Prevalence of C-shaped canals in mandibular second and third molars in a central India population: A cone beam computed tomography analysis

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Abstract

Introduction: To evaluate the prevalence of C-shaped root canals in mandibular molars using cone beam computed tomography (CBCT) in a subpopulation of Central India.

Materials and Methods: CBCT scans of patients from diagnostic imaging center were selected in accordance with the criteria given by Fan et al. (2004) for C-shaped canals. A total of 238 CBCT scans fulfilled the inclusion criteria and thereby divided into two groups: Group 1: Images showing C-shaped canal configuration in mandibular second molars. Group 2: Images showing C-shaped canal configuration in mandibular third molars. The frequency and distribution of canals and their configuration along with the position of lingual/buccal grooves in the images were evaluated, and the data was analyzed.

Results: CBCT evaluation showed that 9.7% of second molars and 8% of third molars had C-shaped canals. A prominent buccal groove was seen in these teeth. The data showed a significant difference \((P = 0.038)\) for the presence of such anatomy on the right side for mandibular third molars.

Conclusion: The study showed a significant prevalence of C-shaped canal configuration in the subpopulation studied.

Keywords: Cone beam computed tomography; C-shaped canal; mandibular second molar; mandibular third molar

INTRODUCTION

In endodontics, root canal treatment of a tooth with variable anatomy is a rule rather than an exception. One such anatomic variation is the C-shaped root canal system, although most commonly seen in mandibular second molars have also been observed in mandibular premolars, maxillary first molars, and maxillary and mandibular third molars.\(^{[1-3]}\) Historically, various authors have done numerous investigations on the prevalence and ethnic variation of such canal systems.\(^{[4]}\) Initially, named as “gutter-” shaped canals by Nakayama and horseshoe reduction forms, the term C shaped was originally described by Cooke and Cox in endodontic literature in the year 1979.\(^{[5,6]}\) Manning postulated that the reason for the occurrence of C-shaped canals was the failure of Hertwig's epithelial root sheath to fuse. It is usually characterized by the presence of a fin or web connecting the individual mesial and distal canals having a C-shaped axial section.\(^{[7-9]}\) The C-shaped canal configuration has frequently been reported in Asian countries with a high prevalence of 2.7%–45.5% in mandibular second molars. Incidence studies have been reported in Chinese, Indian, and Iranian population, with the highest frequency being reported in the Chinese population (29.7%) in case of...
mandibular premolars. The C-shaped canal anatomy has also been reported in maxillary first molars (0.12%), maxillary third molars (4.7%), mandibular third molars (3.5%–4%), and mandibular second premolars (1%). Numer 

Methods to evaluate root canal morphology of extracted teeth such as tooth sectioning, dye infiltration, or the transparent model method have been used. Two-dimensional intraoral periapical (IOPA) radiographs do not give an accurate image of the presence or absence of such morphology due to superimposition of adjacent anatomic structures. Staining and clearing, the dental operating microscope, and computed tomographic (CT) scans are more contemporary methods of studying the varied root canal anatomy. Cone beam computed tomography (CBCT) is a three dimensional radiographic technique which is noninvasive, with low radiation exposure and analyzes the presence and configuration of such canals. Most studies on variant canal morphology have been done on mandibular second molars. With increasing life expectancy and patient awareness to preserve their natural dentition, third molars have become a strategic tooth for evaluation and preservation. No studies have been done regarding the anatomic configuration of the third molars in the Indian population. The aim of this study was to use CBCT as a diagnostic tool to evaluate the prevalence of C-shaped root canals in second and third molars in a subpopulation group.

MATERIALS AND METHODS

CBCT images of 478 patients who required radiographic examination by CBCT as a part of their dental treatment were examined from the database of a diagnostic imaging center in Central India, after obtaining informed consent from the patients. The sample size analyzed was from the data collected between 2011 and 2014, with the age group of the subjects ranging between 28 and 50 years. The study was approved by the Research Advisory Committee and the Institutional Ethical Committee of the institution in which the examiners are associated with. Of the total scans observed, 238 cases were selected based on the inclusion criteria. The selection criteria were as follows:

**Inclusion criteria**

1. Well-developed mandibular second and third molars with complete root formation
2. Teeth with fused roots
3. A longitudinal groove on the lingual or buccal surface of the root
4. At least one cross-section of the canal that showed the C1, C2, or C3 configuration.

**Exclusion criteria**

1. Presence of root canal fillings
2. Deep caries associated with mandibular second and third molar

3. Teeth with open apices, resorption, or calcifications.

**Cone beam computed tomography machine details**

CBCT (KODAK CS.3D 9000C, 70 kVp, 10 mA, 36 s scan time, 10.8-s exposure time, 5 cm diameter, 5 cm height scan volume, France) images of 478 patients who presented at the diagnostic imaging center between June 2011 and March 2015 were taken. All CBCT exposures were performed by an appropriately licensed radiologist, with the minimum exposure required for adequate image quality.

**Image analysis software**

The CBCT images were analyzed with the inbuilt KODAK CS3D imaging software in an HP workstation with a 19"HP light-emitting diodes screen with a resolution of 1280 × 1024 pixels on a dual monitor. The images were digitally enhanced for better visualization. Type of canal configuration and presence of extra root and numbers of canals were evaluated using the NNT toolbar by carefully rolling downward from the pulp chamber to the root apex in the axial tomographic slices. The CBCT image slices were taken in all the three coronal, sagittal, and axial planes [Figure 1]. All observations were made by three endodontists and a radiologist with a consensus between the examiners. Canals were considered as C shaped only if they fulfilled the criteria given by Fan et al. (2004) [Figure 2]. The axial slices were also observed at different levels of the root to confirm the presence of a C-shaped morphology.

**Statistical analysis**

Frequencies and percentages of variables were calculated. Data was further analyzed using Fisher’s exact test. P < 0.05 was considered statistically significant. Data analysis was performed using Statistical Package for Social Sciences (SPSS version 21.0, IBM, Armonk, New York, USA) for Windows.
RESULTS

The prevalence of C-shaped canals in mandibular second and third molars was found to be 9.7% and 8.0%, respectively [Table 1].

About 4.2% of mandibular second molars on the left side and 5.5% on the right side had C-shaped canals. There was no significant difference for the presence or absence of C-shaped canals in mandibular second molars according to the tooth position [Table 2].

Nearly 2.1% of mandibular third molars on the left side and 5.9% of on the right side had C-shaped canals. There was significantly greater prevalence of C-shaped canals in mandibular third molars on the right side in comparison to the left side [Table 2]. No cases of bilateral C-shaped molar teeth were seen in the data that were observed.

DISCUSSION

C-shaped root canals are an important variation seen in routine endodontic practice. Morphologically, these canal systems may present a conical or square root anatomy[16] on a two-dimensional periapical radiograph with a greater occluso-apical height and a lower level of bifurcation. An occluso-apical groove is also present indicative of the line of fusion of the mesial and distal roots. Clinically, they may present as a single ribbon-shaped opening connected by an 180° arc.[17] Numerous ramifications, intercanal anastomoses, and change in the configuration along the length make endodontic treatment of such roots canals challenging. Mostly seen in mandibular second molars, C-shaped canals have a racial predilection, with a high prevalence in the Asian population as reported by numerous studies.[18,19] The gene causing C-shaped roots has been mapped on chromosome 5 in studies done in mice. The prevalence of a C-shaped canal in mandibular second molars estimated in various population groups is as follows:

- 2.7%–7.6% in American
- 8% in Turkish
- 10.6% in Saudi Arabian
- 19.1% in Lebanese
- 31.5% in Chinese, and
- 32.7%–44.5% in Korean populations.[20,21,22]
Very few studies in this regard have been observed in the Indian population which comprises a diverse group that can be traced. One of the studies done in North Indian population showed the overall incidence of C-shaped root canals to be 6.72%. The initial classification of C-shaped canals by Melton in 1991 was, however, modified by Fan et al. in 2004 [Figure 2]. Teeth with C shaped canals possess several interconnections and ramifications that act as bacterial niches which are difficult to debride and disinfect. 

Emphasis has thus been placed on accurate diagnosis of such canal systems which may be missed in two-dimensional IOPA radiographs. This study evaluated the presence of these canals in mandibular second and third molars.

Third molar teeth are increasingly gaining significance in endodontic treatment as these can be used as abutments for fixed partial dentures. Accurate diagnosis is thus imperative for the successful outcome of treatment procedures. In this study, we found more number of second molar teeth with deep buccal grooves (43.5%) [Table 1], which is similar to that observed in a study done by Ladeira et al. in a Brazilian sub population 2014. However, contrasting results have been observed in studies done by Fan et al. 2004 which showed C-shaped root having a prominent lingual groove. This again signifies an ethnic variation among the population groups studied. It was seen that around 47.4% of third molars were grooved in both directions.

The success of root canal therapy depends on the prompt identification of the anatomic variations. In this study, the prevalence of C-shaped canals was found to be 9.7% in second molars and 8% in third molars which is comparable to that of the Turkish population. The prevalence is high enough to warrant an accurate diagnosis of these anomalies which will enhance the treatment prognosis.

Various techniques such as fiber-optic transillumination, computer-aided tomography, and magnetic resonance imaging help in the diagnosis of three-dimensional anatomy. However, CBCT has emerged significantly as the imaging help in the diagnosis of three-dimensional morphologies. However, CBCT has emerged significantly as the imaging help in the diagnosis of three-dimensional morphologies. Emphasis has thus been placed on accurate diagnosis of such canal systems which may be missed in two-dimensional IOPA radiographs. This study evaluated the presence of these canals in mandibular second and third molars. In this study, we found more number of second molar teeth with deep buccal grooves (43.5%) [Table 1], which is similar to that observed in a study done by Ladeira et al. in a Brazilian sub population 2014. However, contrasting results have been observed in studies done by Fan et al. 2004 which showed C-shaped root having a prominent lingual groove. This again signifies an ethnic variation among the population groups studied. It was seen that around 47.4% of third molars were grooved in both directions.

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Various techniques such as fiber-optic transillumination, computer-aided tomography, and magnetic resonance imaging help in the diagnosis of three-dimensional anatomy. However, CBCT has emerged significantly as the diagnostic tool of choice to such patients because of its low radiation dosage, ease of use, and economical viability.

CONCLUSION

The results of the present study showed that there is a high prevalence of C-shaped canals in the population group evaluated. Further studies are required to analyze the configuration of these canals at different levels for their effective management during endodontic procedures to ensure a predictable outcome.

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Conflicts of interest
There are no conflicts of interest.

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