMed, Scopus, Science Direct, and Web of Science from the period January 2012 to December 2022. Out of 1135 results, 29 articles were reviewed after elimination of duplicates.

Keywords- Navigation, Guided endodontics, computer assisted treatment.

Introduction

Traditionally, the anatomical laws of the pulp chamber which were formulated by Krasner and Rankow are used to aid in locating the canal. Endodontic access cavity is prepared freehanded, according to the operator's clinical experience and knowledge of tooth anatomy. Moreover, a dental operating microscope can be used as an aid during this treatment step to reduce the possibility of iatrogenic mishaps. However, some clinical conditions, such as canal obliteration can prolong the location of a root canal up to 60 minutes even with the help of a dental operating microscope. Further, technical failures, including missed canals, crown or root perforations, canal transportation, or weakened tooth structure, can reduce treatment success or lead to tooth extraction. Furthermore, due to some systemic conditions, e.g., patients taking bisphosphonates, tooth extraction is contraindicated, thus making locating even severely obliterated tooth canals essential in the case of apical periodontitis. Therefore, to facilitate the management of difficult and complicated endodontic cases, the concept of Guided Endodontics was introduced. (1) Many conditions might cause the root canal system (RCS) to become partially or fully destroyed. Owing to dentin adhesion during the course of their lives, older patients may present with severe root canal calcification. (2-4) The number of elderly patients and their endodontic treatment

needs is increasing due to the fact that teeth remain in the oral cavity for a longer time. Orthodontic treatment as well as dental traumatism may also generate the onset of accelerated dentin deposition. Pulp obliteration may be considered a sign of pulp cure, irrespective of the result of pulp sensitivity testing, and in this case, there is no need for endodontic treatment. However, there is a risk ranging from 7 to 27% that the pulp of these teeth may become necrotic, so that endodontic treatment is indispensable, particularly when there are symptoms of the development of apical periodontitis. The remaining canals of severely calcified teeth are localized in the more apical portions of progressively straighter roots, making it difficult to gain access to their entire extension.(5-7) Because this concerns a challenging stage of endodontic treatment, the localization and negotiation of calcified root canals has been related to an increase in the rate of technical failures and an unfavorable prognosis, even when the procedures have been performed by experienced professionals.(8-10) This procedure is commonly performed in a long period of time, and demands caution and professional experience, in addition to the need to have different radiographs taken for checking the root canal trajectory and the use of an operating microscope. Nevertheless, loss of orientation of the bur or ultrasonic insert may generate excessive loss of dentin structure and high risk of perforation.(11) Although CBCT is known to be helpful in the treatment of severely calcified canals, it is necessary for the professional to have knowledge of dental anatomy and a precise mental map of the root canal system at the time of performing conventional access.

Guided endodontics may be an excellent option for the resolution of these challenging situations such as calcifications, because it is a simple, precise technique that does not demand extensive experience of the operator. Furthermore, there is no need to use the operating microscope.

Materials and method

Study Design

Search Strategy

Databases such as PubMed, Web of Science, Scopus, and Cochrane Library were searched by two independent reviewers. The search covered all the literature that was published from 1st jan 2012 of each database to December 2022. The search strategy used in PubMed was as follows: “Surgical navigation systems”[Mesh] OR “Dynamic navigation” OR “Guided endodontic” OR “Computer-assisted treatment” OR “Computer-aided navigation” OR “Image-guided treatment” OR “Navigation system” OR “Real-time tracking” OR “Dynamic guide”. The same terms were used in adapted versions of the search strategy for each database. An additional manual search was performed to identify the potentially eligible studies that were not indexed in the databases mentioned above.

Study Selection

The titles, abstracts and full texts of the identified studies were independently screened for eligibility by two reviewers. Literature reviews and clinical cases were excluded at the initial stage of screening. The inclusion criteria involved the following:

- Randomized experimental trials (RETs) or clinical trials (RCTs);

- Non-surgical endodontic treatment using a dynamic navigation system;
- Outcomes compared to conventional freehand technique;
- Articles available in full text.

The exclusion criteria were as follows: case reports, reviews, non-English language articles, studies using CBCT as mean of navigation technique, performing surgical endodontic treatment or having no control group.

Data Extraction

The data extraction from each eligible study was accomplished by two reviewers (S.A and N.B) separately. No differences between the collected information consisting of references (authors, year of publication, country), study design, sample size, type of teeth, measured parameters and results were observed at the end of data extraction.

In cases of multiple experimental groups, the data conforming to PICO were collected. When the data were missing or unclear, the corresponding authors of the relevant studies were contacted.

A total of 129 relevant articles were selected out of which 34 articles were reviewed.

Results

Bibliographic research was carried out from different databases (Pubmed, Science Direct, Scopus, and Web of Science), which were transferred to the Mendeley reference manager software in order to facilitate their organization and storage, as well as to discard duplicates and select only those from the last 12 years. A total of 1088 articles were obtained. Subsequently, their titles and abstracts were read, and 129 articles were eligible. Finally, the remaining articles were read entirely, resulting in 34 studies that were included in this review.

Discussion

Guided endodontic treatment is a reliable alternative when treating calcified canals, anatomical variations, or to increase the accuracy of apical surgery. When comparing the actual cavity to the virtual planning, all studies described guided surgery and guided access cavity preparation as highly accurate techniques. (12-15)

Access cavity preparation

In the study by Gambarini G et al. Ultra-conservative access (comparing guided endodontics and manual) consisting of linear access to the teeth was performed with the aim of minimizing tooth weakness, preserving as much tooth tissue as possible, and reducing instrument stress during treatment. Generally, minimally invasive cavities generate a trajectory towards the canal that causes the endodontic instruments to bend and generate stress on the canal. This can lead to iatrogenic accidents such as fractures or steps. However, by means of guided endodontics, this did not occur since the access is direct, linear, and parallel to the axis of the canal. (16)

According to few pre-clinical studies, guided access cavity preparation appears to be accurate. Zehnder et al. (2016) reported a mean angle deviation of 1.81° along with mean mesial/distal, buccal/oral, and apical/coronal deviations of 0.29 mm, 0.47 mm, and 0.17 mm, respectively, at the tip of the bur.(17) Lower values, including a mean angle deviation of 1.59° , a mean

mesial/distal deviation at the tip of the bur, a buccal/oral deviation of 0.34 mm, and an apical/coronal deviation of 0.12 mm, were reported by Connert et al.(18) Moreover, the two authors reported no statistical differences between access cavities performed by two different operators, which shows that the technique is reproducible between different operators.

One in vitro study, using 3D printed teeth, conducted by Connert et al. 2019 compared a guided endodontic procedure with conventional access preparation using three operators: a 9-year experienced endodontist, a 3-year experienced general dentist and a newly graduated dentist. The guided-treatment allowed the operators to find, regardless of their experience, 92% (22/24) of the canals, a statistically higher proportion compared with the traditional technique (42%, 10/24), confirming what was previously indicated in pre-clinical studies. (18)

Calcified canal treatment

The guided endodontic access (GEA) approach to locating and accessing calcified root canals appears to be a promising way to prevent such complications. Two ex vivo studies demonstrated that guided endodontics is an impressive approach that is reliable, accurate and operator-independent. A more recent study found significantly less substance loss and a shorter treatment duration for guided versus conventional access cavity preparations in 3D-printed teeth. Several clinical cases have shown that the guided endodontic procedure can be successfully used to treat anterior and posterior teeth with PCO and apical periodontitis. In one clinical study, guided root canal treatment allowed the successful location and negotiation of all root canals in 50 single-rooted teeth with PCO. Furthermore, equipment for the guided endodontic procedure has been miniaturized, and it was shown to be beneficial even in narrow-rooted teeth such as mandibular incisors. One group demonstrated the possibility of overcoming the problem of limited interocclusal space in the posterior region as well as performing GEA preparation in a molar tooth by transforming the virtual drill path into a composite-based intracoronal guide. (19-21)

Glass fiberposts' removal

The re-treatment of teeth that require fiberglass posts' removal can be performed with Guided endodontics. The removal of fiberglass posts is mainly carried out after a previously failed treatment and it can be performed with the help of ultrasound tips. It still carries a risk of perforation of the tooth. In addition, the color of the post, which blends in with the adjacent dentine, is an added difficulty. Even so, the practitioner's experience performing this treatment influences the amount of extra dentine removed around the post, which is greater and leads to a widening of the radicular canal after the removal of the post. For these reasons, guided endodontics is suggested as a treatment alternative. (22,23)

Osteotomy and apicectomy

Apicoectomy and osteotomy guided endodontics is a now adopted by professionals. A retrospective study by Galino Buniag A et al is the only one that presents the follow-up of patients who underwent guided endodontics treatment after at least 1 year, showing that it is as valid a treatment option as the conventional one which involves performing a full-thickness flap and using drills and reamers. However, it does not report the process of the guided endodontics

procedure performed. More studies similar to this one with longer follow-ups of patients treated with both types of guided endodontics may be needed. (24)

Disadvantages

When planning for a guided access cavity, it should be noted that the technique is limited to straight canals. Because the drill is straight and not deformable, it should only be used on the straight portion of the canal and not beyond the curvature. However, it is possible to apply the technique in molars that tend to have greater curvatures, as most of the curvatures would be localized in the apical third, while calcifications would initially begin in the coronal third and extend apically. The latter would allow access to the canal in its straight portion. Yet, in cases where the curvature would prevent safe access to the target region, apical surgery would be indicated. Also, reduced mouth opening could impose a limitation when trying to implement this technique in the posterior region. Not only space could be a limitation, but also the thickness of the root should be taken into account. This might be the case when planning an access cavity on mandibular incisors with smaller roots in comparison to central maxillary incisors. Thinner drills are then necessary as suggested by various authors. (25,26)

It is of concern that the forces generated by the tip of the bur can generate cracks on the tooth surface, as well as produce excessive heat that can be harmful to the periodontal ligament and alveolar bone. Therefore, cooling is of great importance while using the guide. However, providing sufficient space to allow the passage of irrigating solutions to the alveolar bone and access cavity may not always be possible as it may compromise accuracy.

Krastl et al and Connert et al affirmed that the guided endodontic technique could be restricted to the anterior teeth due to the accessibility to and presence of curvatures. (27) However, Lara-Mendes et al, demonstrated that it was possible to perform the guided root access procedure in molars, as in the cited study the access guide was used in the second and third molars. Therefore, the guided endodontic technique is feasible for use in posterior teeth, provided that the patient presents no limitations in mouth opening. Curvature of the canal may be a limiting factor for the use of this technique, however, taking into account that the majority of root calcifications are found in the cervical and middle root thirds and the curvatures, in the apical third of canals, guided endodontics have been widely used. (28)

Considering the limitations of guided endodontics, it must be acknowledged that this technique may be a 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. Moreover, the technology used to design and elaborate the guides is today available worldwide. Thus, in the future, guided endodontics may be more widely used in clinical practice, at least when treating pulp canal obliteration (PCO) teeth and complex surgical cases.

Future Prospects for Guided endodontics

For the future, it would be desirable if the systems were further reduced in size to improve handling on the patient. In addition, all systems should have the possibility to digitally plan the required markers in order to avoid having to perform another CBCT scan if a scan (without

markers) is already available. Of course, it would be even better if no markers were needed at all and the system could orient itself to the existing anatomical structures. (29)

Augmented reality (AR) navigation might be the next step towards simplification and improving the operator experience with dynamic navigation. The AR approach overlays images, such as radiographic images and navigation paths, with a view of the operative field in a wearable head-up display or a dedicated microscope. Thus, the operator can simultaneously visualize the operative field and 3D navigation images without having to look up at a display. Whilst such approaches have been used in neurosurgery (30) clinical implementation in endodontics has only been proposed but has not yet been implemented in a clinical setup (31).

Conclusion

Guided endodontics is a promising technique that offers a highly predictable result and a reduced risk of iatrogenic damage. Chairside time can be decreased and minimally invasive treatment can be carried out. However, since it is based on scant and subpar evidence from case reports, observational studies, in vitro and ex vivo studies, it should be interpreted with caution. It is necessary to conduct larger population studies with longer follow-up times, as well as standardized experimental studies with comparable sample sizes, goals, and measurement techniques.

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