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Instrument retrieval using ultrasonics and minimally invasive guided endodontics using AReneto® system: a case report

Varun Prabhuji[1,2*], Pucha Sai Manaswini[2], A. Srirekha[2], C. Champa[2] and S. Archana[2]

Abstract

Introduction Instrument separation during root canal treatment presents a significant challenge, particularly in the apical third of the canal. This case report highlights the use of ultrasonics for retrieving a separated instrument and demonstrates the application of augmented reality using the AReneto® system to perform a minimally invasive guided access opening through the dental prosthesis, allowing root canal treatment to be performed without the need for prosthesis removal.

Case presentation A 61-year-old Indian male presented with pain in the lower left front teeth, following root canal treatment on tooth 33. Clinical examination revealed tenderness on percussion, and radiographs showed a separated instrument in the apical third of tooth 33, along with periapical radiolucency involving teeth 33 and 32. Ultrasonics under magnification were used to successfully retrieve the separated instrument from tooth 33, followed by sectional obturation and anatomic post placement. Subsequently, guided access for root canal treatment was performed on tooth 32 using the AReneto® system without removing the existing porcelain-fused-to-metal bridge. The procedure was guided using augmented reality to assist the access opening through the bridge. At the 6-month follow-up, the patient was asymptomatic, and radiographs indicated healing.

Conclusion The use of ultrasonics combined with magnification enabled effective instrument retrieval, while the AReneto® system facilitated a minimally invasive approach to root canal treatment through an existing prosthesis. This case demonstrates the potential of augmented reality technology to enhance precision and preserve tooth structure in endodontics. Further advancements in augmented reality-guided systems will likely expand their clinical utility across various dental treatments.

Keywords Separated instrument, Instrument retrieval, Ultrasonics, Areneto® system, Medical innovation, Augmented reality (AR), Assistive technology, Guided endodontics, Minimally invasive endodontics, Digital dentistry

Introduction

Instrument separation during root canal treatment is a significant challenge faced by endodontists. The approach to managing a separated instrument depends on various factors, including its location within the canal and the type of instrument involved [1]. In cases where the instrument is lodged in the apical third, retrieval is particularly challenging, and when symptoms persist, intervention becomes necessary [2]. Retrieval in such cases often relies on the use of ultrasonics, enhanced by

*Correspondence:
Varun Prabhuji
prabhuji.varun@gmail.com
[1] Roots to Cusps® Private Limited, 57, 2nd Cross, Gayathri Devi Park Extension, Opposite to Stella Maris School, Bengaluru, Karnataka 560003, India
[2] Department of Conservative Dentistry and Endodontics, The Oxford Dental College, Bengaluru, Karnataka, India

the magnification provided by a dental operating microscope [3].

Augmented reality (AR) is increasingly being integrated into various fields, including dentistry, owing to its ability to overlay crucial information directly in the user's field of view [4]. One innovative application of this technology is the AReneto® system, developed by Roots to Cusps® Private Limited [5]. The AReneto® system facilitates preoperative planning within specialized software, which is then transferred to AR glasses [5]. This setup allows the clinician to visualize preplanned data without the need to shift the focus away from the patient, enabling precise, guided access during root canal procedures [5].

This case report highlights the successful retrieval of a separated instrument from the apical third using ultrasonics under magnification, combined with a minimally invasive guided access opening through existing prosthesis utilizing the AReneto® system.

Case report

A 61-year-old Indian male patient presented to the department with pain in his lower left front teeth region. The patient reported undergoing root canal treatment 1 month prior on tooth 33. There was no relevant medical, family, or psychosocial history. Clinical examination revealed tenderness on percussion in the same tooth. Radiographic evaluation identified a separated instrument in the apical third of tooth 33 along with periapical radiolucency involving both teeth 33 and 32 (Fig. 1A). The initial treatment plan focused on addressing tooth 33, with the option to treat tooth 32 if symptoms persisted.

To manage the separated instrument, access opening was performed, and the previous obturating material was removed. A Gates Glidden Drill was used to enlarge the canal, allowing access to the apical third where the instrument fragment was lodged. Magnification provided by a dental operating microscope facilitated the visualization of the separated fragment, significantly improving the chances of successful retrieval. Ultrasonic activation was employed to loosen and retrieve the separated instrument fragment (Fig. 1B). Following retrieval, sectional obturation was performed (Fig. 1C), and an anatomic post was placed within the canal (Fig. 1D). The patient was asymptomatic following the treatment at the 1 and 2-week recall period.

However, the patient returned 1 month later, reporting recurrent pain in the same region. Clinical examination revealed tenderness on percussion associated with tooth 32. The patient had a 4 unit porcelain-fused-to-metal (PFM) bridge, extending from tooth 32 to tooth 42, following vital tooth preparation. Given the clinical scenario, the patient was presented with two treatment options: removal of the prosthesis for conventional root canal treatment or a minimally invasive guided endodontic approach using the AReneto® system. The patient opted for the guided approach.

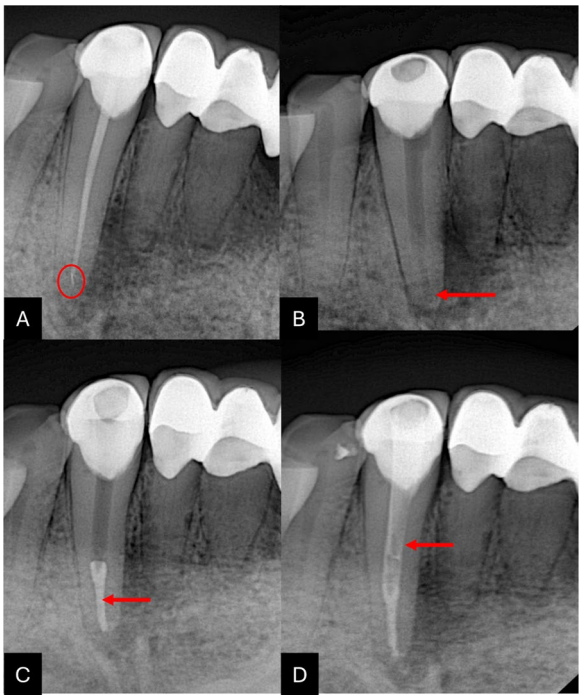

Fig. 1 **A** Pre operative radiograph showing separated instrument indicated by red circle; **B** Radiograph post instrument retrieval indicated by red arrow; **C** Sectional obturation indicated by red arrow; **D** Anatomic post indicated by red arrow

A cone-beam computed tomography (CBCT) scan was advised to facilitate planning the access opening. The guided access procedure was meticulously planned using the BlueSkyBio software (Fig. 2), and the planned data were transferred to augmented reality (AR) glasses for execution via the AReneto® system (Fig. 3A). Local anesthesia was administered, and rubber dam isolation was performed. Guided by the preplanned drill orientation, a minimally invasive access opening was conducted using the AReneto® system (Fig. 3B). The working length was determined, biomechanical preparation was completed, and the canal was subsequently obturated (Fig. 3C).

A total of 1 week post-treatment, the patient was recalled for follow-up. Clinical examination revealed no tenderness on percussion, and the patient reported relief from symptoms. The temporary restoration was replaced with a permanent post-endodontic composite restoration, and ceramic repair was carried out to restore the esthetics of both teeth (Fig. 3D).

At the 6-month follow-up, the patient returned with no symptoms and expressed satisfaction with the treatment

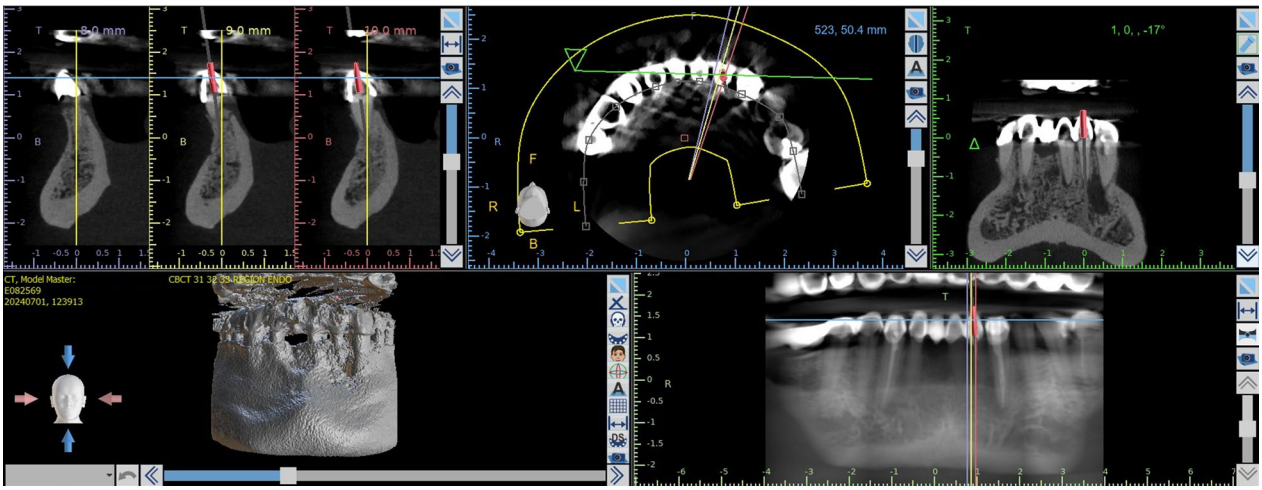

Fig. 2 Guide designing on BlueSkyBio software

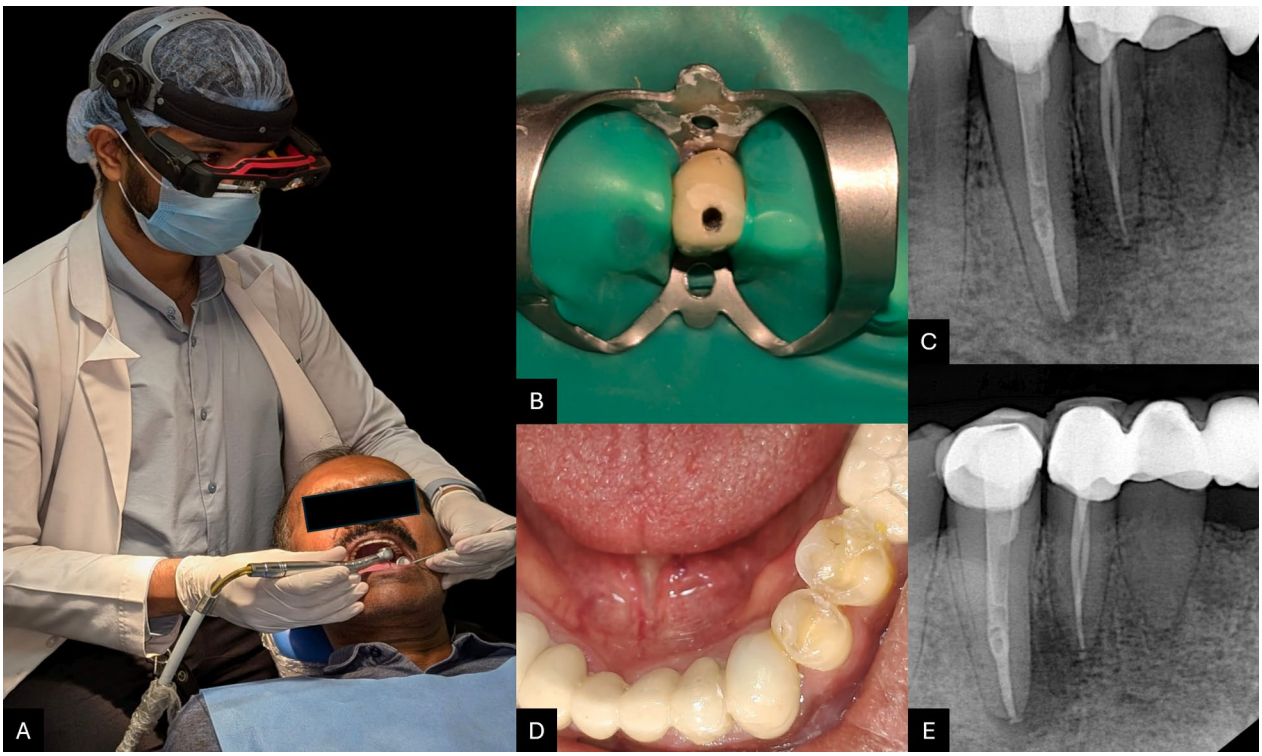

Fig. 3 **A** Guided access opening using the AReneto® system; **B** guided access opening; **C** obturation; **D** ceramic repair; **E** follow up

results. The radiograph revealed a decrease in radiolucency, indicating healing of the periapical lesion (Fig. 3E).

Discussion

The occurrence of pain following the separation of an instrument during root canal treatment is reported in approximately 29.6% of cases [6]. In this case, the patient presented with pain, necessitating the retrieval of the separated instrument. Various techniques are available for instrument retrieval, including the use of ultrasonics, specialized instrument retrieval kits, and braiding technique [7]. Ultrasonics have consistently provided the best results and therefore this method was chosen [3]. Given that the instrument was located in the apical third of the

canal, we first enlarged the canal using a Gates Glidden Drill to gain adequate access [8]. Ultrasonics, employed under magnification, were then used to loosen the separated fragment and facilitate its removal [3]. Following successful retrieval, biomechanical preparation was performed, and sectional obturation was completed. Owing to the canal enlargement with a Gates Glidden Drill, the tooth was subsequently restored using an anatomic post to provide structural support [9].

Vital tooth preparation, as part of the process for placing a porcelain-fused-to-metal (PFM) bridge, can expose dentinal tubules, potentially leading to sensitivity, pain, or periapical pathologies over time [10]. In this case, the patient had a PFM bridge on the mandibular incisors, with tenderness on percussion specifically noted in relation to tooth 32. Traditionally, performing root canal treatment on teeth with existing prostheses requires the removal of the prosthesis [11]. This procedure, however, can result in damage to the tooth or prosthesis, increase treatment costs, and necessitate multiple visits, adding to the patient's burden [12].

To circumvent these challenges, the patient was offered a minimally invasive alternative: root canal treatment through the existing prosthesis using the AReneto® system. This system involves preoperative planning using implant planning software to accurately determine the access opening [5]. The preoperative CBCT scan was imported into BlueSkyBio software. A custom implant was selected and oriented to gain access to the root canal through the bridge. This design was then transferred to the AR glasses to assist the dentist in performing the procedure. The use of augmented reality (AR) glasses allows the clinician to visualize the planned orientation directly in their field of view, thereby maintaining focus on the patient without the need to shift attention between the laptop screen and the operating area [4]. One of the significant advantages of AR glasses is that they do not obstruct the surrounding environment, as they overlay information onto the real world [13]. This feature ensures that the dentist has an unobstructed view of the operating area and the patient, enhancing both precision and comfort during the procedure [14].

The AReneto® system functions as an assistive tool to facilitate minimally invasive access openings, potentially improving the long-term prognosis of the treatment [5]. However, it is important to note that the system is still in the developmental stage and currently serves as a passive assistant to the clinician [5]. The accuracy of the procedure largely depends on the clinician's expertise and experience. As this technology continues to evolve, further advancements are needed to fully bridge the gap between novel technological developments and their practical implementation in dentistry.

Conclusion

The field of dentistry is rapidly advancing with the integration of new technologies, and augmented reality (AR) is emerging as a transformative tool. In this case, the retrieval of a separated instrument in the apical third of a tooth was successfully achieved using ultrasonics under magnification, followed by a minimally invasive, guided root canal treatment through an existing prosthesis with the AReneto® system. This case highlights the practical applications of AR in guided endodontics, demonstrating its potential to enhance precision and improve patient outcomes. AR also holds promise in other branches of dentistry, including guided implantology, guided orthodontics, and guided restorative treatments. However, while AR technology shows great potential, further developments are necessary to enhance its integration and usability in everyday dental practice. Continued innovation and research will be crucial in bridging the gap between emerging technologies and their effective implementation in the field of dentistry.

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Concept and design: VP. Acquisition, analysis, or interpretation of data: VP and PSM. Drafting of the manuscript: VP. Critical review of the manuscript for important intellectual content: VP, PSM, SA, CC, and AS. Supervision: SA, CC, and AS.

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Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

Competing interests
Dr. Varun Prabhuji declare(s) employment, a patent, and stock/stock options from Roots to Cusps® Private Limited. Dr. Varun Prabhuji is the director and a shareholder of Roots to Cusps® Private Limited, holding 50% of the company's stock. Intellectual property info: Roots to Cusps® Private Limited filed a provisional patent application with the application number 202441050112 on 1 July 2024 at Intellectual Property India, with Dr. Varun Prabhuji as the innovator. Additionally, the trademark for AReneto® has been filed and accepted.

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