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Case report

Retreatment of a C-shaped maxillary second molar: case reports and literature review

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ABSTRACT

The root canal systems of maxillary second molar (MSM) variations are complicated, especially the prevalence of fused roots and consequent merged and C-shaped canals, which represent a clinical challenge because canal configurations can be irregular and unpredictable. The purpose of this article was to present 2 cases with a C-shaped configuration diagnosed during root canal retreatment and perform a literature review of this MSM anatomy. Case 1 reports that two palatal root canals fused into a C-shaped configuration that finally formed an apical foramen, which was classified as Type D. Case 2 reflects the fusion of the distobuccal canal and palatal canal into a C-shaped configuration and the configuration was Type C, which was first reported in a case report. Nonsurgical retreatments were proposed and conducted. Evaluation at a 24-month recall revealed that the two patients were symptom-free, and radiographic examination revealed normal periapical tissue. This report serves to remind clinicians of the complexities of the root canal system and that possible anatomic variation should always be anticipated when formulating an effective root canal treatment plan. The use of CBCT imaging coupled with an operative dental microscope will be helpful in locating and identifying supernumerary canals when a preoperative periapical radiograph shows signs of a fused-rooted MSM.

1. Introduction

Root canal treatment has become a routine effective method for pulpal and periapical diseases, and root canal treatment of the maxillary second molars (MSMs) can be very difficult. Beside the innermost anatomical position of the molar and limited perspective, the complexity and variation of MSM root canal systems are the major reasons for the difficulties of root canal treatment. These untreated and merged canals with irregularities and isthmuses affect the efficiency of removing pulpal tissue and cleaning bacteria from infected root canal system resulting in root canal treatment failure [1, 2]. When root canal treatment fails, nonsurgical root canal retreatment is considered a good treatment option, which seems to be more complicated when dealing with a complex tooth anatomy [3]. To achieve a more effective eradication of these bacteria in the complex tooth anatomy, mechanical debridement must always be implemented with abundant irrigation to treat endodontic infection and reinfection [4]. Hence, a thorough knowledge of root canal anatomy, a good anticipation of their possible anatomic variations and a corresponding treatment strategy will help clinicians to reduce endodontic failure and enhance the success rate of root canal treatment and retreatment.

The most common MSM configuration is the presence of 3 roots and 3 root canals [2, 5, 6, 7, 8, 9]. These roots include the mesiobuccal (MB) root, the distobuccal (DB) root, and the palatal (P) root [2, 8]; a tooth could have one of each type of root. The prevalence of the 3 separate roots varies from 58% to 94.6% [2, 5, 6, 7, 8, 9, 10]. Some anatomic variations of the MSMs have been reported in the literature. The number of roots ranges from 1 to 5 [2,11], with the number of root canals ranging from 1 to 5 [2,12,13]. Compared with that of maxillary first molars (MFMs), the incidence of MSM root fusion was higher, at 5.9%–52.9% [5, 6, 7, 8, 9, 14, 15, 16, 17]. Within root fusion of MSMs, the presence of merged canals was 10.6%–62.3% [6, 14, 16, 18, 19], whereas the prevalence of C-shaped canals was 5.1%–22% [14, 20].

We present successful retreatments of 2 C-shaped canals of MSMs. One patient had 2 P root canals fused into a C-shaped configuration, and the other patient, which was first reported in a case report, reflects the fusion of the DB canal and P canal into a C-shaped configuration. A literature review was also conducted to identify and compare relevant published cases.

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2. Case presentation

2.1. Case 1

A 26-year-old female was referred for root canal retreatment of the maxillary right second molar (tooth #17) because of spontaneous dull pain in the tooth during the process of root canal therapy in another stomatological hospital. The patient's medical history was negative. Clinical examination showed the tooth being sealed with temporary filling material was tender in response to percussion and did not respond to cold or electric pulp tests (Figure 1a-b). Radiological examination revealed radiopaque filling material in the coronal third of the canal but discreet periapices (Figure 1c). There seemed to be periapical radiolucency present at the apex of the DB root (Figure 1c). The CBCT (GIANO, NewTom, Verona, Italy) images were evaluated at a resolution of 0.15 mm. The CBCT axial image revealed a C-shaped canal morphology in the P root. There were 2 different canal orifices in the coronal third of the P canal, but in the middle third, the canals joined to form a C-shaped ribbon-like pattern with one foramen in the apical part (Figure 1d–1f). The sagittal image also revealed the two P canals joined to one foramen in the apical part (Figure 1g). The diagnosis was previously started root canal treatment with symptomatic apical periodontitis in tooth #17. The treatment plan was nonsurgical root canal retreatment, and informed consent was obtained of tooth #17.

Local anaesthesia was achieved with 2% lidocaine with 1:100,000 epinephrine. Treatment was performed using a dental operating microscope (DOM) (OMS 2380, Zumax Medical Co. Ltd, Suzhou, China). Tooth #17 was clamped, and a rubber dam (RD) was placed. After removing the temporary filling material and vitapex in the coronal third of the root canal with an ultrasonic tip (Komet Dental, Lemgo, Germany), three orifices (MB, DB and P) and the unremoved mesial roof of the pulp chamber were found (Figure 2a). When the mesial roof was removed and the isthmus on the C-shaped canal was carefully opened with ultrasonic instruments (Komet Dental) under the DOM, the mesio-palatal canal orifice was explored with a DG16 endodontic explorer (Hu-Friedy, Chicago, IL, USA) (Figure 2b), but the canal was slightly calcified. Four canal orifices (MB, DB, mesio-palatal and disto-palatal) were found. A size #10 K-file (MANI, Inc., Shioya, Japan) was precurved to negotiate the mesio-palatal canal, and the working length (WL) of all the canals was determined with an electric apex locator (Raypex5, VDW, Munich, Germany). Biomechanical instrumentation was performed with a ProTaper Gold File System (Dentsply Sirona, Ballaigues, Switzerland). Sodium hypochlorite (NaOCl, 2.5%) coupled with ultrasonic agitation and ethylenediaminetetraacetic acid (EDTA, 17%) were used for canal irrigation. The mesio-palatal canal orifice was obvious after preparation (Figure 2c). Then, the canals were dried with paper points and calcium hydroxide ($Ca(OH)_2$) (ApexCal®, Ivoclar Vivadent, Liechtenstein) was applied to the canals. The access cavity was sealed with Cavit (3M Espe, Seefeld, Germany), and Fuji IX GP® (GC America Inc., Alsip, IL, USA) was placed for temporalization. Two weeks later, all the canals were irrigated with NaOCl (2.5%) and EDTA (17%). A master cone radiograph was obtained (Figure 2d). Then, obturation of the canals was completed by warm vertical compaction with AH Plus (Dentsply Sirona) as sealer cement.

A final periapical (PA) radiograph was taken to determine the extent of the obturation (Figure 2e). Two weeks later, there was no tenderness to percussion, palpation, or biting. The tooth was restored with a fibre post (Figure 2f) and a full ceramic crown. After one year, CBCT images were acquired to plan orthodontic treatment. Treated tooth #17 showed that the lamina dura surrounding the root was intact; in addition, the periodontal ligament space was uniform on PA radiographs (Figure 2g) and CBCT images (Figure 2h-2j) and was not associated with symptoms.

2.2. Case 2

A 32-year-old female was referred by her dentist for root canal retreatment on tooth #17 because the root canal filling was not good and

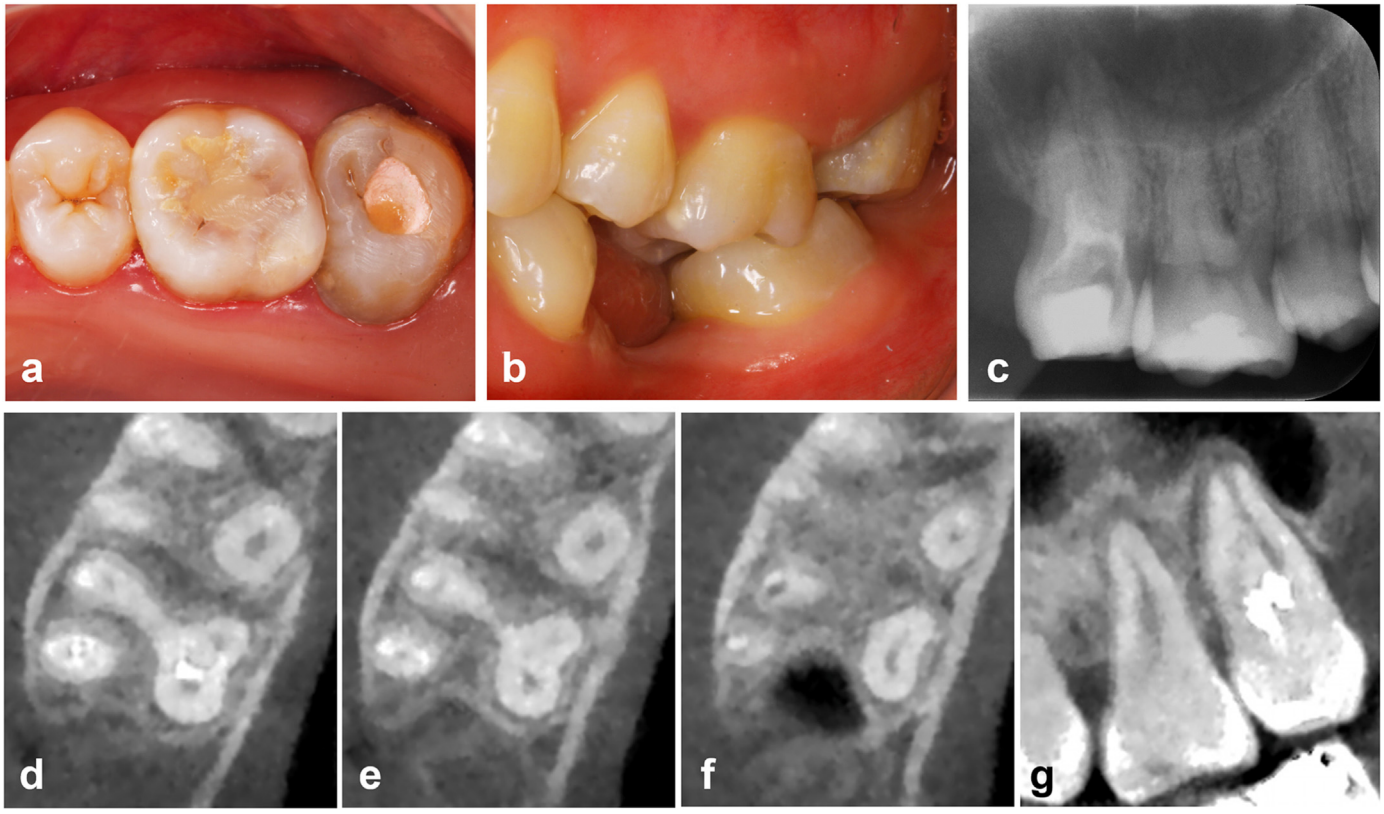

Figure 1. Preoperative assessment by intraoral and radiological examination of the maxillary right second molar. a The tooth was sealed with temporary filling material; b the buccal view; c a preoperative periapical radiograph; d, e, f CBCT axial views (coronal third, middle third, and apical third); g CBCT sagittal view.

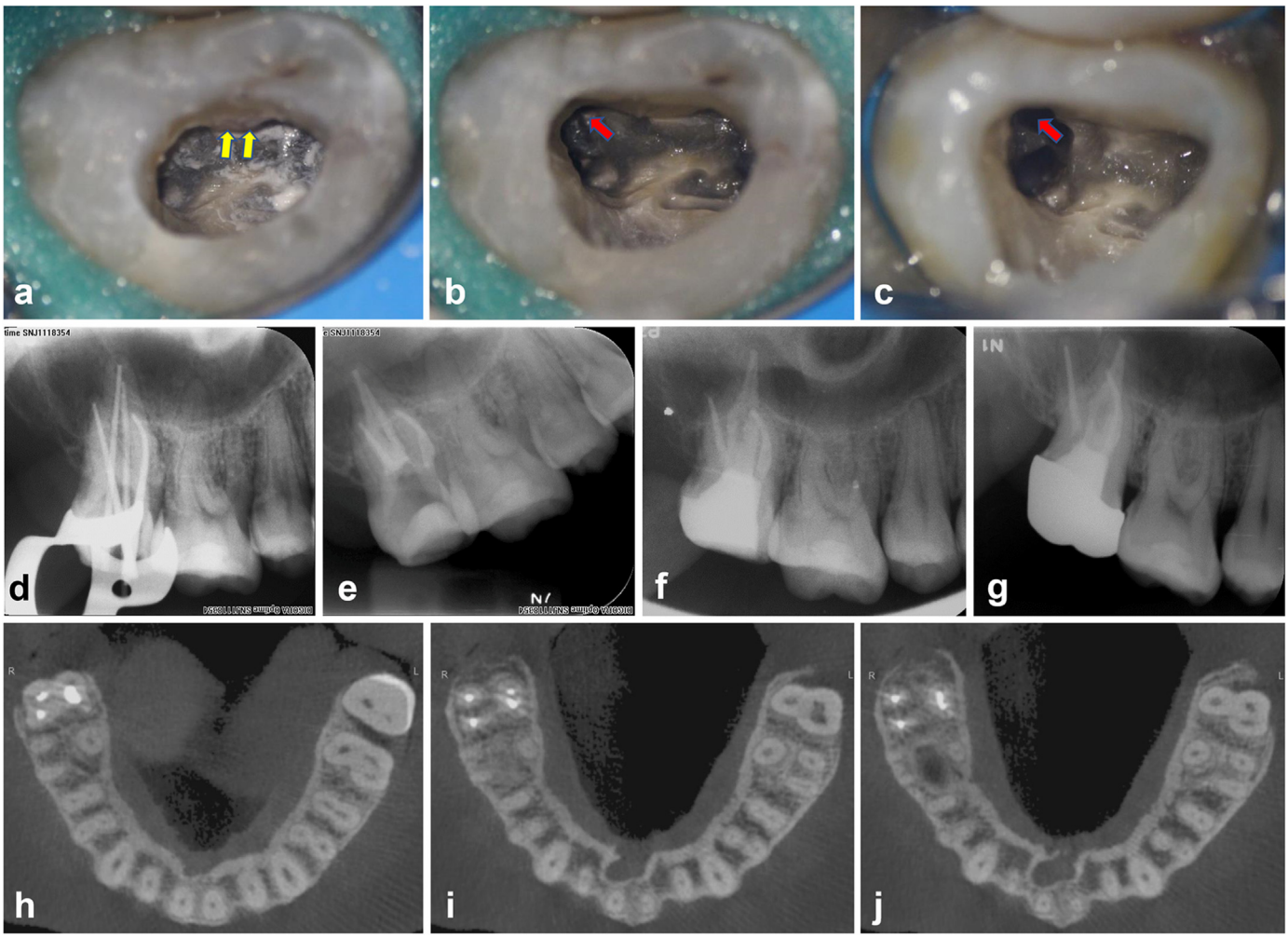

Figure 2. Intraoral and postoperative exhibition of the maxillary right second molar. a pulp cavity after removing the temporary filling material; yellow arrows represent unremoved mesial roof of the pulp chamber; b pulp cavity after removing mesial roof of the pulp chamber; red arrow represents the mesio-palatal canal orifice; c mesio-palatal canal orifice after preparation (red arrow); d master cone fit; e obturation; f post-treatment radiograph; g one-year recall radiograph; h, i, j one-year recall CBCT axial views (coronal third, middle third, and apical third).

the patient had caries and no permanent crown on tooth #17. The patient was symptom-free. The medical history was noncontributory. Clinical examination showed a large composite resin filling on the distal and occlusal aspects of the tooth and caries around the composite resin filling margin (Figure 3a-3b). PA radiography indicated that the root canal of this tooth had been previously filled, though insufficiently with material, and there seemed to be periapical radiolucency present at the apex (Figure 3c). The CBCT (GIANO, NewTom) axial images revealed a C-shaped canal morphology with MB root, DB and P root fusion. The DB and P orifices merged into one orifice, and the MB orifice was independent (Figure 3d–3f). The CBCT sagittal view revealed the mucosa in left and right maxillary sinus slightly thickened (Figure 3g; image not shown for left maxillary sinus). The diagnosis was previously treated with asymptomatic apical periodontitis in tooth #17 and suspected maxillary sinusitis. Nonsurgical retreatment was proposed and the informed consent was signed by the patient. The patient was then referred to otolaryngology department for consultation.

Local anaesthesia was administered with 2% lidocaine with 1:100,000 epinephrine. Tooth #17 was isolated with a RD. After removing composite restoration and carious dentine, two orifices with gutta-percha (GP) filling material were found (Figure 4e). GP was removed with a ProTaper Retreatment Kit (Dentsply Sirona) under a DOM. The WL was obtained using an electric apex locator (VDW). A periapical radiograph with files was taken for working-length determination (Figure 4a). Cleaning and shaping were performed utilizing a ProTaper Gold File System (Dentsply Sirona). NaOCl (2.5%) and EDTA (17%) were used as irrigation solutions. The canal was then dried with sterile paper points and medicated with Ca $(OH)_2$; access was sealed with Cavit (3M Espe) and Fuji IX GP® (GC America Inc). One week later, the DB and P apex third were sealed with mineral trioxide aggregate (MTA) (Figure 4b, 4f). One day later, the DB and P canals were backfilled with warm gutta-percha, and MB was obturated by warm vertical compaction with AH Plus as sealer cement (Figure 4g). A PA radiograph was taken (Figure 4c). Two weeks later, the patient was asymptomatic with tooth #17 exhibiting no apical tenderness or percussion sensitivity. The tooth was restored with onlay (Figure 4h). After 24 months, the patient was symptom-free, and a radiograph of tooth #17 indicated periradicular healing (Figure 4d).

All patients in this study provided written informed consent regarding their personal or clinical details along with any identifying images to be published in this study.

3. Discussion

The two case reports present the unusual anatomy and retreatment of MSMs with C-shaped canal configurations. The morphological variation, failure of root canal treatment and posterior location make retreatment more complicated to perform. Understanding the anatomy and anatomic

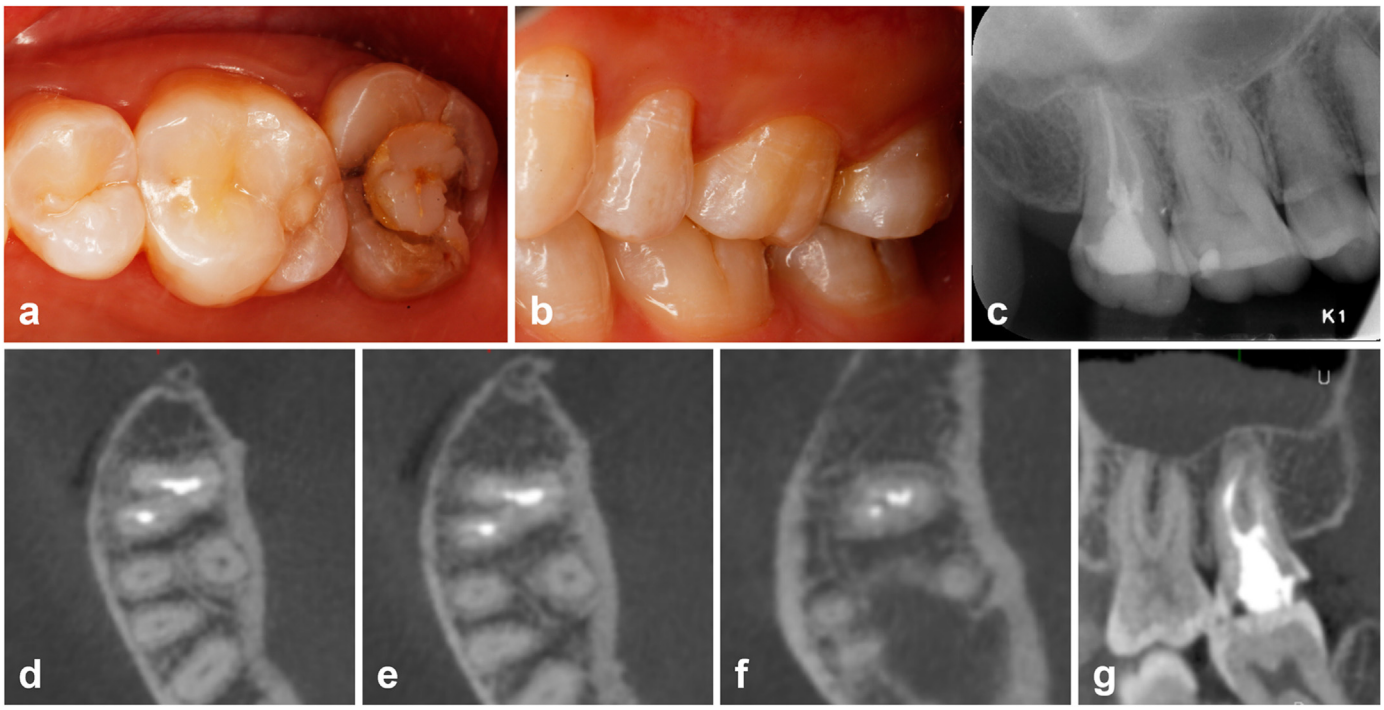

Figure 3. Preoperative assessment by intraoral and radiological examination of the maxillary right second molar. a The tooth was sealed with composite resin and caries around the composite resin filling margin; b the buccal view; c a preoperative periapical radiograph; d, e, f CBCT axial views (coronal third, middle third, and apical third); g CBCT sagittal view.

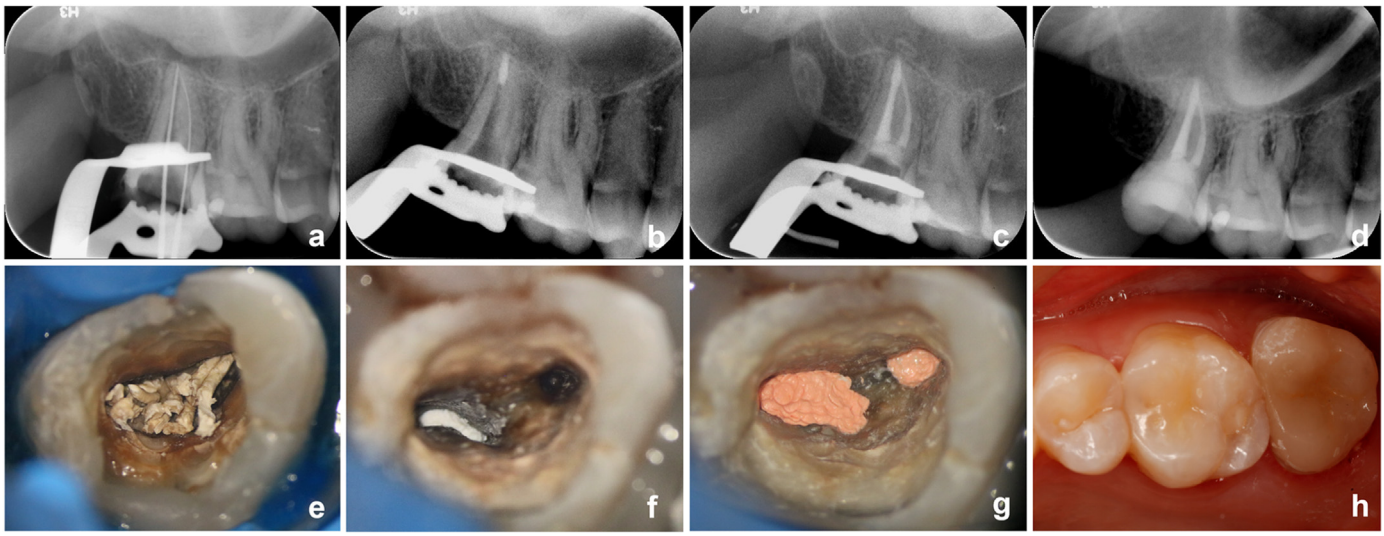

Figure 4. Intraoral and postoperative exhibition of the maxillary right second molar. a periapical radiographs taken for working-length determination; b distobuccal and palatal apex thirds were sealed with MTA; c obturation; d one-year recall radiograph; e pulp cavity after removing composite resin and caries; f MTA in the distobuccal and palatal root canal (the white filling material); g pulp cavity after root canal filling; h onlay over tooth #17.

deviations of roots and their root canals enhances the success rate of root canal retreatment. Moreover, judicious utilization of a DOM and CBCT facilitates the location and negotiation of root canals in upper molars [21].

Root fusion could be observed [22] in maxillary molars. Currently, fusion more frequently occurs in MSMs than in MFMs, which may be the reason for the higher variation in MSMs compared to that in MFMs [14]. It was reported that the prevalence of root fusion in MSMs was 42.25% in China [15], 25.2% in Portugal [18], 14% in Uganda [19], 10.71% in Korea [7], 6.7% in India [16], and 0% in Thailand [23] and Burma [24]. Moreover, the prevalence of root fusion in women (48.44%) was significantly higher than that in men (31.91%), and the percentage of fused roots increased with age in both men and women [8]. The most likely reasons for these outcomes are age- and sex-related cementum deposition, which result in different forms and prevalences of root fusion [8]. Yang et al. [25] classified the shape of the fused root into six categories. Based on the six types, Martins JN et al. added a new one—Type 7: Single conical shaped root [18]. The present case 1 would be classified as Type 2 – MB root fused with P root and case 2 would be classified as Type 3 – DB root fused with P root according to CBCT.

De Moor firstly attempted to classify the fusion of the distobuccal and palatal roots as a maxillary C shape in the year 2001 (0.09%) based on previous documented cases and 2175 root-filled MFMs by X-rays [26]. But this information is only an estimate and cannot be taken as the true

prevalence in the general community. In 2006, Yilmaz et al. [27] reported a C shape in a MFM between the mesiobuccal and distobuccal root, and a few years later, Kottoor et al [28] described a maxillary C-shaped configuration on the palatal root. Until 2016, Martins classified maxillary C-shaped configurations into five types according to which roots were fused by CBCT images of 2227 upper molars [29]: Type A, fusion between the MB and P roots; Type B, fusion between MB and DB root canals, including subtype B1 and subtype B2; Type C, fusion between DB and P roots; Type D, the presence of a large P root canal or fusion between 2 P roots; and Type E, fusion of 3 roots, including subtype E1 and subtype E2. The prevalence for the second molar [29] was 0.5%, 2.1%, 0.2%, 0.1%, and 1.0% for each type, respectively. From the available literature, it was shown that Type B is a more common condition than the other types. Case 1 reports an unusual right MSM with a C-shaped P canal (two P root canals fused into a C-shaped configuration that finally formed an apical foramen), which is Type D. The case is similar to Mamta Singla's report [30], which was classified as Type D with two independent apical foramens in the P root canal. Case 2 in the present report reflects the fusion of the DB canal and P canal into a C-shaped configuration; thus, the configuration was Type C. This is the first case report based on past case reports. As documented in the literature, only 4 articles, including the case report presented in this article, reporting 5 cases, describe the C-shaped canal of MSMs. We collated the relevant information about these cases in Tables 1 and 2. We found three different types (4 cases) of pulp chamber anatomies: 2 patients exhibited fusion of 2 P canals (Type D), 1 patient demonstrated fusion of the MB canal and the DB canal (Type B2), 1 patient showed fusion between the DB and P canals, and 1 patient [2] did not fit into any category (4 canals with one C-shaped MB root, two fused DB roots, and one bulky P root).

Moreover, it was reported that the bilateral symmetry of roots and root canals of MSMs ranged from 61.6% to 84% [5, 8, 9, 31]. Zhang et al. [9] reported that bilateral symmetry of roots and root canals of MSMs was present in 84.0% of the Chinese population. However, a recent report showed that the bilateral symmetry of MSMs was only 13% in the Saudi Arabian population [14], which is significantly lower than values reported previously. The reason for this outcome may be related to ethnic variations and the sample number. However, bilateral symmetry was not found in Table 1. The small sample size could not represent the whole trend. Furthermore, all the cases described in Table 1 involved female patients. It was reported that [14, 29] the occurrence of C-shaped configurations in maxillary molars was higher in females than in males, but the reason for this difference is still unknown.

Table 1. Summary of the case reports with C-shaped canals in maxillary second molars.

References	Age (years) & sex	No. of canals	Location of the C-shaped canal	Other canals	Bilateral	Type
Mamta Singla (2010) [30],	36, female	3	Fusion between 2 P canals	MB, DB	No	D
Daniela Siqueira Lopes (2016) [35],	50, female	2	Fusion between MB and DB canals	P	No	B2
Chang Zeng (2016) [2],	26, female	4	Fusion between 2 MB canals	DB1, DB2, P	No	N/A
Present study, case 1	26, female	3	Fusion between 2 P canals	MB, DB	No	D
Present study, case 2	32, female	2	Fusion between DB and P canals	MB	No	C

MB, mesiobuccal; DB, distobuccal; P, palatal; N/A, not available.

Table 2. Summary of the types of pulp chamber anatomies in the case reports.

Type	Subtype B: Fusion between MB and DB canals	Type C: Fusion between DB and P canals	Type D: Fusion between 2 P canals
Reference	Daniela Siqueira Lopes (2016) [35]	Present case 2	Mamta Singla (2010) [30]; Present case 1

MB, mesiobuccal; DB, distobuccal; P, palatal.

The variation of root canal system represents a challenge to both endodontic diagnosis and treatment. Although the incidence of the variations is not common, if the prognosis of individual cases is concerned, their importance should not be underestimated. The clinician should be aware of unusual root morphologies and their canal configurations and make every effort to locate and treat all canals to avoid incomplete root canal preparation failure of treatment. When root canal retreatment is needed, all available information of the first root canal treatment and radiographic examinations should be obtained for the identification of possible root canal variations prior to retreatment. In the present retreatment cases, CBCT was used to identify the number of root and root canals and to evaluate the quality of the primary root canal filling by providing 3-dimensional images [32]. The higher magnification and illumination by the DOM facilitated localization of root canal orifices and identification of supernumerary canals of MSMs, preferably combining with ultrasonic devices and endodontic explorer. Ultrasonic tips were used to clean the isthmus and grooves, and ultrasonic agitation of the irrigants was applied to maximize the root canal disinfection. Several studies have reported that the combined use of magnification and CBCT images significantly enhanced the success of root canal treatment and retreatment [33, 34]. Meanwhile, some concepts such as champagne test, color roadmap and white line test could be useful to find untreated canals in root canal retreatment. If only the basic principles of root canal retreatment are followed, the prognosis of C-shaped anatomies retreatment will be promising.

4. Conclusion

In this article, two cases of C-shaped maxillary second molar retreatment were reported for the first time. It can be concluded that these cases show the importance of having in-depth knowledge of the existence of these anatomic variations, which ultimately can help in the determination of the possible root and canal configuration of a particular tooth. Meanwhile, careful preoperative clinical examination, rational interpretation of different angles of radiographs and necessary CBCT images, and meticulous treatment plan-making and implementation will improve the prognosis of root canal retreatment.

Declarations

Author contribution statement

All authors listed have significantly contributed to the investigation, development and writing of this article.

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Data availability statement

Data included in article/supp. material/referenced in article.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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