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## Guided Endodontics : A Novel Invasive Technique For Access Cavity Preparation - Review

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### ABSTRACT

Precision medicine (PM) refers to the modifying of medical or dental treatment according to the individual features of each patient. Imaging has become a central part of PM since the last decade. PM takes into account and aims to exploit the specific profile of the patient's unique biology and problem. Imaging plays an important role by providing morphologic and functional information, focusing and guiding treatment and assessing response to therapy. Image-guided treatment (IGT), or here specifically image-guided endodontics, is not a strategy that tries to optimize 3-D cleaning, shaping and disinfection, and filling root canal systems. Importantly, IGT is not about simply making a smaller access or smaller shape. It is concept for preserving dentin and restoring the balance. It is about planning access, planning shape using a directed approach, and evaluating the response to treatment. So, in this meta-analysis review, we discuss about the role of image guided therapies like static CT guidance & Dynamic guidance, guided rail based on CBCT (3D printer-based template) used in conventional endodontic therapies and in endodontic surgery. The used of CBCT in the various branches of dentistry such as oral implantology, periodontology has been increased due to its three-dimensional visualization. For the technology to be fully transferred to everyday clinical endodontic practice, there are number of considerations. The novel concepts of guided endodontics has been reported as an effective method to obtain safe and reliable method during variable endodontic procedures.



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### INTRODUCTION

The main aim of the endodontics is treatment of the infected root canal. It includes three-dimensional approach which includes access opening, biomechanical preparation and 3D filling of root canal with obturating material. The first step in non-surgical root canal treatment is access cavity preparation which is most critical and foremost important step for successful root canal treatment. (Connert *et al.*, 2019) Access is achieved through the crown of the tooth. An adequate coronal access preparation provides even and tapered channels from the orifice to the apex that allows instruments, irritants and medicaments to attempt cleaning and shaping of the entire length and circumference of the canal. Access

cavity mostly include two surfaces that is mesial and distal marginal ridges which reduces the cuspal stiffness up to 63%. Whilst credited to insignificant loss of structure integrity to the tooth. To avoid such complications the minimal invasive approach for the access cavity in endodontics is highly appreciated to kept the preparation conservative as possible.

Determining the number, location and preservation of pericervical dentin using conventional technique is difficult in many cases such as calcified coronal pulp space or sclerosed canal, developmental anomalies if present or full coverage restoration is seen. The risk of perforation and higher susceptible to fracture due to thin roots and more amount of tooth structure is needed to be removed are the consequences occurs due to conventional treatment. In this context it has been demonstrated that any alteration of natural geometry of the root leads to significant changes in tooth rigidity. (Tavares *et al.*, 2018)

To avoid such complications recently, the endodontist improves there knowledge regarding advancement in treatment modalities and shift to era of digitization as in other fields of dentistry. The progressions of technology generally arouses a range of emotions in people from all walks of life. Digitalization in any field brings the world closer for solving the many challenges and increase the efficiency of work. In medical field precision medicine is gaining most popularity in the last few decades. Precision medicine refers to the tailoring of medical or dental treatment to the individual features of each patient. PM takes into account and aims to exploit the specific profile of the patients unique biology and problem.1 Imaging has become an important part of the PM during the last decades due to advance developments in imaging system like CT, CBCT and 3D PRINTING technology. Imaging plays an important role in providing morphological and functional information, focusing and guiding treatment and assessing response. (Zehnder *et al.*, 2016).

In dentistry, the use of 3D technique i.e, introduction of CBCT is highly suggested for diagnosis and treatment planning of difficult cases. As there may be lot of problems come across while using conventional radiographs that it dose not provides sufficient information regarding the morphology of tooth and its surrounding structure (Patel *et al.*, 2020).

The used of CBCT in the various branches of dentistry such has oral implantology ,periodontology has been increased due to its three-dimensional visualization . It helps to gain the knowledge of quantity of bone level and information about location of nearby anatomic structure such as mani-

dibular nerve, mandibular canal, border of maxillary sinus. And prevents inadvent trauma to such structure while performing surgical procedures.

Nowdays the application of CBCT is increased in guided implant surgery for planning implant surgery by studying implant site preparation and insertion using templates so that implnts are placed at the desired angulation and depth. Recently the trending concept of 3D printing devices is highly recommended for the production of these template based on match the surface scans with CBCT data. (Krastl *et al.*, 2016)

Although there is huge difference in the chemical and mechanical properties of dentin compared to alveolar bone and it may impact the precision, this computer aided technique has been incorporated in the endodontic practice like oral implantology. Due to its higher success rate in challenging cases such as managing calcified canals and providing minimal invasive approach while access cavity preparation provokes its use for greater beneficiary.

In accordance with CBCT and 3D printing the virtually planned concept of guided endodontics has been reported and gradually used by many clinicians. The guided endodontic procedure was first termed by Krast *et al.*, who offered its use for teeth with calcified canal in pulp that is undergone root canal treatment. (Krastl *et al.*, 2016).

In this procedure, a digital impression is taken and is overlaid onto cone computed tomography data. Using the computer aided design software path for the drilling is created and a guide is designed to access the root canal. Finally the guide is printed with the help of 3D printer.

Preclinical studies have been reported that the operators skills or experience doesnot influene the high accuracy treatment done by using the drilled path.

Additionally, the application of this modalities for treatment may reduce chair side time compared the conventional approach. Nowadays the increasing demand for accurate and precise treatment in difficult cases, such as calcified canal, developmental anomalies where the access is difficult, normal access cavity preparation to reduce the time and minimize the loss of pericervical dentin to increase the strength and better prognosis the guided endodontics gained popularity. In case micro-endodontic surgical procedures the use of guided technique has been increased to reduce the inadvertent trauma and to reduce the post-operative complications such as pain , swelling and helps fast healing of the wound. (Trudeau *et al.*, 2016)

This novel concept help clinician during treatment to avoid unnecessary complications therefore improved prognosis and better treatment outcome is expected.

### Procedures Of Guided Endodontic

There are two types of guidance - static and dynamic.

#### Static CT Guidance

Accuracy of the osteotomies cut prior to placement of implant fixtures affect the outcome implant surgery to some extent and like endodontists, implant surgeons have great pride in their artful ability to direct this critical procedure free-handed. Despite that confidence, poor positioning of implant fixtures remains the most common mistake in implant surgery. Several authors proposed static CT based drill guides as a solution. However, these guides poses several in vivo difficulties for use in conventional access which include

1. For positioning of guide ring over the tooth, there is lack of inter-occlusal distance to accommodate the additional 10mm of drill or bur length.
2. No guide rings exist that work with high-speed handpiece burs which spin at when cutting through enamel, ceramics, and cast restorations.
3. Endodontics is a less elective procedure than implant surgery. Before scheduling the procedure, it is easy for implant surgeons and their patients to wait, for receiving printed or milled drill guides. But the same pose difficulty in case of patients with root canal disease.
4. Drill guides have 4-6mm guide rings for each drill path, making it necessary to have a drill guide for each canal and thus a matter of expense in upper molars with four canals.
5. Also static drill guides do not allow the minor but important changes in treatment plan that are often wanted during surgery.
6. Other problems includes cost of product and time required to plan and manufacture static guides.
7. In addition to all these ,it may not possible to use static guides in patients with limited mouth opening or in the second molar regions where access is poorer. ([Álvaro Zubizarreta-Macho et al., 2020](#))

### Dynamic Guidance

Mentioned first in 1998 at a medical imaging symposium. Optical guidance was first tested in 2005 for accuracy in transferring CT-based implant treatment planning to patient's jaws. However, the processing speeds necessary to manipulate CT datasets in real-time could only be found in super computers, making it an impractical solution for everyday implant surgery. Dynamic guidance is basically depends upon computer-aided navigation Technology and analogous to global positioning system. Five years later, this technologic inflection point was reached and dynamic optically-driven guidance systems were developed for clinical use and their accuracies are again found to be similar to static drill guidance. And by 2016 Emery and Block introduced the X-Guide Dynamic Guidance System (X-Nav Technologies, LLC, Lansdale, PA) and proved its accuracy in clinical implant surgery. This system was designed only for implant surgery, but Dr. Charles an Endodontist who also places implants used dynamically guided access(DGA)X\_NAV system for the first time in 2016 to access cavities in calcified. He understood that optically driven dynamic guidance solves all the problems that static drill guides present in endodontic application. The access cavities prepared using the computer-aided dynamic navigation system had very narrow and parallel walls. ([Torres et al., 2019](#))

#### The advantage of dynamic guidance for conventional endodontic access

1. Optimally driven guidance does not require drills or burs.
2. High RPM drills and burs are easily used as they do not have to rotate within a guide ring.
3. No waiting period is required for a 3D printed or milled drill guide to be delivered from the lab. RCT can be done within 15 mins of scanning the patient with an X\_ Clip fiduciary in place.
4. No guide rings are required .so it is easy to plan and execute multiple drill path in multi cancelled posterior teeth.
5. Any treatment changes if needed are allowed to me made at the time of surgery. So drills can be updated as new information is acquired during the procedure.
6. It has been recommended that the greater accuracy of dynamic navigation reduces the potential risk of damage to critical anatomic structures and increases intra-operative safety, resulting in better treatment results.

## Template fabrication

An introral scan was performed and uploaded in software for virtual implant planning. Both the surface scan and CBCT were matched based on radiographically visible structure after the additional upload of the CBCT. For guided endodontic drill was used has a total length of 37mm working length of 18.5 mm and diameter of 1.5mm. This was virtually applied to the tool known as Co diagnostic X software and virtually superimposed to the root canal. (Connert *et al.*, 2017) The axis of the drill was angled in such a way that the tip of the extended drill would reach the radiographically visible apex of the tooth. A virtual template was designed by applying the template designer tool of the CODIAGNOSTIX software after planning of drill positioning was completed. As for the drill, a guiding sleeve (2.8 mm external diameter, 1.5 mm internal diameter and 6 mm length) was customized using a software tool and virtually incorporated into the planning, prior to the creation of template. The virtual template was exported as an STL file and sent to a 3D printer (Eden 260 V, Material: MED610, Stratasys Ltd., Minneapolis, MN, USA). To fabricate the designed sleeve computerized numerical control (CNC) technology was used, which was integrated into the printed template to guide the drill during cavity preparation. (Connert *et al.*, 2017)

Template fabrication in guided osteotomy procedures was similar to guided endodontic procedure. The osteotomy dimensions of teeth were determined with virtually positioned surgical pins that were 1.5 mm in diameter. The lower margin of the osteotomy for each root defined the cutting plane, consistent to the recommended 3 mm apical resection level and the bevel angle degree. The upper margin of the osteotomy was planned with a vertical distance of 4 mm to the lower margin, according to the dimensions of the diamond-coated retrotips of the microsurgical instruments. (Ahn *et al.*, 2018) These predefined margins could be implemented in the software with the aid of these individually positioned surgical pins. For achieving these specifications with a guided preparation procedure, technical stereolithography (STL) files of corresponding piezoelectric instruments were imported and virtually used within the planning software. (Moreno-Rabié *et al.*, 2020).

## Endo Guide Burs (SS WHITE, NT, USA)

It is instrument which supports the minimal invasive dentistry. The founder of this burs is Dr. David Clark and Dr. Jhon Khademi. Both are the Pioneers of Micro-dentistry.

**Features-** It is a set of uniquely designed 8 carbide

burs. It is used in the preparation of root canal. It is available in conical shaped having micro diameter tip and variety of shank length, head size and shapes.

It increases visibility and control during endodontics exploration while locating canals and navigating deeply calcified canals. It also helps in retrieving separated instruments. Due to its conical shaped and micro-diameter tip it acts as self centering guide. It provides precision guidance for efficient canal access, create ideal guide-path for endofiles (no gouging), efficient for canal identification and conserves peri-cervical dentin to preserve the strength of tooth. It maximizes treatment efficiency and reduce instrumentation and reduce procedure time.

Two ex vivo studies have already shown the high success rate of the guided endodontic technique with a low deviation of angle (1.59\_1.8 degree) for all 3d aspects and at the tip of the bur (0.12\_0.47). The first study was performed on maxillary teeth using a bur of 1.5 mm diameter is not suitable for treatment of mandibular incisors. Therefore the instrument diameter were decreased in diameter to 0.85mm. (Lara-Mendes *et al.*, 2018)

Connert *et al.* in 2019 in their in vitro study stated about the substance loss during access cavity preparation. Author compared the conventional root canal access preparation with guided endodontic methods and concluded a result showing 9.8mm substance loss seen after preparation with guided method and 49.9 mm with conventional technique.

While studying the results of guided surgery, according to Ackerman *et al.* (2019) procedures done with guided approach endures successful result. It shows that the end of drill path was within apical 4mm of teeth. Guided osteotomy procedures reduces postoperative complications by reducing the length of surgical procedures and enhance the healing.

The one of the novel indication of 3-D guided endodontic in the removal of glass-fiber reinforced composite post while simultaneously shaping the canal for the new post endodontic restoration. For this procedure two instruments were used a long neck diamond dental bur and 2.2 mm implant drill. The accuracy of guided post-endodontics should be comparable with that found for guided trepanations at calcified teeth. Some limitations also seen while using these technique which can be eliminated by developing a tapered drill instead of parallel drill design. It minimizes the substance loss. It has been identified that difficulty in irrigation while using guide, it blocks the cooling to avoid such problem it has been recommended use drill with interl cool-



ing channel is present. A set of matching titanium or fiber-reinforced posts for immediate restoration is also claimed by author while utilizing this technique. The use of this 3D guided technique is more technique sensitive, feasible and reduce the complications in post-endodontic management. (Schwindling et al., 2020)

### Limitations of guided endodontics

1. For guided access cavity preparation as mentioned by Buchgreitz et al in 2019, stated that the spatial resolution of the CBCT does not always allow visualization of the canal. (Buchgreitz et al., 2019)
2. Another limitation regarding the imaging technique is that in many cases introral radiography is used during followup. Given the 2D nature of the image, the deviation of the access cavity underestimated in terms of its bucco-lingual position as well as the healing of periapical lesions. (Ali and Arslan, 2019)
3. When planning for guide access cavity, it should be noted that it can be used only in straight portion of the canal and not beyond the curvature.
4. It should be mentioned that reduced mouth opening could impose limitations when trying to implement this technique in posterior region.

### CONCLUSIONS

Guided endodontic procedures are a promising technique offering a highly predictable outcome and lower risk of iatrogenic damage. Minimally invasive treatment can be performed, and chairside time can be reduced. However, this should be interpreted with care since it is based on limited and low-quality evidence from case reports, observational studies, in vitro and ex vivo studies. Larger population studies with longer follow-up periods are required, as well as standardize experimental studies with similar sample size, aim and a standardized measuring method.

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