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Confronting the C-Shaped Canal Configuration in Permanent Mandibular Second Molars: A Series of Five Cases

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Case Report

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Abstract: Successful endodontic treatment is based on the holy trinity of access preparation, chemo-mechanical cleaning and shaping and three-dimensional obturation of the root canal system. The complexity of root canal system and its variations may adversely affectthe endodontic treatment outcome. Therefore it is necessary to be aware of the possible anatomic variations for their successful management. Adental practitioner seldom faces C-shaped canal configuration in the mandibular second molar during its endodontic treatment. This type of canal configuration may cause diagnostic and anatomic difficulties which can lead to endodontic mishaps, if not managed strategically. The presented case series unveils the endodontic management of the different types of C-shaped canal configurations that would occur in mandibular second molars through a case series of 5 reports.

Keywords: C- shaped canal, mandibular second molar, anatomical variation, irrigation, warm vertical compaction.

INTRODUCTION

Knowledge of the root canal anatomy and its variations is indispensable for the success of any endodontic treatment. Mandibular first premolars and third molars have earned their reputation to exhibit most complex and highly variable root canal anatomy [1]. Other teeth which show such canal variations include; mandibular second premolars, maxillary first molars and mandibular second molars [2, 3]. In the mandibular second molars different canal configurations are evident such as, single to two, three or more canals or C- shaped canal [4]. C-shaped canal configuration was first studied by Cooke and Cox in 1979 [5] where a connection exist in the root canals by a fin or a web to form a 'C'- shaped root canal orifice. There have been various radiographic and morphologic studies carried out in the different ethnic groups which have investigated the prevalence of C-shaped canal configuration and it has been found to be highly prevalent in the Asian population [6].

Apart from the mandibular second molars, the C-shaped canal configuration has also been reported in mandibular premolars, maxillary second molars as well as in mandibular first molars. The C-shaped canals are difficult to identify in a conventional intra-oral periapical radiograph (IOPA) due to image super-imposition. Radiographically the second molars with C-shaped canal may appear to have fused roots or two separate roots with a confluence between the two roots. Anatomically, the C-shaped configuration often found on the floor of the tooth and may not continue to the apical third of the root [7]. Irregular areas in a C-shaped canal may render soft tissue remnants or infected debris which may escape thorough cleaning, shaping or obturation procedure and thus became a source of bleeding, persistent pain or reinfection.

The present case series describes the endodontic management of various types of C-shaped root canal configurations observed in the permanent mandibular second molars.

Case-1:

A 20-year old female patient, with a non-contributory medical history, reported to the Department of Conservative Dentistry and Endodontics, with the spontaneous pain in tooth #37 since 2 days. Clinical examination revealed a deep occlusal carious lesion in tooth #37, with exaggerated response showed to the electric pulp test (EPT), when compared to the contra-lateral tooth. IOPA radiograph showed a single conical root, with a suspicion of C-shaped canal (Fig-1a). Tooth #37 was diagnosed with symptomatic irreversible pulpitis (SIP).Root canal treatment was advised and informed consent was obtained from the

patient. The tooth was isolated under rubber dam and access cavity was prepared. A single oval canal was observed suggesting Fan's type C1 configuration. The canal was explored with a #10 K file. Working length was measured using apex locator (Root ZX, J. Morita CO, Tustin, CA) and radiographs (Fig-1b). Cleaning and shaping was done with stainless steel hand files (Mani Inc., Japan). The canal was intermittently irrigated with 3% sodium hypochlorite, 17% ethylene-diamine-tetra-acetic acid (EDTA) and normal saline. Apical preparation was done till #30 k-file. The canal was then flooded with 3% sodium hypochlorite and agitated with Endo-activator tip (Sybron-Endo). The final irrigation was done with distilled water and an IOPA radiograph was taken to confirm the apical extension of gutta-percha mastercone (Fig-1c). The canal walls were then coated with AH Plus sealer and the canal was obturated with warm vertical compaction method (Fig-1d). The cavity was sealed with Cavit G temporary restoration and the post-obturation radiograph was taken.

Fig-1: Tooth #37 showing Fan's C1 canal configuration

Case-2:

A 38 year old female patient reported with pain in tooth #37 since two weeks. Clinical examination showed a large amalgam restoration in tooth#37. IOPA radiograph revealed a radiolucency approaching the pulp beneath the restoration (Fig-2a). EPT showed an exaggerated response and tooth #37 was diagnosed with SIP having C-shaped canal. After obtaining profound anesthesia, access was gained to the pulp chamber which, revealed a semi-colon shaped canal orifices (Fan's C2). The root canal treatment was then completed following standard protocol (Fig-2 b, c, d).

Fig-2: Tooth #37 showing Fan's C2 canal configuration

Case-3:

A 42 year old, healthy male patient reported with spontaneous pain in tooth #47 since a week. Clinical and radiographic examinations showed large occlusal caries involving the pulp and diagnosed with SIP (Fig. 3.a). After obtaining the patient's consent, the root canal treatment was initiated in tooth #47. Access opening showed three root canal orifices connected with a C-shaped groove i.e., Fans C3 (a). Working length radiograph gave the false appearance of perforation in the furcation area as the mesio-buccal canal merging with the distal canal in the apical portion.

The root canal preparation was completed following the standard preparation and irrigation protocols. The obturation of the root canals was performed with warm vertical compaction technique (Fig-3 b, c, d).

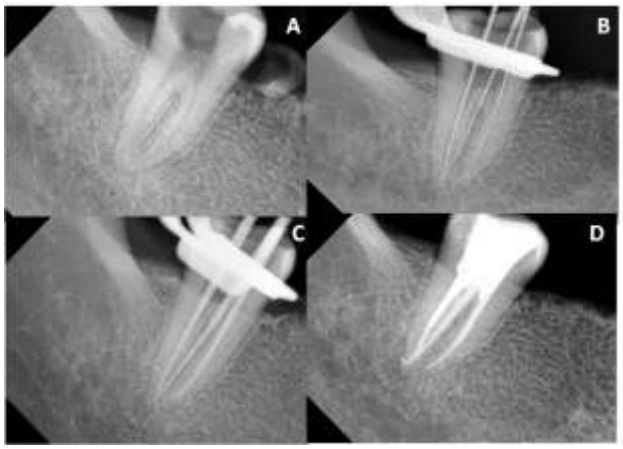


Fig-3: Tooth #47 showing Fan's C3 (a) canal configuration.

Case-4:

A 21-year old male patient reported with dullache in tooth #47 since three weeks. Clinical and radiographic examination of tooth #47 showed distal occlusal caries involving pulp with single fused root exhibiting indistinct root canal anatomy (Fig-4a). EPT showed no response and tooth #47 was diagnosed as pulp necrosis. After obtaining the informed consent, root canal procedure was started. Access cavity revealed a C-shaped groove with two canal orifices showing Fan's C3 (b) configuration. Root canal treatment was completed following the standard protocol as discussed in the previous cases (Fig-4 b, c, d).

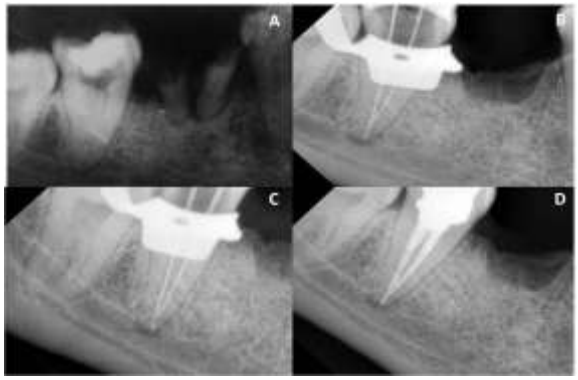


Fig-4: Tooth #47 showing Fan's C3 (b) canal configuration.

Case-5:

A 36 year old female patient reported with a dull pain in tooth #47 since one month. Clinical examination showed fractured amalgam restoration with secondary caries in tooth #47. Radiographic examination of tooth #47 showed widening of the apical periodontal ligament space (Fig-5a). Access opening revealed a single circular canal orifice (Fans C4). EPT showed delayed response and diagnosed with chronic irreversible pulpitis (CIP). Root canal treatment was completed following the standard protocols as described in earlier cases (Fig-5 b, c, d).

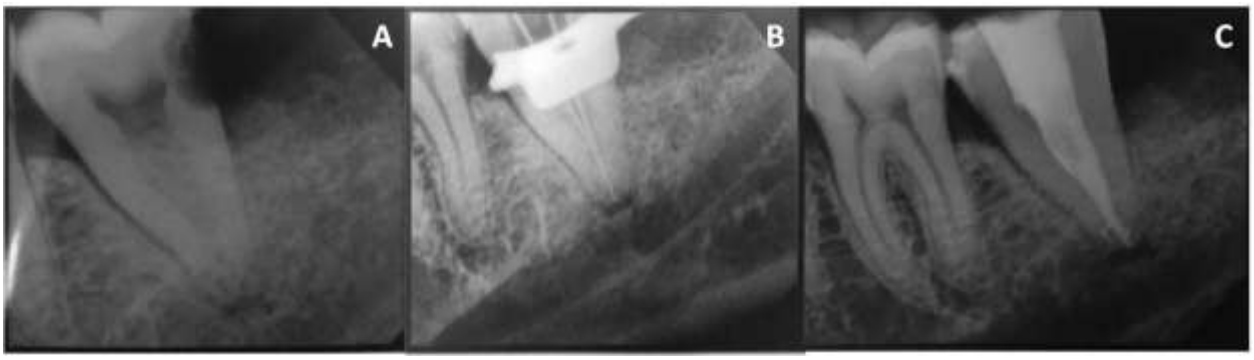


Fig-5: Tooth #37 showing Fan's C4 canal configuration

DISCUSSION

It is imperative for the clinician to be aware of the root canal anatomy and its possible variations for successful endodontic management. Mandibular second molar is one such tooth that shows wide variations in the canal configuration. One such variation is the C-shaped canal configuration. A detailed investigation by Manning of root canal anatomy of mandibular second molars, it was found that C-shaped roots and root canals were first documented in 1908 and 1911, after examination of the skeletal remains of members of the Neanderthal race, which were predecessors of the Mongoloid race that includes Asian populations [8]. This type of configuration shows racial predilection as observed in many studies.

INVESTIGATORS	POPULATION STUDIED	NUMBER OF TEETH STUDIED	% OF C-SHAPED CANALS	METHOD OF INVESTIGATION
Wadhwani *et al.*, (2017) [9]	Central India	238	9.7%	CBCT scans
Wang *et al*., (2012) [10]	Chinese	1146	34.64%	Radiography and clinical examination under microscope
Rogazkyn *et al.*, (2016) [11]	European- Russian	600	14%	CBCT scans
Ladeira *et al*., (2013) [12]	Brazilian	406	15.3%	CBCT scans
Alfawaz *et al*., (2018) [13]	Saudi Arabia	681	9.1%	CBCT scans
Shemesh *et al.*, (2017) [14]	Israel	1465	4.6%	CBCT scans

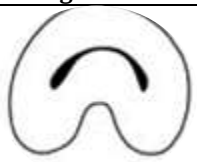
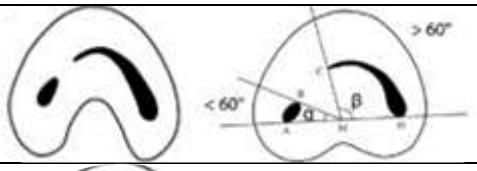
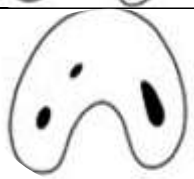
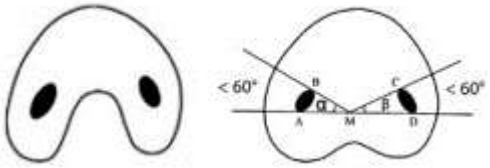
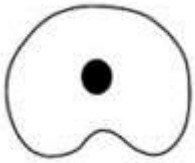
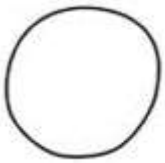
The C- shaped canal configuration offers challenges in the access preparation, cleaning -shaping, debridement and obturation of the canal completely. C-shaped canals were studied in detail by Melton et al, and later it has modified by Fan *et al*., [15, 16]. Fan *et al*., observed thata tooth exhibiting this type of canal system had to show all three of the following features:

- Fused roots.
- A longitudinal groove on the lingual or buccal surface of the root, and
- At least one cross-section of the canal belonging to the C1, C2, or C3 configuration.

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

- Category I: Continuous C-shaped canal running from the pulp chamber to the apex defines a C-shaped outline without any separation.
- Category II: The semicolon-shaped (;) orifice in which dentine separates a main C-shaped canal from one mesial distinct canal and
- Category III: Configuration with two or more discrete and separate canals.

Fan *et al*., modified Melton's method into the following categories:

Type	Configuration	Description
C1		The shape was an uninterrupted "C" with no separation or division.
C2		The canal shape resembled a semicolon resulting from a discontinuation of the "C" outline but either angle α or β should be no less than 60°.
C3(a)		2 or 3 separate canals and both angles, α and β, less than 60°.
C3(b)		
C4		Category IV (C4): Only one round or oval canal in the cross-section.
C5		No canal lumen could be observed (which is usually seen near the apex only).

A recent study was carried out to investigate the world-wide prevalence of C-shaped canals in mandibular second molars, which revealed that the maximum occurrence of C-shaped canal was seen in Chinese population (44%). This study also showed that the women have significantly higher prevalence of this configuration than the men. There was no significant difference observed between right and left side mandibular second molars [17].

The proposed hypothesis behind the occurrence of C-shaped canal configuration is due to the failure of adhesion of the Hertwig's epithelial root sheath (HERS) to the buccal or lingual root surface [18].

The tooth exhibiting C-shaped canal characteristically has conical or squarish shape root. This root may show an occluso-apical groove either facially or lingually, which represents the line of fusion between mesial and distal roots. The surface of root opposite to the groove is often convex. The apico-occlusal height of the pulp chamber is usually greater leading to the bifurcation more apically, giving rise to false feeling of perforation. The root canal configuration may show broad, fan-shaped communications from coronal to apical aspect of the canal. These communications may not continuous but might show variations at different levels in the root canal. This aspect makes the root canal debridement and obturation extremely challenging, hence affecting the outcome of the treatment.

Endodontic implications

The C-shaped canal configuration is highly unpredictable and is notorious for inadequate debridement and obturation. An IOPA radiograph showing a single root with an indistinct root canal configuration might suggest this type of anatomy. However, the IOPA is mere a 2-dimensional representation of the tooth, and may not reveal actual root canal configuration. Other advanced methods to identify the root canal configuration are CBCT and Spiral CT. CBCT is an excellent non-invasive tool that can unveil the canal configuration and helps in

diagnosis with relatively less radiation exposure than the Spiral CT.

The access opening of such teethusually needs modification dictated by the canal configuration. The C-shaped orifice often runs from mesiolingual canal curving bucally and ending distolingually. After access opening, the pulp chamber anatomy should be carefully observed for the number of orifices present along with any recesses, fins, anastomoses or isthmi. The various methods to identify canal orifices include champagne bubble test, tactile exploration with DG 16 probe, staining with dyes, etc. As the number of canals may be uncertain, three files are inserted initially in a continuous C-shaped orifice (two extremes and center), two files in an oval orifice (one at each extreme) and a single file in a circular orifice.

The complex anatomy can be dealt with the use of hand files or additional rotary instruments. In the current case series, we have used hand files to ensure adequate debridement of the canal system. Care must be taken while preparing the isthmi area with hand files. Overzealous preparation may lead tothe strip perforation. Other methods to adequately clean the confluent areas include ultrasonics and self adjusting file (SAF). Irrigation plays the significant role in the debridement of the system. The present case series shows use of 3% sodium hypochlorite with Endoactivator system for the debridement of the isthmus area where hand and rotary instruments do not reach and clean. The obturation technique used in the above cases was warm vertical compaction method. This technique ensures a three-dimensional fill of the canal system and its possible anastomoses. The sealer used was AH Plus sealer for its flow properties and sealing ability of the resin.

CONCLUSION

The knowledge of root canal anatomy and its aberrations is essential for successful endodontic treatment. The C-shaped canal configuration although rare, is challenging one to diagnose and manage endodontically. Use of dental operating microscope (DOM) and CBCT help in identification and diagnosis of C-shaped canal configuration. Modifications may be required in access cavity preparation, shaping and cleaning procedure, and obturation of the root canal system in a tooth showing this configuration.

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