GUIDED ENDODONTICS: PAVING ITS WAY THROUGH THE OBSTACLES

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ABSTRACT

The aim is to discuss the use of guided technology in endodontics, particularly calcified canals and also the amount structure loss by use of this technology. Endodontic treatment of teeth with canal obliteration poses a challenge given the higher chances of procedural errors and complications during treatment. This is possible by a combined approach of Cone Beam Computed Tomography (CBCT) and intra-oral scan which can be used to design a personalized 3-D printed intra-coronal guide for the patient. Although, at present, a conventional access cavity preparation combined with (CBCT) in cases of pulp canal obliteration is followed, it leads to high loss of dental hard tissues, Hence, guided endodontics provides a highly accurate technique for the preparation of minimally invasive cavities. This review article concentrates on the clinical applications, the operative steps in endodontic cases, the recent techniques and also gives a perception about the current and future aspects of this guided access technique in endodontics.

Keywords: Guided endodontics, digital imaging, pulp canal obliteration, endodontic guide, root canal treatment.

Introduction

Endodontic treatment can be challenging in cases of pulp canal obliteration, complex root anatomy, or limited access due to restorations. Traditional methods often rely on the clinician's experience and tactile sense, which can increase the risk of procedural errors. Preserving the pericervical dentin is the main aim now a days as it functions as a stress distributor. The endodontic treatment of teeth with pulp canal obliteration is often a major challenge. It involves a lot of time and energy in negotiating the obliterated canals and there are increased chances of perforations finding these canals.1

Recent technological advances have led to the development of guided endodontics, which utilizes cone-beam computed tomography (CBCT), digital planning software, and 3D-printed guides to perform minimally invasive and highly accurate endodontic procedures.

Guided Endodontics has been introduced as an alternate solution in partial or complete canal obliteration cases. The term guided endodontics was coined to localize calcified root canals in a minimally invasive way. A guided endodontic access preparation can be approached in two different ways: static guidance, implies the use of a template, whilst dynamic navigation relies on markers positioned in the patient's mouth and a camera system. 3-D templates are fabricated to guide the drills into pre –planned positions for localization and exploration of root canal orifices.[2]

Principles of Guided Endodontics

Guided endodontics involves the integration of:

CBCT Imaging: It provides 3D visualization of root canal anatomy and surrounding structures.

Digital Surface Scanning: It captures surface morphology of the dentition for guide fabrication.

Planning Software: The DICOM (Digital Imaging and Communication in Medicine) and STL(Standard Triangle Language) files are into the digital planning software. It allows precise path planning for endodontic access.[3]

3D Printing: It produces a custom-made guide to direct endodontic instruments during treatment.

There are two types of guided endodontics:

Static Guided Endodontics (SGE): It uses pre-fabricated guides.

Dynamic Guided Endodontics (DGE): It uses real-time navigation systems similar to GPS.

Clinical Applications

1. Pulp Canal Obliteration (PCO)

Guided endodontics allows safe and predictable canal localization in calcified teeth, significantly reducing the risk of perforation.[4]

2.Tooth Anomalies and Malpositioning

Cases with abnormal morphology or access limitations (e.g., dens invaginatus, malpositioned teeth) benefit from digitally guided access.

3.Retreatment Cases

Guides help navigate through complex obturations or posts, minimizing unnecessary dentin removal.[5]

4.Access Through Crowns or Bridges

Guided access preserves the integrity of prosthetic

restorations, reducing the need for removal and replacement.

STEPS IN GUIDED ENDODONTICS PROCEDURE.

1. CBCT Scan of the Involved Tooth: Obtain a high-resolution CBCT scan. For scanning, there shall be limited patient movement, limited artefacts, minimal slice thickness, and conventional exposure. The CBCT image allows to localize the visible part of the root canal and define the position of virtual image of drill in this way plan the access path to the root canal preserving pericervical dentin.[6]

2. The Surface Scan: A detailed record of the tooth surface and soft tissue surfaces is required. If an intra-oral scanner is available, the tooth arch scanning can be done directly chairside, or indirectly by scanning a model created after an impression. To ensure solid support for the guide, the scan must encompass at least one quadrant of the tooth arch.[7]

3. Merging the CBCT Scan and Surface Scan with Software: The software must work with the CBCT scan program. The STL file of the intraoral scan and the DICOM files of CBCT are imported into the digital planning software.

4. Designing of Endodontic Guide: During this phase, 3-6 points or reference marks are marked on both scan files, after which the software automatically blends the two scans. The software allows you to merge the scans by displaying them side by side and adding annotations to the appropriate locations. A teeth supported guide provides good stabilization. The guide shall cover the labial and palatal surfaces.[8]

5.Creating a Virtual Drill Path: With the aid of the necessary software, a virtual drill path can be planned on the CBCT scan. The drill path should start at the tooth's incisal or occlusal surface and head to the target site where a pulp space is believed to exist.[9]

6. Sleeve Selection: A virtual sleeve is added to the scan once the target, the angle, and the diameter of the bur. The height of the built in sleeves shall be adapted to the working length of the tools to reveal the visible part of the canal.[10]

CLINICAL PROCEDURE

1. The correct fit of the template will be checked on the patient. The guide shall cover the labial and palatal surfaces to achieve adequate intra oral stabilization.

The tooth surface's starting point of access preparation is marked with colored resin.

3. After guide removal, the entrance preparation will be done with a high-speed bur.

4. Drilling directly on the dentinal surface with an end guide. The rotational speed must be set to 10,000 rpm and a micro-guided endodontic drill should be used to gain access to the apical third of the root with pumping movements.[11]

DIGITAL AND CLINICAL WORKFLOW OF GUIDED ENDODONTICS.[1]

1. Examination.
2. Cone-beam computed tomographic scan.
3. Digital intraoral impression:

Directly—intraoral scan

Indirectly—scanning impression or plaster model.

4. Import DICOM and STL files into digital planning software.
5. Design the virtual drill path and the endodontic guide.
6. Three-dimensional printing.
7. The fit of the guide before and after placing a rubber dam needs to be controlled.
8. A sign through the guide to indicate the access point in non-treated teeth needs to be made.
9. Remove the enamel until the dentine is exposed.
10. Place the guide on the teeth.
11. Proceed through the guide: utilize rotate burs in dentine and scout the canal through the guide.
12. Removal of the guide to rinse the cavity and clean the burs control endodontic access with the help of an optical microscope.
13. Perform a radiographic examination to confirm the correct canal access.
14. Complete the root canal treatment.

Guided endodontics is a minimally invasive treatment procedure and is a constantly evolving technique with reduced chair side time. This 3D technology increases efficiency and provides stream-lined treatment workflow. It enhances the outcome of treatment procedure resulting in improved root canal filling quality. It has limitations and must be evaluated before planning and executing it.[12]

The endodontic procedure shall be carefully planned and performed to avoid deviation from the original canal path, root perforation, and excessive loss of tooth structures. Severe calcification or a complex anatomy of the tooth may pose a problem or induce stress.The guided endodontic technique has been reported as beneficial when localizing calcified

canals. r planning may be perceived as a disadvantage, it eventually significantly reduces treatment time and stress. The STL file of the intraoral scan and the DICOM files of CBCT are needed to design an endodontic guide. It is important to separate the lower and upper teeth when performing CBCT examinations in order to make DICOM and STL matching possible. Planning with the use of the multi-sectional view makes it possible to access the root canal and avoid the degradation of the incisal edge or other anatomical structures of the tooth by changing the orientation of the long axis of the virtual implant. However, it is important to bear in mind the possible inaccuracy of CBCT examinations and plan the pathway for the endodontic instruments with a margin ensuring sufficient root dentine thickness. The longer the guide sleeve, the lower the risk of a lateral deviation of the endodontic access tool near the apex of the virtual implant.1

Advantages of Guided Endodontics[13]

1. Precision and Accuracy: It facilitates canal localization with minimal risk of iatrogenic damage.
2. Minimally Invasive: It preserves tooth structure and reduces chair time.
3. Predictability: It enhances success rates in complex cases.
4. Educational Tool: It is useful in teaching environments for demonstrating access cavity design and canal negotiation.
5.Time: It reduces the operative time.

Limitations and Challenges[13]

1. Cost and Accessibility: It requires access to CBCT, 3D printers, and software. So the overall cost increases.
2.Learning Curve: It has a learning curve the clinicians must be trained in digital workflows.
3.Time for Guide Fabrication: It takes time to fabricate the guide so it may not be suitable for emergency treatments.
4. Intraoral Fit Issues: If the fit of the guide is not proper it can compromise the accuracy.

Future Directions

The future of guided endodontics is promising, with the developments such as

1. Artificial Intelligence (AI) Integration

The incorporation of AI into treatment planning software will enhance the diagnostic and decision-making capabilities of clinicians. AI algorithms can automatically detect calcifications, identify optimal access paths, and even predict treatment outcomes based on patient-specific anatomy and clinical history.[14]

2. Real-Time Dynamic Navigation

Dynamic guided endodontics—akin to surgical GPS—will become more streamlined and widely available. These systems will offer real-time, hands-free navigation, allowing clinicians to adjust their operative strategy during procedures, improving outcomes in cases with anatomical variation or unexpected findings.[15]

3. Microsurgical and Robotic Endodontics

Robotics and augmented reality (AR) are expected to play a role in endodontics, especially in microsurgical procedures. These technologies can offer ultra-precise instrumentation, enhanced visualization, and even semi-autonomous preparation of canals in complex or high-risk cases.[16]

4. Enhanced Accessibility and Chairside Workflow

With the miniaturization of CBCT scanners and improvements in intraoral scanners, guided endodontic procedures will likely become more affordable and streamlined. Chairside 3D printing will enable same-day guide fabrication, making guided procedures feasible even in urgent scenarios.[17]

As these technologies become more accessible, guided endodontics is likely to become a routine part of endodontic practice, especially for complex and high-risk cases.

7. Conclusion

Guided endodontics represents an advanced therapy that allows clinicians to perform endodontic treatment of teeth with pulp canal obliteration in a more predictable and precise manner and allows clinicians to avoid over-preparation and iatrogenic damage. The time needed to locate canals is also reduced. Besides the calfications ,the guided procedures may help to easily treat specific areas in root such as resorptions, perforations and fractured endodontic instruments.[11]

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