C-Shaped Root Canal Configuration - A Review

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Abstract-
Successful endodontic therapy requires a thorough knowledge of the root canal morphology . C shaped canal, a common root canal variation in mandibular molar are often seen in root canal form having a elongated ribbon shaped arc(C shape) that continues uninterrupted till the apex. These canals are mostly seen in mandibular second molars as an extensive complex root canal system with the presence of fins or webs that connects individual mesial and distal canals. And hence, these canals present challenge to debridement and obturation. Rotary and hand instruments assisted with sonics and ultrasonics and modified obturation techniques aid in effective management of C shaped root canals. This review is done in order to update the current knowledge about C-shaped canals. This helps in understanding C-shaped root canal morphology for proper diagnosis and successful treatment.
Key Words: Single ribbon shaped orifice, Occlusoapical groove, Gutter shaped roots. Radicular fusion

INTRODUCTION

A thorough knowledge of tooth's internal anatomy in addition to proper diagnosis and treatment planning is paramount for achieving success in endodontic treatment procedures. The main objective of root canal therapy is cleaning and shaping of all pulp spaces and its obturation with an inert filling material. Presence of untreated root canal often leads to failure in endodontic treatment.

C shaped canals are cross sectional anatomical variations seen in root canal configuration of mandibular molar which was first documented in endodontic literature by Cooke and Cox in 1979[1]. It occurs mainly in mandibular molars, but also has been reported in maxillary first molars, first and third mandibular molars, and in mandibular lower pre-molars [2].

C-SHAPED CANALS

C-shaped root canal system is defined by the morphology of its horizontal cross section which is in the form of C, with canals which may or may not be separate [3].

These canals does not possess several discrete orifices. The C-shaped canal usually has a single ribbon shaped orifice with 180 degree arc or more in its pulp chamber. The canal originates at the mesiolingual line angle and sweeps around the buccal aspect to end at the distal aspect of the pulp chamber [4]. The root structure of mandibular molarshas a wide range of anatomic variations such as single ribbon like, C shaped canal from orifice to apex[5] with three or more distinct canals below the C- shaped orifice [6]. The incidence of C shaped canals in Indian population is found to be 7.5% [7].

This type of canal configuration is seen in the teeth with the fusion of the roots either on its buccal or lingual aspect. Hence, these C-shaped canals are difficult in debridement and obturation because of their complex anatomical variations as said earlier.

ANATOMICAL FEATURES:

ROOTS

C shaped canals are often seen in conical or square root configuration [8]. C-shaped canals posses a root configuration of molars which may be represented by fusion of either the facial or lingual aspect of the mesial and distal roots. An occluso-apical groove present on the buccal or lingual surface of the roots represents the line of fusion between mesial and distal roots. According to Peiris et al. , mandibular second molars possess 'gutter-shaped' roots which contain C-shaped canals [9].

PULP CHAMBER

The pulp chambers of the teeth with C-shaped canals mostly have greater apico-occlusal width with a low bifurcation resulting in a deep pulp chamber floor [10]. There is a presence of connecting slit which determines the location of "C" shape. If the buccal portion of the mesial and distal roots are fused, the slit goes through the area of fusion and so the "C" is close to lingual. If the lingual portion of the roots are fused, then the "C" is close to the buccal [11].

ROOT CANAL SYSTEM

The C-shaped root canal system shows broad fan shaped communications. These communications are usually present from the coronal to the apical third of the canal. Accessory and lateral canals, inter-canal communications and apical delta are found in the apical region of C-shaped canals [12]. C-shaped canals on cross section reveals thinner lingual walls than buccal wall with the lowest value of 0.26 mm [13].

MANDIBULAR PREMOLARS

Generally, shallow or deep radicular grooves are present in all C shaped premolars.These are located on the external mesiolingual surface of the root which usually starts 3 mm below the cementoenamel junction and does not extend into the apex. At some areas of the root the mean depth can be around 1.5mm[14]. Hence this must be considered while cleaning and shaping.

Morphology of C-shaped canals in mandibular first premolar may fall on below four features [15].

- Continuous C-shaped canal only
- Semilunar buccal canal only
- Combination of continuous C-shape and semilunar buccal canal
- C-shaped canal interrupted by non C-shaped canal

AETIOLOGY OF C-SHAPED CANALS

Basically, Hertwig's Epithelial Root Sheath (HERS) is responsible for the shape and number of roots that each tooth possesses.

This HERS bends in horizontal plane below the cementoenamel junction and fuses in the centre leaving the opening for the roots [16]. The main cause for the formation of a C-shaped roots is the failure of the HERS to fuse on the lingual or buccal root surface.

As said earlier, these canals contain a fin or web communication between the individual canals. It is found that C shaped roots can also be formed as a result of deposition of cementum with time. When fusion of either the buccal or lingual aspects of the mesial and distal roots occur, C shaped canals are formed. These canals remain irregular and the roots are connected by the means of inter-radicular ribbon [17].

CLASSIFICATION OF C-SHAPED CANALS

Melton's classification

Melton et al .1991 proposed the following classification based on the cross sectional shape of C-shaped canals [18].

- **Category I:** Continuous C shaped canal running from the pulp chamber to the apex defines a C-shaped without any separation.

- **Category II:** The semicolon shaped orifice in which dentine separates a main C shaped canal from one mesial distinct canal.
- **Category III**: Refers to those with two or more discrete and separate canals
    - **I. Subdivision I:** C-shaped orifice in the coronal third that divides into two or more discrete and separate canals that join apically.
    - **II. 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.
    - **III. Subdivision III:** C-shaped orifice that divides into two or more discrete and separate canals in the coronal third to the apex.

Fan et al in 2004 modified Melton's classification into following categories [19]

- **Category I (C1):** The shape was an interrupted 'C' with no separation or division.
- **Category II (C2):** The canal shape resembled a semicolon resulting from a discontinuation of the 'C' outline, but either angle or should be no less than 60 degree.
- **Category III (C3):** Two or three separate canals and both angles,were less than 60 degrees.
- **Category IV (C4):** Only one round or oval canal in that cross section
- **Category V (C5):** No canal lumen could be observed.

Fan's Classification (Radiographic classification)

Fan et al classified C-shaped roots according to their radiographic appearance into three types :

a. **Type I:** Conical or square root with a vague, radiolucent longitudinal line separating the root into mesial and distal parts. There was mesial and distal canal that merged into one before exiting at the apical foramen
b. **Type II:** Conical or square root with a vague, radiolucent line separating the roor into distal and mesial parts. Mesial and distal canals appeared to continue on their own pathway to the apex.
c. **Type III:** Conical or square root with a vague, radiolucent line separating the roots into distal and mesial parts with mesial and distal canals, one canal curved to and superimposed on this radiolucent line when running towards the apex, and the other canal appeared to continue on its own pathway to the apex.

DIAGNOSIS OF C-SHAPED CANALS

Preoperative radiographs completely aid in identification of any variation on root canal morphology. Some investigators described four radiographic characteristics which can allow the prediction of existence of the C-shaped canals [20]. They are

- Radicular fusion
- Radicular proximity
- A large Distal canal
- A blurred image of a third canal in between.

A C-shaped root may present radiographically as a single-fused root or as two distinct roots with communication fin. C-shaped teeth are divided into three types based on radiographic appearance according to Fan et al. They are :

a) Type I: The C-shaped canal system actually appears as two distinct canals, because the isthmus that links the mesial and distal "main" canals is very thin and hence is not detected radiographically.
b) Type II: The C-shaped canal system runs as two distinct canals because the mesial and distal canals assume their own individual course to apex.
c) Type III: One canal continued its course to the apex giving the image of a distinct canal whereas the other proceed close very close to or within the fused area between the to main root in the apical third as a "web" [19].

Recent researches are done to diagnose the canal anatomy using the Spiral computed tomography, but the dissolution of the image is not yet high enough to show irregular or fine canal structures and the X-ray exposure is also another concern [21].

CLINICAL DIAGNOSIS OF CANALS

A longitudinal groove on lingual or buccal surface of the root with a C-shaped anatomy may be present which may predispose the tooth to localised periodontal disease. The pulp chamber in the teeth with C-shaped canals may be large in occluso-apical dimension and it is possible to pass an instrument from a mesial to distal aspect without obstruction [9].

MANAGEMENT OF C-SHAPED CANALS

Access cavity preparation

The first step is the access cavity preparation following root canal diagnosis. The preparation of access cavities are by application of two principles.

1) Principle of Color change- The colour of the pulp chamber floor is always darker than that of the walls.
2) Principle of orifice location- The orifices of the root canals are always located at junction of walls and floor.

In addition to this, Cementoenamel junction (CEJ) can also be considered as landmark for access opening as the apex of the canal orifice lies 2-3mm below the CEJ.

Cleaning and Shaping

Gates Glidden Drill is used to widen the slit or communication so as to access all the irregularities in the C-shaped canal system [22]. But these drills cannot be used in cases of narrow, interconnecting isthmus as it may lead to the perforation of the preparation and hence 25 file sizeor smaller is indicated in such cases of narrow isthmus. Abou-Rass et al recommended anti-curvature filing technique to avoid danger zones in C-shaped canals [23]. Canal irrigation techniques with ultrasonics were fund to be effective in achieving adequate debridement. However few studies showed that injudicious ultrasonic instrumentation carries the risk of perforation [24]. Self adjusting file system is more efficacious as it has a nickel-titanium metal lattice. This metal lattice of the file adapts itself to canal walls and with continuous irrigation along with vibrations that produce a scrubbing effect on the canal walls. Hence it is more efficacious than protaper system [25].

Recent researches show that the nickel titanium rotary instruments seem to be safe in C-shaped canals as H-files or K-files can be passively introduced into the canal after instrumentation with nickel titanium rotary instruments.

OBTURATION

Larger diameter file is inserted in the distal canal and then the master cone is seated following withdrawal of file before placement of the master cone in the mesial canal. Then the middle portion of the C-shaped canal is obturated using accessory cones. Using lateral condensation technique sealing of buccal isthmus is difficult because it does not permit deeper penetration of spreader since the isthumus cannot be flared. Thus gutta-percha, thermoplasticized with electric spreadersor delivered by injectable systems is considered more appropriate. Martin et al developed Endo Tech II that combined the qualities of both ease and speed of lateral compaction as well as superior density gained by vertical compaction of warm gutta-percha [26]. System B technique produces better obturation and root fillings consisting of over 90% gutta percha at most levels was found [27]. Obtura III, injecctable thermoplasticised gutta percha system, is found superior as it has accurate temperature control for precise consistent viscosity [28].

The quality of obturation is generally because of the unshaped divergent areas which offers resistance to the flow of the obturating material and the communications between the main. Proper placement of sealer with ultrasonic endodontic files is critical, regardless of the obturation technique.

CONCLUSION

The C-shaped anatomy remains a big challenge to dentist during negotiation, debridement and obturation. However, the conditions should no longer be an enigma to the clinicians with the advancement in the diagnostic tools.

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