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Unraveling the C-Shaped Mystery: Three Case Reports in Mandibular Second Molars

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ABSTRACT

The intricacies present in this variation of canal morphology can pose a challenge to the clinician during negotiation, debridement and obturation. Knowledge of the C-shaped canal configuration is essential to achieve success in endodontic therapy. Radiographic and clinical diagnoses can aid in identification and negotiation of the fan-shaped areas and intricacies of the C-shaped anatomy. Effective management of this anomalous canal configuration can be achieved with rotary and hand instrumentation assisted with sonics and ultrasonics. Modifications in the obturation techniques will ensure a 3-dimensional fill of the canal system and chamber retained restorations like amalgam or composites, serve as satisfactory post endodontic restorations. The main reason for failure in endodontic treatment of mandibular second molars is the inability to detect the presence of C-shaped canals prior to an endodontic therapy. This case report presents successful management of three cases of C-shaped canal configurations.

Keywords

C-Shaped canals, mandibular second molar, root canal configuration, root canal obturation.

INTRODUCTION

A thorough knowledge of the normal as well as unusual configuration of root canal anatomy is essential for successful debridement and obturation of root canal system. Variation in the root canal system has great clinical significance, since they are difficult to diagnose and create problems during endodontic treatment. One of the most important variations is the 'C' shaped configuration of the root canal system, which was first described by Cooke and Cox in mandibular molars[1].

C shaped molars are so named because of the cross-sectional morphology of their root and root canals. Main cause of C-shaped root canal is failure of fusion of the hertwig's epithelial root sheath. 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.[2] 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]

Earlier, the irregular fusion of the Hertwig's epithelial sheath was attributed to trauma, such as radiation or chemical interference, but following the documentation of racial predilection, it is more likely to be of genetic origin. The root canals in such teeth merge in a very wide, slot like, single, continuous root canal morphology, which can assume the shape of a letter C.[4]

The C- shaped canal configuration shows an ethnic predilection. East Asian population groups like Chinese (0.6%-41.27%) and Koreans (31.3%-45.5%) display a high prevalence of this variant.[5,6] 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.[7,8] Higher incidence of C-shaped anatomy was documented in Lebanese population (19.1%) as compared to the other West Asian population groups (Iranian, Jordanian, Saudi Arabian).[9,10]

Canal configuration has been shown to have a high prevalence in mandibular second molars with a percentage ranging between (2.7%-45.5%). 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%).[11,12,13,14] Bilateral occurrence of C-shaped canals has been reported in a percentage of (70%-81%).[15]

These case reports describe the endodontic management of mandibular second molars with Meltons Category I, II (C1, C2) root canals. This aberrant root canal morphology was identified using a dental loupe and successfully treated by using Endo-activator (Dentsply, USA) and Calamus Dual (Dentsply USA) obturating unit.

Case Report – 1

A 35-year-old female patient reported to Department of Conservative Dentistry and Endodontics, Haldia Institute of Dental Sciences and Research, Purba Medinipur, with a chief complaint of spontaneous pain in lower left back region of jaw since 3 days. The patient's medical history was not contributory. Intra oral examination revealed deep distal cavity in the left mandibular second molar (i.e. 37) with lack of

swelling. History revealed intermittent pain in the same tooth to hot and cold stimuli for past 1 month. The tooth was tender to vertical percussion. Radiographic examination revealed single conical root with deep distal radiolucency extending to the pulp with presence of peri-apical radiolucency and widening of PDL space (fig 1). Vitality testing of the involved tooth with dry ice (RC Ice Prime Dental Products, Mumbai, India) and with heated gutta percha caused an intense lingering pain. Electric pulp tester (Parkel Electronics Division, USA) showed premature response. Diagnosis was made as irreversible pulpitis. Patient was informed regarding endodontic treatment and written consent was taken.

Tooth was anesthetized by using 2% lignocaine containing 1: 20,000 epinephrine (LIGNOX 2% A). The 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 (Fig 2). The tooth root showed a distal C-shaped canal that extended from the cervical third up to the apex with separate mesio-lingual canal extending from middle to apical third of root, thus categorizing the root canal system as a Fan's Category II (C2) shaped anatomy.

Coronal pre-flaring was done with #2 gates glidden drill. Working length was determined using apex locator (Dentaport ZX, J. Morita Japan) and confirmed radiographically (Fig 3). Cleaning and shaping was done using Coltene Hyflex CM file system. Between instrumentation, canal was irrigated with 2.5% sodium hypochlorite and activated with sonic unit (Endo-activator Dentsply USA) for 1 minute for maximum debridement of the complex anatomy of the root. Intracanal calcium hydroxide medicament was placed until next appointment. After removal of smear layer using 17% of EDTA, final irrigation was done with 2.5% of sodium hypochlorite. The canals were dried with paper points. AH Plus sealer was placed and obturation was carried out using warm vertical compaction with Calamus dual (Dentsply, USA). Apical seal in mesio-lingual canal & C-shaped canal was obtained using GP no.30 (4%) & no.40 (4%), respectively (Fig 4). Rest of the C-shaped canal was back filled with thermos-plasticized gutta-percha technique (Calamus Dual, DENSPLY USA) (fig 5). The tooth was then restored with composite resin (Z 100; 3MDental products). The patient was advised for a full coverage crown and tooth was asymptomatic during the subsequent follow–up period.

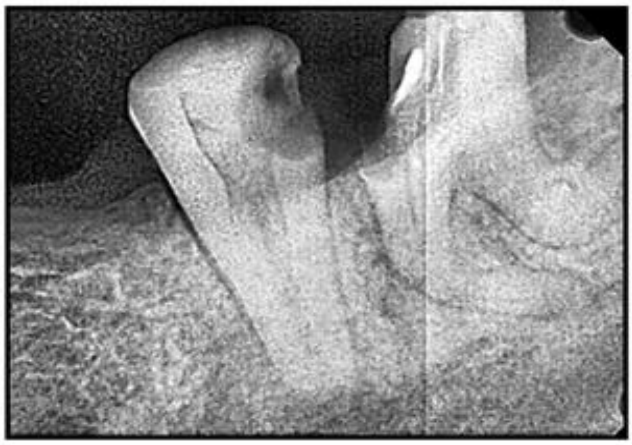

Fig 1: pre-operative radiograph showing deep distal caries extending to the pulp

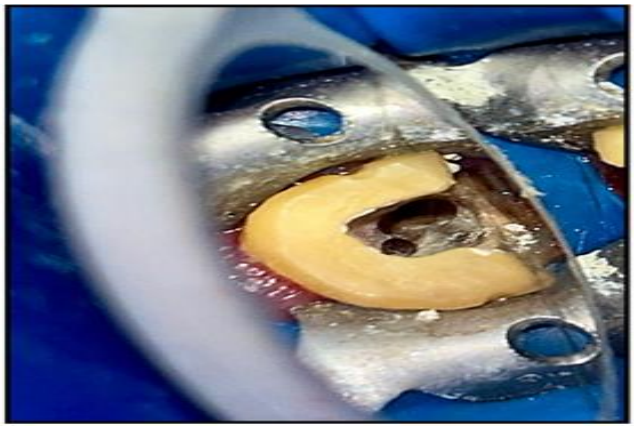

Fig 2: Access cavity preparation showing C shaped canal.

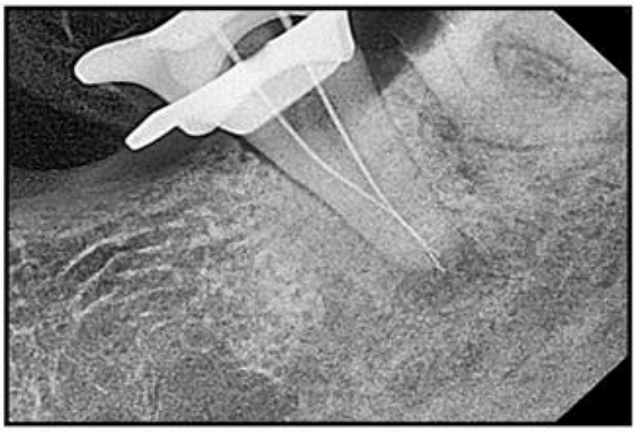

Fig 3: Working length radiograph

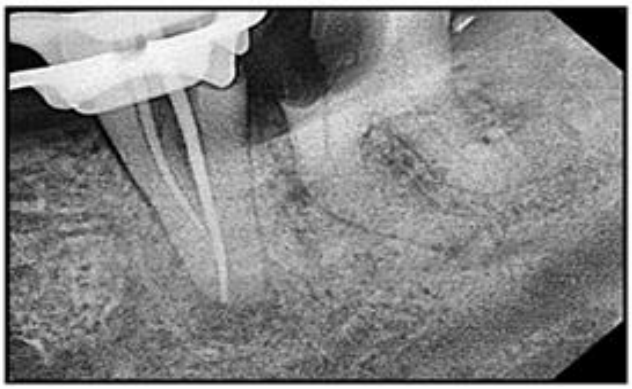

Fig 4: Master cone radiograph

Fig 5 post-operative radiograph

Case Report – 2

A 23-year-old female patient reported to the department with chief complaint of pain in lower right back teeth region of jaw for 1 week. The patient's medical history was not contributory. Intra oral examination revealed deep mesio-occlusal cavity in right mandibular second molar. Tooth was tender on percussion. Radiographic examination revealed single conical root with deep occlusal radiolucency extending to the pulp with large apical foramen. Diagnosis was made as irreversible pulpitis. Patient was informed regarding endodontic treatment and written consent was taken.

Endodontic therapy was performed similar to case report 1 (Fig 6 to Fig 10). The pulpal floor showed a C-shaped orifice extending till the apex, thus categorizing the root canal system as Fan's Category I (C1) shaped anatomy. The canal was dried with sterile paper points. Apical seal was obtained with GP no.40 (4%). Obturation of the root canal system was performed with warm vertical condensation (Calamus dual) and resin-based sealer (AH Plus). Post endodontic restoration was done with composite resin (Z 100; 3MDental products).

Fig 6: Pre-Operative Radiograph Showing Deep Disto-Occlusal Caries Extending To The Pulp

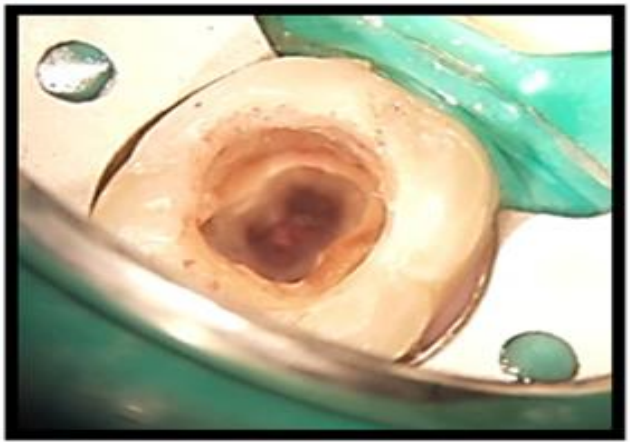

Fig 7: Access Cavity Preparation Showing C Shaped Canal

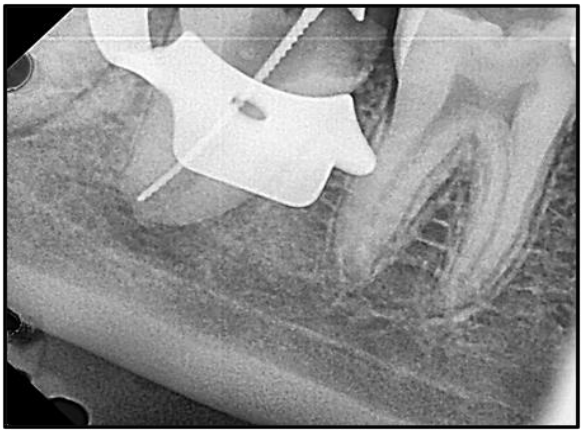

Fig 8 Working length radiograph

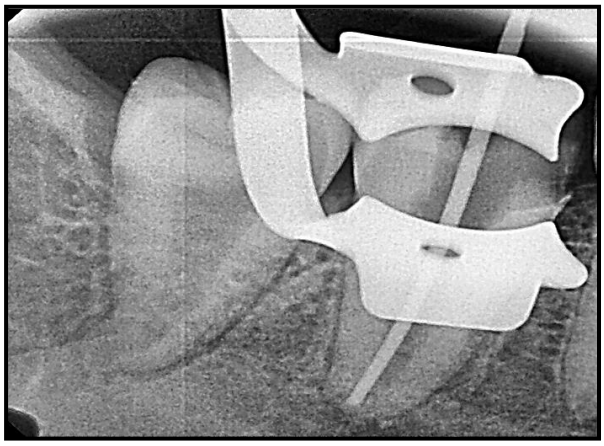

Fig 9: Master Cone Radiograph

Fig 10: Post-Operative Radiograph

Case Report – 3

A 40-year-old male patient reported to the department with chief complaint of pain in lower right back teeth region of jaw for 1 week. The patient's medical history was not contributory. Intra oral examination revealed deep class V cavity in the buccal surface of right mandibular second molar. Tooth was tender on percussion. Radiographic examination revealed single conical root with deep cervical radiolucency extending to the pulp with large apical foramen. Diagnosis was made as irreversible pulpitis. Patient was informed regarding endodontic treatment and written consent was taken.

Endodontic therapy was performed similar to case reports 1 and 2 (Fig 11 to Fig 15). The pulpal floor showed a single round or oval shaped orifice extending till the apex, thus categorizing the root canal system as Fan's Category IV (C4) shaped anatomy. The canal was dried with sterile paper points. Apical seal was obtained with GP no.40 (4%). Obturation of the root canal system was performed with warm vertical condensation (Calamus dual) and resin-based sealer (AH Plus). Post endodontic restoration was done with composite resin (Z 100; 3MDental products).

Fig 11: Pre-Operative Radiograph Showing Deep Class V Cavity Extending to the Pulp

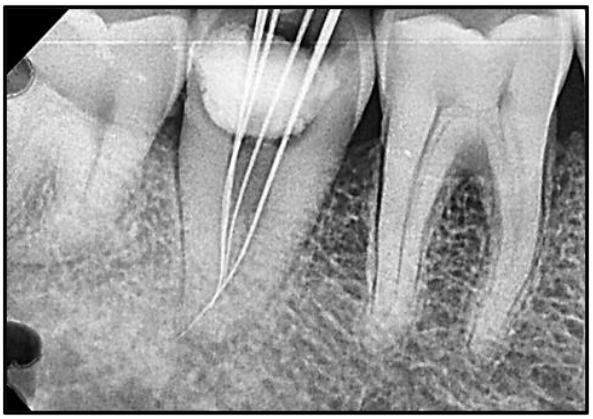

Fig 12: Working Length Radiograph

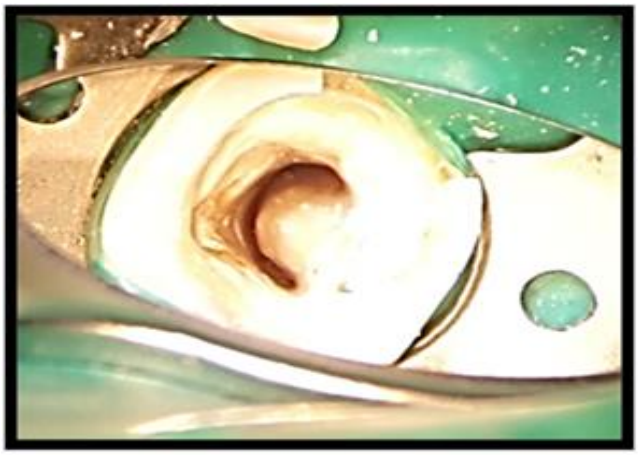

Fig 13: Access Cavity Preparation Showing C Shaped Canal.

Fig 14: Master Cone Radiograph

Fig 15: Post-Operative Radiograph

DISCUSSION

The variability of root canal system of multirooted teeth represents a challenge to diagnosis and treatment. C shaped canal is one of the most difficult situations in endodontics which was first described by Keith (1908) and later by Keith and Knowles (1913), Pederson (1949), Tratman (1950) and Cook and Cox (1979).[16]

There are certain pertinent features in relation to the external root anatomy and configuration of the pulp chamber in C-shaped mandibular molars. A conical or square configuration is characteristic of roots having a C-shaped canal. The roots display an occluso-apical groove on the buccal or lingual surface, which represent the line of fusion between mesial and distal roots.[17] Wang et al. referred to the C-shaped roots of mandibular second molars as being 'gutter-shaped'.[18] The pulp chambers of teeth with C-shaped canals mostly have greater apico-occlusal width with a low bifurcation which results in a deep pulp chamber floor. Min et al [19] classified pulp chamber floor of teeth with C-shaped canal into four types: -

- **Type I:** Continuous C-shaped orifice surrounding a central "peninsula" of dentin.
- **Type II:** A buccal dentin connection splits the C-shape into mesial and distal orifices.

- **Type III:** A single mesial dentine connection separates a small mesiolingual (ML) orifice from a larger, connected mesiobuccal-distal (MB-D) orifice.
- **Type IV:** Non-C-shaped, showing distinct distal and mesial canal orifices.

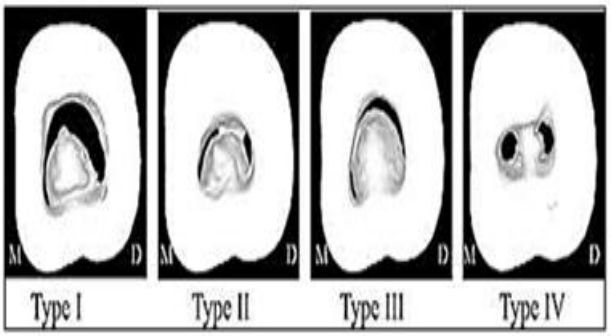

Fig 16: Min's Classification Of Pulp Chamber Floor Of Teeth With C-Shaped Canal

The clinician should not assume a fixed spatial relationship, if a C-shape is identified, but rather be aware of other possibilities. To facilitate a better understanding of the root canal anatomy of C-shaped canals, numerous classifications were proposed. The earliest classification was proposed by Manning and Melton et al [20] in 1991 and they classified C shaped canals into three types: -

- **Type I (C1):** The continuous C-shaped canal from pulp chamber to the apex without any separation.
- **Type II (C2):** The semicolon shaped canal, where dentin separates one main distinct canal from a mesial/buccal/ lingual canal.
- **Type III (C3):** Two or more (usually two) discrete and separate canals.

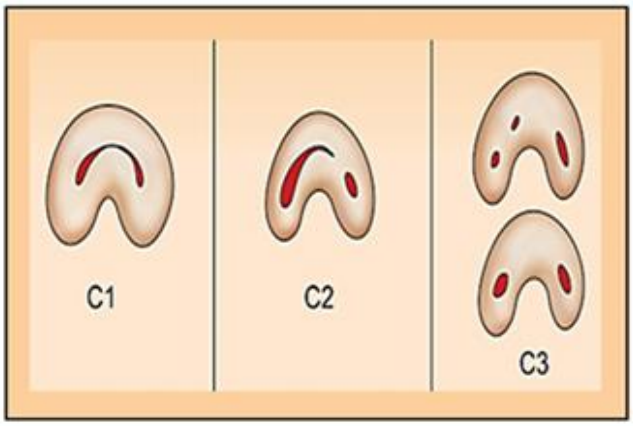

Fig 17: Melton's Classification

In all the three cases, shape of access cavity was modified and canal morphology was confirmed under dental loupes. The connecting fins or isthmus is usually a thin area and its irregular area contain soft tissue remnants or infected debris that may escape regular cleaning and shaping procedure.[21] Because of

that sonic irrigation was used to thoroughly debride the root canal system.

In order to access all the irregularities in the C-shaped canal system, the orifice portion of the slit can be widened with Gates Glidden drills. 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. It has been suggested that for such narrow, interconnecting isthmus areas, Gates Glidden drills should not be used and cleaning should be carried out by using a size 25 instrument or smaller.[22] 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.[23] After instrumentation by NiTi rotary instruments, K-files or H-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.

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.[24]

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. To ensure proper placement of the master cones in C-shaped canals, Barnett [3] 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.

If a cold condensation technique is adopted for obturation, deeper penetration of condensation instruments in several sites will be necessary.[25] 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.[26] In this regard, the thermo-plasticized gutta-percha technique may prove to be more beneficial.

The aim of thermo-plasticized 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.[27]

Walid's technique [28] 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.

In the study by Cheung & Cheung, none of the prepared canals had a canal wall greater than 1 mm on the furcal aspect after instrumentation.[29] 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 in C shaped canals. Besides, no prefabricated post (circular or conical cross section) would fit the C-shaped canals.

Management of C-shaped canals is challenging because of their complex and highly variable anatomy. Effective irrigation with activated sodium hypochlorite and chelating agents helps clean the irregular spaces. During obturation, techniques that ensure better adaptation of filling materials to the complex canal anatomy are preferred. Therefore, successful treatment of C-shaped canals requires thorough knowledge of their morphology, meticulous cleaning, and careful filling procedures.

CONCLUSION

Management of C shaped canal represents a great challenge with respect to diagnosis and treatment. Magnification and illumination can help to identify these hard to detect C shaped configuration. Proper access cavity preparation, meticulous mechanical and chemical debridement and three-dimensional obturation should be carried out to successfully manage C- shaped root canals.

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