Case Series

Endodontic Management of Mandibular Second Molars with 'C' Shaped Root Canal Configuration – Reports of Three Cases

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ABSTRACT

Recognition of unusual variations in the canal configuration is critical because it has been established that the root with a single tapering canal and an apical foramen is an exception rather than the rule. The C- shaped configuration, which is an important anatomic variation, is characterized by a C-shaped groove that connects one or more root canals. This groove can occur anywhere along the root canal system, making it difficult to diagnose and treat. Furthermore, C-shaped canals are challenging if not possible to predict radio graphically.

The aim of presented three case reports is to describe different types of C-shaped canals in mandibular second molars and their endodontic management. In the first case report of tooth #47, preoperative radiograph showed fusion of roots, and the root canal outline were not clear. Therefore CBCT was advised to the patient confirming the C shaped root canal configuration, which persisted along the entire length and width of the C-shaped root canal and exits at single apical foramen. In the second case report of tooth #47, the anatomy of the floor of the pulp chamber suggested an incomplete "C" with the fusion of the mesiolingual and distal root canals and a separate orifice for mesiobuccal root canal giving the appearance of semicolon (;) The third case report of tooth #47 radiographically, the tooth had unusual root morphology with a single conical root. Clinically, the pulp chamber floor had a C-shaped continuous trough.

KEY WORDS: cone beam computed tomography, c-shaped canals, c-shaped root canal configuration, mandibular second molar,

INTRODUCTION:

A thorough knowledge of the anatomy of teeth involved in root-canal treatment is essential for successful debridement and obturation of the root-canal system. Recognition of unusual canal configurations and variations are paramount because it has been established that the root with a single tapering canal and an apical foramen is an exception rather than the rule.[1] Root canal configuration of the mandibular second molars shows great deal of variations. The "C"-shaped canals were first documented by Cooke & Cox[2] in three case reports. The frequency of C- shaped canals ranges from 2.7 to 8%.[2, 3]

The main anatomical feature of C- shaped canal is the presence of a thin fin connecting the root canals.[4] 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. Two or three canals may be found in the 'C' shaped groove, or the C-shape may be continuous throughout the length of the root.

Although C-shaped root canals are most frequently seen in the mandibular second molars, but they can occur in any mandibular molars and premolars. They have been reported in maxillary molars as well.[5]

Mandibular molars with C-shaped root canal system display fusion of the roots from the buccal or lingual aspect, with a radicular ridge opposite to a convex surface, and a root morphology which may be conical, square or in C-shape[6, 7, 8]. 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 anatomical appearance.[4,9]

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The pulp chamber has a single ribbon shaped orifice with a 180 degree arc from distal to mesial canals.[10]

The concavity of the C may be oriented buccally or lingually.[11] In other cases the orifice may take the form of an incomplete 'C', with the union of the distal and mesiobuccal canals, and the presence of an isolated mesiolingual canal, giving the canals an appearance of a semicolon.[9, 12] It may also present as a C-shaped canal with the union of distal and mesiolingual canals, and a separate mesiobuccal canal. It is important to emphasize that this C-shaped variation of the anatomy can occur throughout the length of the root canal, which complicates the stages of biomechanical preparation and obturation of teeth displaying this type of internal anatomy.

Preoperative radiographs of the mandibular second molars with C-shaped canals demonstrate close fused roots or images of two distinct roots. This occurs when the communication is thin and thus, not visible on the X-rays. This makes the clinical recognition of the C-shaped canal unlikely until access to the pulp chamber has been achieved.[4] Radiographs taken whilst negotiating the root-canal system may suggest such anatomy as they can reveal two characteristics: instruments tending to converge at the apex[13] or instruments appearing both clinically and radiographically to be centered and appearing to be exiting the furcation. This can cause confusion and initiate a search for a perforation.[4,8]

The aim of presented three case reports is to describe C-shaped canals in mandibular second molars with type-1 and type-2 configurations and their endodontic management.

CASE REPORT 1:

A 22 year old male patient reported to Department of Conservative Dentistry and Endodontics of Sri Aurobindo College of Dentistry and P.G. Institute, Indore with a chief complaint of spontaneous pain in lower right back tooth region of jaw. The patient's medical history was not contributory. One week before patient visited a dentist with same chief complaint and underwent some treatment. Intra oral examination revealed presence of an intermediate restorative material sealing the occlusal cavity of right mandibular second molar (#47). The tooth was severely tender on vertical percussion. Diagnosis of irreversible pulpitis with acute apical periodontitis was made and endodontic treatment of tooth was planned.

Radiographic examination revealed a fused single conical root with unusual and complex anatomy. There was widening of periodontal ligament space (Figure 1). After administration of anesthesia, rubber dam was applied and under surgical operating microscope the access cavity was refined. The floor of pulp chamber revealed a C shaped canal. To confirm the complete anatomy CBCT was adviced. CBCT was suggestive of true Type 1 of Melton's classification (Figure 2).

Figure1: Preoperative radiograph showing fused single conical root with unusual and complex anatomy.

The access cavity was flushed with 5.25% of sodium hypochlorite and 17% EDTA solution. The pulp chamber floor was examined carefully. Instead of having three separate orifices, it had a continuous C-shaped trough that started from the location of mesiobuccal canal orifice to the location of distobuccal canal orifice, with its convexity facing towards the buccal surface. Coronal flaring was done with the help of Sx Protaper (Dentsply Maillefer) and the canals were irrigated copiously again with 5.25% of sodium hypochlorite and 17% EDTA solution. Working length was determined with the apex locator Root ZX (J Morita) which was confirmed radiographically (Figure 3).

The irrigating solution in the root canals was activated with ultrasonic device (P5 booster Satelec with attached endosonic files) to debride the canal more effectively. The resulted 'acoustic streaming' allowed greater volumes of irrigants entering and penetrating the canal system, thus promoted thorough cleaning of the narrow areas of the canal. Cleaning and shaping of the root canal was initiated with rotary Protaper (Dentsply Maillefer) in the wider portion of the root canals, followed by circumferential filing using the hand instruments, K and H files (Mani INC) to achieve uniform canal preparation. During the preparation inspite of having sign and symptoms effective anesthesia patient complained of pain for which intra pulpal anesthesia was administered. The

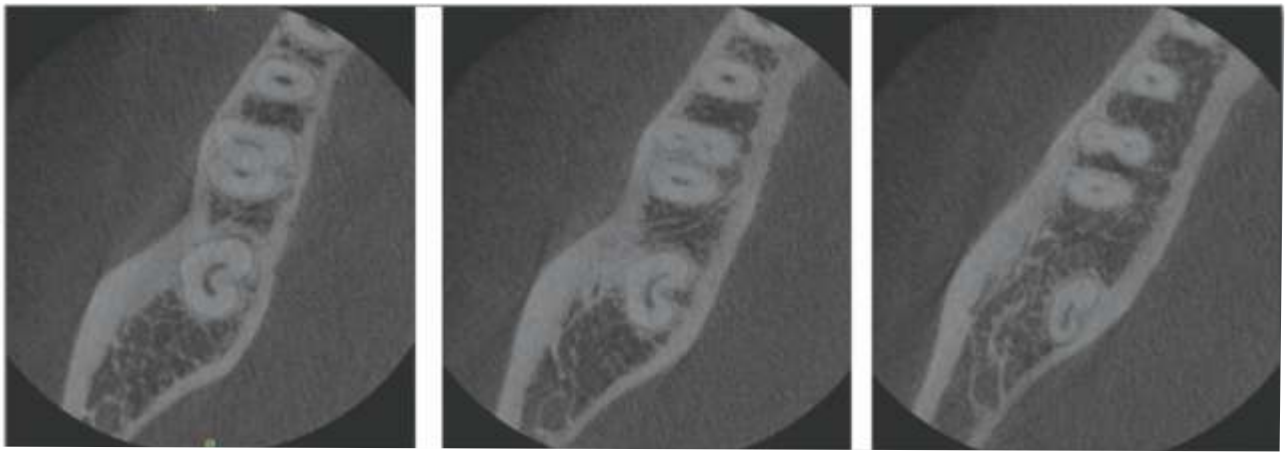

Figure 2: The CBCT scan view showing true type 1 Melton's classification at coronal, middle and apical third of the canal.

Figure 3: Radiographic determination of working length.

Figure 4: Radiograph showing the snuggly fitted master Gutta percha.

pulp space was again flushed with 5.25% of sodium hypochlorite and 17% EDTA solution. All the canals were dried using the sterile absorbent paper points. The canals were coated with AH-26 sealer (Dentsply Maillefer) and the tooth was obturated with thermoplasticised injectable gutta-percha technique along with a master cone to prevent extrusion of gutta percha beyond the apex (obtura II Obtura corporations) (Figure 4,5).

Tooth was temporized with IRM cavit G (3M ESPE). Post obturation radiograph was taken which revealed well obturated root canal space with the C shaped communication extended to the apex of the tooth (Figure 6). The patient was recalled after one week for permanent restoration.

After one week the tooth was asymptomatic and it was restored with composite resin. The patient was kept on periodic follow up for six month.

CASE REPORT 2:

A 24 years old male reported to the department with the chief complaint of pain and food lodgement in mandibular right back tooth region since last 15 days. The pain was dull in nature with mild intensity. On clinical examination the tooth #47 was grossly carious with an exposed pulp. Intra oral periapical radiograph of the tooth displayed fusion of roots and a conical root morphology with a periapical radiolucency associated with the root apex of tooth #47 (Figure 7).

Figure 5: Radiograph showing the completely obturated #47

The outlines for the individual root canals were not clear. The tooth was non tender on percussion and had no pain on palpation. On electrical (Digite ST Parkell) and thermal pulp testing, the tooth was non responsive to stimuli, suggesting loss of vitality. A diagnosis of chronic irreversible pulpitis with chronic apical periodontitis was made and an endodontic treatment of the tooth #47 was planned.

All the principles of endodontic treatment were followed. After preparation of access cavity pulp chamber floor was carefully examined. The anatomy of the floor of the pulp chamber suggested an incomplete 'C' with the fusion of mesiolingual and distal root canals and a separate orifice for mesiobuccal root canal giving the appearance of semicolon(;). This case therefore, demonstrates the morphological pattern of Melton's type- 2 C shaped root canals (Figure 8).

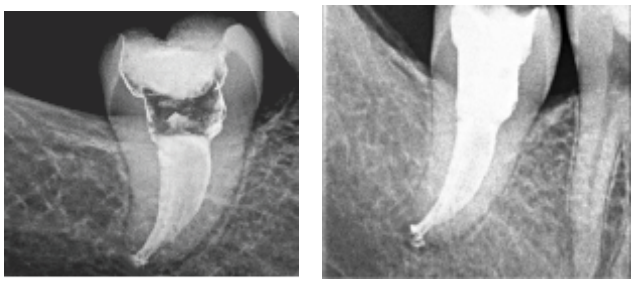

Figure 6: Radiograph showing post endodontic restoration with #47.

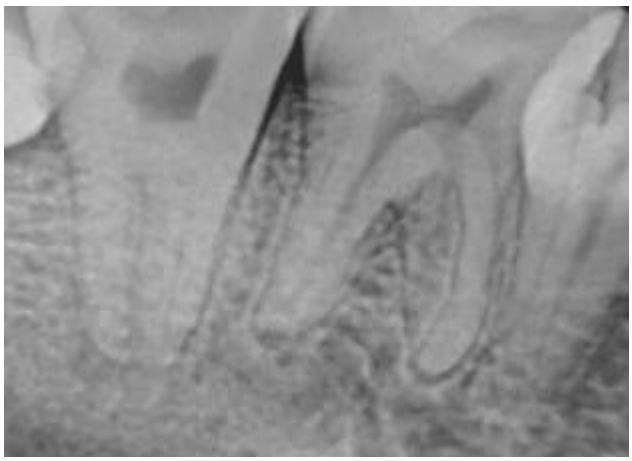

Figure 7: Intra oral periapical preoperative radiograph #47 showing fusion of roots and conical root morphology.

The instruments in the mesiolingual and distal root canals were confluent at the apex and exit at single apical foramen (Figure 9). However, the orifice of mesiobuccal root canal was separate. Since the anatomy of the floor of the pulp chamber suggested an incomplete 'C' with the fusion of mesiolingual and distal root canals and a separate orifice for mesiobuccal root canal. Therefore, a combination of the thermoplasticized and cold lateral condensation techniques were used to achieve the effective sealing of the root canal space.

Figure 8: A mandibular right second molar with an incomplete "C". Note the fusion of mesiolingual and distal root canals and a separate orifice for mesiobuccal root canal giving the appearance of semicolon (;).

Figure 9. The instruments in the mesiolingual and distal root canals were confluent at the apex and exits at single apical foramen. Note the separated orifice of mesiobuccal root canal.

All the root canals were coated with AH-26 sealer. The separated Mesiobuccal root canal was obturated with the conventional cold lateral condensation technique since, the mesiolingual and the distal root canals were fused; therefore, thermoplasticised injectable gutta-percha technique was used. Post obturation radiograph was taken which revealed well obturated root canals with the C shaped communication between the mesiolingual and distal root canals extended to the level apical one third (Figure 10).

Figure 10: Immediate post obturation radiograph.

Figure 11:. Preoperative radiograph of tooth #47 revealed a single wide conical root

CASE REPORT 3:

A 45 years old female reported to the Department with the chief complaint of pain in the right mandibular back tooth region since past one month. The pain was throbbing in nature and severe in intensity. The pain aggravated during lying down position. On clinical examination, the tooth #47 had a deep carious lesion involving the pulp. Intra oral periapical radiograph revealed unusual root morphology with a single conical root. The periodontal ligament space associated with the root apex of tooth #47 was thickened (Figure 11).

The tooth was tender on vertical percussion and had no pain on palpation. On thermal heat pulp testing, the tooth exhibited an immediate, intense painful response. On electrical pulp testing (Digite ST Parkell) the tooth was non responsive suggesting loss of vitality. A diagnosis of chronic irreversible pulpitis with apical periodontitis was made and an endodontic treatment of the tooth #47 was therefore planned. The endodontic treatment procedure instituted is same as of case report 1 (Figure 12, 13 and14).

Figure 12: A mandibular right second molar with complete C- shaped canal. Note the floor of the pulp chamber had a C-shaped continuous trough .

Figure 13: Working length radiograph showing all the endodontic instruments confluent at the apex and exiting at single apical foramen.

DISCUSSION:

The 'C' shaped root canal often poses a challenge to the clinician owing to its complex root canal anatomy. Because of their atypical anatomy, C-shaped canals demand more concern at all stages of the procedure. This represents a true challenge to the operator, in the diagnosis, cleaning and shaping, and three dimensional sealing.[2, 6, 13, 14, 15, 16]

Variations in the number as well as the position of the canals can occur in different thirds of

Figure 14: Immediate post obturation radiograph showing well obturated c- shaped canal. Note the C shaped communication extended to the apex of the tooth.

the root.[8] A tooth with a C-shaped canal orifice may have a canal system that presents a continuous C-shape from the coronal to the apical third. In this instance, endodontic instruments of small size used to explore the canal may pass freely through the foramen. This canal type is also known as a 'true' C shape. Often, a true C-shaped canal will be recognized because it has a C-shaped orifice. However, a true C-shaped canal can also occur while presenting separate orifices at the pulpal floor level. A C-shaped canal may commonly bifurcate at any level in the root from coronal to apical[12], and anastomoses between canals can also occur.[8,16]

Melton, et al[8] proposed the following classification based on the different configurations of the orifices in C-shaped canal systems.

- **Type I**- A continuous C-shaped canal, with no separation of the canals.
- **Type II**- The canal orifices resemble a semicolon (;), where a C-shaped canal is present buccally or lingually, separated from another distinct canal by a dentine wall.
- **Type III**- Two or more separate canals are present, as in a typical lower molar, with three canal orifices.

The presented case report 1 and 3 can be assigned to type 1 of Melton's classification as it has got a continuous 'C' shaped trough at the floor of the pulp chamber. The trough was extensive and persisted along the entire length and width of the C-shaped root canal and exits at single apical foramen. These cases demonstrate the morphological pattern of the true type 1 C-shaped root canal.

The Second case report can be assigned to type 2 of Melton's classification. The anatomy of the floor of the pulp chamber suggested an incomplete C with the fusion of mesiolingual and distal root canals and a separate orifice for mesiobuccal root canal giving the appearance of semicolon (;). This case demonstrates the morphological pattern of type- 2 C shaped root canals. Melton et al [8]. also commented on the large amount of debris in instrumented canal space for which many authors agree on using ultrasonic files to facilitate their removal. Similarly, in the presented case reports 5.25% of sodium hypochlorite and 17% EDTA solution was used as an irrigant and activated by ultrasonics. The resulted "acoustic streaming" allowed greater volumes of irrigants entering and penetrating the canal system, thus promoted more thorough cleaning of the narrow areas of the canal.17% EDTA is used in combination with 5.25% of sodium hypochlorite to remove the smear layer.

Cooke and Cox[2] described three cases of endodontic treatments in lower molars with C-shaped canals which highlighted the difficulty of identifying C-shaped root canals based only on the pre-operative radiographic appearance, since in all the three reported cases the radiographs gave the impression of two roots, and the anatomy of the floor of the pulp chamber suggested separate canals. The finding of presented case reports was in contrast to Cooke and Cox[2]. In the presented case reports, the C shaped root canal configuration could be predicted by careful examination of a good quality preoperative radiograph, as the tooth had unusual root morphology with a single conical root.

Barnett[9] commented that the radiograph can indicate the presence of distinct root canals, even when the tooth has a C-shaped canal system. It is very difficult to identify this atypical configuration at the initial radiographic examination, and only after the access cavity has been made will the diagnosis become clear[5,7,9,11].In the presented case reports radiographically, all three teeth had unusual root morphology with a single conical root which is suggestive of abnormal root canal configuration. Diagnosis of 'C' shaped root canal configuration became clear only after the access cavity has been made and examining the floor of the pulp chamber.

Rice & Gilbert[13] considered the interpretation of pre-operative radiographs fundamental to the success of the endodontic treatment of C-shaped canals, since it can demonstrate the presence of atypical root configurations. The importance of good quality preliminary radiographs taken from at least two angulations cannot be overstated. Jerome[15] believed that limited information about whether roots

are fused or merely close can be obtained from evaluation of pre-operative radiographs, affirming that the radiographic appearance of two roots does not eliminate the possibility of the presence of a C-shaped canal system, in such cases the dentine isthmus that joins the roots may so be fine that it does not appear radiographically.[14,15] In the presented case reports it is suggested that the importance of good quality preoperative radiograph as the abnormal configuration could be predicted by carefully examining the preoperative radiographs.

When the radiographs are taken for the purpose of working length measurement, the endodontic instruments can appear to be misplaced in the furcation, especially in Class 1 C-shaped canals. This can lead the operator to mistakenly suspect a perforation. [8, 9, 14, 15] Another factor that can cause the operator to suspect perforation is the occurrence of intense hemorrhage during access to the pulp chamber. In addition, the patient may complain of constant sensitivity throughout the appointment, even after intrapulpal anesthesia, giving rise to difficulty with procedures such as pulpectomy and biomechanical preparation of the canals.[2, 7, 13,15] Similarly, in the presented first case report, the patient constantly complained of pain and sensitivity during cleaning and shaping of the root canals.

In all the three types of C-shaped canals, the 'main' canals can be cleaned and shaped normally; however, the instrumentation of the isthmus that connects these canals requires care, because although it may be extensive, it may also be very narrow.[9,15] These areas are prepared using small sized endodontic instruments and copious amounts of irrigants. Gates Glidden drills cannot be used in the isthmus due to the great risk of creating a perforation to the periodontal ligament.[15] In this situation the irrigation solutions assume a very important role. 5.25% of sodium hypochlorite, with its capacity to dissolve organic material, is the solution of choice.[11,15] Manual instrumentation can be augmented with ultrasonic devices to debride the canal more effectively[9,13], since they can result in greater volumes of irrigants entering and penetrating the canal system, thus promoting more thorough cleaning of the narrow areas of the canal. Similarly, in the presented case report 5.2% of sodium hypochlorite and 17% EDTA was used as an irrigant. The irrigation solution was activated by ultrasonics for the effective debridement of the root canals.

For obturation of such an atypical configuration, one should select a technique that facilitates the effective sealing of complex root canal systems. Because of the C-shape, complete obturation of the canal is difficult. The technique of cold lateral condensation, which is clinically satisfactory in the majority of cases, is not sufficient to ensure complete obturation of the complex root canal, as cold gutta percha cannot fill all the unevenness. In such situation the thermoplasticised gutta percha is an appropriate technique; because, thermoplasticisation allows better dispersal of the endodontic sealer and gutta percha, and so they are more likely to fill the irregularities of the C-shaped canal system. Similarly, in the presented first case report, the pulp chamber floor had a C-shaped continuous trough. The trough was extensive and persisted along the entire length and width of the C-shaped root canal. Hence, thermoplasticised technique of obturation was used.

Walid[17] suggested obturating the main root canal using lateral condensation and the central part of the canal with thermoplasticized technique. Similarly, in the second case report, since the anatomy of the floor of the pulp chamber suggested an incomplete 'C' with the fusion of mesiolingual and distal root canals and a separate orifice for mesiobuccal root canal, a combination of the thermoplasticized and the cold lateral condensation techniques were used to achieve the effective sealing of the root canal space. Mesiobuccal root canal was obturated with the conventional cold lateral condensation technique. Since, the mesiolingual and the distal root canals were fused; therefore, thermoplasticised technique is used to obturate the fused canals.

The root configuration of molars having this canal shape may be represented by fusion of either the facial or lingual aspects of the mesial and distal roots. Radiographic detection of root fusion is difficult since the criteria for its recognition are ambiguous. Thus, recognition of C-shaped canals is improbable until access to the pulp chamber has been achieved. The criteria used for the radiographic recognition of C-shaped mandibular second molars, although based on their morphology, may be misleading as the anatomic complexities of all teeth is well established in the literature and roots can have great variations in size, shape, and orientation. Presence of instruments or filling materials in the furcation area may also be seen in cases of furcation perforation. However, this finding, in combination with the poorly distinguished floor of the pulp chamber, can lead to radiographic recognition of a C-shaped configuration. Clinical recognition of C-shaped canals was based on definite and 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.

Cooke & Cox[2] asserted that it was impossible to diagnose C-shaped canals on preoperative radiographs.[18]

The magnification provided by the Dental Operating Microscope is a great aid in the interpretation of the anatomy of the floor of the pulp chamber, and thus facilitating effective access to the canal system.

Various clinical studies have highlighted the role of CBCT as an objective analytical tool to ascertain complex root morphology. Conventional 2D radiographs might not provide adequate diagnostic information for clinician to appreciate complicated morphology of root canal system, these problems can be overcome by using SCT and CBCT, which can provide 3D images of individual teeth and surrounding tissues. But it is equally important that radiation doses should be low. Matherne et al. in their study have reported the superiority of CBCT over other diagnostic methods and suggested the simultaneous use of the operating microscope and CBCT.[19] Although µCT has been compared to CBCT and reported to be more precise with up to 2 µm resolutions[20,21], however, the limitations include amount of time required and its usage restricted to only ex vivo studies[22, 23]. Accuracy of CT imaging is well-documented. Major advantages of CBCT over conventional CT scans include X-ray beam limitation[24], rapid scan time[25] and effective dose reduction[26]. The approach offers a non-invasive reproducible technique for 3D assessment of root canal systems and aids the clinician to visualize the internal anatomy precisely[27]. Furthermore, use of this technique has been firmly advocated in the recent past for diagnosis of root canal aberrations.[28]

CONCLUSION:

C-shaped canal in mandibular molars is one of the most difficult situation with which the dentist is confronted during endodontic treatment of teeth. Magnification and illumination can help to identify these hard to detect C shaped configurations. Majority of the partially missed canals were detected at apical third level which suggests that clinically it is more difficult to clean, shape and obdurate this area in C-shaped canal system. Clinically, it is extremely important to perform root canal instrumentation cautiously during treatment as a lot of variation and anatomical diversity pertaining to the shape and thickness exist at each level in teeth with C-shaped canal system. One should be aware of these danger areas so as to avoid the perforation during treatment of such canal system.

These case reports suggested that the existence of C-shaped canal system could be predicted by studying carefully the pre operative radiographic image of mandibular second molar. However, clinical examination of the floor of the pulp chamber, and pre-treatment radiographs are equally important when attempting to diagnose a C-shaped canal configuration.

It is evident that, for endodontic treatment of teeth with C-shaped canal systems to be successful, there must be modification of procedures at all stages of the treatment and new resources must be used.

The magnification provided by the dental operating microscope would be of great aid in the interpretation of the anatomy of the floor of the pulp chamber, and thus facilitating effective access to the canal system.

As well known from literature that periapical radiographs are misleading therefore; we strongly recommend use of CBCT as diagnostic tool in detecting aberrant canal configuration. Computer Aided Tomography (CAT scan) would be an additional resource for such an abnormal configuration of root canals which enables three-dimensional reconstruction of root canal systems in high resolution.

Use of 5.25% of sodium hypochlorite with 17% EDTA solution for irrigation activated by ultrasonic instrumentation aid greatly in debridement and devices for thermoplasticisation of Gutta Percha for effective sealing of the root canal space is recommended.

Clinically, when a C-shaped canal system is observed, one cannot assume that such a shape continues throughout its length. The prognosis of such complex canal anatomies can be improved by simultaneous use of sophisticated techniques such as surgical operating microscope and CBCT.

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