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3-D Guided Endodontics: A Comprehensive Review

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ABSTRACT: The introduction of 3-D Guided Endodontics has transformed dentistry beyond recognition, significantly improving the accuracy and reliability of endodontic treatments. 3-D Guided Endodontics is a technology-driven treatment protocol, which provides safe and predictable solution in cases of partial and complete root canal calcifications and root end surgeries. Special software aligned with CBCT, and 3-D scan allows virtual planning of drilling paths in access cavity preparations and osteotomy sites. Subsequently, a 3-D template can be developed to guide the drill which can help to preserve the tooth structure and avoid any procedural errors. This review paper seeks to deliver an extensive overview of the technological innovations, clinical uses, technique of fabrication of 3-D templates and advantages associated with 3-D Guided Endodontics.

KEYWORDS: CBCT, Endodontic surgery, Guided Endodontics, 3-D template

I. INTRODUCTION

Background:

Guided Endodontics is a contemporary method that improves the accuracy and predictability of endodontic procedures by utilizing cutting-edge imaging and navigation technologies. For teeth with irreversible pulpitis or apical pathosis, as well as pulp canal obliteration, Guided Endodontics was developed as a substitute for traditional access cavity preparation.[1]

Using 3-D radiological imaging, such as cone-beam computed tomography (CBCT), this approach creates a virtual map of the root canal system. It is then carried out with the aid of computer-aided templates or dynamic navigation systems.[2] Either static navigation, which uses templates like guided implantology, or dynamic navigation, which uses a camera-marker system, are used to perform guided endodontics.[1] A 3-D endodontic guide, also known as an endo-guide, is a template made to direct drills into predetermined locations for root canal orifice localization and exploration, bone trephination, and root end resection.[3]

II. OBJECTIVES

1. Precision: helps to locate and reach the root canal system precisely, especially in complicated situations like calcified canals or anatomical abnormalities.[4]

2. Minimally Invasive Treatment: Promote long-term tooth viability by reducing needless removal of dentin and other tissues while maintaining healthy tooth structure.[2]

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3. Safety: By giving the clinician a clear visual cue, the chances of iatrogenic errors like missing canals and perforations are minimized.[4]

4. Reliable Results: Regardless of the clinician's degree of experience, standardize endodontic techniques to generate reliable and superior clinical results.

III. NEED FOR GUIDED ENDODONTICS

Need for better navigation and minimally invasive endodontics led to the development of Guided Endodontic technique. Minimally invasive endodontics is a concept for maximum preservation of healthy coronal, cervical and radicular tooth structure during endodontic treatment. [5]

IV. TYPES OF GUIDED ENDODONTIC APPROACHES

1. Static Guided Endodontics: With this method, a physical guide or template is created using preoperative 3D imaging, such as CBCT scans.[6] In order to ensure precise access to the root canal opening, the guide is then utilized throughout the process.

2. Dynamic Guided Endodontics: This method gives the endodontic tools real-time input and direction during the treatment by using real-time navigation systems that use a camera-marker system.[6]

V. DIFFERENT KINDS OF ENDODONTIC GUIDES

Depending on how they are used in endodontic procedures:

1. Non-surgical Guides: These helps identify calcified canals that can be opened by apically expanded access or non-surgically.

2. Surgical guides: These are utilized in endodontic treatments, particularly those involving the excision of the root end. **[2]**

Depending upon their support:

1. Tooth-supported guide: Placed over the patient's teeth and doesn't require an anchor pin. It is utilized for guided endodontic procedures that don't require surgery.

2. Bone-supported guide: Following flap reflection, this guidance lies on the surface of the bone. It involves inserting fixation pegs into the bone. It is applicable to endodontic surgery. **[2]**

VI. TECHNIQUE

Guided Endodontic is a way to use CBCT merged with optical impression, creating a platform for the design of a virtual drill path subsequent to clinical procedure of drilling using a guide. The steps of 3- D Guided Endodontics are as follows [7]:

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1. Surface scan of the involved tooth
    - In this step, the details of tooth and soft tissue surface are recorded.
    - It can be done directly chairside if intraoral scanner is available or indirectly by scanning a model after an impression.
    - It should cover atleast one quadrant of tooth arch to secure a stable support for the guide.
    - An intraoral impression is transformed into a 3D stereolithography file using the R700 Desktop scanner, and it is subsequently transferred to the virtual implant planning program (Simplant version 11). Lara-Mendes ST, Camila de Freitas MB, Machado VC, Santa-Rosa CC
2. CBCT scan of the involved tooth
    - CBCT is an excellent measure for localizing root canals.
    - It is necessary to scan with standard exposure parameters e.g. 0.2 mm voxel, grey scale,14 bits,26.9 s X-ray exposure, 120 kV and 37 mA are commonly used.[8]
    - It is important to make sure that tooth surface is smooth and sound while scanning so that the guide can rest on it properly.[9]
3. Merging CBCT scan and surface scan
    - For the guidance to be accurate and fit, CBCT data and surface scans must be superimposed.
    - 3-6 reference landmarks are marked on both scan files and software merges the scans automatically by posting marks on corresponding spots.
4. Template planning for Endodontic Guide

    To locate and explore root canal orifices, bone trephination, and root end resections, the template is made to direct drills into certain areas. Steps in fabricating a Endodontic Guide:
    - ✓ Trace the calcified canals on CBCT scan
    - ✓ A virtual drill path is planned on CBCT Scan with the help of implant software keeping in mind-
        - Target point (12 mm working length)
        - Angle of the drill path (to reach the visible lumen of the root canal and avoid the incisal edge)
        - Diameter of the drill (1.3 mm diameter)
    - ✓ A guiding sleeve (with 3mm external diameter, 1.4 mm internal diameter and 8mm in length) is virtually customized and incorporated into the template, to guide the drill onto the tooth surface.
5. With the help of 3-D printing, endodontic guide is made from the template designed using software. Endoguide is seated on the tooth arch.
6. Guided Drilling- The guided access preparation is started with the drill (operated at 1200 rpm).
7. Intermittent IOPAs are taken to judge the depth and direction of drilling. This process is continued till the target point is reached i.e. apex of the obliterated root canal while preparing the access or apex of the root while performing apicoectomies.

VII. APPLICATIONS

1) Calcified Canals – characterized by deposition of hard tissue in pulp canal space. Preparing access cavities in calcified canals is a challenge leading to technical failures like perforation of root, file fracture, unsuccessful canal negotiation and needs special modus operandi for its diagnosis and treatment.

2) Endodontic Microsurgeries- osteotomy for apicoectomies. Osteotomy itself is a challenge especially in case of intact cortical bone. The site and size of osteotomy with precise angulations are difficult to reach if no aids are used. Hence, such

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complex procedures are simplified with the help of 3-D Guided Endodontics which is extremely predictable and minimally invasive.[5]

VIII. ANALOGY- CONVENTIONAL V/S GUIDED APPROACH

- In teeth with calcified canals, an attempt to locate root canals through traditional approach results in higher tooth substance loss whereas in guided approach, canal location is much more precise, guided by CBCT with lower risk of iatrogenic damage shown in Fig 1. Therefore, minimal invasive access cavities have a benefit of increased fracture resistance.
- Dentin loss in conventionally prepared root canals occur in any direction while in guided approach the loss of hard tissue is concentric around calcified canals.
- Conventional approach has detrimental impact on inner tooth morphology, fracture strength whereas small diameter of bur, apically extended access cavity preparation through Guided Endodontics entails clear advantages for structural stability of treated tooth. [10] (Fig.1)

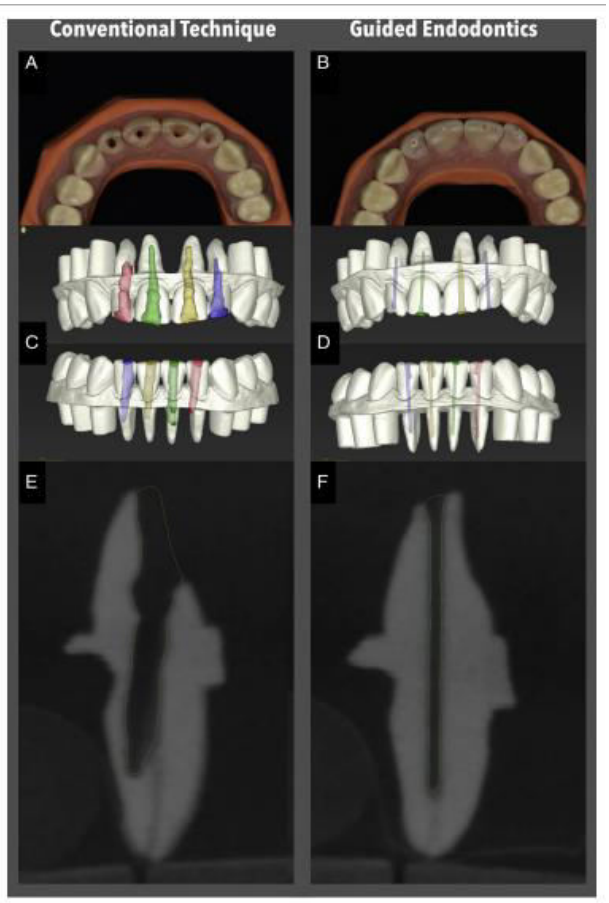

Fig. 1 An attempt to locate root canals through traditional approach results in higher tooth substance loss whereas in guided approach, canal location is much more precise, guided by CBCT with lower risk of iatrogenic damage.

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IX. CONCLUSION

With the evolution of digital dentistry, what started as a basic localization technique has followed the growth of modern technology beyond specialized uses. 3-D Guided Endodontics is a promising technique with an immense scope to be used in clinical practice to simplify the complex surgical and non-surgical procedures.

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