CASE REPORT

MANAGEMENT OF C SHAPED ROOT CANALS

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ABSTRACT

The aim of this article is to discuss the etiology, incidence, anatomic features, classification, diagnosis and management of the C-shaped canal configuration along with some case presentations. C-shaped canal configuration is a variation that has a racial predilection and is commonly seen in mandibular second molars. The intricacies present in this variation of canal morphology can pose a challenge to the clinician during negotiation, debridement and obturation.

Keywords: C-shaped canals, mandibular second molar, mandibular first premolar, root canal morphology

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INTRODUCTION

A thorough knowledge of the root canal anatomy and its variations is required for achieving success in root canal therapy, along with diagnosis, treatment planning and clinical expertise. One such variation of the root canal system is the C-shaped canal configuration. It is termed so because of the C-shaped cross-sectional anatomical configuration of the root and root canal. This condition was described for the first time in literature by Cooke and Cox1 in 1979, though Weine et al.,[2] reported that several clinicians had suggested its presence in lectures earlier.

Numerous incidence studies prove the racial predilection of this variation. Though most commonly found in mandibular second molars, the C-shaped canal configuration may also occur in mandibular premolars, maxillary molars, and mandibular third molars. The C-shaped canal configuration presents with variations in both the number and location of the canal(s), as the canal(s) courses from the coronal to the apical third. The complexity of this canal configuration proves to be a challenge with respect to debridement and obturation and possibly the prognosis during root canal therapy. 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. The aim of this article is to discuss the etiology, incidence, anatomic features, classification, diagnosis and management of the C-shaped canal configuration with the help of few case reports.

Etiology

Ever since the identification of the C-shaped canal anatomy, various causes have been postulated for its formation. The failure of fusion of Hertwig's epithelial sheath is the most lucid explanation for the formation of the C-shaped canal configuration. Failure of the Hertwig's epithelial sheath to fuse on the buccal side will result in the formation of a lingual groove, and failure to fuse on the lingual would result in a buccal groove. Hence, this fusion is not uniform and a thin interradicular ribbon connects the two roots together. Failure of the sheath to fuse on both the buccal and lingual sides will result in the formation of a conical or prism-shaped root.[3]

Incidence

The C-shaped canal configuration shows an ethnic predilection. It has frequently been reported in countries belonging to the Asian continent. East Asian population groups like Chinese (0.6%-41.27%) and Koreans (31.3%-45.5%) display a high prevalence of this variant. Among the South Asian countries, Burmese population showed a prevalence of 22.4%, which was much higher than the Indian, Thai or Sri Lankan population.[3]

Canal configuration has been shown to have a high prevalence in mandibular second molars with a percentage ranging between 2.7%-45.5%. Incidence studies in mandibular premolars have been reported in Chinese, Indian and Iranian population, with the highest frequency being reported in the Chinese population (29.7%). The C-shaped variation in canal anatomy has also been reported in maxillary first molars (0.12%), maxillary third molars (4.7%), mandibular third molars (3.5%-4%) and mandibular second premolars (1%).[3] There is no correlation of C-shaped canal configuration with gender and also with age and tooth position. Bilateral occurrence of C-shaped canals has been reported in a percentage of 70%-81%.[3]

Anatomic Features

The following are the pertinent features in relation to the external root anatomy and configuration of the pulp chamber and the root canal system usually found in C-shaped mandibular molars, though similar features may be found in C-shaped maxillary molars and mandibular premolars.[3]

Roots

A conical or square configuration is characteristic of roots having a C-shaped canal. The root configuration of molars having this canal shape may be represented by fusion of either the facial or lingual aspect of the mesial and distal roots. The roots display an occluso-apical groove on the buccal or lingual surface, which represent the line of fusion between

mesial and distal roots. The surface opposite this radicular groove is convex.

Pulp Chamber

The pulp chambers of teeth with C-shaped canals mostly have greater apico-occlusal width with a low bifurcation. This results in a deep pulp chamber floor, which has uncommon anatomical configuration. The connecting slit that gives the tooth its name of "C-shaped" may have closure to the buccal or lingual. If the buccal portion of the mesial and distal roots is fused, the slit goes through the area of fusion, and so the "C" is closed to the lingual. If the lingual portion of the roots is fused, then the "C" is closed to the buccal.

Root canal system

The root canal system of C-shaped canals shows broad, fan-shaped communications from the coronal to the apical third of the canal. The canal(s) change shape from the coronal aspect of the root. For example: A continuous C-shaped canal would change to a semicolon configuration in the midroot and then becomes continuous C-shape in the apical third of the root or vice versa. Accessory and lateral canals, inter-canal communications and apical delta can be found in the apical region of C-shaped canals.

Classification

Classification The C-shaped canal system can assume many variations in its configuration so a comprehensive classification can help in true diagnosis and management.[4]

Melton's Classification

Melton et al.5 in 1991 proposed the following classification of C-shaped canals based on their cross-sectional shape: Melton's Classification Melton et al. 5 in 1991 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

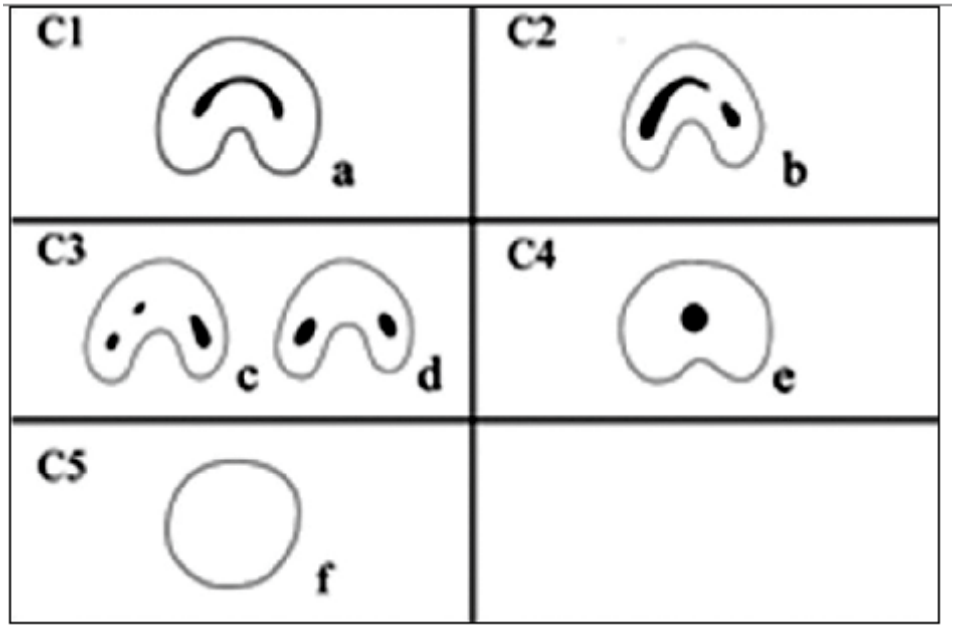


Figure 1. Classification of C-shaped canal configuration[4]

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).

In this classification, there has been no clear description of the difference between categories II and III as well as the clinical significance. Furthermore, they examined three arbitrary levels of the root, and hence little information is present describing how the canal shape may change over its length. Also, they noted that the second type of C-shaped canal is the most common.

Fan's Classification

(Anatomic Classification)

Fan et al. 6 in 2004 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 or (Fig. 2) should be no less than 60°.
3. Category III (C3): 2 or 3 separate canals (Fig. 1C and D) and both angles, and , 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).

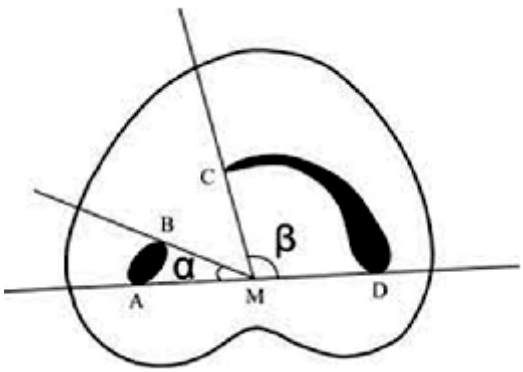


Figure 2. Measurement of angles for the C2 canal. Angle is more than 60°.
(A and B) Ends of one canal cross-section,
(C and D) ends of the other canal cross-section;
M, middle point of line AD; angle between line AM and line BM; angle between line CM and line DM

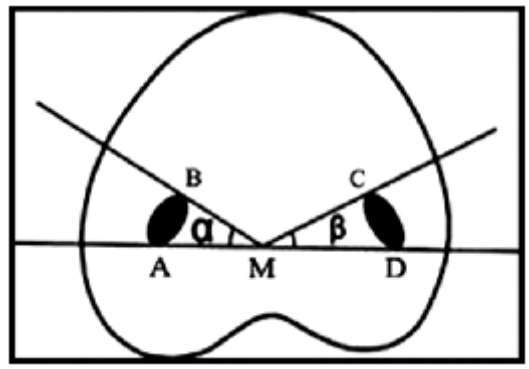


Figure 3. Measurement of angles for the C3 canal. Both angle and angle are less than 60°. (A and B) Ends of one canal cross-section; (C and D) ends of another canal cross-section; M, middle point of line AD; , angle between line AM and line BM; , angle between line CM and line DM

They considered that although the C-type orifice may look like 2 or 3 separate orifices, an isthmus linking them is often discernible. The single, round, or oval canal (C4 in their classification), which may be found near the apex, should be considered as a variation because other parts of the canal have shown the "C" configuration. They noted that "C" shape can vary along the root length so the clinical crown morphology or the appearance of the orifice may not be good predictors of the actual canal anatomy. In this classification, one of the canals in the C2 category would appear as an arc (with 60°, Fig. 2) (i.e., the C2 canal would be more likely to extend into the fused area of the root where the dentin wall may be quite thin). They are more difficult to clean and shape than C3 canals.

Fan's Classification

(Radiographic Classification)[7]

Fan et al. (11) 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).

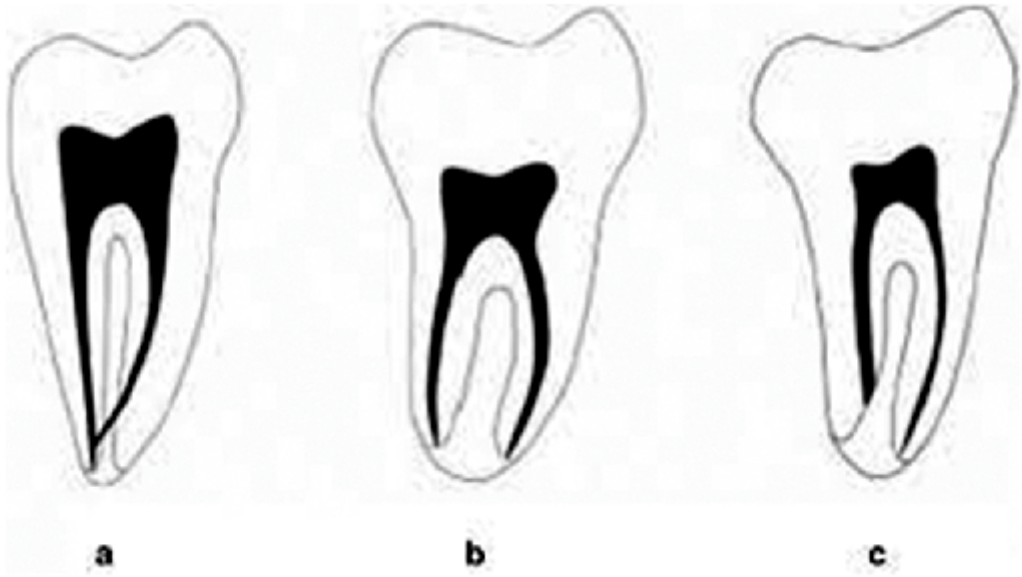


Figure 4. Radiographic types. (A) Type I, (B) type II, and (C) type III4

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).

Diagnosis

Preoperative radiographic diagnosis

A preoperative radiograph usually provides various clues in the identification of any variation in root canal morphology. Some investigators described four radiographic characteristics that can allow prediction of the existence of this anatomical condition: radicular fusion, radicular proximity, a large distal canal or a blurred image of a third canal in between. Hence, a C-shaped root in a mandibular second molar may present radiographically as a single-fused root or as two distinct roots with a communication. 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. The radiograph may also reveal a large and deep pulp chamber, usually found in C-shaped molars.

Fan et al.[8], divided the radiographic appearance that the C-shaped teeth are present with three types In type I, the C-shaped canal system actually appears as two distinct canals, because the isthmus that links the mesial and distal "main" canals is very thin and hence is not detected radiographically. In the radiographic type II, the mesial and distal canals assume their own individual course to the apex. Thus, there are apparently two distinct canals on the radiograph. In type III, one canal continues its course to the apex giving the image of a distinct canal whereas the other(s) proceeds very close to or within the fused area, that is, the "web" between the two main roots in the apical third. Hence, the canal may seem to exit into the groove radiographically. Wang et al.,[9] reported a higher incidence in the recognition of C-shaped canals using a combination of radiography and clinical examination under the microscope (41.27%) than using the radiography (34.64%) or clinical examination (39.18%) alone.

Preoperative clinical diagnosis

The crown morphology of teeth with C-shaped anatomy does not present with any special features that can aid in the diagnosis. A longitudinal groove on lingual or buccal surface

of the root with a C-shaped anatomy may be present. Such narrow grooves may predispose the tooth to localized periodontal disease, which may be the first diagnostic indication.

Clinical diagnosis following access cavity preparation

Some investigators asserted that since radiographic diagnosis is difficult, clinical diagnosis of C-shaped canals can be established only following access to the pulp chamber. Magnification with Loupes and microscopes are very useful for clinical procedures. The pulpal floor in C-shaped teeth can vary from peninsula like with a continuous C-shaped orifice to non C-shaped floors as per the classification given by Min et al., However, when a C-shaped canal orifice is observed, say, under the operating microscope, one cannot assume that such a shape continues throughout its length. Fan et al.,[6] 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.

Clinical and radiographic diagnoses during working length determination

Working length radiographs are more helpful than preoperative and final radiographs in diagnosing C-shaped canals. In a true C-shaped canal, (single canal running from the orifice to the apex) it is possible to pass an instrument from the mesial to the distal aspect without obstruction. In the semicolon type, (one distinct canal and a buccal or lingual C-shaped canal) whenever an instrument was inserted into any side of the C-shaped canal, it always ends in the distal foramen of the tooth and a file introduced in this canal could probe the whole extension of the C. When negotiating the C-shaped canal, instruments may be clinically centered. Radiographically, the instruments may either converge at the apex or may appear to be exiting the furcation, thus adding to the confusion and troublesome task of determining whether a perforation has occurred. Usage of diagnostic aids like cone-beam CT can help in understanding the anatomical variations.

Management

The high percentage of canal irregularities, such as accessory to lateral canals, and apical delta in a C-shaped canal makes it difficult to clean and seal the entire canal system adequately. The wide fins and small surface area of these canals preclude complete debridement using traditional hand instrumentation techniques, which can lead to failure of root canal therapy.[3] Therefore, careful location and negotiation of the canals and the meticulous mechanical and chemical debridement of the pulp tissue should be carried out in order to successfully treat a C-shaped canal.

Location and negotiation of canals

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. 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. 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. Calcifications present in the pulp chamber may disguise the C-shape of the canal system. In such cases, several orifices may be probed that link up on further instrumentation. There are also chances of missing out on canals because of bifurcation, dentin fusion, and curvatures. Exploration should be carried out with small size endodontic files, such as a no. 8, 10, 15 K-file with a small, abrupt apically placed curve, to

ensure that these irregularities are not missed.[3]

Cleaning and shaping

In order to access all the irregularities in the C-shaped canal system, the orifice portion of the slit can be widened with orifice openers. However, C1 (continuous C type) and C2 (semicolon type) configurations always have a narrow isthmus and care should be taken to avoid perforation during their preparation. There is a high risk of root perforation at the thinner lingual walls of C-shaped canals during cleaning and shaping. The Abou-Rass et al.[10],'s anti-curvature filing technique has been recommended to avoid danger zones that are frequently present at mesiolingual walls. However, Jin et al.[11] reported that the tooth structure of the groove area in C-shaped canal was thicker than that of the danger zone of normal second mandibular molar and hence, the C-shaped canals were as safe from strip perforation as other teeth in the limitation of this study. Extreme caution must be taken to prevent strip perforation during cleaning and shaping of C-shaped mandibular premolars, which display thin dentinal walls in the radicular groove area.

Very few studies have evaluated the effectiveness of cleaning procedures in relation to C-shaped root canals. Though nickel-titanium rotary instruments seem to be safe in such canals, further enlargement to an apical dimension greater than size 30 (0.06 taper) is not recommended.[12] After instrumentation by NiTi rotary instruments, K-files could be passively introduced into the canal, and filling could be specifically directed towards the isthmus areas to obtain better debridement in clinical practice. The recently developed self-adjusting file (SAF) system has been reported to be more efficacious than the protaper system for shaping of C-shaped canals.

Because of the large area of canal space, it is doubtful that intracanal instruments can reach and debride the entire portion of the continuum, making irrigation procedures more significant. It is recommended that cleaning of the C-shaped canal system with rotary instruments should be assisted by ultrasonic irrigation. Besides the use of sonication and ultrasonication, the use of chemical agents for disinfection cannot be over emphasized in the treatment of C-shaped root canal system. Some authors have advocated the use of calcium hydroxide as an intracanal medicament for a period of 7-10 days.

With regard to the management of C-shaped canal configuration in mandibular premolars, many complicating factors make them difficult to treat. Anatomically the diameter and width of mandibular first premolar is much smaller than mandibular second molars. The small size of mandibular first premolar limits the coronal access to the complex root canal system, which unlike the mandibular second molar, is found apically.

Obturation

Obtaining a three dimensional fill of a C-shaped canal may prove to be a problem due to the various intricacies present within the root canal system. If a cold condensation technique is adopted for obturation, deeper penetration of condensation instruments in several sites will be necessary. To ensure proper placement of the master cones in C-shaped canals, Barnett13 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.

Studies have shown that following the cleaning and shaping, the remaining dentin thickness around the canals is usually 0.2 to 0.3 mm. The resultant forces of compaction during obturation can exceed the dentin canal resistance, which may result in root fracture and perforation of the root. In this regard, the thermoplasticized gutta-percha technique may prove to be more beneficial. The aim of this technique is to move the gutta-percha and sealer into the root canal system under a hydraulic force. But in C-shaped canals the hydraulic forces can dramatically decrease and can seriously compromise the obturation quality due to the following reasons: (a) there are divergent areas that are frequently unshaped, which may offer resistance to obturating material flow (b) communications exist between the main canals of the C-shape

through which the entrapped filling materials that should be captured between the apical tug back area and the level of condensation may pass from one canal to another. Walid's technique[14] aimed to overcome these problems. This technique involves placing the master points simultaneously in the C-shaped canal. A large plugger is placed on one of the seared master points while the other master point is down packed with a smaller plugger. This increases the resistance towards the passage of obturating material from one canal to another. The smaller plugger is then held in place while the other point is down packed. This offers backpressure on entrapped filling materials and enhances the seal.

Ultrasonic compaction (UC) Lateral compaction was performed, and the extended ends of the cones were seared off. The SO4 ultrasonic spreader tip attached to the Suprasson PMax Ultrasonic unit (Satelec, Merignac, France) with a power setting of [8] was inserted into the canal without force to within 2-3 mm from the end-point of preparation, and was placed into the centre of the gutta-percha mass and activated. The spreader was moved in short continuous in and out motions approximately 8-10 times with slight apical pressure until 2-3 mm short of the working length. Subsequently, the ultrasonic spreader was deactivated, slightly rotated and then withdrawn. The selected finger spreader was used to compact laterally the softened mass of gutta-percha. Additionally, 2-3 accessory cones were laterally compacted in the same manner. Ultrasonic compaction, followed by cold lateral compaction, was repeated one more time.

Canals with increased flare resulted in significantly poorer quality of fill using LC. For wider and irregular-shaped canals, instead of compacting and deforming gutta-percha cones during spreader penetration, the cones will be displaced laterally. Voids and sealer will mostly found along the perimeters of the gutta-percha mass, possibly indicating eventual loss of integrity because of poor adaptation of gutta-percha to the canal walls. Void formation was probably due to the failure of the accessory gutta-percha cones in filling the space created by the compacting instrument..

The pilot study showed that two insertions of the ultrasonic spreader into the canal that was initially filled by the lateral compaction technique were sufficient to thermoplasticize the whole guttapercha mass. Although not significant, this observation suggests that the UC may result in a filling of greater density. A higher percentage of gutta-percha was observed at all three levels in the UC group compared with the LC group.[15] This finding also supports the scanning electron microscope investigation by Baumgardner & Krell [16], where a more homogeneous gutta-percha mass with fewer voids was reported in root canals filled by UC. They found that canals filled by UC resulted in significantly less apical leakage than canals obturated by LC. The warm gutta-percha should adapt more adequately to the canal walls and irregularities. The lower percentage of sealer compared with LC was probably due to the mixing of sealer and gutta-percha during ultrasonic compaction, so the definite areas of sealer became smaller.

Post endodontic restorations

Post endodontic restoration of teeth with a C-shaped canal configuration may also be compromised due to the relatively small amount of dentin between the external surface of the root and the internal canal system. At least 1 mm of sound tooth structure should be present around a post if needed, for resistance to root fracture. Hence, prefabricated or cast posts increase the risk of creating a strip perforation. Besides, no prefabricated post (circular or conical i.e. of a circular cross section) would fit the C-shaped canals. Since the floor of the pulp chamber is deep it can provide ample retention from the available undercuts. Chamber-retained, bonded amalgam or composite is a better choice as the core or as the final restoration in these teeth.[3]

Case 1

Mandibular second molar with irreversible pulpitis, buccal caries, Preoperative IOPA radiograph gave indication of a possible 'C' shaped anatomy. Caries driven access, MB and Distal canals are connected in a C Shape manner. ML canal as a separate one. Manual dynamic and Sonic agitation of Irrigation solutions. (1ml 17% EDTA, 30-35ml 5%Na Hypo), Zno Eugenol Sealer (Zical, Prevest), Obturation by Ultrasonic aided lateral compaction.

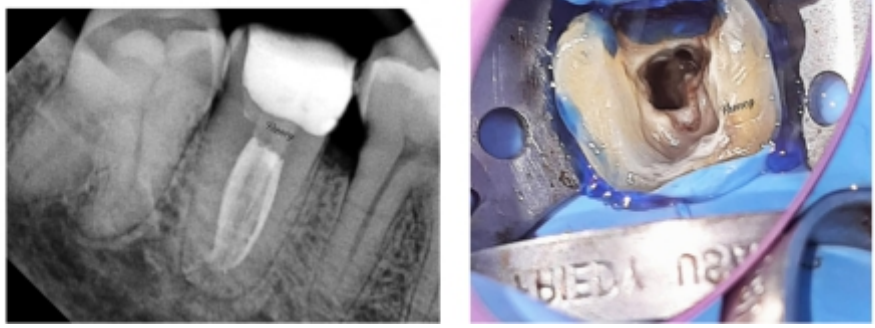
Case 1

Case 2

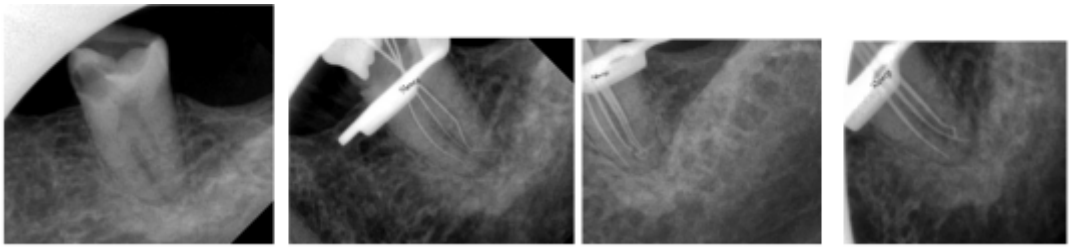
Mandibular second molar with irreversible pulpitis. Preoperative IOPA radiograph gave indication of some abberent anatomy and a possible 'C' shaped canal configuration. On opening 'C'shaped canal configuration found, Mb and D canals were joining. 3 canal openings were found with ML as a separate one. Two visit RCT with CaOH as ICM. Manual dynamic and Sonic agitation of Irrigation solutions (1 ml of EDTA, 40-45 ml of 5% Na Hypo), Zno Eugenol Sealer(Zical, Prevest), Obturation Technique- Ultrasonic aided Lateral compaction.

Case 3

Mandibular second molar with C shape and interesting anatomy. A crack was there in the



Case 2



Case 3

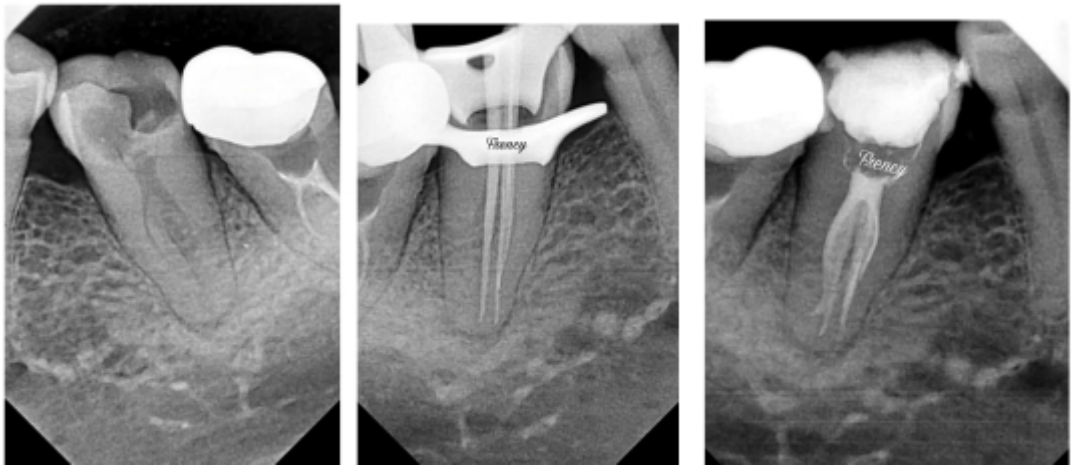
distal wall. Patient informed the risks. We decided to give a try to save the tooth as his first molar is already missing on that side. 4 orifices in a C shape with no obvious coronal isthmus connecting them all,ML canal has separate POE,the other three canals with common exit towards distal aspect. Distal canal is having sharp apical curve. Precurving after coronal flaring helped to negotiate the apical curve. Severely narrow mesial canals. Ultrasonic ,Sonic and Manual dynamic agitation of irrigation solutions(1ml of 17% EDTA,30 ml of 5% Na Hypo),30 gauge side venting metallic needles and Truanatomy needles used for irrigation. Extracanal warming of Na hypo done for final irrigation. Sealer-Zno Eugenol sealer(Zical),Obturation technique-Ultrasonic aided Lateral compaction, Orifices sealed with GIC,Core build up done with paracore.

Case 4

An interesting mandibular second molar with irreversible pulpitis, C shaped anatomy, sonic and ultrasonic activation of irrigation (17%EDTA and 5%Na Hypo), seal apex sealer, ultrasonic aided lateral compaction.

Case 5

C shaped mandibular second molar with



Case 5

irreversible pulpitis, sonic and ultrasonic activation of irrigation (17%EDTA and 5%Na Hypo), seal apex sealer, ultrasonic aided compaction.

CONCLUSION

The C-shaped root canal configuration has an ethnic predilection and a high prevalence rate in mandibular second molars. Understanding the anatomical presentations of this variation will enable the clinician to manage these cases effectively. Usage of diagnostic aids like cone-beam CT and operating microscopes help in understanding the anatomical variations. Continuous circumferential anticurvature filing along the periphery of the C-shaped root canal assisted with ultrasonic activation of sodium hypochlorite enhances tissue removal. Modifications in obturation techniques like ultrasonic lateral compaction and warm vertical compaction help in increasing the adaptation and density of filling.

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