Cone Beam Computed Tomography (CBCT) and Endodontic Microscopic Assessment of C-Shaped Canal Systems in Mandibular Second Molars

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ABSTRACT

By knowing the anatomy of the tooth including root canal, dentists also have gathered physiologically anomalous requirements for effective root canal treatment. An exceptional morphology is present in the root canal system known as the C-shaped root network. A substantial volume of evidence already has come out on C-shaped root canal systems. The analysis provides an extensive description of root through root canals in the form of C. Characteristics of this exceptional morphology were studied mainly focused on macroscopic, microscopic and functional measurements including odontogenic tooth shape analyses. To trying to clarify the clinical nature of C-shaped root canals, we sought to isolate them both. In addition to summarizing existing experiences, another of the objectives of this investigation was to find evidence that supports our interpretation of the C shaped root canal network. In fact, new advances in 3D mapping techniques help clarify the reliable etiology of the physiology of the C shaped root canal network. Studies of extreme scenarios such as C-shaped root anatomy or morphology with rectangle and squared channels will also help us gain the wide range with root morphologies found in man's teeth which eventually result in better care outcomes for patients and dentists and their satisfaction.

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INTRODUCTION

The C-shaped canal is quite commonly located in the mandibular 2nd molars, as shown by a vast number of studies released over the last 2 decades (Kato et al., 2014). This is an essential ethnicity distinction, which is large in Asian individuals. While, previous information on root canal system morphology is presumably growing, guided by an awareness of the physiological variability of different populations which could exist. Although this morphological difference appears mainly in the secondary mandibular molar, it might well be found in the main as well as the first premolar mandibular molar, maxillary 1st and 2nd molars as well (Jahromi et al., 2013). This develops primarily in the 2nd jaw-like molars, and was also recorded in the 1st as well as 3rd jaw molars even in the lower jaw-like premolars (Chandrashekar et al., 2014). C-formed root canal structures molars present a union of oral or lingual root, a nerve entrapment groove against a convex base, as well as a tapered or c-shaped root profile. If root canal network anatomy is C type, root canal assembling may vary (Kumar and Khambete, 2013). The root canal framework is the standard form being used to estimate root canal framework, for which the root canal network is stained and cleared (Kumar and Khambete, 2013; Kailash,
The entrance to the canal normally is shown as a C-formed aperture (arch 180°) in the configuration of a band and also as a shallow semi-mounted ridge linking the canals including distal, mesio-buccal and mesio-lingual. The floor of the pulp region of lower molars displays this uncommon arrangement. The concavity of the C might be mesiobuccally or lingually dominated. An irregular C-shape, with a fusion of the proximal as well as mesio-buccal canals, including an independent mesio-lingual canal could also be found in certain instances, providing the canals a semicolon like resemblance. This may also be a C-shaped canal with both the association of proximal and mesio-lingual channels as well as a distinct mesiobuccal tube. This is essential to stress the fact that somehow this C-shaped modifications in the morphology will take place over the entire stretch of the racinum, which exacerbates the phases of the bio-mechanical procedures and shut-off of the teeth for this form of internal morphology (Kailash, 2014; Solomonov et al., 2012; Wang et al., 2012). Endodontics was not an independent technology with the utilization of amplification.

Endodontics was not an independent technology with the utilization of amplification. This is part of the move towards refinement and implementation of a minimally invasive treatment which formerly demanded lengthy operations in medication and orthodontics. Yet the manner endodontics including endodontic operations are done have been changed completely today. Operation microscopies often help to diagnose additional canals and missing canals, to test the efficiency, to stop / or control orthodontic malfunctions of modern technologies for cleansing & formation (Demirbuga et al., 2013).

Many recent experiments, however, have employed CBCT, which enables fine information to be visualised against chromatic aberration as well as the interference of the surrounding structures (Silva et al., 2013). CBCT isotropic Voxel technique, equally dimensioned in all 3 axes of space, allowing precise regular geometric as well as 3-dimensional data acquisition and observations (Naseri and Kangarioughighi, 2013). The goal of the research will be to determine the percentage of C-shaped canals throughout the 2nd mandibular molars with Cone Beam Computed Tomography (CBCT) including endodontic microscope. CBCT is a semi-intrusive approach that permits reliable analysis.

**Research Objectives**

**Figure 1: Materials Used**

**Figure 2: Equipments Used**

**Figure 3: Surgical Endodontic Microscope (Opto- Sm -1)**
The primary objective of the study is to evaluate the proportion of C-shaped canals in mandibular second molar using endodontic microscope and cone beam computed tomography (CBCT) in Western Maharashtra. Moreover, this study aims to,

1) Assess the proportion of incidence of C-shaped canal systems in mandibular 2nd molar.
2) Estimate the cross-sectional attributes of the root canal including C-shapes by tooth location (right versus left) and gender.
3) Classify C-shaped canals by using cross-sectional CBCT images of C-shaped canals by Fan et al (2004).
4) Ensure the successful treatment for the betterment of patient, prior understanding of root canal anatomy is necessary which can be achieved by vigilant examination of skewed x-rays, appropriate monitoring of exposure including thorough analysis of the maxillary internals.

Figure 4: CBCT Machine- Carestream 9300 (USA) Observation and Result

Literature Review

In the Jordanian community, Qudah et al. studied root canal morphologies of persistent mandibular, 1st and 2nd molar teeth. A total of 685 collected jaws were examined and tested for root numbers and anatomy, both for the first and second perpetual molar teeth, which reported that the mandibular characteristic of Jordan’s 1st and 2nd jaw was identical to the typical Caucasian root canal morphology (Al-Qudah and Awawdeh, 2009).

The root and canal anatomy of secondary mandibular Indian molars (345) has also been examined by Neelakantan et al. for studying root- and canal structures morphologies. The teeth were introduced to a channel bleaching procedure, with the result that two- morphology, with 3 canals, was the commonest root morphological characteristics in the Indian 2nd molars. Both mesial as well as proximal Roots displayed broad differences in channel morphology, prevalent in both mesial and proximal roots of form I and I channel configurations (Neelakantan et al., 2010).

Zheng et al. tested in Chinese mandibulare second molars the morphological characteristics of C-shaped channel structures with CBCT in a sample of 608 Chinese-decent patients with good, excellently-developed 2nd molars. It was also assumed that the second mandibular molars of the Chinese community had a strong incidence of C- canals. Through their structural form, the canal networks differed greatly (Zheng et al., 2011).

Seo et al. analyzed the arrangement of the C-shaped canals in the mandibles of 2nd molars, the width of the canals wall as well as a 1mm thinner field position between the orifices of the channel as well as the vertex with photographs of CBCT. The most prevalent structure forms were Melton Type I (coronal region) and Type III (apical area), that were studied in CBCT- from 92 second Korean maxillary molars having a C- shape root canal. The linguistic middle root region was the slimmest in Korea’s secondary mandibular molar C- root canals. During operational or nonsurgical endodontic operations certain structural modifications should be known (Seo et al., 2012).

Shetty et al. reviewed various techniques used in endodontics for studying the root canal morphology and concluded that recent improvements in digital radiographic imaging systems have brought about many benefits to endodontic practice. Nonetheless the use of these advanced digital systems has been limited because of cost and availability. With the development and rapid progress of technology towards the imaging of the maxillofacial region will bring out success of endodontic treatment by providing accurate details about the root canal morphology (Shetty et al., 2014).

Meel et al. reported a successful treatment of five C-shaped canals in mandibular second molar and concluded that the successful endodontic management requires thorough knowledge about atypical root canal systems. The significant care should be taken during biomechanical preparation and obturation of C-shaped root canals for achieving success in root canal therapy, alongside with good prognosis (Meel et al., 2017).
MATERIALS AND METHODS

The present study was undertaken at Department of Conservative Dentistry and Endodontics, SDS, KIMSDU, Karad. The data acquired from the patients who reported to Department of Conservative Dentistry and Endodontics, SDS, KIMSDU and required endodontic treatment of mandibular second molar using convenient sampling technique over the period of 18 months.

Material Used

Mouth mirror, Endodontic explorer, Probe, Endo Access Kit, Rubber dam kit, 3% Sodium hypochlorite (NaOCl), 17% EDTA, K files (Mani Ink Japan), Apex Locator (Root Zx mini, J Morita, USA), Endo motor (SDenti, BDS), E and Q plus thermoplas-tized obturation (SybronEndo), Intra Oral Camera (Hemant Medicam®, Ind), Surgical Endodontic microscope (OPTO SM II), CBCT (Carestream 9300, CS imaging software. USA), Intra Oral Peri Apical radiographs (IOPA).
Table 1: Distribution of patients based upon their gender

| Gender  | Frequency | Percent |
|---------|-----------|---------|
| Females | 6         | 50      |
| Males   | 6         | 50      |
| Total   | 12        | 100     |

Table 2: Middle third distribution of C-shaped canals

| Middle | Frequency | Percent |
|--------|-----------|---------|
| C1     | 4         | 33.33   |
| C2     | 2         | 16.67   |
| C3     | 4         | 33.33   |
| C4     | 2         | 16.67   |
| Total  | 12        | 100.00  |

Table 3: Distribution of mandibular second molar based upon their occurrence

| Unilateral/Bilateral | Frequency | Percent |
|----------------------|-----------|---------|
| Bilateral            | 6         | 50.00   |
| Unilateral           | 6         | 50.00   |
| Total                | 12        | 100     |

Table 4: Distribution unilateral and bilateral C-shaped canals of patients by gender

| Gender  | Bilateral | Unilateral | Chi square statistic | P value |
|---------|-----------|------------|----------------------|---------|
| Females | 4(66.67)  | 2(33.33)   | 1.33                 | 0.25    |
| Males   | 2(33.33)  | 4(66.67)   |                      |         |
| Total   | 6(50.00)  | 6(50.00)   |                      |         |

Table 5: C-shaped canal systems teeth including root levels

| Canal Configuration | Coronal | Middle | Apical | Chi-square value | p value |
|---------------------|---------|--------|--------|------------------|---------|
| C1                  | 4(33.33)| 4(33.33)| 2(16.67)| 1.80             | 0.94    |
| C2                  | 2(16.67)| 2(16.67)| 2(16.67)|                 |         |
| C3                  | 4(33.33)| 4(33.33)| 4(33.33)|                 |         |
| C4                  | 2(16.67)| 2(16.67)| 4(33.33)|                 |         |

Collection of Data

Inclusion criteria

Teeth with completely formed apices. Teeth which lack root filling, posts and crown restoration.

Exclusion criteria

Immature root apices. Teeth with root fracture. Teeth with missing contralateral mandibular second molar. Pre-existing external defects or cracks on root surface. Caries involving the roots. Root resorption. Previously endodontically treated teeth.

Procedure

Evaluation of C-shaped canal systems according to Min’s method was carried out by clinical approach using surgical operating microscope in permanent mandibular second molar teeth. After confirming the presence of C-shaped canal using surgical endodontic microscope; the 3-D images using CBCT was taken as a part of routine examination, diagnosis and treatment planning (Helvacioglu-Yigit and Sinanoglu, 2013).

Bilateral molar data was obtained to analyze the unilateral and/or bilateral distribution of C-Shaped canal at CBCT(Carestream 9300 USA) centre in Sngli; which were later classified based upon classification given by Fan et al (2004) using CS imaging soft-
ware with 90 Micron size of image. Working length was taken using CBCT and Apex locator and confirmed on radiograph and canal were prepared using K files (Mani Ink Japan). During preparation, all the root canals were irrigated with 2 ml 3% NaOCl solution after each instrument and a final flush was applied using 5 ml 17% EDTA for 1min and 5ml 3% NaOCl for 1min followed by the final rinse with normal saline. The apical third of C1 and C4 canal configuration was obturated by cold lateral condensation followed by middle and coronal third with warm vertical compaction technique using system B by SybronEndo. Obturation where as C2 and C3 canal configuration were obturated using single cone obturation technique followed by warm vertical compaction in middle and coronal third using system B (SybronEndo) Post-operative radiograph was taken to confirm the obturation followed by post obturation restoration which was carried out using composite as permanent restorative material (Pawar et al., 2017).

Statistical Analysis
Statistical analysis for the proportion of C-shaped canal was correlated with gender, number of canals with the direction of root grooves, and unilateral or bilateral presence using Chi squared test. There are two types of chi-square tests. Both use the chi-square statistic and distribution for different purposes. The formula for the chi-square statistic used in the chi square test is,

\[ X^2 = \sum \frac{(O_i - E_i)^2}{E_i} \]

There are a few variations on the chi-square statistic used for contingency tables is,

\[ C^2 = \sum_{i=1}^{k} \left[ \frac{(O_i - E_i)^2}{E_i} \right] \]

Where \( O \) is the observed value, \( E \) is the expected value and “i” is the “ith” position in the contingency table.

Armamentarium Used
Figures 1, 2, 3 and 4 represent the various tools and equipments used during the study.

OBSERVATION AND RESULT

Statistical Analysis
The C-shaped canal arrangements were seen equally in patients of both the sexes, with a frequency of 8%. However, there were no noteworthy variations in the distribution of C-shaped mandibular canal network in regards of root levels among all the subjects (\( P > 0.05 \)) (see Tables 1, 2, 3 and 4).

This study evaluated the proportion of C shaped canal in mandibular 2nd molar using Endodontic microscope and confirmed on CBCT and compared for its distribution and occurrence over the period for 18 months, total 89 patients reported to the department for the endodontic therapy of mandibular 2nd molars, out of which 12 patients (13.48 %) had a C-shaped root canal network. Amongst the 12 subjects, 6 had bilateral presence of C-shaped canal where as 6 patients with unilateral prevalence of C-shaped Mandibular 2nd molar, and all (12 patients) displayed C-shaped canal systems (Table 5). The alteration in canal arrangement from the coronal to apical was evaluated. The utmost generally seen canal arrangements were C1 at the coronal and middle levels. The majority of the roots exhibited a C3 canal arrangement at the Apical level (Figures 5 and 6).

CONCLUSIONS
This paper provides a description of the mechanism of the molar root and the root canals in C type. Features of this exceptional morphology have been studied mainly focused on macroscopic, microscopic and fiscal measurements and odontogenetic tooth shape studies. To trying to clarify the clinical nature of C-canals, we sought to isolate them both. In addition to the overview of existing information, one of the purposes of this study was to find research that supports our C-shaped root canal mechanism knowledge. Future experiments will concentrate on histological analyses on gradual C-shaped root dentine development routes as well as phylogenetic analysis on tooth forming processes. In fact, technological advancements in 3D mapping strategies will enable us to better understand the reliable pathophysiology of the physiology of the Cshaped root canal. Moreover, accounts of extreme scenarios like the rounded phenotype of the root or rectangle or squared rounded channels allow one to consider the broad variety of roots morphologies found in human teeth that eventually result in better therapies as well as patient’s and dentist’s satisfaction.

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Conflict of Interest

I hereby declare that there is no conflict of interest related to this manuscript.

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