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Case Report

Addressing the Complexities of the C-shaped Root Canal Management

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ABSTRACT

A C-shaped canal with varying configurations is frequently observed in single-rooted mandibular second molars. The C-shaped canal was first described in endodontic literature by Cooke and Cox (1979). The high frequency of transverse anastomoses, lateral canals, and apical deltas in these teeth complicates the cleaning and sealing of the root canal system. One major reason for failure in endodontic treatment of mandibular second molars is the challenge of identifying C-shaped canals before treatment begins. This case report discusses the successful management of C shaped canal using thermoplastic obturation technique.

KEYWORDS: C-shaped canal; mandibular second molar; thermoplasticized gutta purcha

INTRODUCTION

The primary goal of root canal therapy is to thoroughly shape and clean the canal and then completely fill them with an inert material. Failure to address an untreated canal can lead to treatment failure[1]. Success in endodontics relies on accurate diagnosis, effective treatment planning, and a solid understanding of canal morphology and its variations. A significant anatomical variation is the "C" configuration of the canal system, first described by Cooke and Cox in 1979, which is named for its distinctive cross-sectional shape[2].

The C-shaped canal is a result of root fusion and a type of taurodontism. It occurs when Hertwig's epithelial sheath fails to properly develop or fuse in the furcation area during tooth development[3]. If fusion fails on the buccal side, a lingual groove forms, while failure on the lingual side can create a similar outcome. If fusion fails on both sides, a conical or prism-shaped root develops[4]. C-shaped canals are particularly common in the mandibular second molars due to the high incidence of root fusion in these teeth. The prevalence of C-shaped canal systems in second mandibular molars has been reported as 31.5% in the Chinese population5, which is significantly higher than the rates observed in other populations[1,6]. For instance, Gulabivala *et al.*[7] found a 22.4% incidence of C-shaped canals in Burmese patients using canal staining and tooth clearing techniques, while another study by the same author, employing Indian ink injection, observed a 10% prevalence in Thai individuals[8]. Additionally, Wang *et al.* reported a 41.27% incidence of C-shaped canal systems in the mandibular second molars of Chinese population[9].

Melton *et al.*[10] proposed a classification system for C-shaped canals based on their cross-sectional shape:

1. Category I: A continuous C-shaped canal that extends from the pulp chamber to the apex, maintaining a C-shaped outline without any separation [C1 in Figure 1].
2. Category II: A semicolon-shaped (;) orifice where dentine separates a main C-shaped canal from a distinct mesial canal [C2 in Figure 1].
3. Category III: Features two or more discrete, separate canals. According to Seo *et al.*[12], the most common types were Melton's type I in the coronal region and type III in the apical region [C3 in Figure 1].

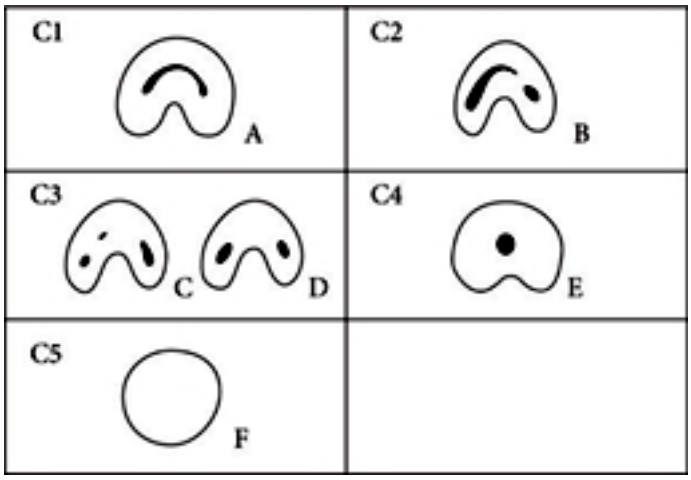

Figure 1: Classification of C-shaped Canal Configuration

Fan *et al.*[10] adapted Melton's method into the following categories:

1. Category I (C1): The shape resembles an interrupted "C" with no divisions or separations [Figure 1A].
2. Category II (C2): The canal shape looks like a semicolon due to a discontinuation of the "C" outline [Figure 1B]. In this category, either angle α or β [Figure 2] must be at least 60°.
3. Category III (C3): Features 2 or 3 separate canals [Figure 1C and D], with both angles α and β being less than 60° [Figure 3].
4. Category IV (C4): Consists of a single round or oval canal in cross-section [Figure 1E].
5. Category V (C5): No visible canal lumen, typically observed only near the apex [Figure 1F].

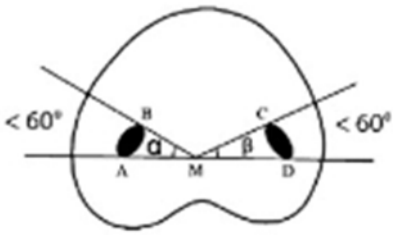

Figure 2

Measurement of angles for the C3 canal: Both angle α and angle β 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

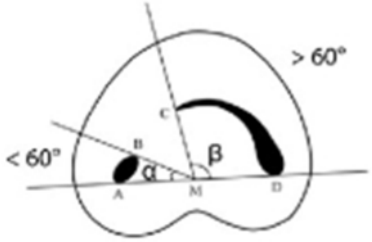

Figure 3

Measurement of angles for the C2 canal: Angle β 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; β, angle between line CM and line DM

Fan *et al.*[11] categorized C-shaped roots based on their radiographic features into three types:

1. Type I: A conical or square root with a faint radiolucent longitudinal line dividing it into distal and mesial sections. This type includes a mesial and a distal canal that merge into a single canal before exiting through the apical foramen(s) [Figure 4a].
2. Type II: A conical or square root with a faint radiolucent longitudinal line dividing it into distal and mesial sections. In this type, the mesial and distal canals each follow their own separate paths to the apex [Figure 4b].
3. Type III: A conical or square root with a faint radiolucent longitudinal line dividing it into distal and mesial sections. This type features a mesial and a distal canal, with one canal curving and aligning with the radiolucent line towards the apex, while the other canal continues on its own path to the apex [Figure 4c]

Instead of having multiple separate orifices, the pulp chamber in a C-shaped canal is characterized by a single ribbon-like orifice with a 180-degree arc. In mandibular molars, this orifice begins at the mesio-lingual line angle and curves around to end at the distal part of the pulp chamber. This canal configuration is typically observed in teeth with fused roots, either on the buccal or lingual side11. Recent research on mandibular molars with C-shaped roots shows that NiTi rotary instrumentation is linked to a higher incidence (59.6%) of un-instrumented canal areas compared to manual K-file instrumentation (41.6%), with more dentine being removed from the convex side of the C-shaped canal[13,14].

The C-shaped canal system presents a significant challenge for effective cleaning and sealing. This case report illustrates a successful approach to managing a C-shaped canal in a mandibular second molar.

CASE REPORT

A 40-year-old female patient reported to the Department of Conservative Dentistry and Endodontics Pacific Dental College & Research Centre, with a chief complaint of pain in the lower right back tooth region. Medical history of the patient was noncontributory. There was presence of prolonged sensitivity to hot and cold. Clinically, there was a presence of deep disto-prox-occlusal carious lesion approaching pulp, the tooth was nontender to percussion. Radiographically, radiolucency was seen involving pulp without any peri-radicular changes [Figure 5]. The patient was diagnosed with chronic irreversible pulpitis. The radiograph also showed a single conical root with two radiolucent canal outline, which were joining at the apical third of the root, suggesting presence of C-shaped canal pattern. .

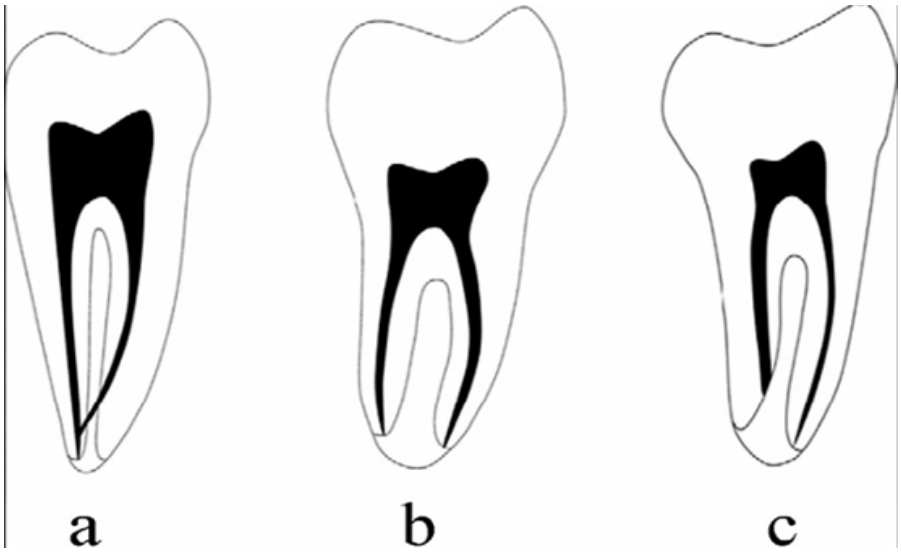

Figure 4: Classification of C-shaped Roots According to their Radiographic Types by Fan *et al*

Figure 5: Pre-operative Radiograph

After rubber-dam isolation and profound anesthesia, an access cavity was prepared. On exploration of pulp chamber, two orifices were recognized, which were then negotiated till apex with the use of multiple small K files with the help of RC-Help (Prime Dent, India) and 3% NaOCl [Figure 6a]. After proper working length determination, an IOPA was taken and it showed that all the canals were joined at the apical third of the root [Figure 6b]. Then, cleaning and shaping was done with ProTaper hand files (Dentsply Maillefer, Ballaigues, Switzerland) till the size of F2 under constant irrigation with saline and 3% NaOCl along with endo-activator.

Master cone was fitted to the working length and radiograph was taken [Figure 6c], and the apical part of the canal was obturated with selected master gutta-percha cone i.e. F2 GP with AH-Plus endodontic sealer (Dentsply Maillefer Company, USA) and then the canals were obturated with thermoplasticized gutta purcha. A temporary restoration was placed [Figure 6d]. The patient was recalled after 1 week for a post endodontic restoration [Figure 6e].

Figure 6(a)

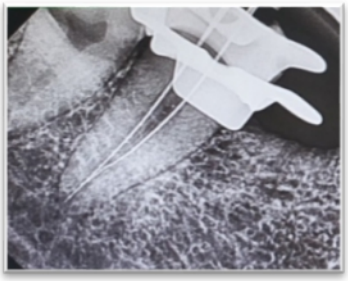

Figure 6(b)

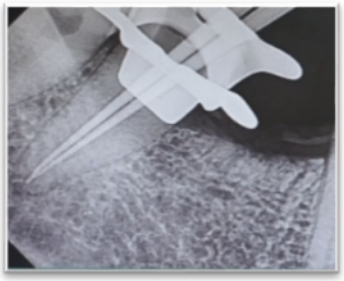

Figure 6(c)

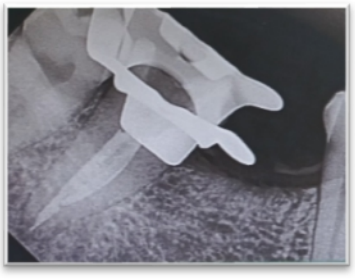

Figure 6(d)

Figure 6(e)

DISCUSSION

The definition of a C-shaped canal is still not fully established. Some scholars categorize C-shaped canals as those that exhibit a general "C" shape within the root, even if separate canals or orifices are not evident[15]. Fan *et al.* employed micro-computed tomography (CT) to study the C-shaped canal system and proposed an updated classification for these canals[10]. They determined that a canal system must display all three of the following characteristics to be classified as C-shaped:

1. Fused roots
2. A longitudinal groove on the lingual or buccal surface of the root
3. At least one cross-section of the canal fitting the C1, C2, or C3 configuration

Their findings revealed that even though a C3-type orifice might appear as two or three distinct orifices, there is often an identifiable isthmus connecting them. Clinical identification of C-shaped canals relies on specific observable criteria, such as the anatomy of the pulp chamber floor and ongoing haemorrhage or pain when separate canal orifices are identified[16].When a deep groove is evident on the lingual or buccal surfaces of the root, a C-shaped canal should be anticipated. New diagnostic methods are needed to not only confirm the presence but also determine the full configuration of the C-shaped canal system[17]. The key feature of C-shaped canals is the presence of a fin or web connecting the individual canals[11]. Identifying C-shaped canals typically involves observing the convergence of root canal instruments at the apex or their alignment exiting the furcation[18].

In this case, the initial radiograph suggested a single root with two canal orifices, hinting at a possible C-shaped canal configuration. After access preparation, only two canals with a semicolon-shaped orifice were located. Using ultrasonics in conjunction with conventional therapy could improve outcomes. Increased volume of irrigant and deeper penetration with small instruments, utilizing sonic or ultrasonic techniques, may enhance cleaning in the fan-shaped areas of the C-shaped canal. The thermoplasticized gutta-percha technique is recommended for managing canal irregularities.

CONCLUSION

Understanding the various potential alterations in tooth anatomy is crucial for successful endodontic treatment. The C-shaped canal system often exhibits significant variability in its anatomical configuration, which can complicate debridement, filling, and restoration processes.

CONFLICTS OF INTEREST: None

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