CASE REPORT

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# Computer aided-dynamic navigation technology for efficient single visit endodontic treatment of pulp canal obliteration: A case report

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## Abstract

Dental trauma causes a variety of issues and perplexes practitioners. One of the consequences of trauma is pulp canal obliteration (PCO), which presents a challenge in treatment due to the high likelihood of procedural errors and complications. To overcome these challenges, Guided endodontics was introduced using personalised 3D guides by overlaying DICOM and STL files (Static navigation) or real-time navigation (Dynamic navigation) of the patient. A dynamic navigation system (DNS) is a computer-aided navigation technology analogous to the Global Positioning System (GPS) navigation. Dynamic navigation provides real-time, precise guidance using 3D imaging, helping practitioners accurately navigate and treat calcified canals by visualising and accessing challenging areas without damaging tooth structure. The current case report describes the management of pulp canal obliteration using the dynamic navigation system in a single visit. A 30-year-old female complained of pain in the upper front teeth region for the past two months, with a history of trauma 10 years ago. The clinical examination revealed no caries, cracks, or discolouration. Tooth 12 was sensitive to percussion. Pulp sensibility tests were negative. On radiographic examination, the pulp canal was partially obliterated until the middle third. Tooth 12 was diagnosed as necrotic pulp with symptomatic apical periodontitis. After reviewing options, the case was root canal-treated using a dynamic navigation system. A successful negotiation of the canal was done followed by completion of root canal treatment. The patient was asymptomatic with intact periapical structures at the 1-year follow-up period. Computer-aided dynamic navigation proved to be safe, fast, and predictable for negotiating calcified canals with minimal risk of errors in a single visit.

**Keywords:** Dental trauma, CBCT, Dynamic navigation system, Guided endodontics, Pulp canal obliteration, Single visit.

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## 1. Introduction

Pulp canal obliteration (PCO) resulting from dental trauma can manifest in approximately 40% of cases. Endodontic treatment is recommended in only 7%–27% of PCO instances when the tooth displays symptoms or radiographic evidence consistent with apical periodontitis [1]. PCO is a frequent sequela of dental trauma characterised by the deposition of hard tissue within the root canal space and yellowish discolouration of the clinical crown [2]. When mechanical stress is applied to the pulp, it typically initiates impairment of the neurovascular supply, though the exact mechanism of the calcification process remains unknown [3]. Dentine formation in the root canal usually becomes very extensive, presumably due to a loss of sympathetic control of the secretory activity of odontoblasts. Furthermore, pulpal haemorrhage after trauma can become the nidus for calcification and lead to the narrowing of the pulp canal space [4].

Teeth with PCO can hinder straight-line access, complicating the negotiation of the entire root canal. This difficulty can lead to iatrogenic errors such as instrument separation and perforation, ultimately compromising the integrity of the tooth structure [5]. The utilisation of advanced equipment such as cone-beam computed tomography (CBCT) and dental operating microscopes (DOMs), along with ultrasonic instruments, as well as emerging technologies like lab-fabricated templates and dynamic navigation system (DNS), has enhanced the precision in planning and treating calcified canals. These advancements enable operators to address challenges associated with such cases effectively [6].

DNS, a technology derived from implant dentistry, is utilised for both surgical and non-surgical endodontic therapy, combining CBCT and spatial positioning technologies through an optical tracking device managed by a unique computer interface which directs the user to provide a specified path for the target site in real-time [7,8].
In endodontics, DNS was utilised for the preparation of minimally invasive endodontic access cavities [9,10], addressing pulpal calcifications [11], performing endodontic micro-surgeries such as osteotomy and apicectomy [12], and removing glass fibre posts in endodontic retreatments [13,14] for delivery of local anaesthesia [15].

A systematic review and meta-analysis conducted by Mekhdieva *et al.* (2023) concluded that the dynamic navigation system significantly improved the accuracy and efficiency of non-surgical and microsurgical endodontic procedures when compared to the free-hand approach, supporting its clinical application in managing complex cases such as pulp canal obliteration [16].

## 2. Case report

The current case report describes the management of pulp canal obliteration using the dynamic navigation system in a single visit. A 30-year-old female patient presented to the Department of Conservative Dentistry and Endodontics with the chief complaint of pain in the upper front teeth region for two months. The patient gave a history of pain on biting and a history of trauma 10 years ago. On clinical examination, tooth 12 showed sensitivity to percussion and palpation. Pulp sensibility tests using an electric pulp tester (Gentle-Pulse, Parkell Electronics Division) and a cold test (Coltene Whaledent, Switzerland) yielded a negative response. Upon intraoral periapical radiograph (IOPAR) examination, the pulp chamber was completely obliterated and the pulp canal was partially obliterated until the middle third, with a thin radiolucent line extending in the apical third (Figure 1B). Tooth 12 was diagnosed as pulpal necrosis with symptomatic apical periodontitis. After discussing various treatment options, informed consent was obtained for dynamic navigation.

## 3. Management

The workflow of dynamic navigation system includes a series of steps as follows; Scan, Plan, Trace and Place.

### 3.1 Scan

The CBCT machine (Cranex 3D Sordex, Tuusula, Finland) was used to obtain a pre-operative scan of the maxillary arch, operating at 90 kVp, 8 mA, with a field of view of 10 cm × 10 cm and voxel size of 0.13 mm and was saved as Digital Imaging and Communications in Medicine. (DICOM) file (ON DEMAND 3D™ server tuusula, Finland) (Figure 1C-E). Additionally, MEDIT i500 (Medit, Seongbuk-gu, Seoul, Korea) was used to obtain a pre-operative intra-oral scan of the maxillary arch and saved it as a Standard Tessellation Language (STL) file (Figure 1F).

### 3.2 Plan

DICOM and STL files were uploaded to the implant/access planning software in Navident (ClaroNav, Toronto, Ontario, Canada). According to the laws of centrality, concentricity, and CEJ, the virtual design of the drill axis and path was ensured such that it passed through the centre of the CEJ in the coronal, sagittal, and axial views up to a target point i.e., where a thin radiolucent line started in the apical third. (Figure 2A). Local anaesthesia (LIGNOX 2% A Santacruz, Mumbai, India) was administered.

### 3.3 Trace

Later, Head Tracker was placed on the patient within the range of the camera tracking system, followed by Trace registration using an intra-oral scan superimposed with the CBCT by selecting six landmarks on the maxillary jaw, which were selected and brushed on incisal, labial, and cusp tips with Tracer-Tag/Tracer-Tool (Figure 2B).

Calibration was done with a drill tag attached to the slow-speed contra-angle handpiece (NSK, Japan) for tracking purposes. Calibration of both the handpiece and Munce discovery bur of size #1 length: 28 mm, diameter: 0.8mm (CJM Engineering, Santa Barbara, CA) was completed using a calibrator tool. The software displayed the calibration percentage, and an optical tracking sensor tracked its progress. After registration and calibration, the DNS computed the spatial position of the target tooth and the slow-speed contra-angle handpiece with Munce discovery bur to guide in real-time treatment.

Before drilling into the tooth, an accuracy check of the Munce discovery bur was verified by placing it in the mesial, distal, and central positions of the target tooth, at different angles to confirm the correct position of the tooth, calibration, and registration.

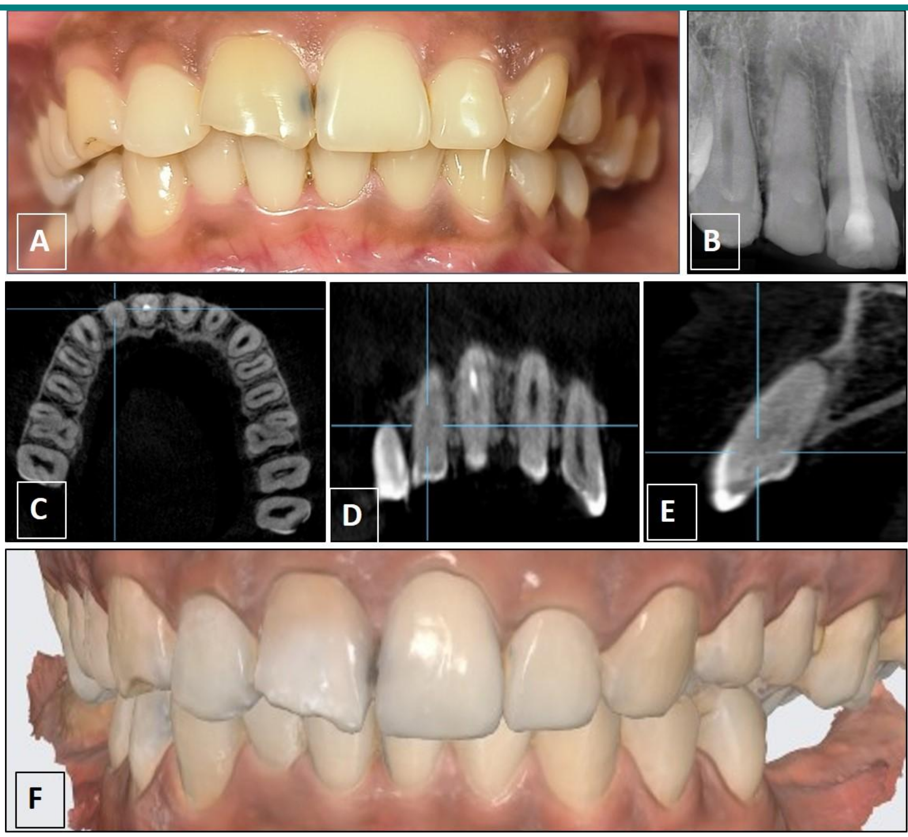


**Figure 1. This figure demonstrates clinical, radiographic, cone beam computed tomographic images and stereo-lithographic (STL) data obtained from scanning. A. Clinical photograph, B. Radiographic image, C-E. Axial, coronal and sagittal views, respectively, and F. STL data.**

### 3.4 Place

As soon as the calibrated device moved towards the patient's jaw, the navigation screen became active. The operator's view on the display represents the dynamic movement of the drill, which was synchronously presented as images on a screen, including the location, angle, and depth. The predesigned drill path provided the visual feedback. Drilling was initiated by aligning the handpiece head and bur tip with the circle at the centre ("Bull's eye") to reach the preplanned target site with a slow, progressive motion in the apical direction. On further orientation, the bur reached the pre-planned target point by visualising all three sections.

A chelating agent, 17% EDTA (RC help, Prime Dental PVT LTD, India), along with a size 10 C file (Dentsply Maillefer, Ballaigues, Switzerland) was introduced into the canal to verify the patency of the canal. The working length was determined (Figure 3B) and confirmed using an intraoral peri-apical radiograph (DIGORA™ Optime | DEXIS). Rubber dam isolation was done. Later, biomechanical preparation was completed using Neo endo flex rotary files (Orikam Healthcare Pvt. Ltd., India). 3% of sodium hypochlorite (Prime Dental products Pvt Ltd, India) was used throughout the procedure followed by alternative application of 17% EDTA (RC help, Prime Dental Pvt. Ltd., India), and final rinse with distilled water using side vented needle (Orikam health care Pvt Ltd, India).

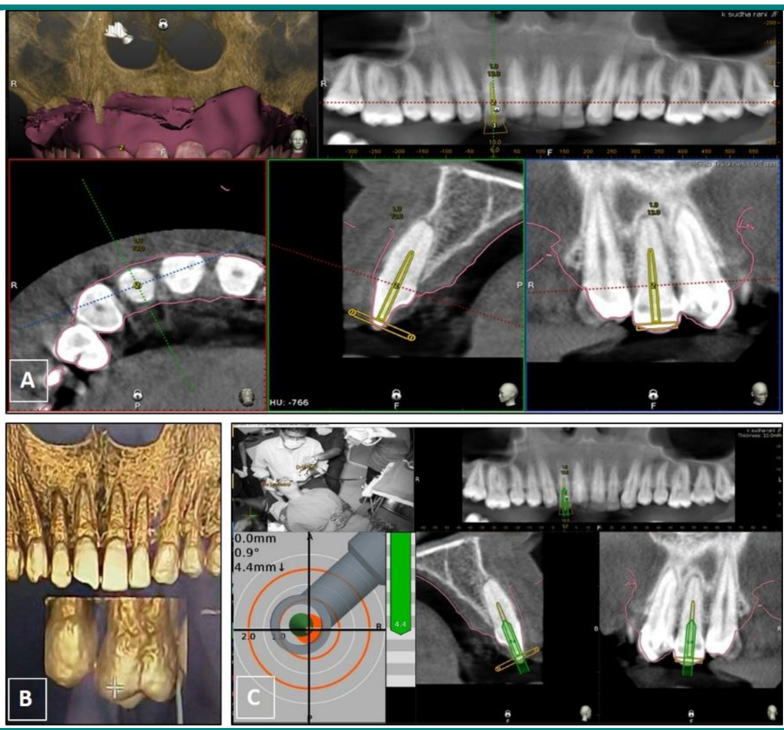


**Figure 2. This figure demonstrates planning and drilling procedure. A. Superimposition of DICOM and STL data followed by planned 3D-virtual access trajectories, B. Tracing of landmarks, C. Placing the bur orientation and drilling guided by bull's eye view on the monitor. The main centre circle has a diameter of 1.0 mm. Each orange circle is separated by 1 mm orange-coloured intervals. The green bar on the right shows the distance (in millimetres) left to drill to the pointed tip of the planned trajectory (in yellow)]. Here, we are 4.4 mm from the predetermined target at an angular deviation of 0.9°.**

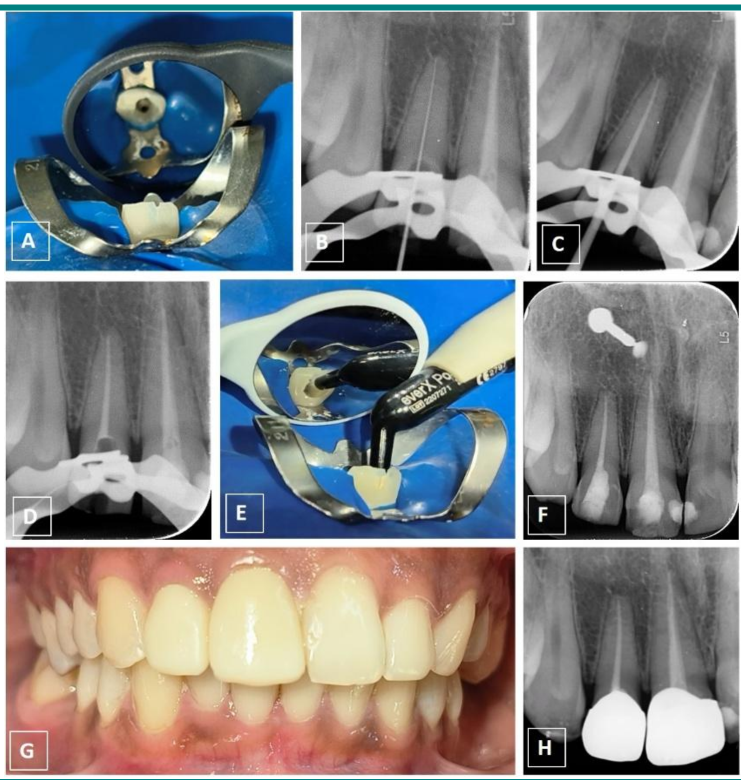


**Figure 3. (A) Access cavity preparation. (B) Working length. (C) Master cone selection. (D) Obturation. (E) Clinical photograph representing cervical reinforcement with EverX posterior. (F) Peri-apical radiographic image representing post endodontic restoration. (G) Clinical photograph after crown placement. (H) Peri-apical radiograph at 1-year follow up.**

The canals were then dried using absorbent paper points (Prime Dental products Pvt Ltd, India). Master cone of size 30/6% taper (Figure 3C) was selected followed by completion of the obturation by lateral compaction technique using AH plus sealer (Figure 3D). Then, completed the post-endodontic restoration using EverX posterior (GC EUROPE, Leuven, Belgium) leaving 2mm for placement of top layer using nano-hybrid composite resin (Filtek Z250XT, 3M ESPE, St Paul, USA) (Figure 3E). At the three months follow up, the patient was asymptomatic and a definitive restoration was given (Figure 3G). At one-year follow-up, tooth 12 remained asymptomatic, with no periapical changes observed (Figure 3H).

## 4. Discussion

Assessment of the anatomy of the pulp chamber and the complexity of the root is a priority for negotiating calcified canals [17]. Endodontic intervention is avoided unless peri-radicular pathosis is detected or the involved tooth becomes symptomatic [18]. The American Association of Endodontists categorised the treatment of teeth with PCO as a case with a high difficulty level [19]. Therefore, endodontic treatments of severely calcified teeth are considered incredibly difficult and complex. In this case, the pulp chamber was obliterated completely and the pulp canal was obliterated up to the middle third of the root suggesting high difficulty to manage. The primary issue involves the necessity of extensive removal of tooth structure during traditional access opening and challenges in locating the obliterated root canal. The dynamic navigation technology has shown significant promise in the field of endodontics, particularly for the challenging task of locating calcified canals. This technology enhances precision and accuracy during procedures, allowing for navigation and identifying these hard-to-find pathways with greater ease. By utilising advanced imaging and real-time feedback, dynamic navigation aids in reducing procedural errors and improving overall outcomes in endodontic treatments [20].

Using DNS software, successful negotiation of the canal was completed with reduced operational time, less fatigue for the patient, improved ergonomics, and less usage of local anaesthetic solution and inter-appointment temporary restorations in a single visit by following a meticulously designed path based on advanced imaging data. This virtual path guided the procedure, ensuring precise navigation through the tooth structure to reach the target site. The software significantly improved the accuracy, reduced the risk of procedural errors, and enhanced the overall efficiency of locating and treating calcified canals. One of the main benefits of DNS was that it enabled a direct view of the operatory field and allowed for readjustment of the direction of the bur in real-time [21].

Reinforcement of the dentin around the cervical area of the tooth, plays a crucial role in maintaining the structural integrity and fracture resistance of endodontically treated teeth [22]. So, EverX posterior, a short fibre-reinforced composite (SFRC) was used to reinforce the structure loss at the cervical third of the tooth. SFRC transfer the stresses from the polymer matrix to the fibres, the individual fibres acting as crack stoppers and short, randomly arranged E-glass fibres into the resin matrix provide isotropic reinforcement in multiple directions [22].

The limitations of the dynamic navigation system include high acquisition costs and its dependence on the operator, as it requires a certain level of practice particularly due to the unfamiliarity of focusing on a monitor rather than directly on the patient [20]. Additionally, any mid-treatment modifications performed without re-registration can lead to canal deviation and potential access failure [6]. A steep learning curve is required for the operator when working with the DNS to maintain the proper position and angulation of the handpiece while looking at a display screen; motor control, eye-hand coordination, manual dexterity, system knowledge, and continued practice are all necessary to attain proficiency [23]. Future advancements in technologies, including augmented reality and robotic-assisted navigation, can make this system more user-friendly and address current limitations.

## 5. Conclusion

In this case report, the dynamic navigation system demonstrated safety and accuracy in successfully managing a calcified canal. Without requiring template manufacturing, the procedure can be completed chair-side in a single visit for patients experiencing acute pain, ensuring a predictable outcome.

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