**CASE REPORT**

**C-SHAPED ROOT CANAL MORPHOLOGY IN MANDIBULAR SECOND MOLAR**

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Abstract: One of the most important anatomic variations is the “C” configuration of the canal system. The early recognition of these configurations facilitates cleaning, shaping, and obturation of the root canal system. “C” configuration, which is an important anatomic variation, presents a thin fin connecting the root canals. This article describes the endodontic treatment of a C-shaped mandibular second molar with a single canal from coronal third to apex along with a review.

Keywords: c-shaped canal, root canal treatment, anatomic variation, mandibular second molar.

Introduction: Knowledge of root canal anatomy and variations between ethnic groups is essential for clinicians to facilitate effective root canal treatment. Of particular interest is the canal configuration of the mandibular second molar. Predicting and negotiating a C-shaped root canal configuration is challenging. The C-shaped canal, which was first documented in endodontic literature by Cooke and Cox, 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 canal is a single ribbon-like orifice with a 180° arc (or more), which in mandibular molars starts at the mesiolingual line angle and sweeps around the buccal to the end at the distal aspect of the pulp chamber. Below the orifice level, the root structure can harbor a wide range of anatomic variations. These can be classified into two basic groups: (1) those with a single, ribbon-like, C-shaped canal from orifice to apex and (2) those with three or more distinct canals below the C-shaped orifice.

Once recognized, the C-shaped canal provides a challenge with respect to debridement and obturation, especially because it is unclear whether the C-shaped orifice found on the floor of the pulp chamber actually continues to the apical third of the root. Failure of the Hertwig’s epithelial root sheath to fuse on the lingual or buccal root surface is the main cause of C-shaped roots, which always contain a C-shaped canal. The C-shaped root may also be formed by coalescence because of deposition of the cementum with time. C-shaped canals appear when fusion of either the buccal or lingual aspect of the mesial and distal roots occurs. This fusion remains irregular, and the two roots stay connected by an interradicular ribbon. The floor of the pulp chamber is deep and has an unusual anatomic appearance. Two or three canals may be found in the C-shaped groove, or the C-shape may be continuous throughout the root length.

Melton’s Classification

Melton et al. proposed the following classification of C-shaped canals based on their cross-sectional shape:

1. Category I: continuous C-shaped canal running from the pulp chamber to the apex defines a C-shaped outline without any separation (i.e., C1 in Fig. 1).
2. Category II: the semicolon-shaped (;) orifice in which dentine separates a main C-shaped canal from one mesial distinct canal (i.e., C2 in Fig. 1).
3. Category III: refers to those with two or more discrete and separate canals: subdivision I, C-shaped orifice in the coronal third that divides into two or more discrete and separate canals that join apically; subdivision II, C-shaped orifice in the coronal third that divides into two or more discrete and separate canals in the midroot to the apex; and subdivision III, C-shaped orifice that divides into two or more discrete and separate canals in the coronal third to the apex (i.e., C3 in Fig. 1).

Fan’s Classification (Anatomic Classification)

Fan et al. modified Melton's method into the following categories:
1. Category I (C1): the shape was an interrupted “C” with no separation or division (Fig. 1A).
2. Category II (C2): the canal shape resembled a semicolon resulting from a discontinuation of the “C” outline (Fig. 1B), but either angle α or β (Fig. 2) should be no less than 60°.
3. Category III (C3): 2 or 3 separate canals (Fig. 1C and D) and both angles, α and β were less than 60° (Fig. 3).
4. Category IV (C4): only one round or oval canal in that crosssection (Fig. 1E).
5. Category V (C5): no canal lumen could be observed (which is usually seen near the apex only) (Fig. 1F).

Fan’s Classification (Radiographic Classification)
Fan et al. classified C-shaped roots according to their radiographic appearance into three types:
1. Type I: conical or square root with a vague, radiolucent longitudinal line separating the root into distal and mesial parts. There was a mesial and a distal canal that merged into one before exiting at the apical foramen (foramina) (Fig. 4A).
2. Type II: conical or square root with a vague, radiolucent longitudinal line separating the root into distal and mesial parts. There was a mesial and a distal canal, and the two canals appeared to continue on their own pathway to the apex (Fig. 4B).
3. Type III: conical or square root with a vague, radiolucent longitudinal line separating the root into distal and mesial parts. There was a mesial and a distal canal, one canal curved to and superimposed on this radiolucent line when running toward the apex, and the other canal appeared to continue on its own pathway to the apex (Fig. 4C).

Prevalence
C-shaped canal is not uncommon, and this is confirmed by studies in which frequencies ranging from 2.7% to 8% have been reported. 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. When present on one side, a C-shaped canal may be found in the contralateral tooth in over 70% of individuals.

Radiographic Diagnosis
The root configuration of molars having this canal shape may be represented as a single fused root or as two distinct roots with a communication, the latter of which may not be very obvious at first glance. Thus, its recognition is improbable until access to the pulp chamber has been achieved. Preoperative radiographs show close fused roots or images of two distinct roots. This occurs when the fin is thin and thus, not visible on the radiograph and makes clinical recognition of the C-shaped canal unlikely until access to the pulp chamber has been achieved. Radiographic interpretation is overall more effective when based on film combinations (“preoperative and working length radiographs” or “preoperative and final radiographs” or “all three radiographs”) than on single radiographs. Among the latter, working length radiographs are more helpful than the preoperative and final ones, whereas preoperative radiographs are the least effective in diagnosing the C-shaped cases.

Clinical Diagnosis
Clinical recognition of C-shaped canals is based on definite observable criteria (i.e., the anatomy of the floor of the pulp chamber and the persistence of hemorrhage or pain when separate canal orifices were found). In a true C-shaped canal, it is possible to pass an instrument from mesial to distal aspect without obstruction. In other configurations, such passage is impeded by discontinuous dentine bridges. If a file could not be passed through the isthmus of the pulpal floor during clinical inspection, the practitioner might consider the root canal as being separated.

Fused roots and C-shaped roots may present with narrow root grooves that predispose to localized periodontal disease, which may in fact be the first diagnostic indication of such anatomic variance.

Case Report
A 32 year old male patient with non-contributory medical history reported in the post-graduate clinics of Institute of Dental Sciences having pain in the left mandibular posterior region. The clinical examination showed large carious lesion in tooth 37 with pulp exposure. The tooth was sensitive to
percussion and palpation. Vitality tests (hot, electric pulp test [EPT]) on the involved tooth showed abnormal responses indicating that irreversible pulpitis had occurred. Preoperative radiograph was taken which revealed deep carious lesion in tooth 37(Fig. 5a). The radiograph also revealed the presence of complex root canal system in tooth 37. Only one root was observed in the radiograph having a large pulp chamber and a single radicular space extending from the coronal third to the apex.

Figure 5. (a) Pre-operative radiograph of left mandibular second molar showing a single conical root and a large pulp chamber (Melton's C1 C-Shaped Canal). (b) Working length radiograph. (c) Post-operative radiograph showing the obturation of the single large root canal.

Nonsurgical endodontic treatment was planned in tooth 37. After the administration of the local anesthetic (2% Lignocaine with 1:1,00,000 epinephrine), access cavity was prepared in tooth 37 under rubber dam isolation. On entry into the pulp chamber, a single large root canal orifice was found with the help #15 K-file (Dentsply, Maillefer, Switzerland) which continued to apex. The pulp chamber was examined with magnifying loupe which showed the presence of only one root canal orifice. Working length was established with radiograph by #15 k-files (Dentsply, Maillefer, Switzerland) (Fig. 5b) and confirmed using an Apex locator (Smarpex, META Biomed, Korea). The canal was cleaned and shaped with hand K-files and nickel titanium rotary files (Protapers, Dentsply Maillefer, Switzerland) frequently irrigating with 5% sodium hypochlorite and 17% EDTA.

Canals were dried with sterile paper points and obturated with gutta-percha and AH Plus sealer (Dentsply DeTrey GmbH, Germany) utilizing thermoplasticized technique using E & Q Plus (META Biomed, Korea). Access cavity was restored with composite resin. Radiograph was taken to confirm the quality of the obturation (Fig. 5c).

Discussion

“C” configuration is known to present a complex canal anatomy, its irregular areas house soft-tissue remnants or infected debris that may escape thorough cleaning or filling procedures, thus requiring supplementary effort to accomplish a successful root canal treatment. The tooth in question has a continuous C-shaped canal running from the pulp chamber to the apex without any separation. Thus it is a Category 1 type of C-shaped canal morphology (C1 of Melton's classification).6 On observing the pulp chamber with magnification loupe, a large root canal orifice was seen which continued to the apex. The hand instrument (K-file) was freely mobile inside the orifice and it could be moved from mesial to distal of the pulp chamber without any interference. The root canal was thoroughly irrigated with 5% sodium hypochlorite to eliminate any pulpal remnants from the existing isthmuses. Extravagant use of small files and 5.25% NaOCl is a key to thorough debridement of narrow canal isthmuses.17 The necessity for deep-orifice preparation and careful probing with small files characterize the C-shaped category more accurately. In all categories, the mesiobuccal and distal canal spaces usually can be prepared normally. However, the isthmus should not be prepared with larger than no. 25 files; otherwise, strip perforation is likely. Alternative canal cleaning techniques, such as those that use ultrasonics, would be more effective. An increased volume of irrigant and deeper penetration with small instruments using sonics or ultrasonics may allow for more cleansibility in fan-shaped areas of the C-shaped canal.6 Obturation of C-shaped canals may require technique modifications. Gutta-percha can be thermoplasticized with spreaders heated in an open flame or electric spreaders or delivered by injectable systems. Single-insertion thermoplasticized gutta-percha condensation devices may not condense gutta-percha adequately into the long narrow
Isthmuses. In addition, proper placement of sealer with ultrasonic endodontic files is critical, regardless of the choice of obturation technique. The compaction of softened gutta-percha and sealer throughout a well-prepared canal space should predictably move gutta-percha and sealer into root canal aberration.

**Conclusion**
The success of root canal treatment in tooth with C-shaped anatomy depends on proper diagnosis, thorough cleaning and shaping using an established technique of obturation and proper post operative restoration. When these sound principles are followed, the long-term prognosis for the C-shaped root retention equals that of other molars.

**References**