Endodontic treatment of the maxillary first molar with palatal canal variations: A case report and review of literature

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Abstract

BACKGROUND
Root canal variations frequently occur in maxillary first molars, which greatly affects the success of its treatment. The second mesiobuccal (MB) root canal is the most common root canal variation. However, only a few studies have been conducted on palatal root canal variations. Herein, we report the presence of two separate root canals in a palatal root of the maxillary first molar.

CASE SUMMARY
A 39-year-old woman complained of pain in the maxillary right region for 1 year, which recently worsened. Clinical examination revealed a poorly restored right maxillary first molar and caries detected at the filling marginal. Cold and heat test results indicated severe pain in the right maxillary first molar. The patient was diagnosed with irreversible pulpitis, and subsequently, root canal treatment (RCT) was performed. In total, five root canals were found in the maxillary first molar, including two separate root canals in the palatal root. RCT was successfully performed using an endodontic microscope and cone-beam computed tomography (CBCT). The CBCT image revealed a vertucci type I canal morphology in the distobuccal root, while the MB and palatal root canals were type IV. At the 1-mo follow-up, the maxillary first molar was completely asymptomatic, and the X-ray results indicated a successful RCT. Finally, the ceramic crown restoration was performed.

CONCLUSION
An endodontic microscope and CBCT are useful in effectively identifying and treating root canal variations.
Key Words: Molar; Root canal; Endodontics; Dental pulp cavity; Pulpitis; Case report

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Core Tip: This report presents a case of non-surgical root canal treatment of the right maxillary first molar. Five root canals were identified in the maxillary first molar, including two separate root canals in the palatal root. Endodontic microscope and cone-beam computed tomography were helpful in the localization and treatment of complex canal variations.

INTRODUCTION

Root canal treatment (RCT) is currently the most widely used endodontic procedure and has been effective against apical periodontitis and pulpitis. Furthermore, RCT is performed to completely treat the infection in the root canals and seal canals tightly to preserve the affected tooth. However, this procedure can also fail due to inadequate removal of the infected pulp, insufficient filling, or missed root canals due to anatomical variations[1]. Therefore, the diagnosis and localization of variant root canals are crucial to RCT's success.

In general, maxillary first molars have three roots, but their root canal structures vary greatly. The most common root canal variation is the presence of a second mesiobuccal (MB2) canal, resulting in four root canals in the maxillary first molars[2]. Current extensive studies are focused on MB2 canals. The incidence of MB2 canals is high (> 50%) but varies among different ethnic groups[3-5]. Another common root canal variation in maxillary first molars is C-shaped root canals, which can be located in mandibular molars, first premolars, or maxillary molars and usually in mandibular second molars[6]. Furthermore, the incidence of C-shaped root canals in maxillary molars is approximately 1.8%[7], of which are in maxillary first molars (0.091%-0.8%)[7,8]. However, the second palatal root or the second palatal root canal in maxillary molars are extremely rare. In 1981, Stone and Stroner[9] first proposed the palatal root variations of maxillary molars. The maxillary first molars have complex palatal root canal morphology. For example, a single palatal root has two separate canals, or two separate palatal roots have one canal each. According to Qun et al[10], the incidence of palatal root variation in maxillary molars is only 1.4%. Examining the internal morphology of the root canal system is a major part of planning and implementing RCT, in which palatal canal variations should be considered.

At present, advanced technology and machines have been useful in clinical and dental treatments. In particular, the cone-beam computed tomography (CBCT) and the endodontic microscope have greatly improved the therapeutic effect of RCT.

This case report presents the non-surgical RCT of the right maxillary first molar with palatal canal variations, performed using an endodontic microscope and CBCT.

CASE PRESENTATION

Chief complaints

A 39-year-old woman presented to the Department of Adult Dentistry for endodontic treatment. The chief complaint of the patient was pain in the maxillary right region for the past 1 year.

History of present illness

The patient reported occasional pain in the maxillary right region for 1 year. Three months prior to visiting our department, she had received tooth-filling treatment for the right maxillary first molar from another clinic. Recently, the patient experienced severe pain that occurred under hot or cold stimulation.

History of past illness

The patient had received tooth-filling treatment of the right maxillary first and second molars.
**Personal and family history**
The patient denied any history of systemic diseases and allergies.

**Physical examination**
Clinical examination revealed a class II resin filling on the right maxillary first molar, with caries detected at the filling margin. All cold and heat tests revealed severe pain in the right maxillary first molar.

**Laboratory examinations**
No laboratory examinations were necessary.

**Imaging examinations**
A preoperative digital panoramic radiograph taken 3 mo ago revealed carious lesions in the mesio-occlusion of the right maxillary first molar, which was close to the pulp (Figure 1A).

**FINAL DIAGNOSIS**
A diagnosis of irreversible pulpitis of the right maxillary first molar was made. The treatment recommendations included RCT and follow-up crown restoration. Subsequently, the treatment regimen was explained to the patient, and the patient's consent was obtained.

**TREATMENT**
The carious lesion was removed using bur and a high-speed handpiece, and the pulp was exposed following the administration of 4 mL of 2% lidocaine as a local anesthetic (Produits Dentaires Pierre Rolland, Mérignac, France). After rubber dam (Coltene, Altstetten, Switzerland) isolation, a routine RCT procedure was performed. The pulp chamber was opened, and an access cavity was prepared. Under the endodontic microscope (OPMI® Pico Zeiss, Carl Zeiss Meditec AG, Jena, Germany), four root canals were explored: MB, MB2, distobuccal (DB), and distopalatal (DP) canals (Figure 1B). In addition, unusual anatomical location of the root canal orifices were observed; the canal orifice of the DP canal was not located in the middle corresponding to the MB and DB canals. Under the endodontic microscope, the pulp chamber floor was carefully probed with a DG-16 explore (KaVo, Biberach, Germany), and a suspected fifth canal was discovered, which was named the mesiopalatal (MP) canal (Figure 1B). All treatment procedures were performed with an endodontic microscope with 10 × to 30 × magnification.

In the DP canal, calcification was detected at the apical region, and the canal was dredged with 17% ethylenediaminetetraacetic acid solution (Pulpdent Corporation, Watertown, United States). The working length of the root canals was measured using an electronic apex locator (Dentsply Propex PixiT, Ballaigues, Switzerland). The MB, MB2, DB, and DP canals were cleaned with 2.5% NaOCl solution and shaped using a Marc III nickel-titanium rotary instrumentation (Bomedent, Changzhou, China). All four canals were thoroughly rinsed using endodontic irrigation tips (VDW EDDY™, Munich, Germany). After drying the root canals, the main gutta-percha (Beijing Dayading, Beijing, China) was used to confirm the working length (Figure 1C). Finally, the root canals of the MB, MB2, DB, and DP were obturated by injectable thermoplasticized gutta-percha technique (B&L-beta Gutta Percha Heating System, Gyeonggi-do, Korea) with AH Plus root canal sealer (Dentsply Detrey GmbH, Konstanz, Germany) (Figure 1D). The CBCT image revealed that three roots in the right maxillary first molar contained two and one canals, respectively, whereas two separate canals (MP and DP canals) were well filled (Figure 1E and F).

CBCT was performed to accurately assess the anatomical morphology of the MP canal. Moreover, the CBCT image revealed three roots in the right maxillary first molar and well obturated MB, MB2, DB, and DP canals (Figure 2A). However, in the palatal root, an unfilled root canal was identified (Figure 2B). We confirmed the presence of two separate palatal canals in the single palatal root. Next, the working length of the MP canal was measured (Figure 2C). The MP canal was mechanically shaped with a Marc III nickel-titanium rotary instrumentation. After careful cleaning using the endodontic irrigation tips, the MP canal was dried with absorbent points. The injectable thermoplasticized gutta-percha technique was used for the obturation of the MP canal. The CBCT image revealed that the two separate root canals were well filled (Figure 2D). Both the X-ray and intraoral photograph revealed that the five canals of the maxillary first molar were well obturated after treatment (Figure 2E and F). Finally, the tooth was restored by resin composite filling.

After the RCT, the quality of the obturation in the right maxillary first molar was evaluated using CBCT. The CBCT images revealed that the maxillary first molar contained three roots (MB, DB, and palatal roots; Figure 3A). The axial plane of the CBCT image showed that the MB and DB roots contained two and one canals, respectively, whereas two separate canals (MP and DP canals) were...
Figure 1 Treatment process under the endodontic microscope and X-ray. A: A preoperative digital panoramic radiograph of the maxillary right region. Carious lesions are identified in the maxillary first and second molars; B: Intraoral photograph reveals five root canal orifices (white arrow) in the maxillary first molar, such as mesiobuccal (MB), second mesiobuccal (MB2), distobuccal (DB), mesiopalatal, and distopalatal (DP) canals; C: The X-ray confirms the working length of the MB, DB, and DP canals; D: The MB, MB2, DB, and DP canals are obturated with injectable thermoplasticized gutta-percha; E and F: The postoperative X-ray and cone-beam computed tomography image confirms that the MB, MB2, DB, and DP canals are tightly obturated.

observed in the single palatal root (Figure 3B). The sagittal sectional CBCT images indicated that the MB, MB2 and DB canals were well filled (Figure 3C). Similarly, the MP and DP canals in the palatal root were densely obturated with the gutta-percha (Figure 3D).

OUTCOME AND FOLLOW-UP
At the 1-mo follow-up, the maxillary first molar was completely asymptomatic, and the X-ray indicated that the RCT was successful (Figure 4A). As a result, tooth preparation and final ceramic crown restoration were performed (Figure 4B). After 9 mo, the tooth was clinically asymptomatic and radiographically sound (Figure 4C and D).

DISCUSSION
This case report demonstrates the RCT of the maxillary first molar with palatal root variations. Two separate canals were detected in a single palatal root, which indicated a type IV morphology (vertucci classification). Furthermore, both endodontic microscopes and CBCT helped detect root canal variations.

The maxillary first molars erupted earlier, and the pit and fissure morphology was more complicated than that of the front tooth. Thus, caries and apical periodontitis were more common in clinical presentation[11]. RCT, as an effective treatment method, has been widely used in clinical endodontics. In addition to mechanical techniques and new chemical materials, anatomical variations of the teeth should also be considered when improving the success rate of RCT. The most common root canal system of maxillary first molars was three roots with four canals[12]. The DB and palatal roots of maxillary first molars usually have only one root canal, while the MB root has two or more canals system[13,14]. MB2 canals are detected in 30%-95% individuals in different populations[15,16]. Despite the diversity of anatomical variations of maxillary first molars, studies on palatal root variations of maxillary molars are scarce.

The palatal root variations of the maxillary molars were mainly manifested as a single palatal root with double root canals, or two palatal roots with one canal each[9]. The majority of maxillary molars have three roots, although four roots can be detected occasionally, i.e., a second palatal root. Aydin[17]
Figure 2 X-ray and an intraoral photograph showing the treatment process of the mesiopalatal canal. A: The cone-beam computed tomography (CBCT) image reveals that the maxillary first molar contains three roots, and the mesiopalatal (MP) canal has not been filled (orange arrow); B: The CBCT image reveals an unfilled MP canal in the palatal root (orange arrow); C: The X-ray demonstrates the measurement of the working length of the MP canal; D: The axial sectional CBCT image reveals that the MP canal is tightly obturated (orange arrow); E: The X-ray reveals that five canals of the tooth are well obturated; F: The intraoral photograph reveals that the mesiobuccal (MB), MB2, distobuccal, MP, and distopalatal canals are obturated with gutta-percha.

reported that the incidence of two palatal roots in maxillary first and second molars is 0.17% and 1.41%, respectively. However, in the northwestern Chinese population, Gu et al.[18] proposed that the incidence of two palatal roots in the maxillary first and second molars was only 0.07% and 0.98%, respectively, suggesting the rarity of the palatal root variations in maxillary molars, especially in the maxillary first molars. Studies in the recent 10 years of maxillary molars with palatal root variations are summarized in Table 1. Majority of the studies suggested that maxillary molars have two palatal roots, and each palatal root has a single root canal[17,19-25]. However, only two reports have described the presence of double root canals in a single palatal root[26,27]. Kottoor et al.[26] reported that two root canal orifices were identified in a single palatal root and that the palatal root canal had a type II morphology, while Shahi et al.[28] suggested the incidence of a single palatal root of the maxillary first molars with two root canals is 0.73%, indicating a type V canal morphology. Neelakantan et al.[29] revealed that the incidence of two root canals in the palatal root of maxillary first molars in the Indian population was 5.4%, of which 4% had a type IV morphology, while the remaining 1.4% had a type V morphology. Zheng et al’s study demonstrated that in the Chinese population, the incidence of two root canals in the palatal root of maxillary first molars was only 1.76%[30]. In this case report, we described the presence of two separate root canals in a single palatal root of the right maxillary first molar. The two palatal root canals demonstrated a type IV morphology, which presented as two separate root orifices extending from the pulp chamber to the apex and with two apical foramina.

The use of endodontic microscopes has greatly contributed to the advancement of endodontic treatment. Through magnification using an endodontic microscope, clinicians can identify root canals that are difficult to locate or overlooked with normal vision. Especially for teeth with complex root canal variations, the endodontic microscope demonstrates superior effectiveness. Studies have reported that the use of endodontic microscopes in RCT can improve the detection rate of MB2 canals, and the 10-year survival rate of teeth treated by endodontists was significantly higher[31,32].

The development of radiographic techniques, especially the application of CBCT, has also been greatly helpful for complex endodontic treatments[33]. Traditional X-rays can only reveal the shape of the roots in two dimensions; however, CBCT can provide a three-dimensional image of the tooth, which can better describe root morphology and locate the anatomical variations in a complex root canal system. CBCT can detect the early stage of periapical lesions and improve tooth preservation through non-surgical treatment[34]. In molars, CBCT also demonstrated a higher detection capability for MB2 and C-shaped canals[3,6]. Through preoperative interpretation of CBCT images, the access cavity can be arranged more reasonably. Postoperative CBCT can also be used to evaluate the outcome of RCT. Shetty et al.[35] recently found that CBCT showed potential application in regenerative endodontic procedures. CBCT has proven to be an effective and important assessment tool in endodontic treatment.
Table 1 Various reports on the palatal root variations in maxillary molars

| Ref.                          | Mesiobuccal canal (No.) | Distobuccal canal (No.) | Palatal variations | Palatal root canal (No.) | Molar type               |
|-------------------------------|-------------------------|-------------------------|--------------------|--------------------------|--------------------------|
| Chakradhar et al[19], 2010    | 1                       | 1                       | 2                  | 2                        | Maxillary first molar    |
| Kottoor et al[20], 2011       | 3                       | 3                       | 1                  | 2                        | Maxillary first molar    |
| Fakhrani and Shokraneh[21], 2013 | 1                       | 1                       | 2                  | 2                        | Maxillary second molar   |
| Badole et al[22], 2014        | 3                       | 2                       | 1                  | 2                        | Maxillary first molar    |
| Wu and Wu[23], 2015           | 1                       | 1                       | 2                  | 2                        | Maxillary first molar    |
| Asghari et al[24], 2015       | 1                       | 1                       | 2                  | 2                        | Maxillary first molar    |
| Mohammadzade Akhlaghi et al [25], 2017 | 1                   | 1                       | 2                  | 2                        | Maxillary second molar   |
| Schryvers et al[26], 2019     | 1                       | 1                       | 2                  | 2                        | Maxillary second molar   |
| M P et al[27], 2020           | 1                       | 1                       | 2                  | 2                        | Maxillary second molar   |
| Aydan[17], 2021               | 1                       | 1                       | 2                  | 2                        | Maxillary first molar    |

Figure 3 The anatomical structure of the right maxillary first molar was analyzed by cone-beam computed tomography. A: The cone-beam computed tomography (CBCT) image reveals that the maxillary first molar contains three roots; B: The axial sectional CBCT image demonstrates that the distobuccal (DB) root has one canal, and the mesiobuccal (MB) and palatal roots have two separate canals; C: The sagittal sectional CBCT image reveals that the MB, MB2, and DB canals are well filled; D: The sagittal sectional CBCT image indicates that the mesiopalatal and distopalatal canals in the palatal root are obturated.

In this case, the distance between the orifices of MB and DP canals was shorter than that of MB and DB canals. This unusual situation suggests the possible presence of anatomical variation in the right maxillary first molar. Through careful exploration of the pulp chamber floor with an endodontic explorer, we successfully located the fifth root canal orifice of the palatal root. Although palatal root anatomical variations of the maxillary first molar are uncommon, clinicians should still consider such variations. For unusual root anatomy morphology, careful exploration should be performed with an endodontic microscope and CBCT to avoid missing variant root canals.
CONCLUSION

Palatal root variations of maxillary first molars, which may present as a single palatal root with two separate root canals, merit attention. Careful exploration of the pulp chamber floor can facilitate the detection of root canal variations. Moreover, endodontic microscopy and CBCT are effective adjunctive techniques for RCT.

FOOTNOTES

Author contributions: Chen K performed the treatment, collected data, and wrote the manuscript; Ran X contributed to data collection; Wang Y conceived the study, provided financial support, and reviewed the manuscript; and all authors read and approved the manuscript.

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