

Nonsurgical retreatment of a maxillary first molar with three mesiobuccal canals, C-shaped distobuccal-palatal morphology, and iatrogenic perforation repair using image-guided visualization: A case report

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Background: The root canal anatomy of maxillary molars can be highly variable, with fused roots, C-shaped canal configurations, and supernumerary canals presenting significant clinical challenges. The presence of three mesiobuccal canals (MB3) is an exceptionally rare anatomical variation that has been reported infrequently in maxillary first molars.

Case description: A 50-year-old Chinese male was referred for evaluation of the maxillary right first molar (tooth #3), which had undergone previous root canal treatment and restoration with a zirconia crown two years earlier. Clinical examination revealed a draining sinus tract approximating the mesiobuccal root. Cone beam computed tomography (CBCT) demonstrated an untreated mesiobuccal root containing three canals (MB1, MB2, and MB3), a C-shaped configuration connecting the distobuccal and palatal canals, an overfilled palatal canal, a poorly obturated distobuccal canal, and a suspected iatrogenic perforation of the pulpal floor. Nonsurgical retreatment was completed in two visits utilizing image-guidance with the Zumax DentSight AR integrated visualization system, and a surgical operating microscope to identify and manage the complex canal anatomy. The perforation was repaired using bioceramic putty and Vitrebond. All five canals were instrumented, disinfected with 6% sodium hypochlorite, 17% EDTA, and laser-activated irrigation, and obturated using warm vertical condensation with gutta-percha and NeoSEALER EZFlo. At the obturation appointment, the sinus tract had resolved and the patient was asymptomatic.

Conclusion: This case demonstrates the importance of CBCT evaluation, image-guided visualization, and the surgical operating microscope in identifying and managing complex root canal anatomy during retreatment. The combination of three mesiobuccal canals and a C-shaped distobuccal-palatal canal configuration in a maxillary first molar is exceedingly rare and, to the authors' knowledge, has not been previously reported.

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Introduction

The success of root canal treatment depends on thorough debridement, disinfection, and obturation of the entire root canal system. Missed canals remain one of the most common causes of endodontic treatment failure, particularly in maxillary molars where the mesiobuccal root frequently harbors a second canal (MB2). Although the MB2 canal has been extensively studied, the presence of a third mesiobuccal canal (MB3) is exceedingly rare. Previous investigations have reported MB3 canals in approximately 1.3%–2.4% of maxillary first molars and described considerable anatomical variability in their configuration and apical anatomy (Ahmad and Al-Jadaa, 2014; Ordinola-Zapata et al., 2020).

The MB3 canal was described in detail by Ahmad and Al-Jadaa (2014), who noted that the most common configuration was type 3-2, in which three orifices converge into two apical foramina. Ordinola-Zapata et al. (2020) further characterized the MB3 canal using micro-computed tomography, demonstrating high anatomical variability, thin dentin walls at the coronal third, and a predominantly confluent anatomy with the other mesiobuccal canals. These findings underscore the clinical challenge of locating and instrumenting this canal, as well as the risk of perforation during exploration.

Maxillary molars may also exhibit root fusion and C-shaped canal configurations, although these anatomical variations are reported more frequently in maxillary second molars than in first molars. C-shaped anatomy may complicate canal location, cleaning, shaping, and obturation because of the presence of fins, webs, and irregular canal communications. These anatomical complexities may increase the likelihood of missed anatomy and contribute to endodontic treatment failure.

When initial root canal treatment fails due to missed canals or inadequate obturation, nonsurgical retreatment offers a predictable treatment option. Contemporary systematic reviews report pooled success rates of approximately 78%–87% for nonsurgical retreatment, depending on the outcome criteria used (Sabeti et al., 2024; Olivieri et al.,

2024). However, factors such as complex root canal anatomy, perforations, and preoperative periapical pathology may negatively influence treatment outcomes (Turan Gökdoğan et al., 2025; Clauser, 2022).

The management of iatrogenic perforations has been significantly improved by the introduction of bioactive calcium silicate-based materials. Bioceramic putty and mineral trioxide aggregate (MTA) have demonstrated favorable biocompatibility, sealing ability, and promotion of hard tissue formation at perforation sites (Silva et al., 2017; Anwar Laithy et al., 2025).

This case report describes the nonsurgical retreatment of a maxillary first molar presenting with three mesiobuccal canals, a C-shaped distobuccal-palatal canal configuration, and an iatrogenic pulpal floor perforation. Although each anatomical variation has been reported individually, the coexistence of three mesiobuccal canals and a C-shaped distobuccal-palatal canal configuration in a maxillary first molar appears to be previously unreported in the English-language literature. The case further demonstrates the value of image-guided visualization, cone-beam computed tomography, and high-magnification microscopy in the identification, treatment, and management of complex root canal anatomy and procedural complications.

Case Report

A 50-year-old Chinese male with a medical history significant for elevated intraocular pressure was referred from a private dental practice to the endodontics department for evaluation of the maxillary right first and second molars (teeth #3 and #2, respectively). The patient's chief complaint was that his dentist had initiated root canal treatment on tooth #2 and referred him for completion, and that he had a "bump" associated with tooth #3, which had undergone root canal treatment and crown placement approximately two years earlier.

Clinical examination revealed a zirconia crown on tooth #3 with intact margins and mild generalized plaque accumulation. A draining sinus tract was

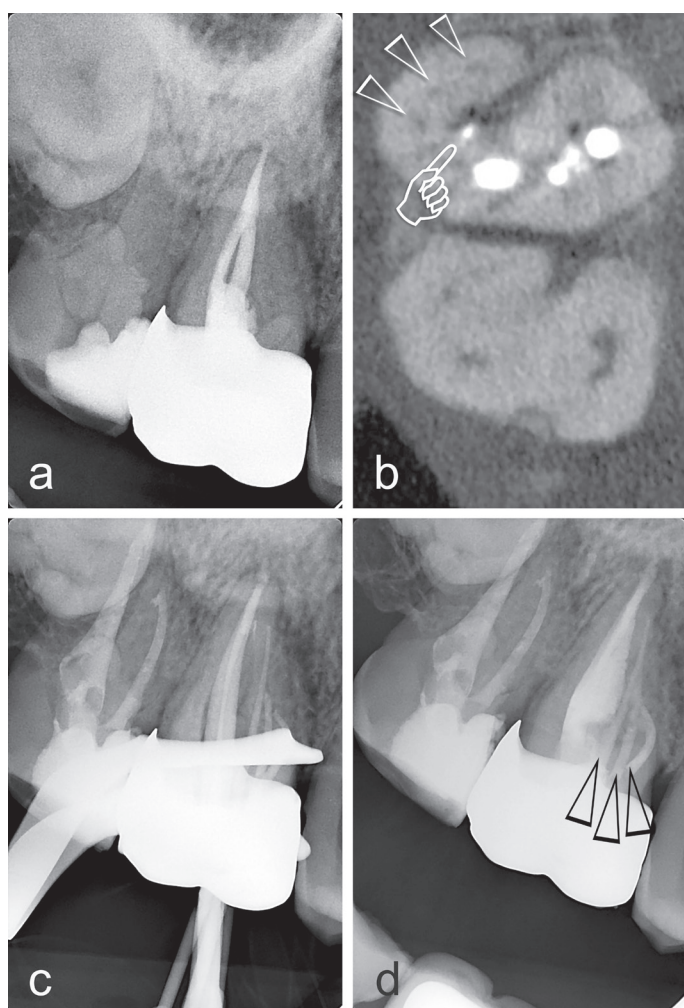


Fig. 1. Radiographic and CBCT findings associated with tooth #3. (A) Preoperative periapical radiograph demonstrating previous root canal treatment with overextension of the palatal canal and inadequate treatment of the mesiobuccal root. (B) Axial CBCT image demonstrating three untreated mesiobuccal canals (MB1, MB2, and MB3), a C-shaped distobuccal-palatal canal configuration, and a suspected pulpal floor perforation (hand icon). (C) Cone-fit radiograph demonstrating master gutta-percha cone adaptation within all five canals prior to obturation. (D) Final postoperative radiograph demonstrating completed obturation of the MB1, MB2, MB3, distobuccal, and palatal canals following warm vertical condensation and bioceramic sealer placement.

present on the buccal attached gingiva adjacent to the mesiobuccal root of tooth #3. A temporary mesio-occlusal restoration was noted on tooth #2. Teeth #2 and #3 did not respond to cold testing (Endo Ice; Coltene/Whaledent Inc., Cuyahoga Falls, OH, USA), consistent with their previous root canal treatment and endodontic access. Both teeth were negative to percussion and palpation. Periodontal probing depths were within normal limits (≤ 4 mm), and physiologic mobility was observed. Adjacent tooth #4 responded normally to cold testing and was negative to percussion and palpation.

Periapical and bitewing radiographs were obtained. The bitewing radiograph demonstrated tooth #2 with a mesio-occlusal restoration and tooth #3 restored with a zirconia crown and previous root canal treatment. The periapical radiograph of tooth #3 revealed obturation material extending approximately 1 mm beyond the radiographic apex

of the palatal root, with inadequate obturation of the root canal in the MB root (Figure 1A).

A limited-field CBCT scan was acquired using a Planmeca ProMax 3D unit (Planmeca Oy, Helsinki, Finland) with a 5×5 cm field of view, 0.10-mm voxel size, 90 kV, and 10 mA. Images were evaluated using Planmeca Romexis software. Axial CBCT images revealed three canals within the mesiobuccal root (MB1, MB2, and MB3), none of which had been treated during the original root canal procedure (Figure 1B). The distobuccal and palatal canals exhibited a C-shaped configuration, visible as a continuous radiopaque arc on the palatal-distal aspect of the root complex. The palatal canal appeared overextended, while the distobuccal canal was inadequately obturated. In addition, a suspected iatrogenic perforation was identified on the pulpal floor between the mesiobuccal and distobuccal canal orifices.

Based on the clinical and radiographic findings, tooth #3 was diagnosed as Previously Treated with Chronic Apical Abscess. Tooth #2 was diagnosed as Previously Initiated Therapy with Asymptomatic Apical Periodontitis. Because the primary purpose of the referral was completion of treatment on tooth #2 and evaluation of the persistent sinus tract associated with tooth #3, root canal treatment on

tooth #2 was completed before addressing the more complex retreatment needs of tooth #3. The patient was informed of the questionable prognosis associated with the complex root canal anatomy, suspected iatrogenic perforation, and failure of the initial root canal treatment on tooth #3. Treatment options, including no treatment, nonsurgical retreatment, and extraction, were discussed.

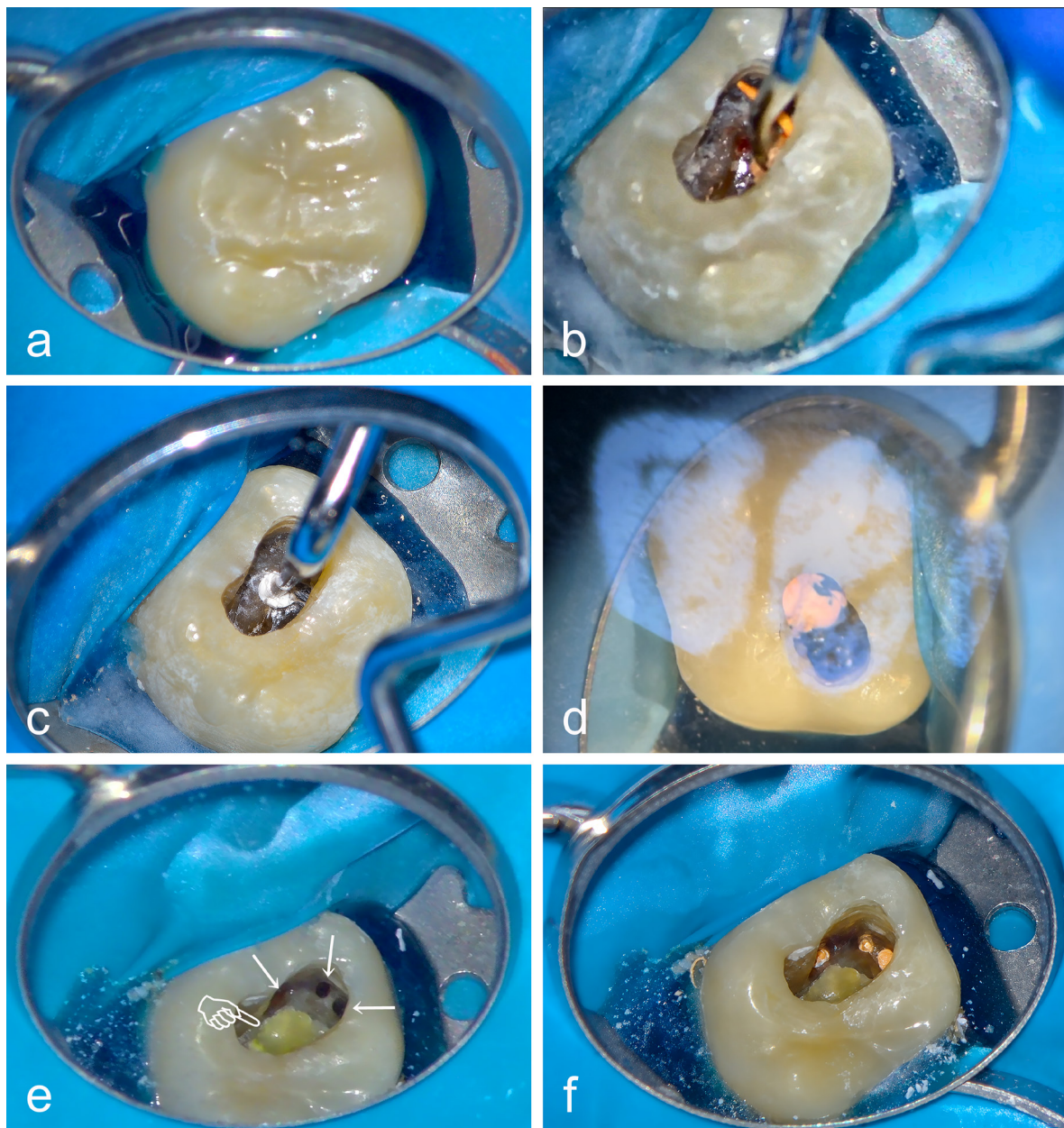


Fig. 2. Clinical photographs captured through the surgical operating microscope during nonsurgical retreatment of tooth #3. (A) Pre-access occlusal view through the existing zirconia crown under rubber dam isolation. (B) Initial view of the pulp floor demonstrating residual obturation material and contamination associated with the perforation site. (C) Perforation repair using EndoSequence BC Putty and Vitrebond following debridement of the defect. (D) Image-guided visualization used to identify the previously untreated MB1, MB2, and MB3 canals. (E) Pulp chamber floor following cleaning and shaping demonstrating identification of the three mesiobuccal canal orifices (MB1, MB2, and MB3). (F) Pulp chamber floor following obturation demonstrating gutta-percha fills within the three mesiobuccal canals.

The patient elected to proceed with nonsurgical retreatment, and verbal and written informed consent were obtained.

Visit 1 - Retreatment Access and Instrumentation

Local anesthesia was administered (two cartridges of 2% lidocaine with 1:100,000 epinephrine) and rubber dam isolation was achieved using blackout resin and a bite block. The occlusal surface of the zirconia crown was photographed under the surgical operating microscope (Zumax Medical Co., Ltd., Suzhou, China) prior to access (Figure 2A).

Access was gained through the existing zirconia crown, which remained intact. The Zumax DentSight AR integrated visualization system was used to locate the previously untreated MB1, MB2, and MB3 canals (Figure 2D). Excess gutta-percha was removed from the pulp chamber until the distobuccal and palatal canal orifices were identified, confirming their C-shaped connection. During removal of the previous obturation material from the perforation site, clinical photographs were captured through the surgical operating microscope, documenting the progressive clearance of gutta-percha and sealer remnants from the pulpal floor (Figure 2B). Gates Glidden drills (size 3) were used for coronal gutta-percha removal, and ProTaper F2 rotary files (Dentsply Sirona, Charlotte, NC, USA) were used for middle-third removal. Chloroform in conjunction with size 10 C-files was used to achieve patency in the previously treated canals.

Working lengths were established using a Root ZX electronic apex locator (J. Morita Corp., Kyoto, Japan). All five canals were negotiated and instrumented using Vortex Blue rotary files (Dentsply Sirona). The mesiobuccal canals were enlarged to size 20/.04, while the distobuccal and palatal canals were instrumented to size 30/.04, respectively. Patency was achieved in all canals. An iatrogenic perforation on the pulpal floor was repaired with EndoSequence BC Putty (Brasseler USA, Savannah, GA, USA) and Vitrebond light-cured glass ionomer liner (3M ESPE, St. Paul, MN, USA) (Figure 2C). Irrigation was performed with 6% sodium hypochlorite (NaOCl) and 17% EDTA throughout the procedure. Following cleaning and disinfection, the canals were dried with sterile

paper points and dressed with Ultracal XS calcium hydroxide paste (Ultradent Products Inc., South Jordan, UT, USA) as an intracanal medicament. The access cavity was sealed with a sterile sponge and TempIT temporary filling material (Spident Co., Ltd., Incheon, South Korea). Postoperative instructions were provided, and over-the-counter analgesics were recommended as needed.

Visit 2 - Obturation

The patient returned 4 weeks later for obturation. He reported no pain since the first visit, and the sinus tract had resolved. Following the same anesthesia and isolation protocol, the temporary restoration was removed and calcium hydroxide was eliminated from all five canals. Working lengths were reconfirmed using the Root ZX apex locator. Final instrumentation was completed with Vortex Blue rotary files, with the mesiobuccal canals prepared to sizes 25/.04 (MB1 and MB2) and 20/.04 (MB3), and the distobuccal and palatal canals enlarged to sizes 40/.06 and 45/.06, respectively.

The final irrigation protocol consisted of 6% sodium hypochlorite and 17% EDTA, followed by laser-activated irrigation using an Er,Cr:YSGG laser (2780 nm; Biolase, Irvine, CA, USA) equipped with a radial-firing endodontic tip operated at 1.5 W and 20 Hz without air or water spray. The laser tip was positioned short of working length and activated in a slow coronal withdrawal motion for 30 seconds per cycle.

Following completion of cleaning and shaping, the pulp chamber floor was photographed through the surgical operating microscope using a dental mirror, demonstrating the three mesiobuccal canal orifices (MB1, MB2, and MB3) after instrumentation (Figure 2E). A subsequent photograph captured the same view following obturation, showing gutta-percha in all three mesiobuccal canals (Figure 2F).

A cone-fit radiograph was obtained to verify master cone adaptation in all five canals (Figure 1C). After drying with sterile paper points, master gutta-percha cones were placed in all canals, with an additional cone placed in the palatal canal, and NeoSEALER EZFlo bioceramic sealer (Avalon Biomed Inc., Bradenton, FL, USA) was placed. Warm vertical condensation was performed using the Elements

obturation unit (Kerr Endodontics, Orange, CA, USA) for downpack, followed by backfilling with the same system. The pulp chamber was cleaned of excess sealer with alcohol, and EndoSequence BC Liner (Brasseler USA, Savannah, GA, USA) was placed over the canal orifices as a secondary coronal seal. Clearfil SE Protect primer and bond was applied, and a core buildup was completed using DC Core dual-cure composite (Kuraray Noritake Dental Inc.). A final postoperative periapical radiograph was obtained (Figure 1D).

The patient was provided postoperative instructions and advised to take over-the-counter analgesics as needed. He was referred back to his general dentist for definitive restoration of the access cavity through the existing zirconia crown. At the one-year recall, the patient remained asymptomatic, and clinical and radiographic examination demonstrated periapical healing (Figure 4).

Discussion

This case highlights several clinically significant findings that collectively represent an exceptionally rare anatomical presentation in a maxillary first molar: three mesiobuccal canals (MB1, MB2, and MB3), a C-shaped configuration connecting the distobuccal and palatal canals, and an iatrogenic perforation, all managed successfully through nonsurgical retreatment.

The MB3 canal is among the rarest anatomical variations reported in maxillary molars. In the present case, all three mesiobuccal canals were missed during the initial treatment, which likely contributed to persistent infection and development of a chronic apical abscess with a draining sinus tract. The successful identification and treatment of these canals highlights the importance of advanced imaging and magnification when evaluating previously treated teeth with persistent disease.

Several case reports have documented maxillary first molars containing three mesiobuccal canals and have emphasized the importance of advanced imaging, magnification, and careful exploration of the pulpal floor for identification of these

uncommon anatomical variations (Kakkar and Singh, 2012; Ahmad and Al-Jadaa, 2014). However, previously reported cases generally involved otherwise conventional root morphology. In the present case, the presence of three mesiobuccal canals in conjunction with a C-shaped distobuccal-palatal canal configuration created a uniquely complex anatomical presentation.

In addition to supernumerary canals, maxillary molars may exhibit root fusion and C-shaped canal configurations, although these anatomical variations are reported more frequently in maxillary second molars than in first molars (Mashyakhy et al., 2019). Martins et al. (2016) classified five categories of C-shaped maxillary molars based on patterns of root fusion. The Type C configuration, characterized by fusion of the distobuccal and palatal roots, was identified in the present case. Sun et al. (2022) reported successful retreatment of C-shaped maxillary molars and emphasized the importance of CBCT imaging and magnification when managing these unusual anatomical configurations. The irregular canal communications, fins, webs, and isthmuses commonly associated with C-shaped anatomy present significant challenges for cleaning, shaping, and obturation.

The combination of three mesiobuccal canals and a C-shaped distobuccal-palatal configuration in a maxillary first molar has not, to the authors' knowledge, been previously reported. This finding highlights the remarkable anatomical variability that may occur even in teeth generally considered to have well-characterized root canal anatomy and underscores the importance of maintaining a high index of suspicion when evaluating previously treated teeth with persistent disease.

The iatrogenic perforation identified on the pulpal floor was likely created during the initial treatment, possibly during attempts to locate the untreated mesiobuccal canals. Perforations are recognized complications of endodontic treatment that may adversely affect prognosis if not properly managed. In the present case, the perforation was repaired with EndoSequence BC Putty, a premixed bioceramic material with favorable sealing ability, biocompatibility, and bioactive properties.

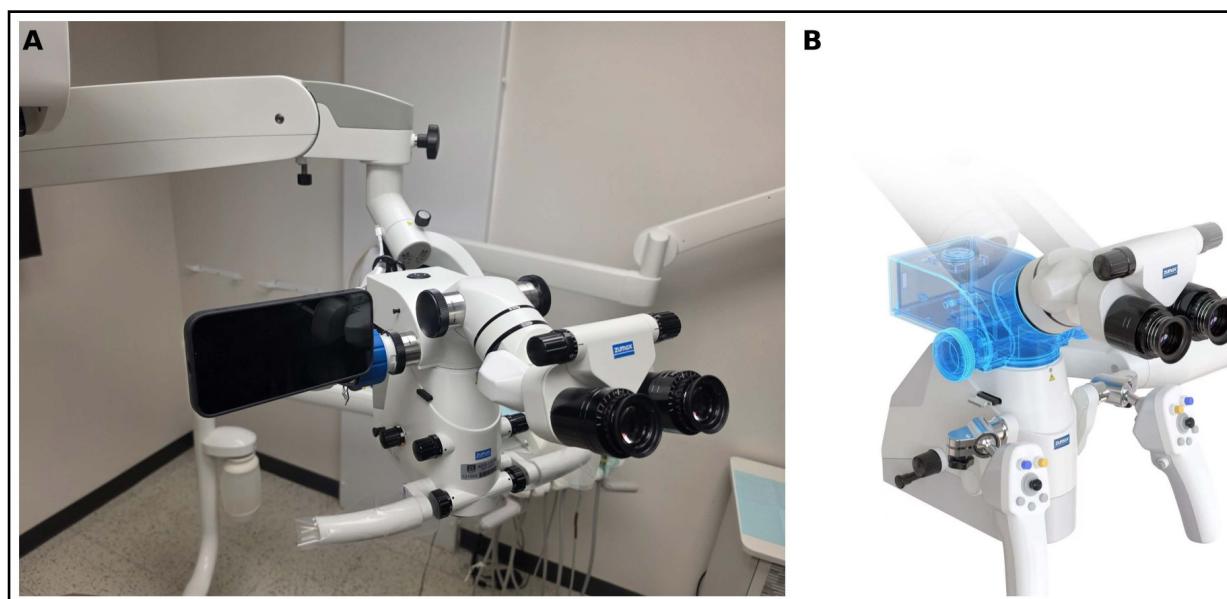


Fig. 3. Image-guided visualization platform used during treatment. (A) Clinical photograph of the Zumax DentSight integrated visualization system mounted on the surgical operating microscope and utilized during nonsurgical retreatment of tooth #3. (B) Manufacturer rendering of the Zumax DentSight integrated visualization platform demonstrating the image-guidance module integrated with the surgical operating microscope, enabling real-time visualization, image capture, and clinical documentation during endodontic procedures.

Vitrebond glass ionomer liner was placed as an additional protective barrier. Clauder (2022) noted that bioactive calcium silicate materials have substantially improved the prognosis of perforation repair compared with previously available materials.

The clinical photographs obtained during removal of the previous obturation material from the perforation site documented the extent of contamination and the progressive debridement of the defect prior to repair.

CBCT imaging was essential for diagnosis and treatment planning in this case. The axial CBCT images clearly demonstrated the three untreated mesiobuccal canals, the C-shaped distobuccal-palatal configuration, the overextended palatal obturation, and the suspected perforation, findings that could not be fully appreciated on conventional two-dimensional radiographs. Current endodontic guidelines support the use of limited-field CBCT in cases involving complex anatomy, previous treatment, and diagnostic uncertainty because of its ability to provide three-dimensional visualization of the root canal system (Sousa Melo et al., 2026). The 2025 AAE/AAOMR Joint Position Statement

specifically recognizes the value of CBCT in the evaluation of previously treated teeth with persistent disease, complex anatomy, and retreatment considerations, all of which were present in this case.

In addition to CBCT imaging, image-guided visualization using the Zumax DentSight AR integrated visualization system and surgical operating microscope facilitated identification, documentation, and management of the complex anatomy encountered in this case (Figure 3). Enhanced magnification and illumination improved visualization of the three mesiobuccal canal orifices and the perforation site, while high-resolution image capture allowed precise clinical documentation. In cases involving rare anatomical variations, advanced visualization technologies may complement conventional magnification and assist clinicians in identifying otherwise overlooked anatomy.

The irrigation protocol employed in this case included 6% sodium hypochlorite, 17% EDTA, and laser-activated irrigation. Advanced irrigation activation techniques are particularly valuable in

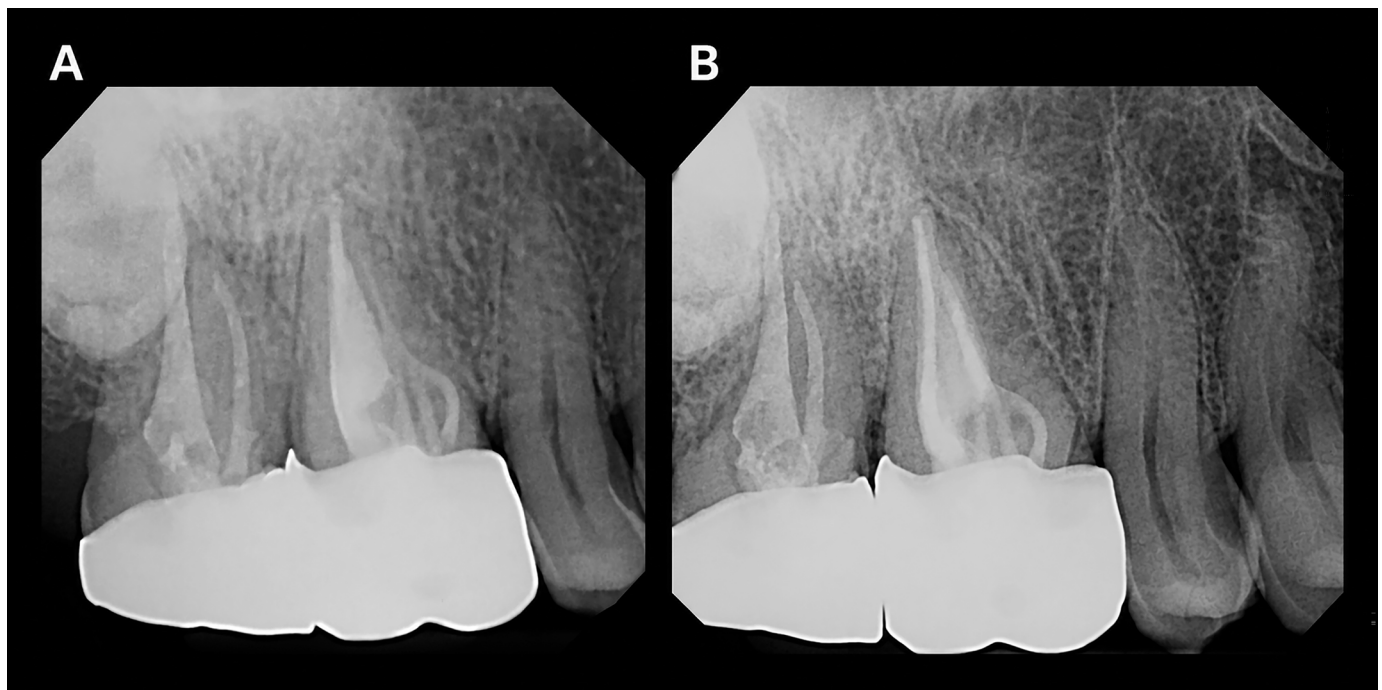


Fig. 4. One-year follow-up periapical radiographs obtained from different angulations (A, B) demonstrating resolution of the periapical radiolucency and satisfactory periapical healing.

teeth with complex canal anatomy because they enhance irrigant penetration into fins, isthmuses, and irregular canal communications that may not be adequately cleaned by instrumentation alone.

Contemporary evidence supports favorable outcomes for nonsurgical retreatment, with pooled success rates ranging from approximately 78% to 87% (Sabeti et al., 2024; Olivieri et al., 2024). Nevertheless, procedural complications and complex canal anatomy may adversely influence outcomes. Resolution of the sinus tract before obturation represented an encouraging early clinical finding; however, long-term follow-up remains necessary despite evidence of periapical healing. The patient has been scheduled for routine recall examinations to monitor healing and treatment outcomes.

Patient Perspective

The patient reported satisfaction with the treatment and resolution of the sinus tract. At the completion of treatment, he remained asymptomatic and was satisfied with the outcome. The patient was informed of the need for continued clinical and radiographic

follow-up and agreed to return for routine recall evaluations.

Limitations

This case report has several limitations. Although the patient remained asymptomatic and demonstrated clinical and radiographic healing at one-year, longer follow-up is still warranted. In addition, as a single case report, the findings should be interpreted cautiously and cannot be generalized to broader patient populations. Despite these limitations, this report documents an exceptionally rare combination of three mesiobuccal canals and a C-shaped distobuccal-palatal canal configuration in a maxillary first molar and highlights the value of CBCT imaging, image-guided visualization, and magnification in the management of complex endodontic retreatment cases.

Conclusion

This case demonstrates the successful nonsurgical retreatment of a maxillary first molar exhibiting an exceptionally rare combination of three mesiobuccal canals and a C-shaped distobuccal-palatal canal configuration, complicated by an iatrogenic perforation. CBCT imaging, image-guided visualization, and surgical operating microscopy were instrumental in the diagnosis and management of this complex anatomical presentation. Clinicians should maintain a high index of suspicion for untreated and variant canal anatomy in previously treated teeth and consider advanced imaging and magnification technologies when managing challenging retreatment cases.

Declaration of Competing Interests

The authors declare no competing interests.

Patient Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying clinical and radiographic images.

Conflict of Interest

The authors declare no conflicts of interest related to this case report.

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