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The C-Shaped Root Canal Configuration: An Endodontic Challenge A Review

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Abstract:

The variations of the root canal anatomy along its root length present major challenges with respect to thorough debridement and proper obturation. C-shaped root canal is one such important anatomic variation which presents a thin fin or web connecting the root canals. It is important for the dentist to have knowledge of its distribution in various teeth and proceed with a thorough radiographic and clinical examination of the pulp chamber floor to ensure better endodontic success.

Key words: Anatomy, C-shaped root canal, canal configuration, mandibular second molar.

1. Introduction:

The basic principles of root canal treatment are the eradication of root canal irritants, obturation of the root canal system, and preservation of the natural dentition [1]. Knowledge of both normal and abnormal anatomy of the root canal system dictates the parameters for execution of root canal therapy and can directly affect the outcome of endodontic treatment [2]. The variation of root canal morphology, especially in multirooted teeth, is a constant challenge for diagnosis and successful endodontic therapy [3].

One of the important dental anatomic variations is the "C" configuration of the canal system. The C-shaped canal, which was first documented in endodontic literature by Cooke and Cox in 1979, is so named for the cross-sectional morphology of the root and root canal. Instead of having several discrete orifices, the pulp chamber of the C-shaped canal is a single ribbon-shaped orifice with a 180° arc (or more), which, in mandibular molars, starts at the mesiolingual line angle and sweeps around the buccal to end at the distal aspect of the pulp chamber [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 [4,5]. Because of the great challenges presented in the management of C-shaped canal system, this review will address its etiology, classification, diagnosis, and treatment.

2. Etiology

Typically, C-shaped canal configuration is found in the teeth with fusion of the roots either on its buccal or lingual aspect [6]. It is speculated that this anatomy is caused by the failure of the Hertwig's epithelial root sheath to fuse on the lingual or buccal root surface. However, this canal configuration may also be formed by coalescence because of deposition of the cementum with time [7].

3. Classification

3.1 Melton's classification:

Melton et al [8] 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 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).

The root canal shape may vary along the length of the root & therefore appearance of the canal orifice may not be a good predictor of the actual canal anatomy. Melton's classification was not elaborate enough in describing these variations.

3.2 Fan's classification (anatomic classification)

As in Melton's classification, there has been no clear description of the difference between category II and III, Fan et al [9] in 2004 modified Melton's classification into following categories:

Category I: the shape is an uninterrupted "C" with no separation (figure 1 a).

Category II: the canal shape resembles a semicolon resulting from a discontinuation of the "C" outline (figure 1 b), but either angle α or β should be no less than 60° (figure 2)

Category III: two or three separate canals (figure 1 c and d) are present and both angles, α and β, are less than 60° (figure 3).

Category IV: only one round or oval canal is found (figure 1 e).

Category V: no canal lumen can be observed, usually seen near the apex (figure 1 f).

3.3 Fan's Classification (Radiographic Classification)

Fan et al [10] 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) (figure 4 a).

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 (figure 4 b).

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 (figure 4 c).

4. Incidence:

C-shaped canal system is most commonly found in mandibular second molars but may also occur in maxillary molars and other mandibular molars and premolars too [4,10,11,12,13,14]. Studies on mandibular second molars have shown a high incidence of C-shaped roots and canals (10%-31.5%) [15]. There is significant ethnic variation as well in the incidence of C-shaped molars. Reported prevalence includes: 2.7-8% for Americans, 13% for mixed Asian population, 31.5% for Chinese and 44.5% for Korean population [16]. It has thus been established that this particular anatomy is more frequent in Asians than in other racial groups. When present on one side, a C-shaped canal may be found in the contralateral tooth in over 70% of individuals [15].

5. Diagnosis:

The variation in morphology of C-shaped canal system is unusual and hence can lead to difficulties during treatment. Therefore proper diagnosis before treatment is extremely important.

5.1 Clinical diagnosis:

Clinical recognition of C-shaped canals is based on specific anatomy of pulp

chamber, difficult to control bleeding because of anastomosis, large pulp chamber in occluso-apical dimension with deep lying bifurcation [12]. C-shaped canal system exhibit features like fused roots, a longitudinal groove on the lingual or buccal surfaces of the root, and at least one cross-section of the canal belongs to the C1, C2, or C3 configuration. Alternatively, the canal can be calcified, disguising its C-shape [9]. At the outset, several orifices may be probed that link up on further instrumentation [4].

5.2 Radiographic diagnosis:

Cooke and Cox [4] stated that it was impossible to diagnose C-shaped canals on the preoperative radiograph, but in the study of Haddad et al [17] almost all preoperative radiographs showed common characteristics. These characteristics formed a typical image that allowed prediction of the existence of this anatomic condition. In fact, most radiographs revealed radicular fusion or proximity, a large distal canal, a narrow mesial canal, and a blurred image of a third canal in between. Radiographs taken while probing the root canal system reveal two characteristics: instruments tend to converge at the apex; instruments appear clinically and radiographically to perforate the furcation [18]. Alternatively, advanced radiographic techniques like cone-beam computed tomography would aid in proper diagnosis.

6. Endodontic management:

In C-shaped canal system, presence of a high incidence of transverse anastomoses, lateral canals, and apical deltas makes it difficult to clean and seal the root canal system. Because of its challenging morphology, the C-shaped canal anatomy would increase the difficulty in root canal therapy and may account for the frequent occurrence of endodontic failures [19]. Therefore conventional root canal treatment techniques have been modified to manage teeth with C-shaped root canal system.

6.1 Root canal cleaning and shaping:

The access cavity for teeth with a C-shaped root canal system varies considerably and depends on the pulp morphology of the specific tooth. Fiberoptic transillumination can enhance variant canal anatomy identification [20]. Also, the increased visibility afforded with the use of surgical operating microscopes would make identification of C-shaped canal system even more obvious [21,22].

The mesiobuccal, mesiolingual and distal canal spaces can be prepared normally. However, the isthmus should not be prepared with larger than ISO no. 25 files; otherwise, strip perforation is likely to occur. Extravagant use of small files and copious irrigation is a key to thorough debridement of narrow canal isthmuses. The ribbon canal space is frequently eccentric to the lingual side of the C-shaped radicular dentin. An anticurvature filing method in the coronal third of the canal is needed to prevent perforation [15].

6.2 Obturation:

Obturation of C-shaped canals may require technique modifications. The mesiobuccal, mesiolingual and distal canal spaces can be prepared and obturated as standard canals. However, sealing the buccal isthmus is difficult if lateral condensation is the only method used. Because this isthmus may not be prepared with a sufficient flare to permit deep placement of the spreader. Therefore, application of thermoplasticized gutta-percha is more appropriate since it can easily flow into the

canal intricacies. In addition, proper placement of sealer with ultrasonic endodontic files is critical, regardless of the choice of obturation technique [20,21,23].

6.3 Post placement:

If post is to be placed, use of only the distal canal should be considered. Proper post-canal adaptation and stress distribution is more likely to result in the tubular distal canal. Placement of posts or antirotational pins in the mesiolingual and mesiobuccal areas of C-shaped root invites perforation. Also, post width should be minimized and it should be remembered that there is a higher risk of root perforation at the thinner lingual walls of C-shaped canals during shaping and post space preparation procedures [20].

7. Conclusion:

C-shape configuration is known to present a complex canal anatomy where it is easy to retain residual pulp tissue, bacteria, and dentin debris, thus requiring supplementary effort to accomplish a successful treatment. Newer diagnostic methods like cone-beam computed tomography shall be considered to aid in accurate diagnosis. Furthermore, root canal instrumentation using ultrasonics followed by thermoplasticised obturation would increase the predictability of root canal treatment in C-shaped canal systems.

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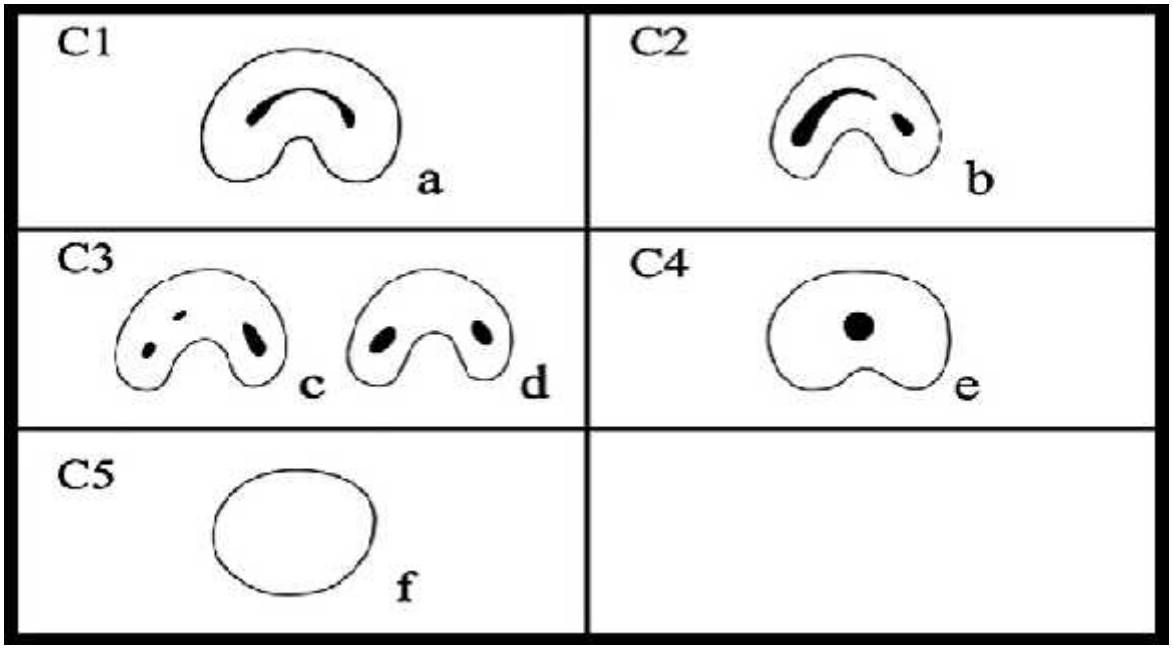

Figure 1: Classification of C-shaped canal configuration

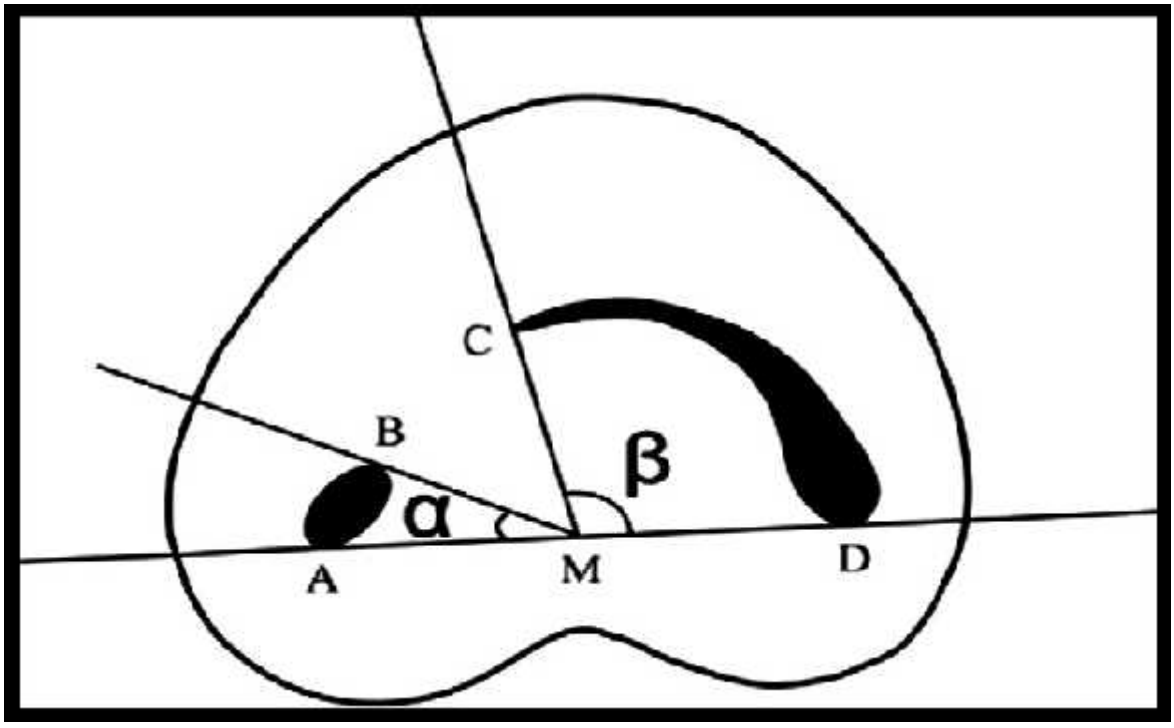

Figure 2: Measurement of angles for the C2 canal. Angle β is more than 60°. A and B - Ends of one canal cross-section; C and D - ends of the other canal cross-section; M - middle point of line AD; α - angle between line AM and line BM; β - angle between line CM and line DM.

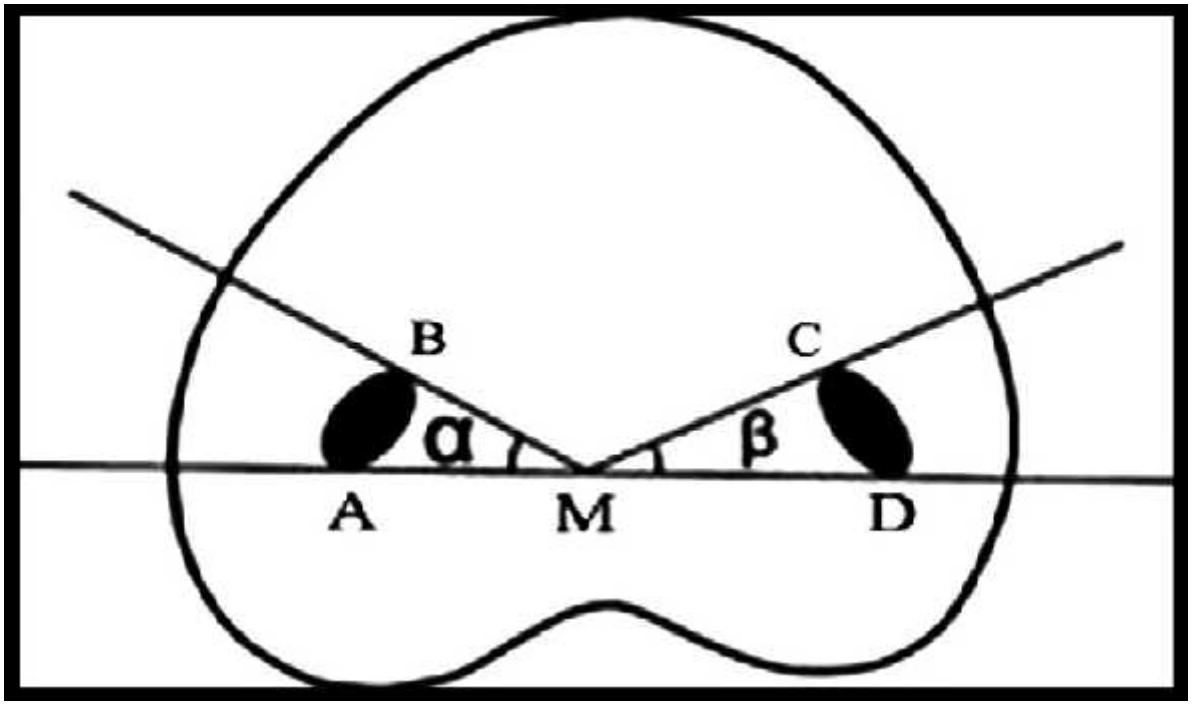

Figure 3: Measurement of angles for the C3 canal. Both angle α and angle β are less than 60°. A and B - Ends of one canal cross-section; C and D - ends of another canal cross-section; M, middle point of line AD; α - angle between line AM and line BM; β - angle between line CM and line DM.

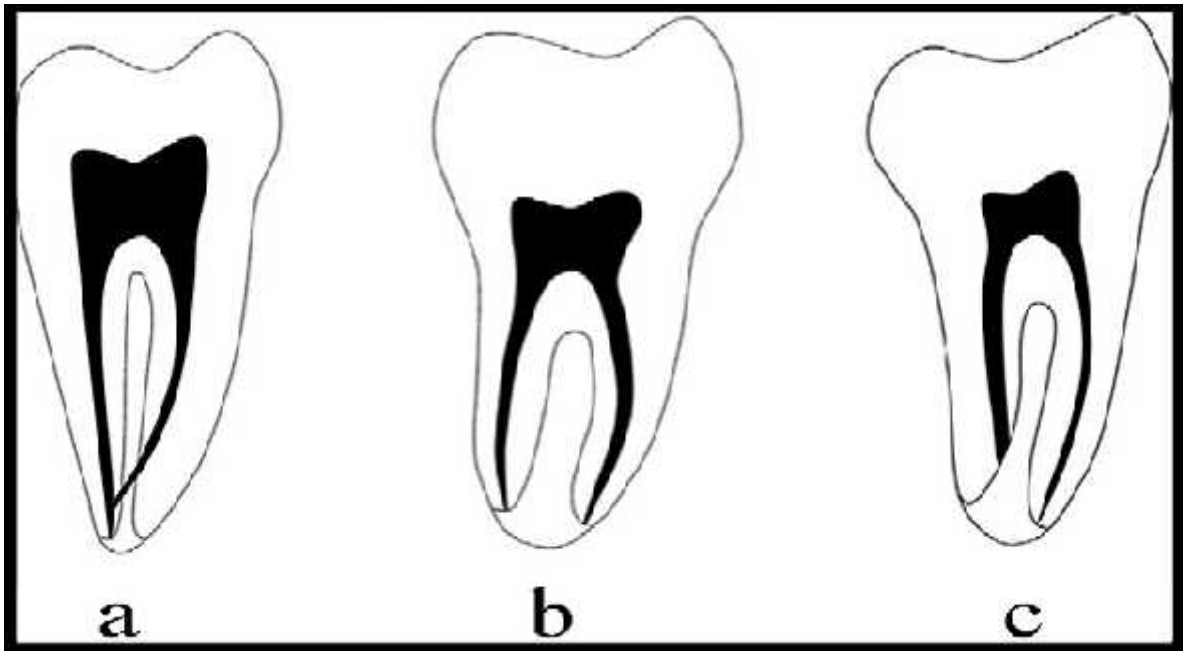

Figure 4: Radiographic types. (*A*) Type I, (*B*) type II, and (*C*) type III