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Static and Dynamic Navigation - "The Future Stars"

Dr. Ayushi Sharma[1], Dr. Sachin Gupta[2], Dr. Vineeta Nikhil[3], Dr. Shikha Jaiswal[4]

[1]PG student, Department of Conservative Dentistry and Endodontics, Subharti Dental College and Hospital, Swami Vivekanand Subharti University, NH-58, Delhi-Haridwar by Pass Road, Meerut -250005
[2]Professor, Department of Conservative Dentistry and Endodontics, Subharti Dental College and Hospital, Swami Vivekanand Subharti University, NH-58, Delhi-Haridwar by Pass Road, Meerut -250005
[3]Head of the Department, Professor, Department of Conservative Dentistry and Endodontics, Subharti Dental College and Hospital, Swami Vivekanand Subharti University, NH-58, Delhi-Haridwar by Pass Road, Meerut-250005
[4] Professor, Department of Conservative Dentistry and Endodontics, Subharti Dental College and Hospital, Swami Vivekanand Subharti University, NH-58, Delhi-Haridwar by Pass Road, Meerut -250005

Corresponding Author: Dr. Ayushi Sharma

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ABSTRACT

Over the last few decades technological advancements have led to a significant impact over dentistry and the field of endodontics is no exception to it. It has covered a long way from apex locators and microscopes to digital radiography and intraoral scanners and finally navigation. "Guided Dentistry" term is used explicitly for navigation in dentistry. In the 19th century, navigation in the medical sciences first appeared and it was used to perform stereotactic surgery on the human brain. It was first used in dentistry in the year 2000 to facilitate the placement of dental implants. Navigation in endodontics is based on the concept of minimally invasive endodontics. Guided endodontics can also be called as "Targeted endodontic treatment". Compared to standard treatment methods, guided endodontics can produce more predictable treatment results. Guided navigation in endodontics is of two types-Static and Dynamic. In Static Guided Endodontics (SGE) the CBCT scan is merged with optical scan to design a virtual drill path using a planning software following which a template is fabricated using 3-D printing. In Dynamic Navigation System (DNS), the virtual drill path is converted into a real time drill path using navigation software.

Keywords: [Guided Endodontics, minimally invasive dentistry, Navigation, Static guided endodontics, Dynamic guided endodontics.]

INTRODUCTION

When we talk about root canal treatment (RCT) some cases are undemanding but there are few cases which can be laborious to even the most trained and experienced endodontist. The very first one being the pulp canal obliteration (PCO). Several studies and research have shown that in case of traumatized teeth the incidence of PCO is increased to 22% in later stages and attempts to locate and negotiate calcified canals pose challenges in the form of gauging, perforation, missed canal etc. [1] Another such complex case is that of Dens Invaginatus (DI) which poses challenge because of abnormal radiographic appearance and difficulty in accessing the main root canal due to enamel and dentine invagination.[2] According to case difficult assessment by American association of endodontists (AAE) ,PCO and DI are categorized under "High Difficulty" cases . Even the most skilled practitioner finds it difficult to obtain a predictable treatment outcome. Another complex scenario which poses challenge to endodontic treatment is failed root canal requiring retreatment through crown/bridge. The practitioner encounters several problems while performing the treatment like misguided orientation and depth of bur. [3] Sometimes a

tooth restored with fiber-post and core might require endodontic retreatment. Free hand fiber post removal, may lead to iatrogenic errors like damage to root structure, perforation, root canal transportation, unwanted removal of the dentin, and gaining patency becomes complicated. [4] Hence, management of such complex cases requires special attention with regard to equipment and instruments. All the above-mentioned situation can be treated predictably, conservatively and quickly using "Guided Endodontics".

DISCUSSION

When there is a desire to research and advance both the diagnosis and the therapy, creativity happens. Guided Endodontics, also referred to as "Targeted endodontic treatment" reinforces the concept of minimally invasive endodontics which allows peri cervical dentin (PCD) preservation. It is the dentin which is found close to the alveolar crest. The occlusal table must transfer load to the root through this essential zone, which is around 4 mm coronal to the crestal bone and extends 4 mm apical to the crestal bone. A large portion of the PCD is irreparable. During conventional (freehand access), much of the PCD may be lost in "high difficulty cases," which lowers the tooth's ability to resist fracture. Therefore, a more conservative approach is required which can preserve this critical zone. For situations with a high degree of difficulty, guided endodontics provides the most conservative solution and aids in PCD preservation.[5] Looking into the hierarchy of guided dentistry, it was the 19th century which marks the inception of navigation in the field of medical sciences. Neurosurgeons were the earlier adopters of this technology and the pioneering work was done by Dr. D.N. Zernov. [6] The guided endodontics has evolved from guided implantology. The term "Guided Endodontics" was coined by Krastl and Zehnder *et al* in the year 2016.[5] The development of 3D printing and tomographic imaging technology led to the introduction of the idea of guided endodontics. The guided endodontics approach is of two types- Static and Dynamic. In SGE, an optical impression and a CBCT scan are combined to create a platform for the creation of a virtual drill. path following which templates are produced through 3D printing.[7] DGE uses optical positioning device controlled by a dedicated computerized interface. A real time interface displays the drill into targeted position.[8]

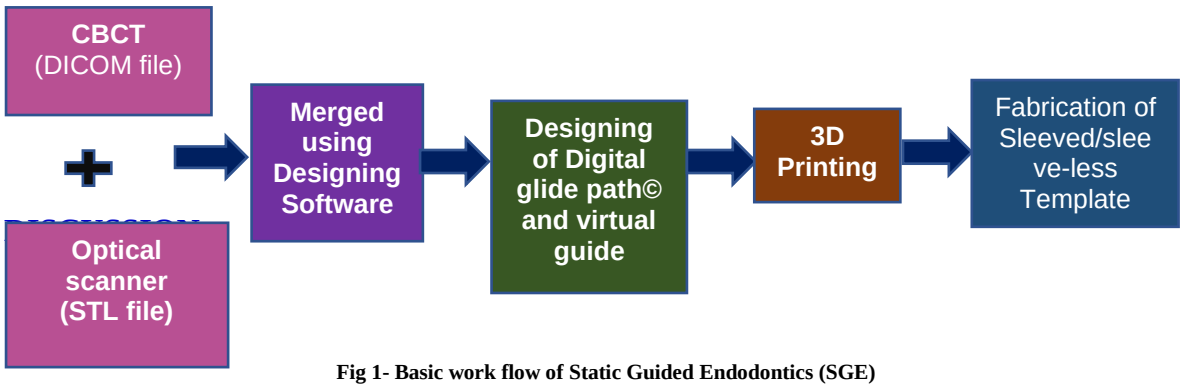

Fig 1- Basic work flow of Static Guided Endodontics (SGE)

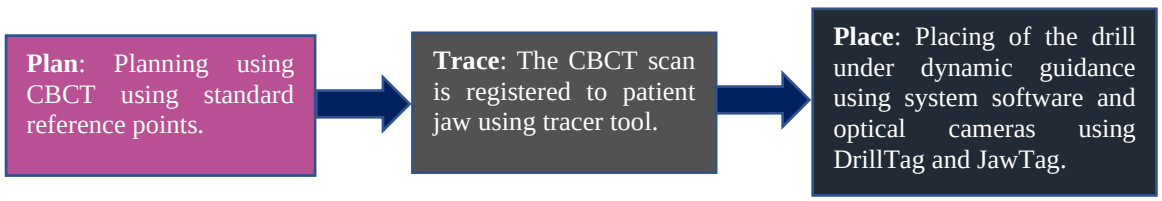

Fig 2- Basic work flow of Dynamic Guided Endodontics (DGE)

SGE has a variety of uses, including pulp canal obliteration, file retrieval, selective retreatment, fiber post removal, post space preparation, dens invaginatus.[5] According to Connert *et al*, in comparison to the conventional endodontic approach, guided endodontics leads to a more predictable and quicker placement of calcified root canals with much less material loss. Contrary to freehand access preparations, the operator's experience has less of an impact on the guided approach.[9] The various components of static guided approach are CBCT, surface scans, designing software, endodontic guide, 3D printing, burs and drills. [7] CBCT is a 3D imaging technique which lays the foundation for 3D printing for template or guide fabrication. Its file format is called as DICOM file. [10] The CBCT parameters in guided endodontics are small FOV [7], kvp of 110 mv [7] and current of 3-5 mA [5] for *ex vivo* studies and 25-35 mA [5] for *in vivo* studies. The resolution should not exceed 200 microns [5]. There are two ways to acquire optical data from the oral cavity: directly (using intraoral scanners) and indirectly (using extraoral scanners). The data from surface scans is stored as STL files. Superimposition of CBCT and surface scan is one of the fundamental phases of SGE, and it is essential for the precision and fit of the guide. 3-6 points or landmarks are noted on both scan files during this phase, and then designing software automatically merges the two scans (DICOM and STL), creating a platform for creating a virtual drill path to the desired location. Designing software are used for merging DICOM Files with STL Files and for planning endodontic guides. Various software utilized for SGE technique includes coDiagnostiX, SICATEndo, 2Ignis, Aceton.[11] Subsequently a template is fabricated using 3D printing.[12] (Fig-1) A template known as an endodontic guide is created to direct drills into pre-planned sites for localizing and exploring root canal orifices or for trephining bone and resealing root ends. These are used exclusively in Static Guided Endodontics. [5] Template can be with sleeve which is more accurate but difficult to use in limited interocclusal space, where sleeveless template [13] can be used. 3D printing helps in printing of customized endodontic guides. [14] The commercially available burs and drills include Straumann drill, SS White Endo bur, munce bur [12]. They are between 25 and 35 mm long to integrate the sleeve's length, and between 1.2 and 1.5 mm wide. [14] The advantages of SGE includes reduced iatrogenic errors, reduced operating time and increased accuracy [5]. However, it may modify the root canal geometry and might cause initiation of dentinal cracks [5]. It is difficult to use in posterior region because of large sized burs and drills restricting access. Also, it involves lab time, lab charges and additional intraoral scanning for template fabrication.[9] To overcome these limitations Dynamic Guided Endodontics (DGE) or Dynamic Navigation System (DNS) came into existence.

Dr. David Burgress compared DGE to the GPS system installed in our automobiles.[15] The application of dynamic navigation is similar to static navigation with more precision and better application in posterior region. The components of DGE include CBCT, handpiece attachment /DrillTag, patient jaw attachment /JawTag, the system with cameras and dedicated software (1st generation which includes Navident, ClaroNav and 2nd generation which includes Navident 2.1, ClaroNav) , natural/fiducial markers, tracer tool and calibration tool and handpiece with bur. [5] While standard reference points are utilized in DGE to fuse CBCT scan with patient jaw using fiducial markers and a tracer tool however in, static guided endodontics marks 3-6 points or reference landmarks on both scan files (DICOM file and STL file) before software automatically merges them.[10] The high-speed handpiece has a drill-tag attached to it . This enables the system to track the bur's direction (angulation), position (x, y, and z axes), and depth (z axis) continuously and display this information as "Crosshair Reticule" on the software screen.[15] An optical tracking tag, also known as a Jaw

Tag, is utilized so that the specialized system can follow the patient's jaw. The system's optical tracking sensor recognizes the tag's black and white pattern, accurately determining the patient's jaw's location. To enable the software to register ("merge") the CBCT scan to the actual patient's jaw, the tracer tool device is used to trace landmarks (3-6), such as the patient's existing teeth, that are detected in the CBCT that has been preloaded into the software. A calibration tool is a multitool calibration equipment that permits the calibration of burs, drills, and piezotome saws driven by rigid dental instruments as well as low- and high-speed handpieces.[15] The basic steps in DNS are Plan, Trace and Place.[16] (Fig-2) The plan of drill placement is created using CBCT data. The CBCT data is registered to the patient's jaw using a tracer tool. The drill is placed under dynamic guidance using system software, drilltag and jawtag. [16] DGE can be used for negotiating calcified canals, post space preparation, surgical endodontics, retreatment, file retrieval, post removal, dens invaginatus.[5] According to Jain *et al*, DNS resulted in lesser mean substance loss and was more efficient in speed and qualitative precision than freehand technique during treatment of simulated anterior canal.[17] According to Dianat *et al*, on comparing the accuracy and efficiency for locating calcified canal in human teeth using DNS and freehand technique, it was observed that DNS was 96.6% more successful in locating root canal as compared to 83.3% with free hand. The procedural mishaps were significantly higher with free hand method than DNS. The mean time to locate canal was significantly higher with free hand than DNS. [18] The benefits of DNS include eliminating the need for long drills and burs, eliminating the requirement for 3D printed guides, making it simple to plan and execute multiple drill paths, lowering lab expenses, and improving isolation. The drawbacks include difficulties in maintaining direct visual contact with the system display during the treatment, expensive equipment procurement and maintenance, bulky and heavy gear, higher patient care expenses, and greater procedural/digital waste. The drawback includes a learning curve that calls for technical skill, eye-hand coordination, and dexterity.[19] In terms of root canal location, Riberio *et al*. found no statistically significant difference between the two guided endodontic systems, with SN and DN having success rates of 98.5 and 94.5 percent, respectively.[20] Endodontists may struggle with the clinical management of challenging endodontic situations, such as those with severely calcified canals. In particular, when carried out by less experienced practitioners, guided endodontic procedures feature minimally invasive and accurate approaches that enable highly predictable root canal location, more tooth structure preservation, and lower risk of iatrogenic damage. Both SN and DN techniques have unique benefits and drawbacks that make them effective in distinct clinical situations. Therefore, it is crucial to carefully assess each clinical case in order to choose the most appropriate guided endodontic procedure.[21]

CONCLUSION

During endodontic treatment or retreatment, the concept of minimally invasive endodontics aids in preserving healthy coronal, cervical, and radicular tooth anatomy. Its foundation is the preservation of PCD, or peri cervical dentin. The development of 3D printing and tomographic imaging technology led to the introduction of guided endodontics.[22] In addition to endodontic cavity access and canal location with PCO, guided endodontics can also be used for osteotomies and apicoectomies, retrograde fillings, removing fibreglass posts, and treating teeth with morphological asymmetries. The guided endodontic technique is simple, reliable, and practicable in a clinical setting. Furthermore, it can be performed by operator with less experience. This approach has emerged as a crucial and great choice in the practice of "saving teeth"

in which there is significant risk of iatrogenic errors like in severely calcified root canal treatments as well as in other difficult endodontic procedures. Although guided endodontics offers excellent and predictable treatment option to prevent complication and improve the prognosis of teeth in complex cases it involves additional steps thus increasing the cost of treatment. Therefore, with time and more innovations probably the cost would come down to make it more affordable treatment strategy for both dentists and patients. [23]

Declaration by Authors

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