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RESEARCH ARTICLE

GUIDED ENDODONTICS WITH DYNAMIC NAVIGATION SYSTEM: A REVIEW

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ABSTRACT

Dynamic as the name suggests is a real-time navigation digital imaging. The innovative concept of Dynamic Navigation has an honest approach to induce a safe and reliable outcome in Minimally Invasive Endodontic procedures. It integrates instrumentation and radiologic images with the help of an optical positioning device controlled by an infatuated computerized interface. These features aids in reducing the prospect of unintentional iatrogenic damage to anatomic structures. In endodontics, it is employed for localization of calcified canals and perform flapless surgery, allows conservative and more accurate access opening, minimally invasive bone trephination for apicoectomy surgery, resulting in reduced patient postoperative discomfort and improved healing. Treatment planning and surgeries may be performed in the same appointment, supported data from patient's cone-beam computerized axial tomography. This technology can be the foundational pillar of endodontics. Relevant literature published between 2004 and 2021 were collected from Pub Med database, Google scholar, and hand-searched journals of Endodontics and prosthodontics, which helped in writing of this review.

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INTRODUCTION

In today's era, it's the need to lookout for fastest, easiest and most accurate fix. Root canal therapy is very common endodontic treatment that saves teeth when the nerves are affected by decay or infection due to attack of microorganisms. There are many technological advances which have improved the accuracy. One of them is Dynamic Dental Navigation System, which were originally introduced in dentistry in 2000 (Pellegrino, 2002). It is used to access real-time feedback which helps in diminishing the complex impact of access cavity preparation of calcified canals, retreatment, microsurgical procedures and iatrogenic errors with an unsurpassed level of precision (Gambarini *et al.,* 2019).

Types of Guidance: Any strategy or guidance that enables us to practice and employ minimally invasive endodontic procedures by preserving structural integrity of teeth and surrounding structures while reducing the chance of iatrogenic injury and satisfying all the odds for minimally invasive endodontic criteria are to be welcomed and accepted. There are basically two types of guidance: Static and Dynamic (D'Haese, 2000).

Static guidance: Static guidance involves the use of a fixed surgical stent based on a preoperative CBCT scan, which is made with computer assisted design/computer assisted production (CAD / CAM) and is supported by tooth, mucosa or bone (Jung, 2009). But it has various disadvantages as it does not help in assisting the angulation, size and depth of the drill. It cannot be made quickly. It has a costly processing and cannot be used for patients with restricted opening of their mouths (Block, 2016).

Dynamic guidance: Dynamic guidance as the name suggest is based on computer-aided navigation technology. It is being used in a number of areas in medicine, such as craniomaxillofacial surgery. In Dynamically guided navigation system involves the use of stereoscopic camera and stents which helps in positioning of the endodontic instruments and guidance, it is correlated to reference points and is planned using computer software and the imported preoperative CBCT data. It provides real- time dynamic plus visual feedback to intraoperatively guide the instruments (Block, 2016). Therefore, information that has been planned on the scan is transferred to the real-life clinical situation and the exact position of the handpiece or instruments to be used can be tracked. To date, there are insufficient data assessing the use of Dynamic Navigation in Endodontics. Therefore, the aim of this review is to present the most relevant literature highlighting the clinical applications, accuracy, relative advantages and also limitations of Dynamic Navigation, focusing specifically on Guided Navigation in Endodontics.

Dynamic Navigation System: Dynamic navigation is a fairly new technology which allows the clinician to navigate different kind of procedures while obtaining real time visual feedback. Hence, the term dynamic. The computer navigation software provides an alternative to static drill guides (CAD/CAM). Working in real-time, rather than requiring hours of planning and fabricating before a patient's appointment, with 3-D printers or milling machines, the 4-hour step of truly making the guide is obviated with Dynamically Guided Access (DGA). The benefit of a Dynamic guide over a Static guide is that the operator cannot deviate from the planned path which facilitates treatment for less experienced operators. Similarly, the immediacy of this guidance system allows adjustments to be made in programmed drill paths literally during the process, such as changing a drill path when faced with unforeseen clinical difficulties. It also includes a one appointment procedure (scan, plan, and treat), verifiable guidance with system checks drill visualization during the procedure, quick and easy planning, and it can be used with limited interocclusal space because a template is not needed (Zubizarreta-Macho, 2020). The Navigation System involves a mobile unit with an overhead light, the overhead stereoscopic cameras, that can detect and track special specific markers or tags which are often called 'fiducial marker'. One of these markers are placed on patient's jaw and the other is placed on dental tool being used. The computer calculates the positions of the handpiece relative to the jaw. Thus, the system knows where the patient is positioned at all times in 3D space and where the dental tool is being used. The doctor then focuses on the screen which displays a target-like graphic (Gambarini *et al.,* 2019).

It has 5 simple steps

- Stent
- Scan
- Plan
- Design
- Place

Stent: The process begins with fitting the stent to the patient's jaw in chairside procedure. It is securely attached to the marker. No lab is involved and stability of the fit can be evaluated to ensure predictable results.Stents are cumbersome, bulky and restrictive in posterior regions. Once planned, the osteotomy path cannot be altered (Jorba-García, 2019).

Scan: One pre-requisite for the use of dynamic navigation is a This CBCT scan, one must take a CBCT scan with the stent in place, this CBCT scan is then transferred on computer and converted into a DICOM image. The system then superimposes the position of the dental tool being used over the virtual CBCT of the patient. Then the clinician by looking at screen interface obtains feedback of the position of the tool in relation the patient's jaw of the virtual scan and can adjust the angulation or depth in order to obtain the wanted procedure outcome. It involves the Trace and Place (TaP) system. TaP may avoid the need for a fiducial stent, with the resultant increase in the accuracy and ease of treatment. A Jaw – Tracker is attached to the patient's jaw and dental instrument, and are traced using an optical tracking system. The tip is superimposed on a patient's CBCT scan that has been traced. TaP technology improves the ease of accuracy and treatment and provides for minimal invasive access cavity preparation and reduces the size of osteotomies. Dynamic Navigation system is also in compliance with ultrasonic tips used for root end retro-preparation. (Fig. 1)

Fig. 1. An optical tracking sensor tracks the JawTracker, Tracer-Tracker, Drill-Tracker and instrument. (Courtesy: Dr. Kenneth S. Serota)

Plan: The access point of entry, axis orientation/angulation, and access cavity depth are all anticipated and planned well in advanced. The Piezotome/drill pathway for microsurgical procedures is selected. If the CBCT scan is compatible with patient's jaw, the preparation stage can be completed at any time prior to the operation. Three to six trace points (landmarks) are selected and labelled/marked on visible and accessible teeth as a preliminary step before the trace entry which helps in proper guidance.

Design: A 2D cross-sectional view occurs while the virtual tip is poised over the 3D model. The Red Cross hair sticks to the landmark, the centre of which is visible on the floor. If the program assumes that the landmark is in the wrong place, it alerts the clinician.

Trace registration: The Jaw-Tracker (mandible or maxilla) or Head-Tracker (maxilla) is attached to the jaw and the optical tracking sensor detects the Tracer Tag/Tracer-Tool as it is moved along the landmarks on the facial, lingual, and occlusal surfaces until the three landmarks have been determined. The software displays the number of points contacted in the form of percentage.

Calibration of the drill: The Drill-Tag is attached to the handpiece, and the drill axis the drill tip is calibrated with one other and the system. The optical monitoring sensor continuously traces the Drill-Tag, and the software displays the location of drill. If the Drill-Tag or Jaw-Tracker is not visible to the camera, the software issues an alert.

Place: With its high precision optical tracking, it provides real time dynamic feedback in precisely locating the planned entry point, adjusting the drill axis to the planned angle, and drilling to the planned depth.

Dentoosseous Real-time Navigation: The monitoring screen is active when the system recognizes the calibrated instrument once it reaches the patient’s jaw. The target view calculates the distance between the instrument’s tip and central axis of the point of entry of designated instrument for access penetration, the glide path or osteotomy. The central axis length of the procedure which is planned is denoted by the centre of white target, and the drill tip is indicated by the moving black cross which follows drill tip (Fig. 2).

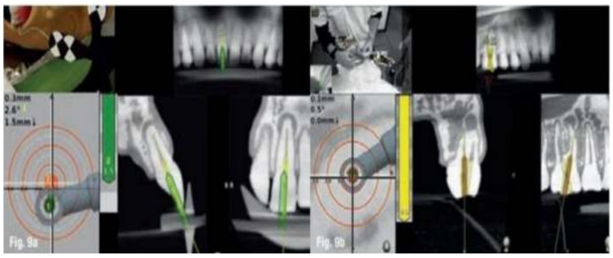

Fig. 2. Calcified central incisor: (1) drill is green; (2) glide path or osteotomy's central axis; (3) depth indicator; (4) angle between drill andosteotomy's central axis, turns yellow when collide. Position on target (yellow: 0 mm).(Courtesy: Dr. Bobby Nadeau).

During the process of drilling, the moving tips of instruments are tracked and traced. The cone shows green signal when the instrument tip is within 0.5 mm and has an angulation of less than 3° to the planned drill axis, glide path or osteotomy and when the instrument is beyond that system shows red signal and indicates to reposition the instrument to the correct planned axis. When the drill tip reaches a distance of 1 mm from the apical or horizontal extent of the planned depth, the indicator turns yellow.

In short, it works a lot like GPS, the map is the patient’s scan and the car is the dental took being used; where you always going at all time and can keep a program of your path in advance.

Errors: Dynamic Navigation System errors are classified into three types: computer, patient/tooth, and operator. Any variation in tracking components may have an effect on accuracy. This include, but are not limited to, unstable X-clip seating, jaw attachment rocking, and eccentric drill rotation relative to the tracked handpiece handle. Patient movement during CBCT acquisition and radiopaque coronal restorations degrade image quality and, as a result, procedural precision. Another clinical condition that induces inaccuracy is tooth mobility.

Advantages of Dynamic Navigation System

- Reduced errors and freehand and preferable use of handpiece/drill (Brief, 2005; Hoffmann, 2005).
- Similar or superior to other computerized procedures, and more accurate (Casap, 2004).
- Minimizing the iatrogenic injury to vital anatomies, including nerves and adjacent teeth, and increasing intraoperative safety (Bun San Chong, 2019).
- Adjustments to the surgical schedule can be made at all times depending on the clinical condition (Ali, 2019).
- Allows for a well-prepared and planned operation.
- Patient chair time decreased.
- Enhanced productivity of dentists as no laboratory is involved.
- The results are predictable and reproducible (Dianat, 2020).

Disadvantages of Dynamic Navigation System

- Need for a wider field of view CBCT.
- Flaws in the fabrication process of fiducial stents
- inaccurate image acquisition.
- Costly equipment, upgrades, and repairs.
- Multiple recalibrations during a single operation.
- Clinician's inability to operate through the guided procedure.
- Heavy and cumbersome sensors on both the handpiece and the patient.
- Increased care costs for patients (Dianat, 2020).

Uses in Endodontics

- Endodontic Access Cavities
- Endodontic Microsurgery
- Calcifications
- Resorptions
- Endodontic retreatments
- Traumatic injuries or cracked teeth
- Apical Surgeries
- Piezo-ultrasonic tip osteotomy
- Retrograde Preparation
- Bone trephination (Bun San Chong, 2019)
- Dens invaginatus (Ali, 2019)

CONCLUSION

In dentistry, innovation occurs when there is a willingness to explore and improve both diagnosis and treatment. Minimally invasive protocols are the need of dentistry’s future. Dynamic Navigation is a promising technique with a high degree of predictability and accuracy with a low risk of iatrogenic damage. Demystifying the obscure and the unseen is just a whim away with dynamic navigation. Tech galore with real time feedback, digital imagery, micro-tracking systems, tactful targeting and navigational excellence, hard tissue safety and precision is ultimately here with Dynamic navigation.

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