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Review Article

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C-SHAPED CANALS: A LITERATURE REVIEW

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ABSTRACT

Knowledge about the root canal anatomy and its variations is very essential for a successful endodontic therapy. One such variation is C-shaped canal. It imposes a challenge to manage the C- shaped canals because of its unusual anatomy and difficulty in diagnosing such complexity. C-shaped root canal is commonly seen in mandibular second molar with geographic predilection. Diagnosis in the initial stages helps the clinician to perform the root canal treatment as efficient as possible. This literature review provides an insight about the classification of the c-shaped canals, its incidence, various radiographic and clinical diagnostic aids and its endodontic management.

KEYWORDS: C-shaped canal, Hertwig's epithelial root sheath, Isthmus, fins, Endodontic management.

INTRODUCTION

Triad for endodontic success includes complete cleaning and shaping of the canals, and filling of the root canal system in three dimensional manner.[1] Complete knowledge of the anatomy and morphology of the root canals is very essential and is an important factor in determining the success of the endodontic therapy.[2] One such variants is the C-Shaped anatomy in which the root canals are joined by a fin or web like structure which gives the characteristic appearance of C shape at the orifice.[3] First case of C shaped root canal system was documented by Cooke and Cox in 1979.[1]

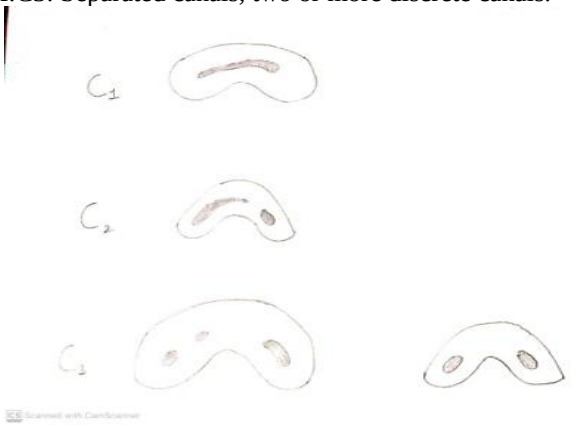
Etiology and Incidence

Hertwig's epithelial root sheath bends below CEJ and fuses in the centre during the stage of tooth development. Any alterations or failure of fusion of Hertwig's epithelial root sheath on the buccal or lingual root surface results in C-Shaped canal system.[4] Prevalence of C shaped canals is higher in mandibular second molars (2.7% to 45.5%) and may also be seen in mandibular premolars (1%), maxillary molars (4.7%) and mandibular third molars (3.5% to 4%). Itself being an anatomical variant, C shaped canals presents with numerous variations in the number and location of the canals from the coronal to apical third. These variations are usually of two types, one being single ribbon shaped canal from orifice to apex and the second type being three or more distinct canals below the C shaped orifice.[5] Meta analysis by Martins etal showed gender and geographic region as major confounding factors rather than age which did not influence the prevalence of C- shaped canals.[7]

Classification:[5,6]

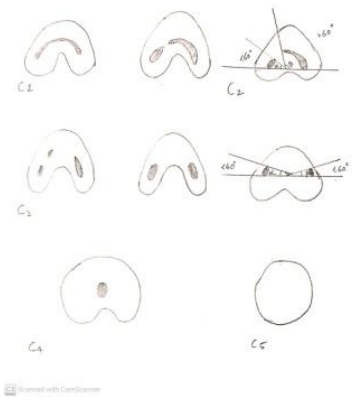
For ease in diagnosing and managing variants of C-Shaped canals many authors came up with different classifications.

According to **Melton,** C-Shaped canals can be classified based on their cross sectional shape as follows
I. C1: Continuous C-shaped canal from orifice to apex.
II. C2: Semicolon shaped (;) - Dentin separates main C-shaped canal from a distinct mesial canal.
III.C3: Separated canals, two or more discrete canals.



Fan's Classification

I.C1: interrupted C with no separation or division.
II.C2: canal shape is of semicolon resulting from discontinuation of the C outline; either α or β should not be less than 60^0.
III.C3: 2 or 3 separate canals and both α and β should be less than 60^0.
IV.C4: one round or oval canal in that cross section.
V. C5: no canal lumen could be observed



Fan's Radiographic Classification

Type I: Conical or square root with a radiolucent longitudinal line separating root to mesial and distal halves; mesial and distal canal merges to one before exiting at the apical foramen.

Type II: Conical or square root with a radiolucent longitudinal line separating root to mesial and distal halves; mesial and distal canals continue in the same path to the apex.

Type III: Conical or square root with a radiolucent longitudinal line separating root to mesial and distal halves; one canal curves and superimposes on the radiolucent line and the other canal continues in the same pathway to the apex.

According to Cooke and Cox, routine preoperative radiographs cannot reveal the exact morphology of the canal variants.[8,9] whereas CBCT and spiral CT serves as a good diagnostic tool for C-shaped canals.[10] Haddad etal in his study mentioned that the pre-operative radiographs though inconclusive, showed few common features such as radicular fusion or proximity, blurred image of the third canal, large distal canal, narrow mesial canal in teeth with category II anatomical outline.[11] In such teeth with complicated outline, CBCT helps in estimating the distance between the cuspal region to the furcation which can be useful to avoid the risk of furcal perforation, also the danger zones throughout the root length can be identified so that these areas can be instrumented carefully in order to avoid strip perforation.[12] Jin etal conducted a study and concluded that though CT provides the detailed information it is impossible to confirm the results histologically and demands for further studies to verify the accuracy of CT over other diagnostic aids.[13] Few other methods which help in detecting C-shaped canals for in-vitro studies and extracted teeth are cross cut section method, dye infiltration method or transparent model method.[14] and methyl salicylate and nitric acid can be used together in preparing a transparent tooth model.[15]

According to few studies, semicolon and continuous shaped morphology of C-shaped canals at orifice levels have a higher chance of splitting into 2 or 3 canals in apical region. According to Melton etal C-shaped canals elicit different canal configurations at different levels. Studies suggests that if sub pulpal clinical examination of the access cavity is continuously connected, separate canal exiting at the apical level should be cross verified.[16]

A study was done by De Moor wherein he compared the morphology of C- shaped canals in the maxillary first molars which is a rare entity. He concluded that the C-shaped anatomy in the distal portion of the pulp chamber is a result of the fusion of distobuccal and palatal roots.[17]

Fan etal in his study concluded that C_1 and C_2 canal configurations were noted in most of the radiographic types. In coronal region type II radiographic forms showed C_3 configuration. In middle third region most of the type I forms showed C_1 and C_2 whereas type II and type III showed C_3 and C_2 respectively. In apical third C_1 and C_4 were greatly seen in type I forms whereas C_3 was commonly seen in type II and type III forms. He also compared the variations throughout the length of the canal and found out that in Type I radiographic forms- C_1 canal morphology was seen at orifice level, C_4 in the apical region and C_1, C_2 forms in the middle third. In Type II radiographic forms- C_3 canal morphology was seen coronally, C_2 in the coronal or middle third, C3,C_4 in the apical third. In Type III radiographic forms- C_2 canal morphology was seen in coronal and middle third and C_3 in the apical region.[18]

Identification and Preparation of C-Shaped Root Canals

Once access cavity is prepared, few equipments like fiber optic transillumination can aid in identification of C-shaped canals. Fiber optic tip once placed on the buccal surface illuminates the pulp chamber which appears as a dark line. Surgical operating microscopes further aid and increases the success rate of the treatment.[6] The complex anatomy in the apical region demands for the accurate determination of working length, thorough cleaning and shaping and three dimensional hermetic seal to ensure success of the root canal therapy. Hamid etal in his study found that the apex locator showed better results and was more reliable than the conventional radiographic techniques. They also suggested Root ZX mini apex locator reduces the risk of over estimating the working length of the canals.[19] Authors suggest deep orifice preparation and use of

small files help to understand the configuaration better. Usage of small K-files and copious amount of 5.25% sodium hypochlorite irrigation helps in thorough cleaning and shaping of the canals and isthmus region. Files larger than size 25 and Gates Glidden Drills are to be avoided as it results in strip perforation.[6] Presence of concavities, isthmuses, fins etc in premolars makes it even more complicated and poses a challenge during cleaning and shaping. Rigorous instrumentation and larger files should be avoided in such danger zone.[20]

Since C-shaped canals are connected by ribbon like isthmus, instrumentation in such region is challenging. Ni-Ti instruments because of their flexibility are mainly aimed in the lumen of the canal and cannot be pressed against the cavity walls which leaves the isthmus uninstrumented. The procedural errors after Ni-Ti instrumentation is very minimal thus the authors suggest initial Ni-Ti file instrumentation followed by H-files and K-files for cleaning and shaping the areas which were untouched.[21] Compared to protaper files, SAF system has proven to be effective in cleaning and shaping such canal variations also alternative techniques like sonics and ultrasonics may be considered.[5] In a study conducted by Bertrand etal, root canal treatment of mandibular second premolar with C- shaped canal anatomy was performed. He suggested that the residual dentin thickness should be minimum of 0.3mm or one third of the root length in order to avoid the risk of vertical root fracture or strip perforation.[22] Gu etal stated that C-shaped canals in mandibular first premolars were usually identified in the apical half of the root and also identified the mesial canals facing the radicular groove were very thin and posed a higher risk for root perforations.[23]

Obturation

According to the studies conducted by Soo etal, apical thirds of the C- shaped canals were poorly filled and showed voids as well which can be attributed to the elongated shape and taper of the canal being greater in the mesiodistal direction rather than the bucco lingual orientation. Another study conducted by Wu etal showed lateral condensation technique in oval canals had least reliability and was time consuming since it required a greater number of accessory cones insertion. Comparative studies done by Baumgardner & Krell revealed less voids & homogenous obturation with ultrasonic compaction however temperature increased while using ultrasonic spreader may harm the periodontal tissues health.[24] Authors concluded that the thermoplastized gutta-percha and the core carrier techniques showed better quality of obturation with less time consumed.[24,25]

Post Endodntic Restoration

Posts and anti rotational pins if required are better placed in the distal canals rather than mesio lingual or mesio buccal canals which are the danger zones and may lead to fracture or perforation. The pulpal floor which is usually very deep in C-shaped canals provides desirable retention from the available undercuts. Bonded amalgam, composite or chamber retained restorative materials serves as a better option for post endodontic restoration.[5]

Endodontic Surgery

In case of an endodontic failure, there may be the requirement of the endodontic surgery. In C- shaped canals, since there is the communication between the individual root canals, apicectomy, root end preparation followed by filling becomes very complicated. Hemisection also provides the tooth with questionable prognosis as the roots with C-shaped canals are fused and are without a visible furcation. In a situation where the endodontic surgery becomes essential, extraction followed by root end procedure and replantation are best considered to have a good prognosis.[26]

CONCLUSION

C-shaped canals are most commonly seen in mandibular second molars. Because of its complex canal anatomy it poses various challenges to the clinician. Understanding the classification and with proper diagnostic aids, cleaning and shaping, obturation techniques one can ensure a better clinical prognosis in such teeth and ultimately reaching the goal of retaining the function of the tooth.

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