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Nonsurgical Endodontic Treatment of a Maxillary First Molar With Four Roots, Including Two Palatal Roots, and Five Separate Root Canals: A Case Report

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Abstract

This case report presents a rare maxillary first molar with four separate roots and five root canals: two mesiobuccal canals, one distobuccal canal, and two distinct palatal canals. During initial access preparation, four canal orifices were identified, including the mesiopalatal canal. However, the initial working-length radiograph suggested the presence of an additional distopalatal canal. Subsequent cone-beam computed tomography (CBCT) examination and microscopic exploration assisted by ultrasonic instrumentation facilitated identification of the previously undetected distopalatal canal orifice at the internal distopalatal line angle of the access cavity. The shaping procedure of the root canal treatment was performed using the ProTaper Gold system (Dentsply Maillefer, Ballaigues, Switzerland). The obturation was performed using matched gutta-percha points and a bioceramic sealer. After six months, the patient had no clinical symptoms. This case underscores the possibility of complex anatomical variations in maxillary first molars, which can be addressed through a precise assessment of pulpal floor anatomy and the application of advanced imaging and magnification technologies to minimize the risk of missed canals.

Categories: Dentistry
Keywords: cbct, dental operating microscope, five roots, maxillary first molar, root canal anatomy, two palatal roots

Introduction

Encountering morphological variations in endodontic practice is a common finding [1]. According to the literature, the maxillary first molar is one of the teeth that presents significant endodontic challenges due to its wide variety of root canal anatomical variations [2]. Failure to identify additional canals during endodontic treatment can pose a significant challenge for clinicians, potentially leading to treatment failure [3]. Therefore, a comprehensive understanding of the root canal system in maxillary first molars is essential for effective treatment planning and endodontic procedures to recognize these anatomical variations and minimize the risk of missed canals or improper treatment [1,2].

Permanent maxillary molars generally develop three roots, one palatal and two buccal; however, the occurrence of a second mesiobuccal canal is a common variation, with a prevalence ranging from 48% to 97.6% [4]. In contrast, the prevalence of four-rooted maxillary first molars has been estimated at approximately 0.047%, of which 27.27% were reported to have five canals. Additionally, two palatal canals with separate orifices and foramina, or a single palatal canal with two separate foramina, have been reported, with the incidence of an additional palatal canal in maxillary molars ranging from 2% to 5.1% [2]. However, the incidence of two separate palatal roots in maxillary first molars has been reported to be 0.9% in a cone-beam computed tomography (CBCT) study [5]. Liu and Shen [6] reported the successful endodontic management of a maxillary first molar with four distinct roots, including two separate palatal roots, highlighting the critical importance of recognizing these anatomical variations and their unique challenges during endodontic procedures. This report underscores the essential role of advanced diagnostic methods, such as CBCT, and the application of microscopic techniques in identifying and treating such cases.

Although understanding conventional root canal orifice configurations, such as triangular or rhomboidal patterns, can guide clinicians in locating root canals, anatomical variations may produce atypical arrangements of canal orifices on the pulpal floor, such as trapezoidal or square configurations. In such cases, careful assessment of the pulpal floor anatomy and modification of the access cavity may be necessary to identify additional canals and minimize the risk of missed canals [5]. In addition, Christie et al. [7] introduced a radiographic classification of maxillary molars with two palatal roots and established three anatomical patterns. Type I is characterized by elongated palatal roots that exhibit greater divergence than their buccal counterparts. Type II includes relatively short buccal and palatal roots with rounded apices and nearly parallel orientations, producing a radiographic image that resembles two roots positioned mesially and distally. Type III is distinguished by the incorporation of the palatal and mesiobuccal canals into a common mass of root dentin, whereas the distobuccal root remains anatomically independent and diverges from the others.

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The advent of dental operating microscopes and CBCT has significantly enhanced visualization in endodontic treatment [8, 9]. These technologies allow clinicians to assess complex tooth morphology and root canal systems with greater accuracy, whereas conventional periapical radiographs are limited to two-dimensional representations [10].

This case report presents a rare anatomical variation of a maxillary first molar with four separate roots, including two palatal roots, and five distinct root canals, which were identified using CBCT imaging and a dental operating microscope, along with consideration of possible variations in the root canal orifice arrangement.

Case Presentation

A 60-year-old male patient with severe pain associated with tooth #3 was referred for endodontic treatment. His medical history was noncontributory. Clinical examination revealed an extensive distal carious lesion in the right maxillary first molar. The tooth was tender to vertical percussion but showed no tenderness to palpation. It responded positively to the electric pulp test and demonstrated a positive response to the cold test, characterized by pain that lingered for more than 30 seconds after removal of the cold stimulus. A periapical radiograph revealed extensive distal caries and localized bone loss distal to tooth #3 (Figure *1*). No periapical radiolucency or other pathological changes in the periradicular tissues were observed. The lamina dura appeared intact, and the periodontal ligament space was within normal limits.

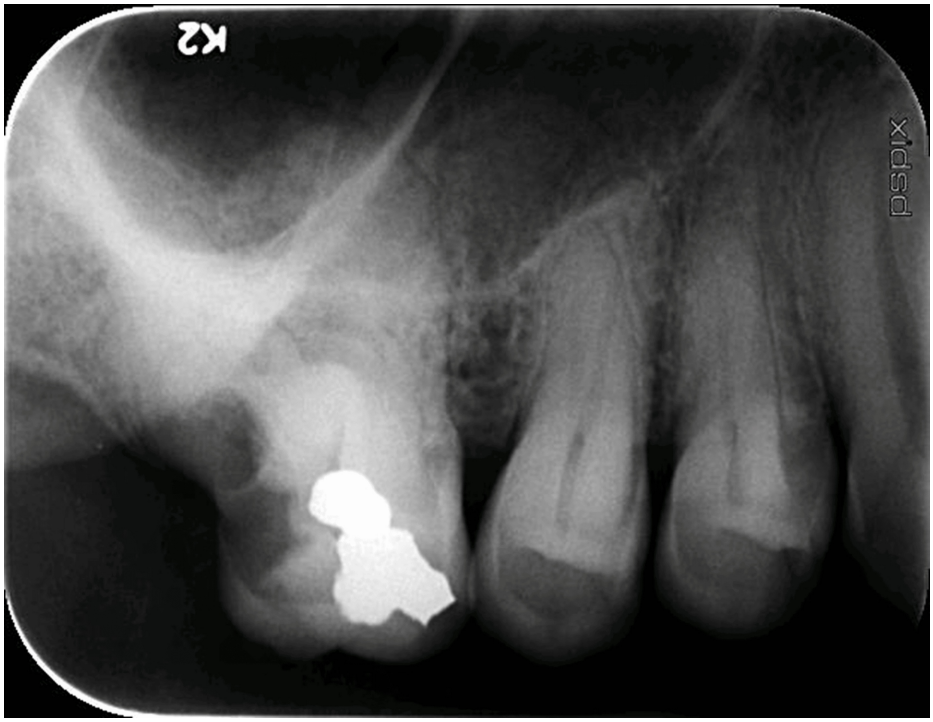


FIGURE 1: Preoperative radiograph of tooth #3.

Based on the clinical and radiographic examinations, the tooth was diagnosed with symptomatic irreversible pulpitis. Initially, extraction was considered because of the extensive distal carious lesion. However, no tooth mobility, furcation involvement, periodontal pockets, or bleeding on probing were noted. After careful evaluation of the periapical radiograph, caries removal, and clinical assessment, the tooth was considered restorable because sufficient coronal tooth structure remained to support a restoration. Additionally, as tooth #3 was the most distal tooth in the arch, adequate access to the distal gingival margin could be achieved to prevent the formation of an overhanging restoration. All risks and alternative treatment options were explained to the patient, and both written and verbal informed consent were obtained.

Following local anesthesia with 2% lidocaine containing 1:100,000 epinephrine (Darou Pakhsh, Tehran, Iran) and rubber dam isolation of tooth #3, a conventional access cavity was prepared. On the pulp chamber floor, four canal orifices were initially identified in a rhomboidal arrangement: the first mesiobuccal, second mesiobuccal, distobuccal, and palatal canals. The initially identified palatal canal was subsequently designated as the mesiopalatal canal after identification of the additional distopalatal canal. The canals were navigated with #15 and #20 hand K-files (Dentsply Maillefer, Ballaigues, Switzerland). Initial working lengths were determined using an electronic apex locator (Raypex 5, VDW GmbH, Munich, Germany), confirmed radiographically, and recorded. However, the initial radiograph obtained with mesial angulation

suggested the possible presence of a missed distopalatal canal (Figure 2).

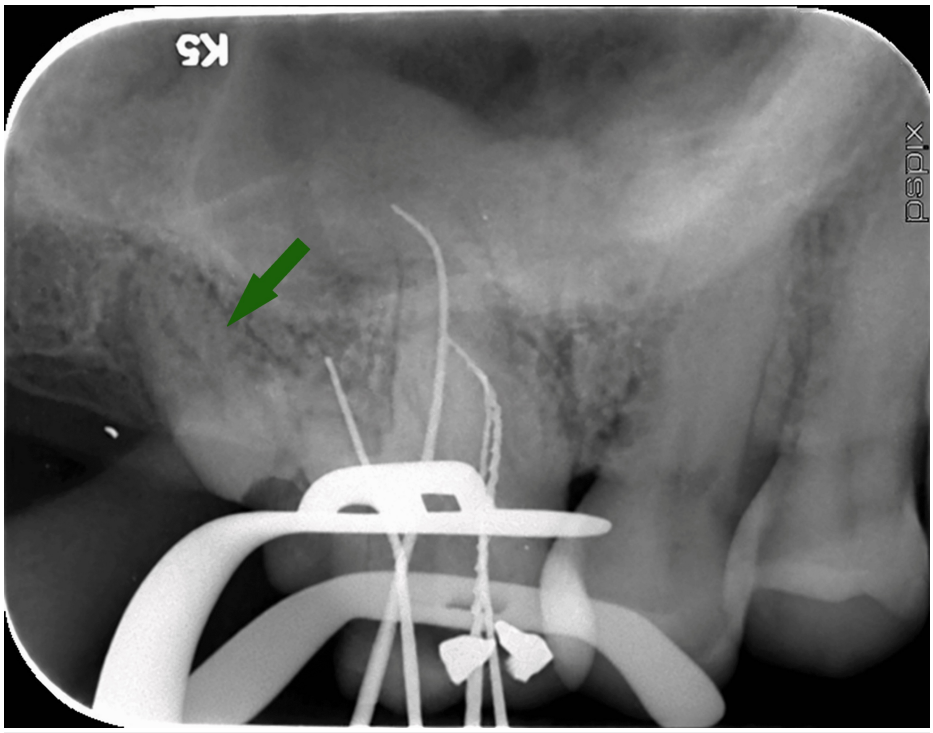


FIGURE 2: Periapical radiograph demonstrating the missed distopalatal root canal (green arrow).

Therefore, CBCT was obtained (Figure 3). With the aid of CBCT imaging and a dental operating microscope (OPMI Pico, Carl Zeiss, Baden-Württemberg, Germany), the access cavity was extended distopalatally toward the internal distopalatal line angle using an Endo-Z bur (Dentsply Maillefer, Ballaigues, Switzerland). Despite this extension, no additional canal orifice was identified with an endodontic explorer, and no bleeding was observed, suggesting calcification of the distopalatal canal orifice. A dark developmental groove extending distopalatally from the mesiopalatal canal orifice was traced using a diamond-coated ultrasonic tip (ET18D; Satelec Acteon Group, Mérignac, France). Further dentin removal using an ET40 ultrasonic tip revealed the previously undetected distopalatal canal orifice, changing the canal orifice configuration from rhomboidal to square, with the two palatal canal orifices located notably far apart (Figure 4). During exploration of the pulp chamber floor, copious irrigation with 3% sodium hypochlorite (NaOCl) was performed, followed by ultrasonic activation to enhance irrigant penetration and facilitate debris removal. Given the complex root canal anatomy, particular attention was paid to thoroughly examining the pulp chamber floor under a dental operating microscope using an endodontic explorer, ultrasonic tips, and frequent NaOCl irrigation to rule out the presence of additional canal orifices.

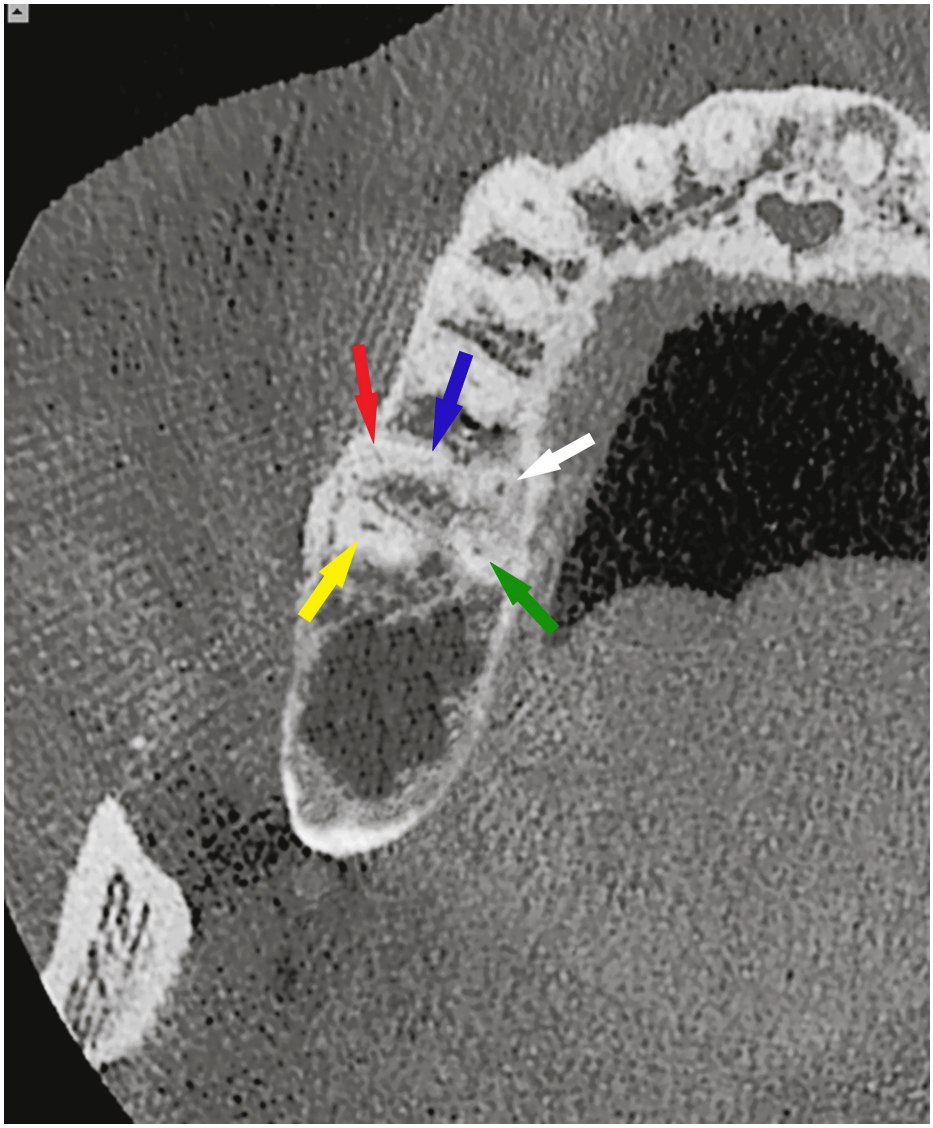


FIGURE 3: Axial cone-beam computed tomography (CBCT) image suggested four roots and five root canals. First mesiobuccal (red arrow), second mesiobuccal (blue arrow), distobuccal (yellow arrow), mesiopalatal (white arrow), and distopalatal (green arrow) canals are indicated.

Complete root separation along the entire root length could not be definitively confirmed from this single axial section, as additional multiplanar CBCT reconstructions were unavailable.



FIGURE 4: Endodontic access opening of tooth #3. Five root canals can be identified: first mesiobuccal (red arrow), second mesiobuccal (blue arrow), distobuccal (yellow arrow), mesiopalatal (white arrow), and distopalatal (green arrow).

A subsequent working-length radiograph obtained with marked mesial horizontal angulation confirmed all five canals (Figure *5*). The canals were prepared using the ProTaper Gold system (Dentsply Maillefer, Ballaigues, Switzerland) to size F2 (25/.08) for the mesiobuccal and distobuccal canals and size F3 (30/.09) for the palatal canals. Throughout instrumentation, the canals were irrigated with 3% NaOCl and 17% ethylenediaminetetraacetic acid (EDTA). Before obturation, the root canals were irrigated with 3% NaOCl, followed by ultrasonic activation using an IrriSafe tip (Acteon, Mérignac, France) for three 20-second cycles. Subsequently, 17% EDTA was applied and ultrasonically activated using the same tip for an additional three 20-second cycles, followed by a final rinse with normal saline. Root canal obturation was completed during the same visit.

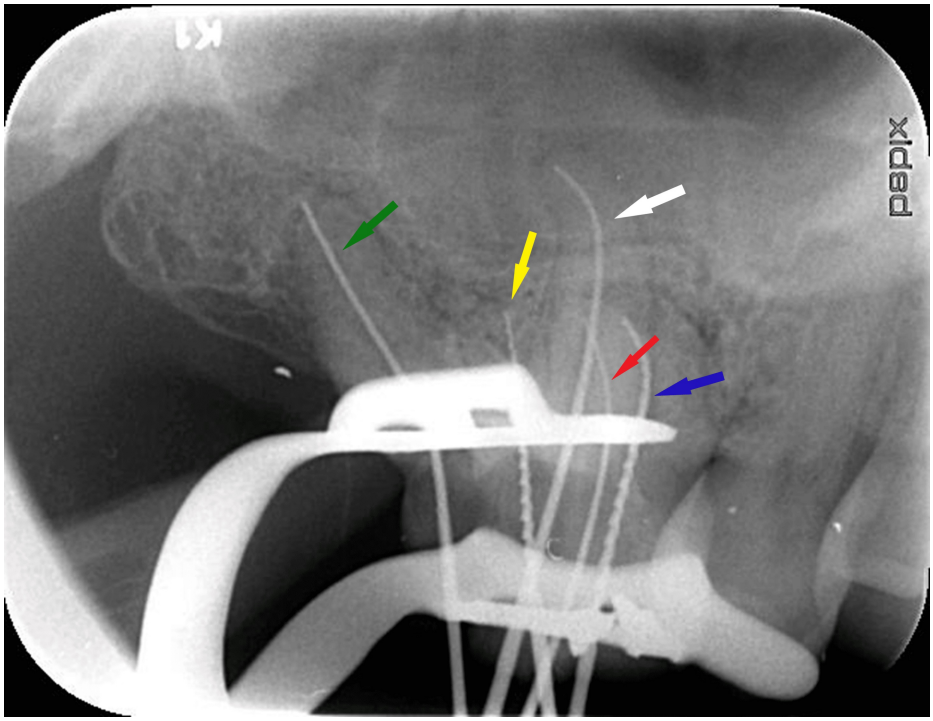


FIGURE 5: Intraoperative radiograph shows two long palatal and three short buccal root canals. First mesiobuccal (red arrow), second mesiobuccal (blue arrow), distobuccal (yellow arrow), mesiopalatal (white arrow), and distopalatal (green arrow) canals are indicated.

All canals were dried with paper points and subsequently obturated using a single-cone technique with corresponding F2 and F3 gutta-percha cones (ProTaper Gold Conform Fit; Dentsply Sirona, Charlotte, NC, USA) coated with a bioceramic root canal sealer (BioRoot RCS; Septodont, Saint-Maur-des-Fossés, France). A postoperative periapical radiograph obtained with marked mesial angulation demonstrated five individually obturated root canals with adequate obturation lengths (Figure *6*). A piece of Teflon was placed in the cavity, and a temporary filling was placed using GC Fuji Triage GIC (GC Corp, Tokyo, Japan).

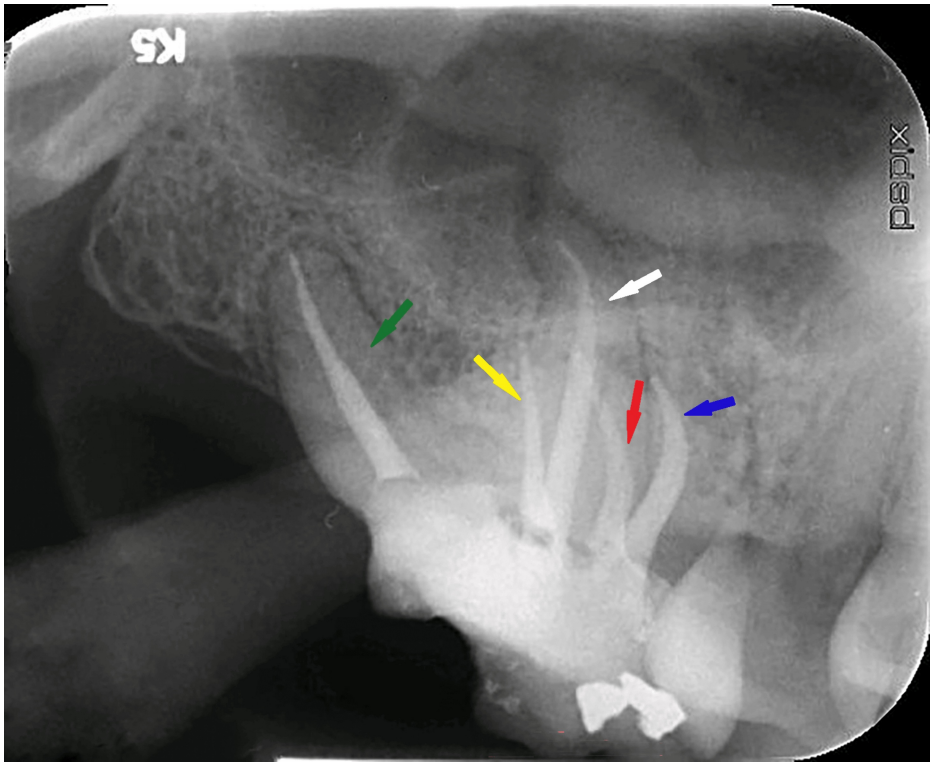


FIGURE 6: Postoperative radiograph showing five separate root canals: first mesiobuccal (red arrow), second mesiobuccal (blue arrow), distobuccal (yellow arrow), mesiopalatal (white arrow), and distopalatal (green arrow) canals.

At the second visit, after removal of the provisional filling material (Figure 7), the tooth was restored with amalgam. At the six-month follow-up, the patient was asymptomatic (Figure 8).

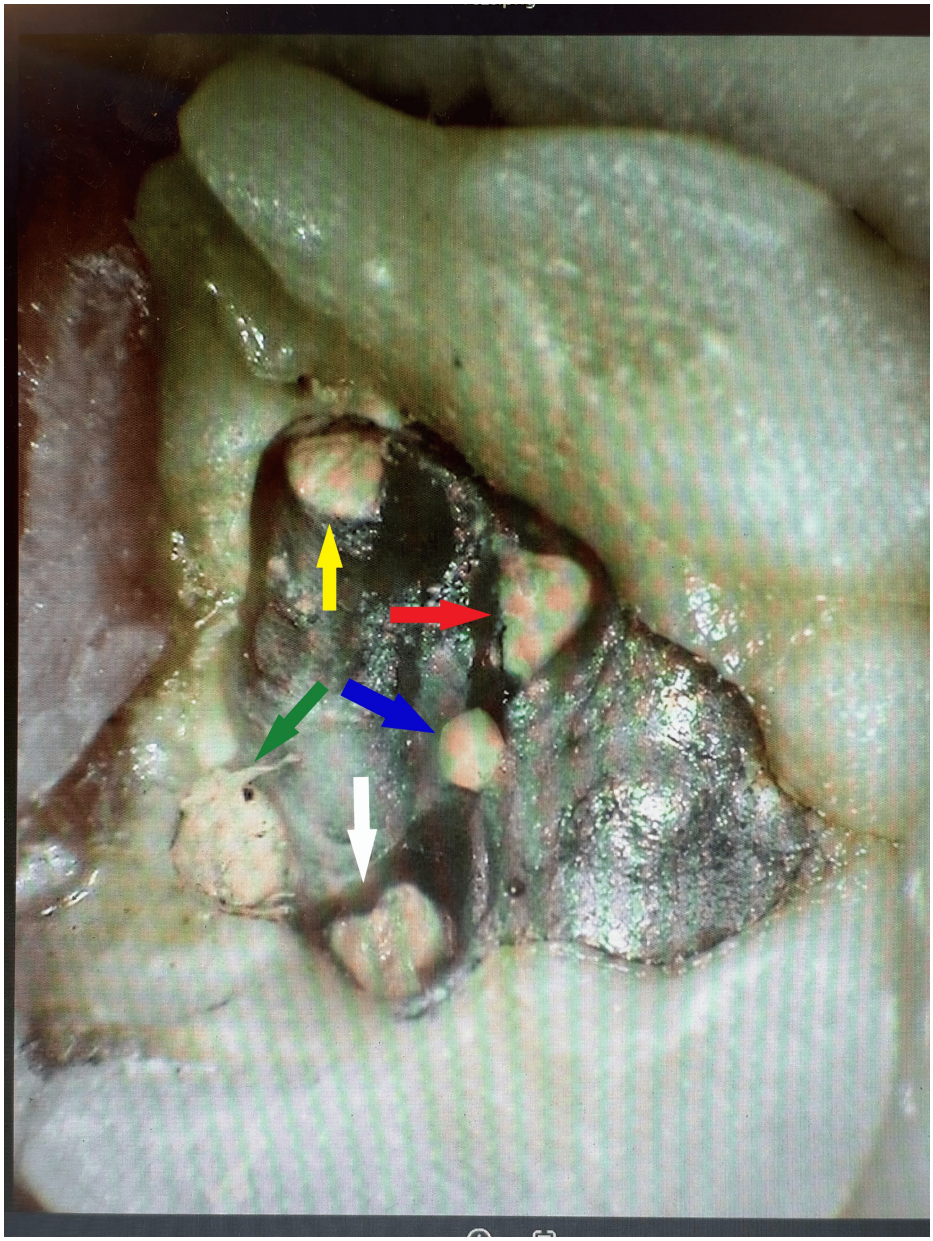


FIGURE 7: Obturation of the five root canals of tooth #3. First mesiobuccal (red arrow), second mesiobuccal (blue arrow), distobuccal (yellow arrow), mesiopalatal (white arrow), and distopalatal (green arrow) canals are indicated.

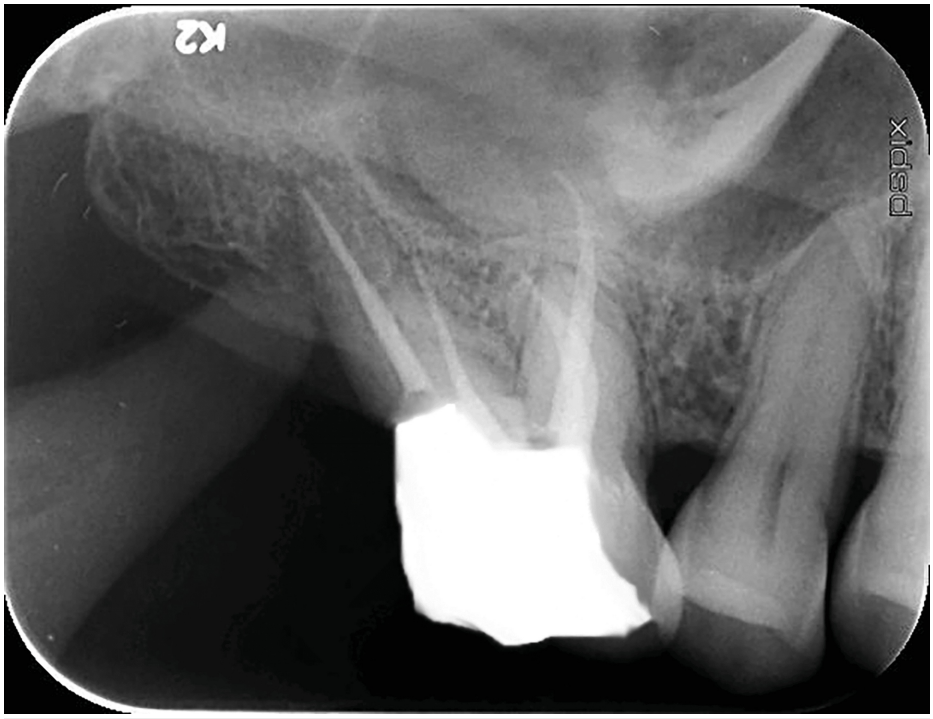


FIGURE 8: Six-month follow-up radiograph showing no clinical or radiographic findings.

Discussion

Variations in root canal morphology and the presence of additional root canals may present significant challenges in endodontic practice. These anatomical variations require clinicians to carefully explore the pulp chamber floor and consider the use of advanced diagnostic technologies when conventional clinical and radiographic findings are insufficient.

The anatomical features of the pulp chamber floor can be used as practical guides for locating root canal orifices [11]. However, variations in root canal morphology and the presence of extra canals may result in atypical orifice configurations, making it more difficult to identify the canals during endodontic treatment [12,13]. The root canal orifices of maxillary first molars generally exhibit a triangular configuration formed by the mesiobuccal, distobuccal, and palatal orifices; this shape becomes rhomboidal when a second mesiobuccal canal is present [14]. Nevertheless, anatomical variations, especially the presence of additional roots and canals, may change this standard arrangement and complicate the identification of root canal orifices [15]. Teeth with two palatal roots often have a greater mesiodistal dimension; therefore, the access cavity should be extended further palatally than usual, resulting in a square rather than a triangular outline [3]. Asghari et al. [16] described a maxillary first molar with two palatal roots in which the orifice map exhibited a square configuration rather than the conventional triangular or rhomboidal patterns.

These findings are consistent with the present case, in which four root canal orifices were initially identified in a rhomboidal arrangement, including the first and second mesiobuccal, distobuccal, and mesiopalatal canals. However, the initial working-length radiograph suggested the possible presence of an additional distopalatal canal. By expanding the access cavity distopalatally toward the internal distopalatal line angle and using an ET40 ultrasonic tip for selective removal of calcified dentin, the distopalatal canal orifice was exposed. Consequently, the identification of the additional distopalatal orifice resulted in a square canal orifice arrangement, with the two palatal orifices positioned notably far apart.

The anatomical configuration of the present case, consisting of four separate roots and five distinct root canals, should be distinguished from previously reported variations. Liu and Shen [17] described a C-shaped, calcified maxillary first molar with five root canals, including two distobuccal canals, two mesiobuccal canals, and one palatal canal, within a single fused root. In contrast, the present case exhibited five distinct root canals, with the presence of four anatomically separate roots inferred from intraoperative, postoperative, and follow-up radiographs obtained at different horizontal angulations, together with the available single axial CBCT image. This comparison demonstrates that the number of root canals does not necessarily correspond to the number of roots and emphasizes the considerable anatomical variability of maxillary first molars. In another case report, Liu and Shen [6] described the endodontic treatment of a maxillary first molar with two separate palatal roots using CBCT and microscopic techniques. Although the

presence of two palatal roots was common to both cases, the present case additionally demonstrated a second mesiobuccal canal, resulting in five distinct root canals.

To the best of our knowledge, maxillary first molars with five distinct root canals within four separate roots, including two palatal roots, have only rarely been documented in the literature. Moreover, previous studies have estimated the prevalence of four-rooted maxillary first molars at approximately 0.047%, with 27.27% of the reported four-rooted cases exhibiting five root canals, indicating the rarity of this anatomical configuration [2]. Taken together, the presence of four distinct roots, including two separate palatal roots, and five root canals makes the present case particularly unusual and anatomically distinctive. The present case is categorized as Type I according to the classification proposed by Christie et al. [7], with two distinct and widely divergent palatal roots, while the buccal roots are cow-horn-shaped and less divergent. Since this classification primarily describes root morphology rather than the number of root canals, the presence of two mesiobuccal canals within a single mesiobuccal root does not contradict the Type I classification.

The application of magnification in endodontic procedures, including dental loupes and operating microscopes, may improve visualization during access cavity preparation and canal identification [18]. Furthermore, when combined with CBCT imaging, magnification may facilitate the assessment of complex root canal anatomy and the identification of additional canal orifices [8]. Previous case reports have described the use of CBCT, dental operating microscopes, and ultrasonic instruments for locating calcified canals [6,16,17]. In the present case, these adjunctive techniques were particularly useful because the additional distopalatal canal was not identified during the initial examination. CBCT provided information regarding the suspected canal location, while microscopic magnification and ultrasonic instrumentation facilitated its exposure through selective dentin removal.

The clinical significance of identifying additional root canals has also been supported by previous research. Hao et al. [19], in a CBCT-based study, reported an association between missed root canals and periapical lesions in endodontically treated teeth. This finding emphasizes the importance of carefully investigating suspected additional canals to reduce the possibility of leaving untreated portions of the root canal system. In the present case, the initial radiograph suggested the presence of a missed distopalatal canal, which was subsequently identified and treated following further anatomical assessment.

Following cleaning and shaping, all five canals were obturated using the single-cone technique with BioRoot RCS, a calcium silicate-based bioceramic sealer. This obturation approach was selected to achieve sealing of the prepared canals using gutta-percha cones in combination with a bioceramic sealer. Previous investigations have reported favorable biological and physicochemical properties of calcium silicate-based sealers, including biocompatibility and alkaline pH [20]. However, these experimental findings should not be considered direct evidence of superior clinical performance or long-term success of the single-cone technique in the present case.

The present case report has certain limitations, including the unavailability of additional multiplanar CBCT reconstructions, which precluded definitive confirmation of root separation along the entire root length based on CBCT imaging alone. Furthermore, the relatively short six-month follow-up period limits the assessment of long-term treatment outcomes, although the patient remained asymptomatic.

Conclusions

This case report underscores the importance of carefully evaluating root canal anatomy in maxillary first molars, especially when clinical and radiographic findings do not match the arrangement of the typical root canal orifice. Additional root canals may complicate both diagnosis and treatment. In this case, two separate palatal roots and five distinct root canals posed significant challenges. Careful modification of the access cavity, combined with magnification and CBCT, facilitated identifying and treating the additional canal.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Reza Sayyad Soufdoost, Shaiva Thakar, Naeim Rajaei

Acquisition, analysis, or interpretation of data: Reza Sayyad Soufdoost, Shaiva Thakar, Naeim Rajaei

Drafting of the manuscript: Reza Sayyad Soufdoost, Shaiva Thakar, Naeim Rajaei

Critical review of the manuscript for important intellectual content: Reza Sayyad Soufdoost, Shaiva Thakar, Naeim Rajaei

Supervision: Reza Sayyad Soufdoost

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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