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Guided Endodontics: A Literature Review

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ABSTRACT: The concept of guided endodontics is employed to achieve predictable and safer results for access cavity preparation and endodontic surgery. The results are very predictable, and there is a lesser chance of iatrogenic damage. This approach can be advantageous for the endodontic or surgical treatment of challenging cases. It can be used for a variety of procedures, but it is particularly helpful for accessing and identifying root canals in teeth with pulp canal obliteration, performing microsurgical endodontics, and removing glass fiber posts during endodontic retreatments. Additionally, it is less time-consuming for the patient to receive treatment, has better accuracy, and is safer than traditional endodontics. It is also independent of a clinician's level of competence. Based on the scientific literature that has been published to date, the primary goal of this article is to generate an updated literature review on guided endodontics.

KEYWORDS: Guided endodontics, Pulp Canal Obliteration, Guided approach, Virtual drill, CBCT Scan.

I. INTRODUCTION

Guided Endodontics has recently been reported as an alternate solution in partial or complete canal obliteration cases.[1] The term 'guided endodontics' (GE) was coined as an alternative to conventional access cavity preparation for teeth with Pulp canal obliteration and irreversible pulpitis or apical pathosis.[1] Using three-dimensional radiological imaging such as cone-beam computed tomography and a digital surface scan, optimal access to the root canal orifice can be virtually planned with the appropriate software. Guided Endodontics is performed either using templates similar to guided implantology (static navigation) or with the help of dynamic navigation based on a camera-marker system[1].

Minimally Invasive Endodontics aids in the preservation of healthy coronal, cervical, and radicular tooth structure during the endodontic procedure as it is based on the concept of peri-cervical dentin (PCD) preservation. During the traditional deroofing process, a lot of PCD is lost, resulting in reduced fracture resistance of the tooth.[1] Guided Endodontics aids in the preservation of PCD and renders the most conservative approach for complex cases: calcified canals. The notion of Guided endodontics was introduced with enhancements in 3D printing technologies and tomographic imaging.[1] These computer-designed guides are used for access cavity preparation and endodontic surgery to achieve better results. It is now also gaining popularity in endodontic surgery.

"3D endodontic guide or endo-guide is a template fabricated to guide drills into pre-planned positions for localization and exploration of root canal orifices or bone trephination and root end re-section".[2]

II. TYPES OF GUIDED APPROACH[2]

The guided approach can be static/dynamic. Before beginning the clinical process, the virtual drill path is designed using the optical impression that is combined with the CBCT scan in the static-guided method. In Dynamic Guiding, CBCT data is combined with drill movement recordings.

CBCT and surface scan are matched on radiographically visible structures like the patient's teeth. The software creates the virtual image of the commercially available bur. The virtual copy is superimposed with the radiographically visible part of the calcified canal. Different software like 2IngisR technology, coDiagnostiXR, and AcetonR Imaging software are used.

III. TYPES OF ENDODONTIC GUIDES[2]

1. Depending on their use in endodontic treatment procedures:

a) Non-surgical Guides: Aids in locating calcified canals non-surgically or apically extended access opening cavities.

b) Surgical Guides: Used for endodontic surgeries, especially for root end resection procedures.

2. Depending upon their support:

Tooth-supported guide: Rests over patient's dentition. No anchor pin is required. Used for non-surgical guided endodontic treatments.

Bone-supported guide: Rests on the bone surface after flap reflection. Fixation pins are inserted into the bone. It can be used for surgical endodontics.

IV. STEPS IN GUIDED ENDODONTICS PROCEDURE.

1. CBCT Scan of the Involved Tooth:

Obtain a high-resolution, constrained field-of-view CBCT scan. For scanning, limited patient movement, limited artefacts, minimal slice thickness, and conventional exposure conditions are required. The tooth must have a strong, smooth surface to ensure the guide rests properly when scanning.

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.

3. Merging the CBCT Scan and Surface Scan with Software:

The software must work with the CBCT scan program. For accuracy and precision, superimposition of CBCT data and surface scan is essential for the guide's suitable fit.

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. For precise planning, use image superimposition. It is verified that neither the virtual bur nor the sleeve is touching the surface scan at the combined image control.

5. Tracing the Canal:

Finding the calcified canals on a scan comes first. Most of the time, we can discern the faint radiolucency of the pulp, which aids in tracing the entire canal system. In cases of guided endodontics for anterior teeth, where there is frequently no curvature, it is always simple to trace and choose the right case. Only the first curve in the canals with curves can be reached with guided access. The law of canal centrality should be followed while planning if the canal is not visible on the CBCT scan.

6. 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.

7. Sleeve Selection:

A virtual sleeve is added to the scan once the target, the angle, and the diameter of the bur are determined.

CLINICAL PROCEDURE

1. The correct fit of the template will be checked on the patient.
2. 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[2].

DIGITAL AND CLINICAL WORKFLOW OF GUIDED ENDODONTICS.

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 Standard Tessellation Language files into digital planning software.
5. Plot 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 constantly evolving technique. Technological advances provide more precise and adequate tools for Endodontics, directing toward a more accurate technique with affordable cost and greater reach to the clinician. It has limitations and must be evaluated before planning and executing it.

Pulp canal obliteration, calcific metamorphosis, and pulp canal calcification are all terms that describe the increased apposition of tertiary dentin in the root canal system. Decreased translucency of the tooth due to increased apposition of dentin causes discoloration; this is the most commonly seen clinical sign of pulp canal obliteration.[7] This obliteration makes it even more challenging to proceed with complicated root canal treatment, negotiate canals, and increase the risk of iatrogenic events.[7]

When performing a root canal using the traditional method, the practitioner must memorize the structure of the tooth and have good visualization abilities to find the canals.[7] Access cavity overextension, missed root canals, iatrogenic perforation, file separation, and root canal movement off the original course are some potential issues that could occur during root canal therapy. Endodontic therapy is safer and more predictable when using guided endodontic access. The entrance point, bur direction, and depth can all be planned.

The complexity of the architecture of root canals may also serve as some of this technique's limitations, planning must be carefully reviewed, with wear and drilling being directed solely to the straight portion and bending being avoided.

CBCT exams that produce image artifacts in the region can also restrict the virtual planning and accuracy of the prototype guides for the technique. However, the evolution of the advanced technological tools used leads to expanding its indications and greater exploration of Digital Endodontics. More innovative software with a greater number of resources has enabled a more faithful copy of the internal anatomy of the teeth, avoiding distortions that lead to access errors and inaccuracy. Thus, with the elimination of image artefacts arising from high-density materials, guided access can be planned efficiently in a majority of indicated cases.

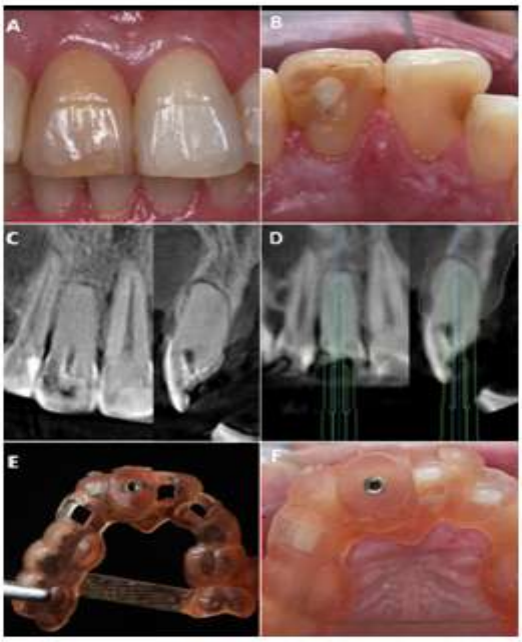
In this way, technological advances open up other possibilities, reducing many operative steps. With the latest software capable of accurately reconstructing anatomical structures without any distortions, intraoral scanning may soon be eliminated. The 3D reconstructions will be used as three-dimensional models and converted into Standard Tessellation Language (STL) files. This reduction in operative steps is advantageous to both the patient (lower cost in guide preparation) and the professional (lesser distortions due to the elimination of steps).

ADVANTAGES OF GUIDED APPROACH

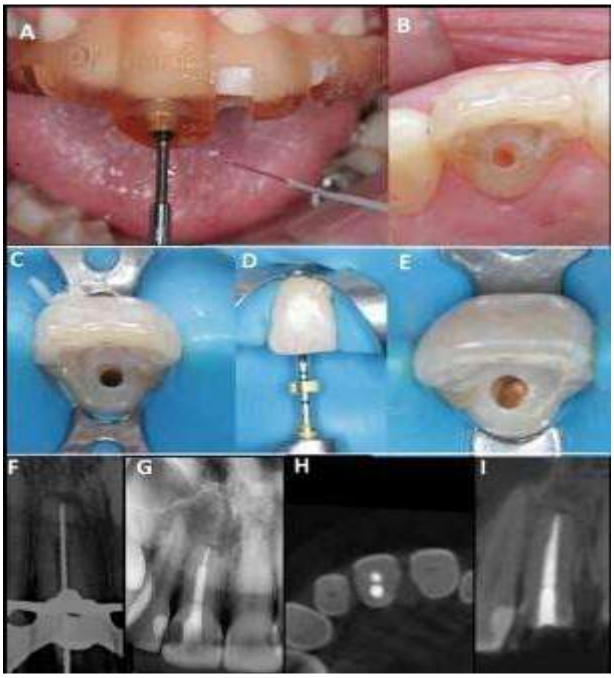
1. Minimizes the error common in conventional visualization and free-hand treatment.
2. Promotes replicable positioning and accuracy that allows access to smaller cavities regardless of the level of clinician's experience.
3. Does not require a Dental Operating Microscope.
4. Reduced operative time.

DRAWBACKS OF THE GUIDED APPROACH

1. Guided access is only possible in the straight areas of the root canal and becomes imprecise in curvature regions.
2. Canals with extremely narrow diameters may not be seen in the CBCT images as the voxel sizes are larger.
3. Patients with restricted mouth opening may contraindicate guided access, especially in posterior teeth.
4. The presence of metallic restorations/ filling of teeth leads to artifacts on the radiograph.
5. Not economically favorable to all patients.



Initial clinical appearance: frontal view (A) and occlusal view (B) of the maxillary central incisors. Tooth 11 has a darkening of the entire coronal structure and glass-ionomer cement restoration in the center of the palatal surface. CBCT images: coronal (C1) and sagittal (C2) sections show canal calcification of tooth 11 and the incorrect course of the first attempt at endodontic access, starting at the center of the palatal surface and towards the buccal surface. In D1 and D2, the access path outlined by the digital planning can be seen. Endodontic Guide: (E) occlusal view shows a support base from tooth 16 to tooth 25, and a stabilization bar connecting teeth 15 and 25, (F) shows a metallic ring installed in the access guide and inspection windows for verification of guide adaptation.



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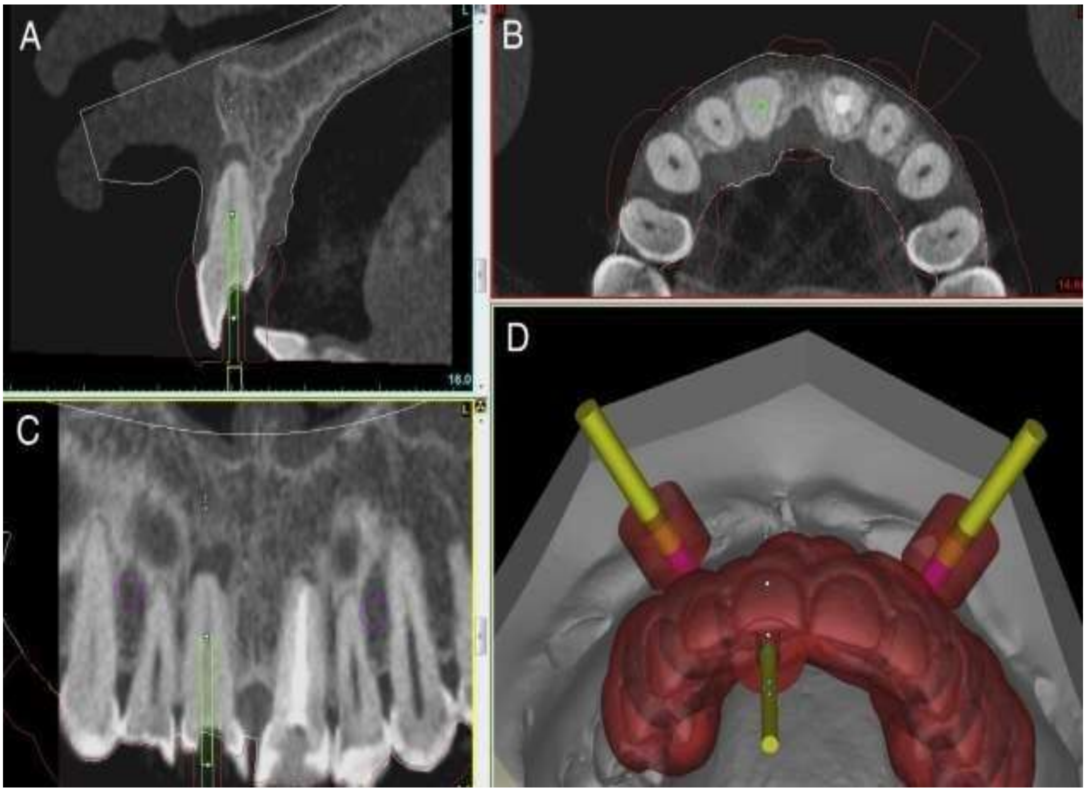
Endodontic Access: Front view (A) shows the endodontic guide and drill in place while being irrigated with saline solution; occlusal view (B) shows the initial wear after virtual planning is verified. Endodontic Treatment (C) Final Aspect of Endodontic Access in Occlusal View (D) Frontal view with X5-pro taper Next file, the file is in the root canal position, with an occlusal view of the sealed canal in (E). Cone-beam computed tomography imaging examinations: (F) radiograph with a file at the working length following root canal preparation; (G) periapical radiograph of the filled canal and the restored tooth; (H) and axial (I) sections following obturation and final coronary restoration.[10]



A CBCT picture of the right maxillary central incisor showing apical periodontitis and severe Pulp Canal Calcification.
(A to C) Virtually guided endodontic planning.(D) The model scan with the drill's virtual replica and 3D templates in alignment.[12]

V. CONCLUSION:

Guided endodontics (GE) is an innovative method that uses 3D imaging (cone beam computed tomography, CBCT) and surface scans for minimally invasive access cavity preparation using virtual preoperative planning. A bur is guided to the planned position through a template sleeve system, similar to the guided implantology technique. It offers a safe and predictable method for locating calcified root canals. It also lowers the risk of iatrogenic damage. and proving it to be a highly promising technique. It represents a new perspective for complex endodontic cases, which could lead to errors in conventional procedures. It is an effective, precise, and easy technique. Furthermore, it takes a shorter number of clinical sessions, increasing patient comfort and reducing professional stress.

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