Four-rooted maxillary first molar having C-shaped palatal root canal morphology evaluated using cone-beam computerized tomography: a case report

Jojo Kottoor, BDS,a Natanasabapathy Velmurugan, MDS,b Suma Ballal, MDS,c and Anna Roy, MDS,d Chennai, India
DEPARTMENT OF CONSERVATIVE DENTISTRY AND ENDODONTICS, MEENAKSHI AMMAL DENTAL COLLEGE AND HOSPITAL

The aim of this article was to present an endodontically managed maxillary first molar with unusual C-shaped palatal root morphology confirmed by cone-beam computerized tomography (CBCT) images. CBCT axial images showed the presence of C-shaped palatal root canal anatomy with a palatal root bifurcation at the apical third. The evaluation of CBCT images can result in better understanding of root canal anatomy, which enables the clinician to investigate the root canal system and to clean, shape, and obturate it more effectively. (Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:e41-e45)

The goal of root canal treatment is the thorough cleaning and obturation of the entire root canal system.1 The main reasons for endodontic failure are apical percolation and the presence of microorganisms caused by incomplete instrumentation, inadequate cleaning, insufficient canal obturation, and the presence of untreated canals. Therefore, a thorough knowledge of the root and root canal morphology and an anticipation of their possible morphologic variations are essential to reduce endodontic failure caused by incomplete root canal preparation and obturation.

The largest tooth in volume and most complex in root and canal anatomy, the “6-year molar,” is possibly the most treated and least understood posterior tooth. Anatomic characteristics of permanent maxillary molars are generally described as a group of teeth with 3 roots, 1 palatal and 2 buccal, each root with 1 root canal. In vitro and in vivo studies have demonstrated substantial variation in human maxillary first molar anatomy regarding their roots and root canals. One of the most important anatomic variations is the “C” configuration of the root canal system, which was first described by Cooke and Cox in mandibular molars. C-shaped root canals in maxillary first molars have been reported to have an incidence of 0.12%.8

Once recognized, the C-shaped canal provides a challenge regarding debridement and obturation, especially because it is unclear whether the C-shaped orifice found on the floor of the pulp chamber is continuous up to the apical third of the root.9 Owing to their inherent limitations, radiographs are of limited value in determining the complexity of C-shaped root canal patterns.10 Several clinical studies have highlighted the role of cone-beam computerized tomography (CBCT) as an objective analytical tool to ascertain complex root canal morphology.5,11 The present case report describes the endodontic management of a maxillary first molar with a root canal configuration not yet reported in the dental literature. The tooth had a Melton type III, subdivision II C-shaped anatomy in the palatal root. This aberrant root and canal morphology was diagnosed with an operating microscope and confirmed by using CBCT.

CASE REPORT
A 42-year-old man presented with a chief complaint of spontaneous pain on the right side of his face for the past 2 days. History revealed intermittent pain in the same tooth to hot and cold stimuli for the past 1 month. The medical history was noncontributory. Clinical examination revealed an amalgam restoration with secondary caries in the maxillary left first molar (tooth no. 14). The tooth was tender to vertical percussion. Tooth mobility was within physiologic limits, and the gingival attachment apparatus was normal. Vitality testing of the involved tooth with heated gutta-percha (Dentsply Maillefer, Ballaigues, Switzerland) and dry ice (RC Ice; Prime Dental Products, Mumbai, India) caused an intense lingering pain, whereas electronic pulp stimulation (Parkel Electronics Division, Farmingdale, NY, USA) caused a premature response. Preoperative radiographic evaluation showed evidence of radiolucent area in tooth no. 14 approach-
ing the pulp space with periodontal ligament space widening in relation to the palatal root. Careful observation revealed the presence of 2 distinct root outlines in the apical third of the palatal root (Fig. 1, A). A diagnosis of symptomatic irreversible pulpitis with symptomatic apical periodontitis was made, and endodontic treatment was suggested to the patient.

The tooth was anesthetized by using 1.8 mL (30 mg) 2\% lignocaine containing 1:200,000 epinephrine. The mesial surface of the tooth was restored with type IX glass ionomer cement (Fuji IX; GC Corp., Tokyo, Japan) following caries excavation to allow for optimal isolation. Endodontic access was obtained under rubber dam isolation. Clinical evaluation of the pulpal floor with a DG-16 endodontic explorer (Hu-Friedy, Chicago, IL, USA) revealed 3 root canal orifices: mesiobuccal, distobuccal, and palatal. Observation under the dental operating microscope (Seiler Revelation, St. Louis, MO, USA) revealed a small hemorrhagic area in a groove 2-3 mm mesial to the earlier located palatal orifice. On troughing away the dentin occluding the orifice of the second palatal canal by using ET 18D ultrasonic tips (Satelec/Acteon, Mérignac, France), the 2 palatal canals were connected by an isthmus appearing as the letter C. The conventional triangular access was modified to a trapezoidal shape to improve access to the 2 palatal canals.

Coronal flaring of the root canals was carried out by using a ProTaper SX rotary file (Dentsply Maillefer) to improve the straight line access to the MB, DB and the C-shaped palatal canal (Fig. 1, B). Working length was determined with the help of an apex locator (Root ZX; Morita, Tokyo, Japan) followed by radiographic confirmation. The 2 files in the C-shaped palatal canal appeared to have 2 separate apical exits in the working length radiograph (Fig. 1, C). To confirm this unusual palatal root canal morphology and to rule out the presence of any additional roots/canals, it was proposed to perform CBCT imaging of the tooth. The access cavity was sealed with Cavit G (3M Espe, Seefeld, Germany). Informed consent was obtained from the patient, and a multislice CBCT of the maxilla was performed (Kodak 9500 Cone Beam 3D) with a tube voltage of 60 kV and tube current of 5 mA. All protective measures were undertaken to protect the patient from scattered radiation. Axial images were transmitted to a commercially available dental program (Kodak Dental Imaging Software 3D module v. 2.4) to reformat panoramic and cross-sectional images in all 3 planes. Axial slices of the maxilla were obtained at different levels to determine the palatal canal morphology (Fig. 2, A-C). The palatal root showed 2 distinct root canal orifices with an interconnecting C-shaped isthmus that extended from the cervical third up to the junction of the middle and apical third (Fig. 2, A and B). Further apically, the CBCT axial images confirmed the presence of the root and canal bifurcation (Fig. 2, C and F), thus categorizing the palatal root canal system as a Melton type III, subdivision II C-shaped anatomy.\textsuperscript{12}

CBCT images provided valuable information regarding the canal/root configuration and confirmed the presence of 4 roots and 4 canals which were not clearly visualized in the preoperative periapical radiographs. After administration of 1.8 mL (36 mg) 2\% lignocaine with 1:200,000 epinephrine, cleaning

---

Fig. 1. A, Preoperative radiograph of tooth no. 14. B, Access opening showing mesiobuccal (MB), distobuccal (DB) and the C-shaped palatal canal. C, Working length radiograph of tooth no. 14 demonstrating 2 distinct apical exits for the C-shaped canal within the palatal root. D, Postobturation radiograph of tooth no. 14.
and shaping was performed under rubber dam isolation by using ProTaper Ni-Ti rotary instruments (Dentsply Maillefer) with a crown-down technique. An apex locator reading in conjunction with measurements using the CBCT software (Kodak Dental Imaging Software 3D module v. 2.4) was used to confirm the working length. The isthmus connecting the 2 palatal canals was then circumferentially cleaned and shaped by using hand files (FlexoFiles; Dentsply Maillefer) to ISO no. 25. Irrigation was performed by using normal saline, 2.5% sodium hypochlorite solution, and 17% EDTA coupled with ultrasonic agitation. After completing the biomechanical preparation, the root canals were dried with absorbent points (Dentsply Maillefer), and calcium hydroxide (Calcicur; Voco, Cuxhaven, Germany) was placed as an intracanal medicament with a Lentulo spiral (Dentsply Maillefer). The access cavity was then sealed with Cavit G (3M Espe Dental Products, St. Paul, MN, USA).

At the next appointment, the patient was asymptomatic. Final rinsing of the canals was performed by using 2% chlorhexidine digluconate coupled with ultrasonic agitation. The canals were dried with absorbent points. AH Plus sealer was placed by using Lentulo spiral coupled with ultrasonic agitation. Obturation was carried out using warm vertical compaction of gutta-percha with the Touch ‘n’ Heat system (model 5004; Analytical Technology, Orange, CA, USA) and back-filling with the Obtura II system (Obtura Corp., Penton, MO, USA). The tooth was then restored with a posterior composite resin core (Z100; 3M Dental Products, St. Paul, MN, USA; Fig. 1, D). The patient was advised to accept a full-coverage porcelain crown and was asymptomatic during the subsequent follow-up period.

DISCUSSION

The C-shaped root canal, which was first documented in endodontic literature by Cooke and Cox in 1979, is so named for the cross-sectional morphology of the root and root canal. Instead of having several discrete orifices, the pulp chamber of the C-shaped root canal is a single ribbon-shaped orifice with a 180° arc (or more). This variation may occur in mandibular first molars, maxillary molars, mandibular first premolars and even in maxillary lateral incisors, but it is most commonly found in mandibular second molars.

The majority of maxillary first molars have a Vertucci type I root canal system, and the commonest variation is the presence of a second palatal root canal. The incidence of 2 root canals in the palatal root of maxillary molars has been reported to be between 2% and 5.1%. Other variations include a palatal root canal bifurcation or a trifurcation, fused distobuccal and palatal roots, or 2 distinct palatal roots.

Newton and McDonald in 1984 reported the first case of C configuration in the maxillary first molar. Another case of bilateral C-shaped canals was reported in 1990. In 2002, de Moor concluded that the probability of observing C-shaped canals in maxillary first molars was as low as 0.091%. In a literature review, Cleghorn et al. reported C-shaped roots and canals in only 0.12% of maxillary first molars. Case reports of maxillary first molars with C-shaped root canal morphology are summarized in Table I.

De Moor noted that the C shape in maxillary molars usually results from the fusion of the distobuccal and palatal roots, which may extend to the apical third of the fused roots. The fusion or the lack of division of the roots would lead to an intercommunication between the root canals, resulting in a C-shaped canal pattern.
However, in the present case the palatal root itself contained the C-shaped canal system, with a root bifurcation in the apical third. This could imply that 2 palatal roots were possibly present that failed to divide up to the junction of the middle and apical third, resulting in the C-shaped canal system.

Recently, Singla and Aggarwal25 diagnosed a C-shaped canal in the palatal root of a maxillary second molar using spiral computerized tomography (SCT). They reported 2 different root canal orifices for the palatal root that fused in the middle third to form a C-shaped ribbon-like pattern and exited as 2 separate apical foramens. In the present case, CBCT axial images showed a semicircular ribbon-shaped communication between the 2 palatal root canals until the junction of the middle third and apical third (Fig. 2, D and E). Additionally, the apical third of the palatal root bifurcated into 2 separate palatal roots (Fig. 2, F). Melton et al.,12 in 1991 proposed a classification for C-shaped canals based on their cross-sectional shape. The palatal root canal configuration can be classified under Melton type III, subdivision II (i.e., a C-shaped canal orifice in the coronal third that divides into 2 or more discrete and separate canals in the midroot to the apex). In 2006, Min et al.26 classified C-shaped canals when viewed under a surgical operating microscope. Based on that classification, the present case would be categorized as type I (i.e., a peninsula-like floor with a continuous C-shaped orifice).

In certain instances, conventional 2-dimensional radiographs might not yield sufficient diagnostic information for the clinician to appreciate complicated morphology of the root canal system, as in the case of an unusual complex C-shaped palatal root canal. These problems might be overcome by using newer diagnostic methods, such as SCT and CBCT, which can produce 3-dimensional images of individual teeth and the surrounding tissues.11 However, it is essential that the radiation dose is kept “as low as reasonably achievable” when exposing patients to ionizing radiation.27 In our case, CBCT was used over SCT because of its low effective radiation dose. Each radiation exposure must be justified, after which the radiographic view and therefore patient radiation dose taken must be optimized.

C-shaped canals are certainly an endodontic challenge. The access cavity for teeth with a C-shaped root canal system varies considerably and would require modifications based on the pulpal morphology.28 In the present case, a modified trapezoidal access cavity was prepared to locate the 2 palatal canals and allow for their subsequent instrumentation. C configuration is known to present a complex root canal anatomy. Its irregular areas house soft-tissue remnants or infected debris that may escape regular cleaning and shaping procedures, necessitating supplementary efforts to accomplish a successful root canal treatment.9,29 The connecting fin or isthmus is usually a thin area and is susceptible to rupture during canal preparation, resulting in a strip perforation.9,10 The CBCT images also provided valuable information regarding the critical remaining dentin thickness in the isthmus area of the palatal root canal system. Considering these factors, observant use of circumferential filing coupled with ultrasonic irrigation was used to thoroughly debride the narrow canal isthmus in the palatal root. Proper placement of sealer with ultrasonic agitation of endodontic files is critical, regardless of the choice of obturation technique.22 Gutmann and Rakusin29 suggested use of thermoplasticized gutta-percha for obturation of C-shaped canals. Accordingly, thermoplasticized gutta-percha by means of the Touch ‘n’ Heat and Obtura II systems were used to allow for a more complete obturation of the complex root canal system.

CONCLUSIONS

This case report highlights 2 important anatomic variations in the palatal roots of maxillary first molars. The first is the presence of a palatal root bifurcation at the junction of the middle and apical thirds, and the second is the presence of a C-shaped root canal within the palatal root. Careful location and negotiation of the canals and the meticulous mechanical and chemical debridement of the pulp tissue should be carried out to successfully manage a C-shaped root canal.

Table 1. Case reports of maxillary first molar having C-shaped root canal configuration

<table>
<thead>
<tr>
<th>Root configuration</th>
<th>No. of canals</th>
<th>Root canal anatomy</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 roots</td>
<td>2</td>
<td>C-shaped canal</td>
<td>Newton and McDonald (1984)3</td>
</tr>
<tr>
<td>2 roots</td>
<td>2</td>
<td>C-shaped canal</td>
<td>de Moor (2002)7</td>
</tr>
<tr>
<td>2 roots</td>
<td>3</td>
<td>C-shaped canal</td>
<td>Dunkner et al. (1990)23</td>
</tr>
<tr>
<td>2 roots</td>
<td>3</td>
<td>C-shaped canal (bilateral)</td>
<td></td>
</tr>
<tr>
<td>2 roots</td>
<td>4</td>
<td>C-shaped canal (trifurcate in the apical one-third)</td>
<td>Yilmaz et al. (2006)24</td>
</tr>
</tbody>
</table>

Table 1. Case reports of maxillary first molar having C-shaped root canal configuration
REFERENCES


Reprint requests:
Dr. Jojo Kottoor
Postgraduate Student
Department of Conservative Dentistry and Endodontics
Meenakshi Ammal Dental College and Hospital
Alapakkam Main Rd.
Maduravoyal, Chennai – 600 095
India
drkottoor@gmail.com