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Management of C Shaped Canals: A Case Series

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Abstract
Introduction: *The complexity of root canal system and its variations may affect the negotiation of the canals, chemo-mechanical cleaning and shaping and three-dimensional obturation of the root canal system thus, ultimately the endodontic treatment outcome. C-shaped canal configuration is commonly seen in mandibular second molars. This article aims to discuss the different variation in C-shaped canal morphology, preoperative radiographic diagnosis, clinical diagnosis upon access preparation as well as guidelines for endodontic treatment of the same.*
Case series: *This case report highlights the management of four different cases of C- shaped canal configurations using lateral condensation gutta-percha technique and management of retreatment of C- shaped canal.*
Conclusion*: Complex intricacies and diverse morphology of C shaped canals can be managed with advanced irrigation technique in combination with lateral condensation obturation technique. Therefore, it is necessary to be aware of the possible anatomic variations for their successful management.*
Keywords: *C- shaped canal, mandibular second molar, retreatment*

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I. Introduction

The C-shaped canal was first documented in endodontic literature by Cooke and Cox is so named for the cross-sectional morphology of the root and root canal.[1]The pulp chamber of the C- shaped canal is a single ribbon shaped orifice with a 180˚ arc (or more), which in mandibular molars starts at the mesiolingual line angle and sweeps around the buccal to end at the distal aspect of the pulp chamber.[2] Below the orifice level, the root structure can harbour a wide range of anatomic variations. Failure to identify & detect C-shaped anatomy may potentially lead to shaping only of the main canals & inadequate cleaning of connecting fin & webs. This may result in failure of endodontic treatment due to following reasons (1) remaining pulpal tissues in the small branches (2) anatomical complexity: isthmus between the two canals filled or an apical ramification that had not been treated; (3) missing canal: untreated canal regardless of the presence of an isthmus; (4) underfilling (5) iatrogenic problem: perforation, transportation, or file separation; and (6) calcified canal.[3,4]

Therefore, careful study of the root canal anatomy and morphology in preoperational radiograph followed by location and negotiation of the canals and the meticulous mechanical and chemical debridement of the pulp tissue and three dimensional obturation should be carried out to successfully treat a C-shaped canal.

II. Case I

Figure 2-1 Preoperative radiograph

A 40-year-old male patient reported with a chief complaint of spontaneous pain in lower left back region of jaw since 3 days. Radiographic examination revealed single conical root with deep occlusal radiolucency extending to the pulp with absence of peri-radicular changes radio-graphically. A diagnosis of symptomatic irreversible pulpitis with chronic apical periodontitis was done. The tooth was anesthetized by using 1.8 ml 2% lignocaine containing 1:200,000 epinephrine. Endodontic access cavity was prepared under rubber dam isolation. The pulp chamber was irrigated with 2.5% sodium hypochlorite to debride the chamber fully and to identify the nature of the canal system. The pulpal floor showed one mesial orifice & a broad C-shaped distal orifice resembling semi-colon type morphology thus categorizing the root canal system as Fan's category II shaped anatomy. Working length was determined using apex locator (ROOT ZX mini, J. Morita Japan) and confirmed radiographically. Cleaning and shaping was carried out with ProTaper Gold rotary

Figure 1-2 Working length radiograph

Figure 1-3 Master cone radiograph

endodontic system followed by circumferential filling was done in each canals and fins and troughs with 25number type K-file (Maillefer, Ballaigues, Switzerland). Using 5 ml 17% of EDTA with 3ml of saline for 1 minute for smear layer removal followed by final irrigation protocol of 3ml EDTA for 1 min per canal, 3ml of saline for 1min per canal and 3ml of 5.25% of sodium hypochlorite for 1min per canal coupled with ultrasonic agitation was employed. The canals weredried with paper point. Obturation was carried out by lateral condensation technique with AH Plus sealer. Apical seal in mesio-lingual canal & C-shaped canal was obtained using gutta percha no.45 (6%) & no.40 (6%), respectively. Tooth was then restored with composite resin (Z350 XT 3M ESPE), followed by coronal coverage.

Figure 1-4 Post obturation radiograph

III. Case II

Figure 2-1 Pre-operative radiograph

Figure 2-2 Access cavity preparation

Figure 2-3 Working length radiograph

Figure 2-4 Master cone radiograph

Figure 2-5 Post-obturation radiograph

A 25-year-old female patient presented with a chief complaint of spontaneous, intermittent pain in lower right posterior teeth for the past 7 days. Intra oral examination revealed deep occlusal caries in right mandibular second molar. A root with a wide root canal is seen on the pre-operative radiograph of a mandibular right second molar with a diagnosis of asymptomatic irreversible pulpitis. After access preparation is done, a careful evaluation of the pulp chamber floor reveled the C-shaped configuration of the canal orifice and single canal. Thus, the anatomy revealed classified as category IV of Fan's anatomic classification. The lengths of the root canal were measured electrometrically with (ROOT ZX mini, J. Morita Japan). Cleaning and shaping were done with ProTaper universal system followed by circumferential filling in each canal and fins and troughs with 25number type K-file (Maillefer, Ballaigues, Switzerland). Protocol for cleaning and shaping same as case I was followed. The apical seal of the canal was obtained with gutta-percha no. 50 (6%). Tooth was then restored with composite resin (Z350 XT 3M ESPE), followed by coronal coverage.

IV. Case III

A 36-year-old man presented with a chief complaint of intermittent pain on lower posterior teeth for the past 1 month. The tooth was tender to vertical percussion. Preoperative radiographic evaluation showed evidence of radiolucent area approached the pulp space. The diagnosis of chronic irreversible pulpitis was done. The tooth was anesthetized by using 1.8 mL (30 mg) 2% lignocaine containing 1:200,000 epinephrine. Endodontic access was obtained under rubber dam isolation. Clinical evaluation of the pulpal floor revealed one distal and connecting mesiobuccal, mesiolingual orifice thus classified as category III (C3) of Fan's anatomic classification. Working length was determined with the help of an apex locator (Root ZX; Morita, Tokyo, Japan) followed by radiographic confirmation. Cleaning and shaping were performed using ProTaper Ni-Ti rotary instruments (Dentsply Maillefer) with a crown-down technique.

Figure 3-1 Pre-operative radiograph

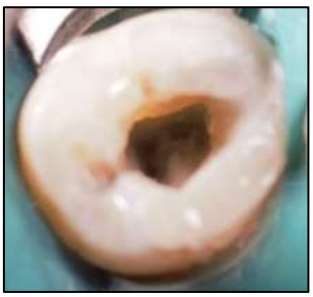


Figure 3-2 Access cavity preparation

Figure 3-3 Master Cone radiograph

Figure 3-4 Post obturation access cavity

The isthmus connecting the mesiobuccal and mesiolingual was then circumferentially cleaned and shaped by using Type-K files (Maillefer, Ballaigues, Switzerland). Irrigation was performed by using normal saline, 5.25% sodium hypochlorite solution, and 17% EDTA coupled with ultrasonic agitation as mentioned in case I. The canals were dried with absorbent points. Obturation was carried out with lateral condensation technique. The tooth was then restored with a composite resin (Z350 XT 3M ESPE).

Figure 3-4 Post- obturation radiograph

V. Case IV

Figure 4-1 Pre-operative radiograph

Figure 4-2 Access preparation

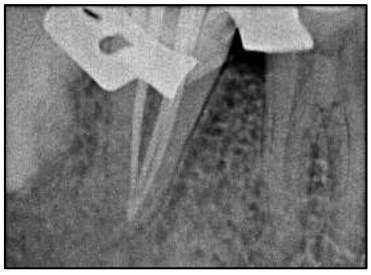


Figure 4-3 Master Cone radiograph

Figure 4-4 Post obturation radiograph

Figure 4-5 Post obturation access cavity

A 35-year-old man presented with a chief complaint of Spontaneous, intermittent pain on lower right side in the oral cavity for the past 10 days. Radiographic examination revealed poor endodontic treatment. Tooth was anesthetized by using 1.8 mL (30 mg) 2% lignocaine containing 1:200,000 epinephrine. Endodontic access was obtained under rubber dam isolation. Removal of gutta-percha was initially performed by means of ProTaper retreatment D1, D2 and D3 rotary files (Maillefer, Ballaigues, Switzerland) and then manually completed with Type-K files (Mani Inc., Japan), solvent made from orange oil (RC solve Prime dental) and 5.25% sodium hypochlorite as irrigating solution. Circumferential filling was done in each canal with K-type of file. Removal of smear layer was done using 3ml of 17% of EDTA with 3ml of saline, followed by final irrigation was done as in case I with additional 3ml of 2%chlorhexdine solution per canal coupled with ultrasonic agitation. Apical seal in mesiobuccal & mesio-lingual canal was obtained using gutta percha no.30 (6%) & no.35 (6%) distal canal. Obturation was completed with lateral condensation method. Tooth was then restored with composite resin (Z350 XT 3M ESPE), followed by coronal coverage.

VI. Discussion

This case series describes the treatment of four mandibular second molars with a C-shaped root canal system. C-shaped canal configuration mostly found in mandibular second molars with frequencies ranging from 2.7% to 45.5% but few authors documented this in maxillary first, second and, third molar, mandibular first and, third molar, mandibular first premolar and even in maxillary lateral incisor.[5,6,7,8,9,10,11,12] The C-shaped canal configuration shows an ethnic predilection, it has frequently been reported in East Asian population groups like Chinese (0.6%-41.27%) and Koreans (31.3%-44.5%) display a high prevalence of this variant.[3] The pulp chamber of the C-shaped canal is a single ribbon-shaped orifice with a 180° arc (or more). Various techniques like Pre-operative radiographs,[13,14] Cone Beam Computed Tomography (CBCT),[15] Panoramic dental radiography,[16] Micro-Computed Tomography (μCT)[17] etc. along with clinical access cavity preparation can help in diagnosis of C-shaped canal morphology.

Preoperative radiographic diagnosis:

Fernandes M. et al. stated that recognition of a C-shaped canal configuration before treatment can facilitate effective management, which will prevent irreparable damage that may put the tooth in severe jeopardy.[18] A preoperative radiograph and an additional radiograph with 20˚ mesial or distal projection may be the noninvasive means to clinically provide clues about the canal morphology. Usually, radiograph shows radicular fusion or proximity, a large distal canal, a narrow mesial canal, and a blurred image of a third canal in between.[13,14] When the communication or fin connecting the two roots is very thin, it is not visible on the radiograph and may thus give the appearance of two distinct roots.[19] In C-shaped molars the radiograph may reveal a large and deep pulp chamber. The pulp chamber in the teeth with C-shaped canals may be large in the occlusoapical dimension with a low bifurcation. The fact that the canal may be connected in the coronal portion yet separated in the apical region. When the canal orifice appears continuously connected at the subpulpal level, a separate root canal exiting at the apical level may be present.[18,20]

Clinical diagnosis following access cavity preparation:

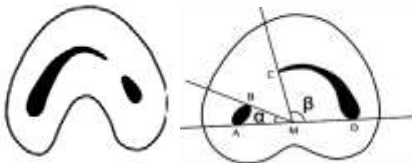
Clinical diagnosis of C-shaped canals can be established only following access to the pulp chamber. Fan et al.[20] stated that for mandibular second molar to qualify as having a C-shaped canal system, it has to exhibit all the following three features:

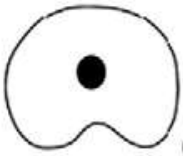
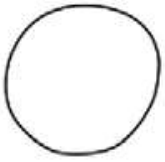
a. Fused roots

b. A longitudinal groove on lingual or buccal surface of the root

c. At least one cross-section of the canal should belong to the C1, C2, or C3 configuration, as per Fan's anatomic classification.[18,20] (Table.1)

Table 1. Fan's Anatomic Classification of C-shaped canals

C1		**Category I:** The shape was an interrupted "C" with no separation or division
C2		**Category II:** The canal shape resembled a semicolon resulting from a discontinuation of the "C" outline, but either angle α or β should be no less than 60°
C3		**Category III:** 2 or 3 separate canals, and both angles, α or β were less than 60°

C4		**Category IV:** Only one round or oval canal in that cross section
C5		**Category V:** No canal lumen could be observed (which is usually seen near the apex only).

During the attempts to locate all the canals, the overextension of the access cavities in width and depth might result in the perforation in the pulpal floor or in the coronal third of the root. Or an attempt to negotiate the isthmus-like small canals in the connecting fin area may result in unnecessarily too large orifices and/or strip perforation in the corner of the main canal adjacent to the connecting fin area. Modifications in the access cavity designs may be required for teeth with C-shape configuration to facilitate location and negotiation of the complete canal system depending on type of C-configuration is present.[21] When the orifice is continuous C-shape or arc like Mesiobuccal-Distal (MB-D), the number of canals can vary from one to three; when the orifice is oval or flat, the number of canals may be one or two; and when the orifice is round, there is usually only one canal below the orifice.[22] Hence, for continuous C-shape orifice, 3 initial files are inserted, one at either end and one in the middle. When the orifice is oval, two files are inserted, that is, one file at each end of the orifice and when the orifice is round, one initial file is inserted.

Cleaning and shaping:

While cleaning a C-shaped root canal morphology, particular attention should be paid to 'isthmus' (Grocholewiczet al. 2009),[23] 'trough' (Barnett 1986)[24] and 'fin' (Bolger and Schindler 1988)[25]. These structures are narrow, ribbon-shaped communications between two root canals that may contain pulp or pulp-derived tissue and therefore are reservoirs for bacteria. The application of nickel-titanium (NiTi) rotary instruments reduces the risk of perforation during mechanical root canal preparation. After instrumentation by NiTi rotary instruments, K-files could be passively introduced into the canal, and filing could be specifically directed towards the isthmus areas to obtain better debridement in clinical practice. Because of the large area of canal space, intracanal instruments may not reach and debride the entire portion of the continuum, making irrigation procedures more significant.[18] C-shaped canal system with rotary instruments should be assisted by ultrasonic irrigation.[26] Besides the use of sonic and ultrasonic, the use of chemical agents for disinfection cannot be over emphasized in the treatment of C-shaped root canal system. Sodium hypochlorite (5.25% NaOCl) has been used successfully for the dissolution of organic matter in root canals.[3] In addition, ethylenediaminetetraacetic acid (EDTA) was shown to dissolve inorganic matter and to remove the smear layer. A combination of rotary instruments with other assisting instruments should be used as an approach that results in better access to the apical anatomy and consequently a higher success rate for treatment.

The C-shaped canal configuration presents with variations in both the number and location of the canals, it is extremely important to perform root canal instrumentation cautiously to avoid perforation, with copious irrigation and, modification in the obturating technique to enhance the prognosis of the tooth and successfully treat the C-shaped canal.

Obturation:

Obturation of C-shaped canals may require technique modifications.[27] As it is said by sir Herbert Schilder, "What you remove from the root canal is more important than what you place inside it." Cold lateral condensation was the method employed for obturation in each case. If cold condensation technique is adopted for obturation, deeper penetration of condensation instrument in several sites is mandetory.[28] The mesiolingual and distal canal spaces can be prepared and obturated as standard canals. However, sealing the isthmus is difficult if lateral condensation is the only method used. To ensure this, Barnett recommended placing a large diameter file in the most distal portion of the canal, before seating the master cone in the mesial canal. The file is then withdrawn and the master cone of the distal canal is seated, followed by placement of accessory cones in the middle portion of the C-shaped canal.[24] Warm vertical condensation is the method of choice for the three-dimensional obturation of the C-shaped canals.

Postoperative restoration and prognosis:

Composite is a better choice as the core or as the final restoration of these teeth.[29,30] During follow-up radiographic examination, the dentist should look for furcal breakdown because that region is the most difficult to obturate and is associated with the greatest risk of perforation. Restorations with failure in the furcation have a poor prognosis.

VII. Conclusion

The C-shaped canal configuration presents with variations in both the number and location of the canals, it is extremely important to diagnose variation in anatomy and perform root canal instrumentation cautiously to avoid perforation, with copious irrigation and modification in the obturating technique to enhance the prognosis of the tooth and successfully treat the C-shaped canal.

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