CASE REPORT */ CAS CLINIQUE*

Pedodontics */ Pédodontie*

ENDODONTIC MANAGEMENT OF DENS INVAGINATUS USING DYNAMIC NAVIGATION SYSTEM IN PEDIATRIC PATIENT: A CASE REPORT

Ayesha S. Fathima[1] | Sahana Selvaganesh[2] | Ganesh Jeevanandan[3] | Pradeep Solete[4] | Prabhadevi C. Maganur[5] | Ather Syed Ahmed[5] | Satish Vishwanathaiah[5]

Abstract: Dens invaginatus, also known as dens in dente, is a dental anomaly resulting from infolding the enamel organ into the dental papilla. Dynamic Navigation Systems (DNS) like Navident, offer real-time guidance during endodontic procedures, proving especially useful in complex cases, such as calcified canals or pulp obliteration. This case report presents a 13-year-old female, who reported the chief complaint of continuous pain in the upper left front tooth region. Based on the clinical and radiographical findings, a diagnosis of pulp necrosis and chronic periapical abscess in relation to maxillary canine (23) was established with dens invaginated palatal canal (Oehler's type III). Despite CBCT imaging and analysis of canal morphology, difficulty in accessing the palatal canal orifice was encountered. Minimally invasive access with zero deviation from the original plan of negotiating the canal and without iotrgenic errors was achieved using a Dynamic navigation system. This system was a valuable tool because it reduced chair side time, improved patient comfort, and more importantly completed the procedure without the risk of iatrogenic damage to the tooth structure.

Keywords: Dens Invaginatus, Dynamic Navigation System, dens in dente

Corresponding author:
Ganesh Jeevanandan, e-mail: helloganz@gmail.com

Conflicts of interest:
The authors declare no conflicts of interest.

1- Postgraduate Student, Department of Pediatric and Preventive Dentistry, Saveetha Dental College, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai-600077, Tamil Nadu, India.
2- Senior Lecturer, Department of Implantology, Saveetha Dental College, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai-600077, Tamil Nadu, India.
3- Professor, Department of Pediatric and Preventive Dentistry, Saveetha Dental College, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai-600077, Tamil Nadu, India
4- Professor, Department of Conservative Dentistry and Endodontics, Saveetha Dental college, Saveetha institute of medical and technical sciences, Saveetha University, Chennai-600077, Tamil Nadu, India Mail id:
5- Department of Preventive Dental Sciences, Division of Pediatric Dentistry, College of Dentistry, Jazan University, Jazan, Kingdom of Saudi Arabia.
E-mails: ayeshapedo@gmail.com ; sahanas.sdc@saveetha.com ; helloganz@gmail.com ; pradeeps@saveetha.com ; prabhadevi.maganur@gmail.com ; dr.atherahmed@gmail.com ; drvsatish77@gmail.com

***Pedodontics** / Pédodontie*

PRISE EN CHARGE ENDODONTIQUE DE L'INVAGINATUS DE LA DENT À L'AIDE D'UN SYSTÈME DE NAVIGATION DYNAMIQUE CHEZ UN PATIENT PÉDIATRIQUE: À PROPOS D'UN CAS CLINIQUE

Résumé: L'invagination de la dent, également appelée dens in dente, est une anomalie dentaire résultant du repliement de l'organe de l'émail dans la papille dentaire. Les systèmes de navigation dynamique (DNS) comme Navident offrent un guidage en temps réel pendant les procédures endodontiques, s'avérant particulièrement utiles dans les cas complexes, tels que les canaux calcifiés ou l'oblitération pulpaire. Ce rapport de cas présente une femme de 13 ans, qui a signalé une douleur continue dans la région de la dent antérieure supérieure gauche. Sur la base des résultats cliniques et radiographiques, un diagnostic de nécrose pulpaire et d'abcès périapical chronique en relation avec la canine maxillaire (23) a été établi avec un canal palatin invaginé de la dent (type III d'Oehler). Malgré l'imagerie CBCT et l'analyse de la morphologie canalaire, l'accès à l'orifice du canal palatin a été difficile. Un accès mini-invasif sans déviation du plan initial de négociation du canal et sans erreurs iotogènes a été obtenu à l'aide d'un système de navigation dynamique. Ce système s'est avéré précieux car il a permis de réduire le temps passé au fauteuil, d'améliorer le confort du patient et, surtout, de réaliser l'intervention sans risque de lésion iatrogène de la structure dentaire.

Mots clés: Dens Invaginatus, Système de navigation dynamique, dens in dente

Introduction

Dens invaginatus, also referred to as dens in dente or invaginated odontoma, arises from the infolding of the enamel organ into the dental papilla before tooth calcification [1]. This anomaly, which may manifest in various forms such as dilated composite odontoma or dentoid in dente, can be confined to the pulp chamber or extend into the root and apex of the tooth. Its prevalence ranges from 0.3% to 10%, affecting both primary and permanent dentition, with a predilection for maxillary lateral incisors [2]. Although maxillary central incisors can also be affected, occurrences in canines and posterior teeth are rare. Co-occurrence with supernumerary teeth is infrequent. Despite reports suggesting environmental and genetic factors, the exact etiology of dens invaginatus remains elusive [3].

Depending on the location and reason for the affected tooth, two types of invaginations are distinguished: coronal and radicular invaginations. The classification proposed by Oehlers in 1957 allows us to highlight three types of invaginations, according to their radiographic extension from crown to root:

- Type I: It is a minimal invagination, enamel-lined, and confined within the crown of the tooth. It is the most common lesion, with a frequency of 79%.
- Type II: The invagination extends apically to the amelo-cemental line. It forms a blind dead-end that may or may not communicate with the pulp but remains within the root canal without communication with the periodontal ligament.
- Type III: The invagination extends through the root. Normally there is no pulp communication, which is compressed within the root. Two sub-types can be established: type IIIa, when the invagination communicates laterally with periodontal space through a pseudo-foramen, and type IIIb, when the invagination extends through the root and communicates with the periodontal ligament in the apical foramen [4].

Dynamic Navigation [DN] is currently used by many medical specialties, including ophthalmology, otolaryngology, neurosurgery, and surgical oncology. Medical DN systems were used for craniomaxillofacial-based procedures. In the 20th century, to assist in the placement of dental implants, additional systems, such as Navident, have been approved and have been providing very reliable results [5]. DN is an advanced surgical technology that uses real-time imaging with computer software to guide surgical instruments and implants during the procedure. The technology offers greater accuracy and precision compared to traditional surgical techniques, as the operator can visualize the instrumentation and the bone/ tooth during the procedure—this can help improve outcomes for patients and hence, has gained popularity and wide use in dental implantology and endodontics [6].

Dynamic navigation systems can be easily adapted to be used in endodontics, to perform drilling (ie, for calcified canals and fiber post removal) under dynamic guidance. The sole aspect to bear in mind while adapting Dynamic navigation for endodontic usage is that the burs that should be connected to the handpiece must be non-bendable and rigid. Stable burs can be used under Dynamic navigation by attaching a drill tag on the handpiece, the use of files is not viable as the drill tag can detect only non-bendable instruments and the course of the files is not mapped or feedback is not received [7].

The imaging technology used in DN includes computed tomography (CT) scans. These imaging techniques provide high-resolution images that can be used to create a detailed 3D model of the root canal anatomy. Once the 3D model has been created the operator can use computer software to plan the navigation procedure in case of pulp calcification or pulp obliteration. The software allows the operator to visualize the canal anatomy and plan the optimal approach for access opening [8].

During the procedure, the DN system uses optical sensors and stereo-cameras to track the position of the surgical instruments attached with the drill tag which has the optical sensors, in real time. The DN system works on triangulation theory wherein the stereo-camera, the sensors on the patient's jaw, and the sensors on the handpiece with the dominant hand of the surgeon form a triangle. The system compares the position of the air-rotor and the teeth to the 3D model of the patient's anatomy provided by the CBCT which is loaded before the surgical procedure. The patient is fitted with a jaw tracker/ a head tracker according to the jaw in which the procedure is carried out and provides real-time feedback to the operator. This feedback can help the surgeon adjust the position of the instruments to ensure optimal drilling and accuracy [9].

One of the main advantages of DN is its ability to improve accuracy, precision, and patient and operator comfort. The real-time imaging and feedback provided by the system can help surgeons avoid critical structures and ensure that the surgical instruments and implants are placed in the correct position. This can help reduce the risk of complications and improve patient outcomes [10].

Dynamic navigation has been a recent advancement in the field of dentistry and conversely, Cone Beam Computed Tomography (CBCT) offers a radiographic technique capable of generating a three-dimensional depiction of the complete canal system, addressing certain drawbacks associated with traditional periapical radiography, such as structural distortion or overlap.

Case Report

A 13-year-old female walked into the Department of Pediatric and Preventive Dentistry with the chief complaint of pain in the left upper front tooth region. The pain was continuous and gradually increased while drinking water and during mastication. She was systemically healthy with no relevant medical history. On Clinical examination, the tooth exhibited a positive tender on percussion but an electrical pulp test revealed no response. Radiographic examination revealed circumscribed bone resorption and the presence of dens invaginatus in tooth 23. Chronic apical abscess with symptomatic apical periodontitis was provisionally diagnosed.

CBCT offers three-dimensional interpretation, which favors better understanding and treatment planning. CBCT reveals radiopacity extending over the cingulum pit, beyond the radiopaque outline of the enamel, into the dentin and well-defined radiolucency–completely extending beyond the outline of the enamel into the dentin. Two canals were presented: the buccal canal and the palatal invaginated canal.

During the initial treatment session, prophylaxis involving pumice stone and water was conducted before commencing coronary access opening to access both the main and dens invaginatus canals. While exploring the canals, difficulty was encountered in obtaining the patency for palatal dens invaginatus canal due to its calcified nature.

A Dynamic Navigation System (DNS) facilitates the management of complex endodontic cases like accessing calcified canals and managing complicated anatomy and an endodontic retreatment was utilised to identify the canal. Palatal canal was accessed using real time imaging by dyanamic navigation system - NAVIDENT (*Claronav,Canada*).

Figure 1. Planning of the drill access in NAVIDENT Software.

Methodology used with the Navident system

CBCT analysis and planning: Endodontic approach to navigate the canal was planned using the navident system using the endo mode. The drilling access was placed on the tooth in question and locked (Figure 1).

Procedure

On the day of the procedure, the patient was made comfortable and LA was given. A jaw tracker (in this case, headgear, as it was a maxillary tooth) was fixed in the correct position so that the tracker's optical sensor panel was correctly located on the saddle of the nose.

The CBCT with the planning of that particular case was loaded in the NAVIDENT Computer and the calibration process began with the trace registration of the patient's jaw with certain points selected on the CBCT of the patient loaded in the computer. For the trace registration process, the calibrator and a stylus tip tracer were used. Dynamic navigation works with the triangulation theory and the trace registration of the patient's jaw was carried out by matching the data in the CBCT. Once the accuracy was attained, the handpiece fitted with the drill tag was calibrated and drilling was carried out using a long shank round bur. Once the canal was reached, the files were used to navigate till the apex (Figures 2-7).

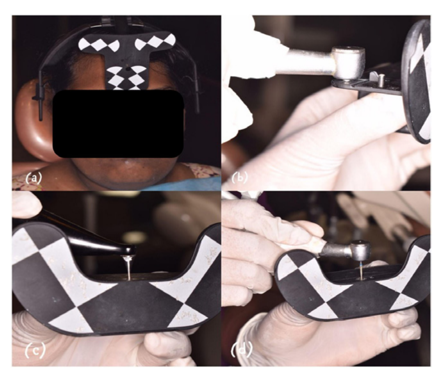

Figure 2. (a) Patient with the head tracker, (b) Access calibration of the handpiece (c) Stylus tip calibration for trace registration (d) Drill tip calibration in the calibration dimple (for depth calibration).

Subsequently, the total length measurement and the biomechanical preparation of the canal were carried out using a manual crown-down technique with K-files No. 15 (Mani

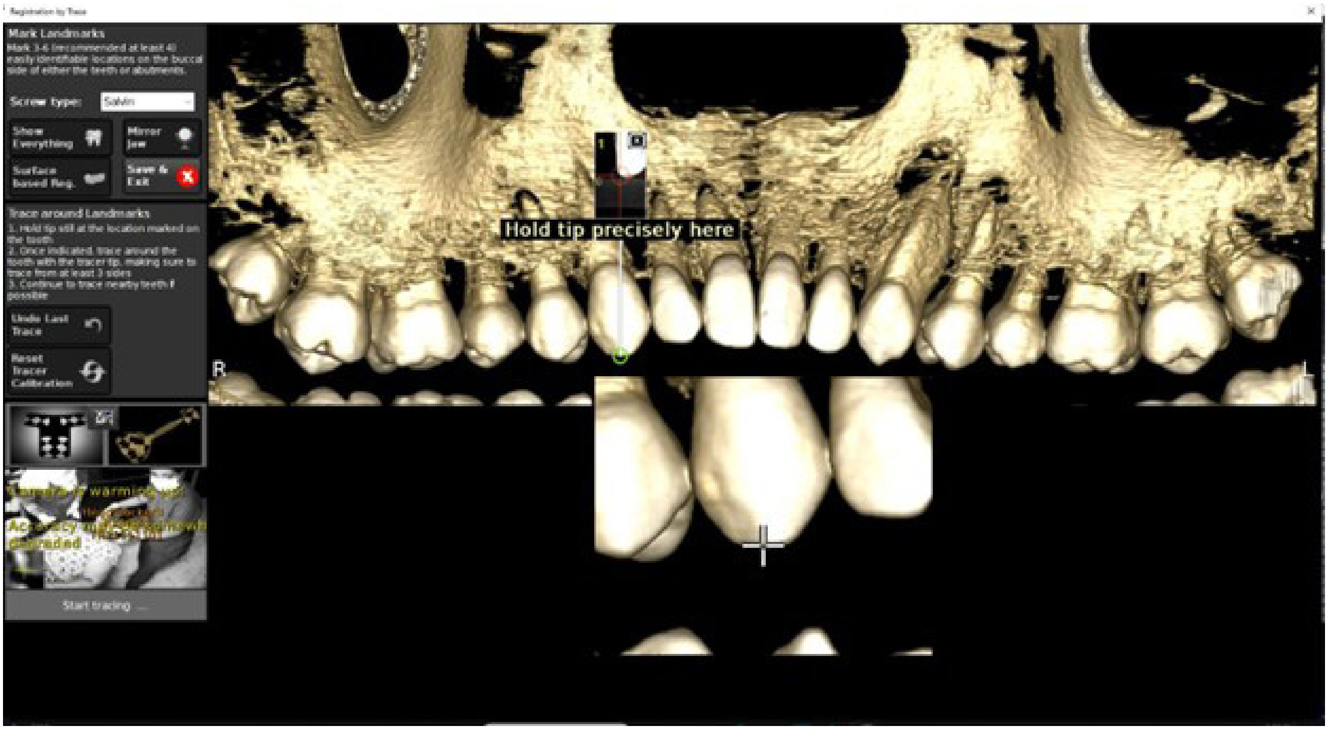

Figure 3. Trace registration process, with tracer tip.

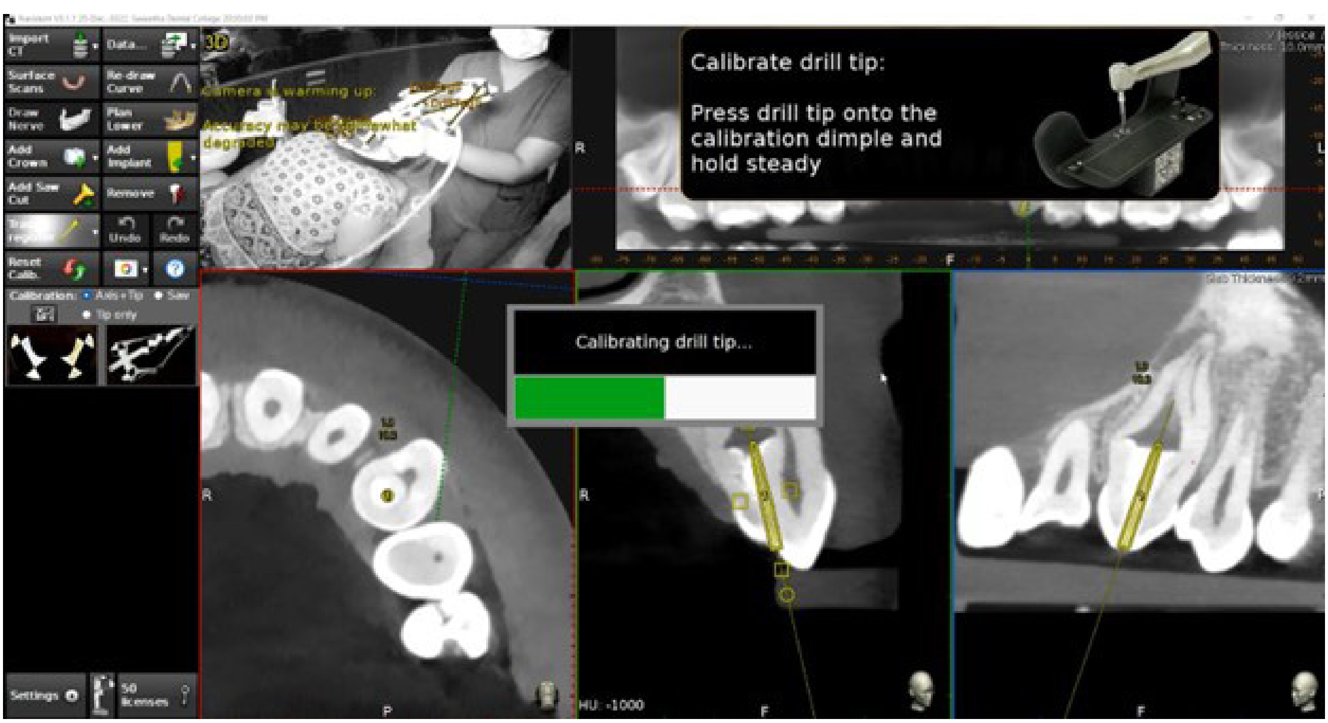

Figure 4. Drill access/tip calibration process.

files, India) and Rotary files with 21mm neoendo files (Neoendo flex, India) in 350 rotations per minute (RPM) and 1.5 Newton centimeters (Ncm) of torque, in the sequence of coronal flaring 17/4, 20/4, 25/4, 20/6, 25/6 using Woodpecker endomotor. Since cleaning and shaping will be compromised in the invaginated canal due to its complex anatomical nature, thorough irrigation using 3% Sodium Hypochlorite and 2 % Chlorhexidine using an ultrasonic irrigation activator was done. Calcium hydroxide (RC Cal, Prime Dental, India) paste was applied in both canals, and the tooth was temporarily sealed with Zinc oxide eugenol.

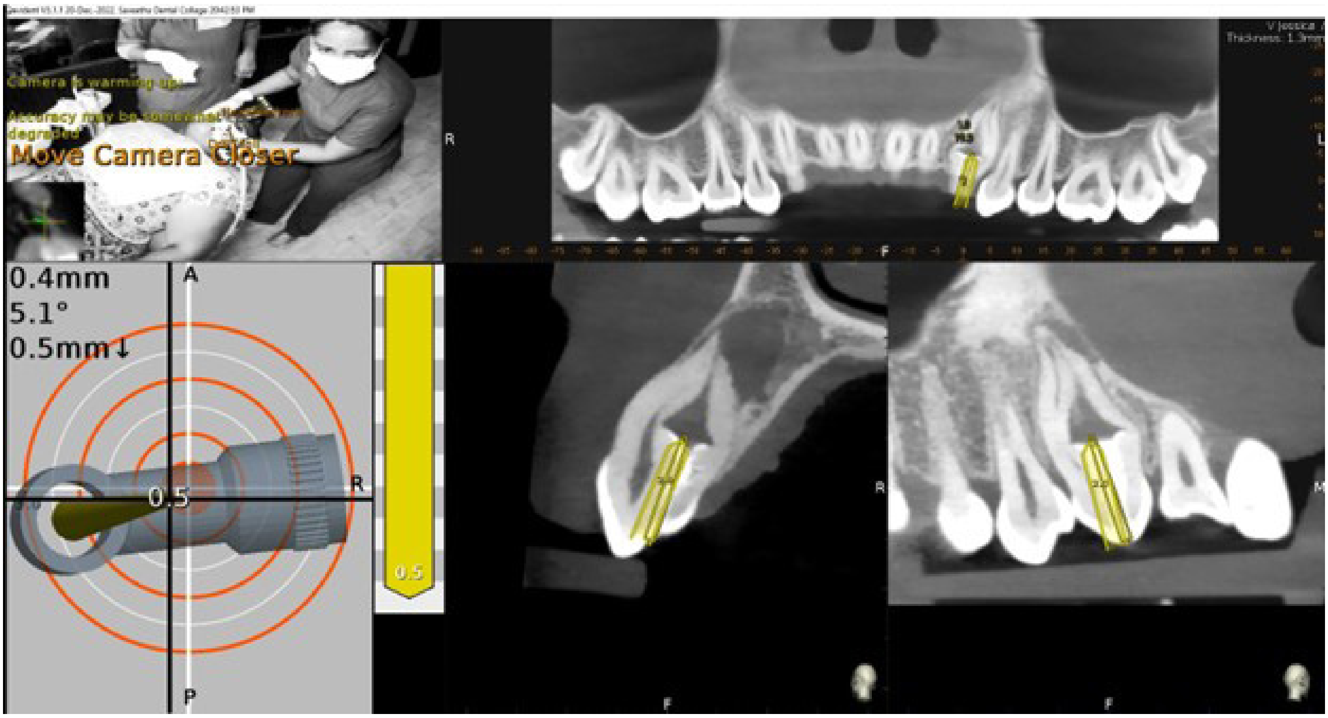

Figure 5. The ongoing drilling process, with the deviation from the planning position shown on the screen of the Navident software.

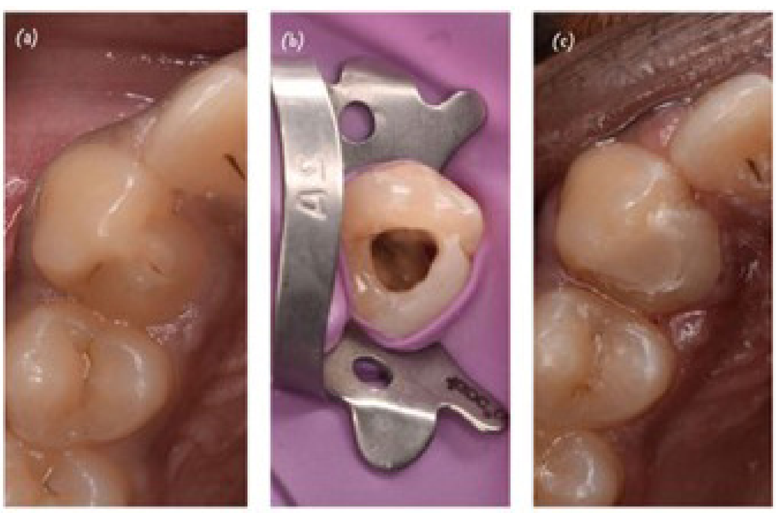

Figure 6. Clinical photograph in relation to 23: (a) Pre-operative (b) access opening (c) Permanent coronal restoration.

Figure 7. Intra-oral periapical radiograph in relation to 23- (a) pre-operative (b) working length determination (c) Master Cone (d) Immediate post-operative (e) 6-month follow-up (f) 1-year follow up.

Systemic medication including Tablet Ibugesic plus (Cipla Ltd, India) 500 mg every 8 hours for three days and Tablet Augmentin 625mg every 12 hours for 5 days was prescribed. The choice of antibiotics was influenced by the difficulty encountered during canal patency, which hindered adequate chemo-mechanical preparation and periapical lesions presented in the palatal aspect of the tooth. At the two-week follow-up appointment, the patient returned pain-free and attempts were made to obturate the canal.

Results

The system allowed precise localization of the root and precise apicoectomy with a minimal invasive cavity, avoiding iatrogenic errors. The whole procedure was performed in less than 45 minutes. Overall, the outcome of the treatment was considered a success with limited postoperative discomfort because of the minimally invasive technology. The healing was good at the controls after 6 months and 1 year. One-year follow-up also showed no complications and the periapical lesion was completely resolved. There was minimal to zero deviation from the original plan for the location of the canal, which resulted in the successful negotiation of the same.

Discussion

The Dynamic Navigation System (DNS) represents a relatively novel technology, offering significant advantages in clinical scenarios requiring precise canal negotiation. However, performing a blinded procedure without DNS carries a high risk of complications, such as perforation. As a guidance tool, DNS is rapidly gaining traction across various domains of dentistry due to its ability to enhance precision and accuracy. It has become a pivotal solution in cases where conventional methods fall short, demonstrating its value as a reliable and innovative approach in challenging clinical situations.

The Dynamic Navigation System (DNS) has been explored in various studies for its application in endodontics, especially in complex scenarios and likelier in difficult anatomy since endodontics always require precision. One of the significant studies conducted by Vasudevan *et al*. provided a comprehensive systematic review of DNS applications in guided endodontics [11]. Gambarini *et al.* detailed the use of DNS in endodontic microsurgery and the study demonstrated the advantages of DNS in precision and real-time guidance for accurate canal location[6] Bardales-Alcocer *et al.* utilized DNS for endodontic retreatment and showcased the system's efficiency in removing previous filling material and accessing canals without significant errors [12]. Dianat *et al.* demonstrated the use of DNS for guided endodontic access in a maxillary molar, emphasizing its capability to significantly reduce substance loss during access preparation [13].

DNS operates using real-time feedback, akin to a GPS system, where the computer provides visual cues to the clinician, guiding the drill path during treatment. However, haptic feedback, which offers tactile sensations to the operator, is not explicitly integrated into DNS. The system primarily relies on visual monitoring rather than tactile feedback, which may be a limitation for clinicians accustomed to manual procedures.

Hand-Eye Coordination: DNS requires the operator to develop strong hand-eye coordination since the clinician must focus on a monitor to guide the drill rather than directly observing the oral cavity. This optically-driven process presents a steep learning curve, especially for less-experienced practitioners. The integration of DNS necessitates acclimatization to simultaneously manage the handpiece and monitor, emphasizing the need for thorough training and calibration to ensure accuracy.

Despite its advantages, DNS is not without limitations. DN is semi-robotic in nature, there is no robotic arm that is attached to the main machine, and the 3D orientation of the handpiece and the drill was left to the operator's skill. There is a deep learning curve associated with the DN system. The system's dependence on real-time tracking and the potential for errors due to hand tremors or loss of jaw tracker stability can compromise precision. Additionally, DNS may involve extended setup times due to preoperative CBCT scanning and calibration processes. Furthermore, DNS systems like Navident and X-guide require substantial investment, making them less accessible in some clinical settings. Moreover, the available evidence is limited to in-vitro studies and case reports, necessitating further clinical trials to validate DNS's efficacy across a broader range of operators.

In the field of pediatric dentistry, gaining a child's cooperation can be challenging and the dynamic navigation system (DNS), with its resemblance to video game interfaces, can potentially engage and intrigue young patients, especially during complex procedures. This can create a positive distraction and reduce anxiety. In situations where precision is critical, such as the management of dens invaginatus, calcified canals, and accessory canals, DNS provides real-time guidance, ensuring accuracy even in smaller anatomical structures and in young permanent teeth. Its application can enhance treatment outcomes and minimize the need for repeat interventions, making it a valuable tool in pedodontic cases where precision is essential. This ties both—the child-friendly appeal and the functional benefits of DNS for precise dental procedures.

DN requires surgeons to be trained prior to their attempt on patients with the DN unit. The most common reported drawbacks are the heaviness of the handpiece and the hand-eye coordination, which is a difficult feat to achieve without a continued practice with the DN unit. The other challenge associated with the DN is the expert skills of the operating surgeon on the haptic feedback—an important factor to consider for implants placed under the DN system [22]. It must be possible for the operating surgeon to do the entire procedure without the necessity to look into the patient's mouth but rather looking at the screen during the drilling.

Conclusion

DNS can be successfully applied in challenging clinical situations like pulp canal obliteration, conservative access, endodontic retreatment, and endodontic microsurgery minimizing the iatrogenic errors and taking a shorter chair time. In conclusion, while DNS holds promise for enhancing precision in endodontics, its limitations, including the lack of haptic feedback and the necessity for robust hand-eye coordination, highlight the need for further refinement and research.

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