



Prevalence of C-Shaped Canals in Anterior and Posterior Teeth of Iranian Population Using Cone Beam Computed Tomography

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Abstract

Background: Lack of knowledge of root anatomy is the second most common reason for failed endodontic therapy. Therefore, acquiring knowledge about it leads to a more effective treatment. C-shaped canal is an anatomical variation that causes clinical challenges. The objective of this study is to determine the occurrence of the C-shaped roots in permanent anterior and posterior teeth of the Iranian population using CBCT (cone beam computed tomography) scans.

Methods: This was a descriptive cross-sectional study. In this study, 1408 teeth were assessed. Cranex 3D Mid was used to prepare CBCT images. Each tooth was examined in axial sections, and five different levels were identified as coronal, medium, apical, 1/3, and 2/3. The canal shapes were classified into 5 categories based on modified Melton's method. Data were analysed using the chi-square test at a significance level of 5% in SPSS version 24.0.

Results: In total, of 1408 teeth which were evaluated, 7.81% (110) were confirmed to have C-shaped canals. The occurrence of the C-shaped canal was significantly higher in molars ($P < 0.001$). The occurrence of the C-shaped canal was significantly higher in mandibular teeth (10.04%) compared to maxillary teeth (5.81%) ($P < 0.001$). The most common C-shaped canal category was C1 (57.27%). The relationship of gender and age with the C-shaped canal occurrence was not statistically significant ($P = 0.585$, $P = 0.562$, respectively).

Conclusions: CBCT is a useful tool to evaluate C-shaped root canal morphology. The high occurrence of the C-shaped canal in the Iranian population requires clinical awareness.

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Background

Lack of information about root anatomy and canal morphology is the second prevalent reason for failed endodontic therapy (1). Therefore, the preoperative recognition of canal morphology and root anatomy leads to more effective cleaning, shaping, and obturation procedures, thereby improving the long-term prognosis of the treatment (1-4).

The root canal system reveals different morphological variations such as C-shaped canal which is reported to cause clinical challenges and to complicate endodontic treatment (5). C-shaped canals were primarily pictured by Keith and Knowles in 1911 and were later defined by Cooke and Cox in 1979 (4,6). This anatomical variation is named C-shaped because of the presence of fin or web connecting the individual canals, leading to a configuration that resembles the letter "C" in a transverse section (4-6). The failure of Hertwig's epithelial root sheath to fuse on buccal or lingual root surface is claimed

Highlights

- ▶ C-shaped canal system has the predilection for mandibular second molars.
- ▶ There was no correlation between gender and the occurrence of C-shaped canals.
- ▶ Besides, this study showed no correlation between age and C-shaped root canal configuration.
- ▶ The high incidence of the C-shaped canal in the Iranian population requires clinical awareness.

to be the main cause of this anatomic variation (4,7,8).

Different techniques were introduced for evaluating the canal morphology and root anatomy including decalcification and cleaning technique, sectioning technique, radio-opaque contrast, modeling method, and imaging (9). Radiography is an easy, practical, and non-invasive technique to study the root anatomy and canal morphology especially in non-extracted teeth (10).

Panoramic radiographs and intraoral radiographs are two-dimensional images (11). Due to the absence

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of the third dimension in these images, the diagnosis of dentin between the roots in C-shaped root systems is very difficult (6,11). Additionally, it is hard and unreliable to clinically predict whether the C-shaped morphology continues throughout the root canal. CBCT (cone beam computed tomography) is an accurate 3D image with high resolution which provides better vision and understanding of anatomy and morphology of C-shaped canals (1,4,6,11).

Since the C-shaped canal is considered to have a genetic predisposition and this anatomic configuration can influence the successful endodontic treatment, in this study, the occurrence of the C-shaped roots in permanent anterior and posterior teeth of the Iranian population was determined using CBCT scans to provide better knowledge in this field.

Materials and Methods

In this descriptive cross-sectional study, 1408 teeth resulting from 250 CBCT images of patients were assessed. This study was designed based on STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines.

Anterior and posterior teeth with fully developed apices were included in the current study. The teeth with caries, restoration, or previous root canal therapy were excluded.

Cranex 3D Mid (Tuusula, Finland) was used to prepare the CBCT images using the following operating parameters: 90 kV and 10 mA, a field of view (FOV) of 6.8 × 6.8 cm, and a voxel size of 200 μm × 200 μm × 200 μm. The CBCT imaging was taken as a part of the patients' diagnostic objectives irrelevant to the current study.

Two of the researchers evaluated the CBCT images. The two researchers were trained on the observation of tomography slices and exclusion of the required data from the images. To measure the inter-observer agreement, the Cohen's unweighted kappa coefficient was used. Estimation of the inter-observer agreement between the two researchers showed that both researchers agreed on all 40 cases. The 40 CBCT images used for assessing the inter-observer agreement were not included in the study. If any controversy occurred during the study, the third researcher assisted in making the decision.

Each tooth was examined in axial sections with the thickness of 0.5 mm, and 5 different levels were identified as coronal (2 mm below the canal orifice), medium (middle distance between canal orifice and radiographic apex), apical (2 mm coronal of radiographic apex), 1/3 (middle distance between medium and coronal) and 2/3 (middle distance between medium and apical) (12).

The canal shapes were categorized based on the modified Melton's method presented by Fan et al as follows (13):

- Category 1 (CI): A continuous C-shaped canal with no division or separation;
- Category 2 (CII): The canal orifice resembles a semicolon, where a C-shaped canal is present buccally or lingually, separated from another distinct canal by

a dentine wall;

- Category 3 (CIII): Two or three separate and discrete canals;
 - Category 4 (CIV): A single oval or round canal;
 - Category 5 (CV): No canal orifice was found.
- SPSS version 24.0 was used to analyze the data. The chi-square test was utilized to compare the frequencies. The significance level was adjusted to 5%.

Results

Out of 250 CBCT images, the data of 234 images were analyzed. Sixteen CBCT images were excluded from the study according to exclusion criteria. The mean age of the patients was 35.98 years old. The youngest patient was 11 years old and the oldest one was 76 years old. Additionally, 41.9% (98) of patients were male and 58.1% (136) were female.

Of a total of 1408 canals which were evaluated, 7.81% (110) were confirmed to be C-shaped and 92.19% (1298) were not C-shaped.

Of 1408 teeth, 36.3% (511), 26.3% (370), and 37.4% (527) were anterior teeth, premolars, and molars, respectively (Table 1). The occurrence of the C-shaped canal was considerably higher in molars compared to premolars and anterior teeth ($P < 0.0001$).

Of 1408 teeth, 47.3% (667) were recorded as mandibular teeth and 52.7% (741) as maxillary teeth. In the current study, C-shaped canals were found in 10.04% (67) of mandibular teeth and in 5.81% (43) of maxillary teeth. The occurrence of the C-shaped canal was significantly higher in mandibular teeth compared to maxillary teeth ($P < 0.001$).

Of the 1408 evaluated teeth, the most common C-shaped canal category was C1 (57.27%) followed by C2 (42.73%). In the current study, C3, C4, and C5 were not observed.

There was no statistical difference in the prevalence of the C-shaped canal between males and females ($P = 0.585$) (Table 2). Additionally, the correlation between the

Table 1. Percentage of C-Shaped Canal Based on Tooth Type

Type of Teeth	With C-Shaped Canal (Number)	Without C-Shaped Canal (Number)
Anterior teeth	0% (0)	100% (511)
Premolars	0% (0)	100% (370)
Molars	20.87% (110)	79.13% (419)
Total	7.81% (110)	92.19% (1298)

Table 2. Percentage of C-Shaped Canal Based on Gender

Gender	With C-Shaped Canal (Number)	Without C-Shaped Canal (Number)
Male	77.38% (38)	61.23% (60)
Female	35.75% (86)	64.71% (88)
Total	36.75% (86)	63.25% (148)

C-shaped canal and age was not significant ($P=0.562$).

Discussion

There are numerous studies on the anatomic configuration of the root canal system of mandibular second molars with diverse results. It is thought that one of the determinants of C-shaped canal configuration is the genetic factor, as most of the population having C-shaped canal is found in the Asian population (1,4,6). In East Asia, the maximum occurrence was reported in South Korea (44.5%) and China (39%) (14,15). In the Middle East, the highest occurrence was reported in Lebanon (19.14%) and the lowest was reported in Iran (7.2%) (16,17). In a Turkish population, the reported occurrence was 8.9% (16). In the Indian population, the occurrence of C-shaped canal configuration ranged from 7.4% to 13.12% (2,18). The occurrence in a Saudi Arabian population varied from 9.1 to 14.4% (4,19).

In different studies, the occurrence of C-shaped canals in mandibular second molars ranged from 2.7 to 44.6% (4). The frequency of C-shaped root canal configuration in mandibular second molars in the studies conducted by Janani et al (10) and Madani et al (20) was 21.4% and 17.6%, respectively. The occurrence was also different in the studies conducted by Weine et al (21) (2.7%), Cooke and Cox (22) (8%), Jin et al (14) (44.6%), and Seo and Park (23) (32.7%). In the current study, the C-shaped canal was found in 7.81% of the samples. Despite the difference in occurrence rate which results from having different ethnic groups, all the above-mentioned studies claim that the C-shaped canal system has the predilection for mandibular second molars (4,10,14,20-23). This finding is also consistent with reports of Mirzaie and Zaban (24), Nielsen and Shahmohammadi (25), Victorino et al (26), Sandhya et al (27), and Rwenyonyi et al (28).

The current study reported no C-shape canal in premolars, which is consistent with the findings of Hajihassan et al (1) and Vega-Lizama et al (5). On the contrary, Zare Jahromi et al (29) observed C-shaped canal in 0.44% of premolars. Additionally, other studies reported the occurrence of the C-shaped canal configuration in premolars (30-33). This controversy may be due to different canal identification techniques or different races.

Only a few articles studied the occurrence of C-shaped canal in maxillary teeth. In the current study, C-shaped canal configuration was only reported in 5.8% of maxillary teeth, and in a study conducted by Jo et al, it was reported in 1.8% of maxillary teeth (34). De Moor et al (35) reported the occurrence of C-shaped canals to be 0.091% in maxillary first molars and Yang et al (36) estimated the occurrence to be 4.9% in maxillary second molars. Ethnic background, sample size, and methodology may be the cause of these differences.

The findings of this study indicated that the occurrence of C1 was higher than C2. Moreover, Duman et al (6), Janani et al (10), Zheng et al (15), Helvacioğlu-Yigit and

Sinanoglu (16), and Kim et al (37) found similar results. However, Kim et al (11), Pawar et al (2), and Seo and Park (23) found that the most common C-shaped canal type was C2. On the contrary, Alfawaz et al (4) and Bahammam (19) found that the most common C-shaped canal configuration was C3. The variations in C-shaped canal configurations among the researches are attributed to various sample sizes and different studied teeth.

Many studies did not assess the effect of gender on the occurrence of C-shaped canals (17,23,38). However, Martins (12), Zuben et al (39), Duman et al (6), Kim et al (37), and Alfawaz et al (4) studied this relationship and indicated that there is a noticeably higher occurrence of C-shaped canals in females compared to males. On the contrary, the studies conducted by Helvacioğlu-Yigit and Sinanoglu (16), Janani et al (10), Zheng et al (15), Jin et al (14), Ladeira et al (40), and the current study found no correlation between gender and the occurrence of C-shaped canals.

Besides, this study showed no correlation between age and C-shaped root canal configuration. These data are in agreement with the results of the studies conducted by Janani et al (10), Kim et al (11), Zheng et al (15), Helvacioğlu-Yigit and Sinanoglu (16), Kim et al (37), and Ladeira et al (40).

The small sample size is the limitation of the current study. Further studies should be carried out to study the prevalence of C-shaped canals in different countries and races.

CBCCT is a useful instrument to evaluate C-shaped root canal morphology. The high incidence of the C-shaped canal in the Iranian population requires clinical awareness.

Conflict of Interest Disclosures

There were no conflicts of interest.

Ethical Statement

There was no ethical statement.

Authors' Contribution

FOR, EM, NM, DM, NK: Conceptualization, Data curation, Methodology, Project administration, Resources, Software
FOR, EM: Funding acquisition, Supervision, Validation, Visualization
FOR, EM, NK: Formal analysis, Investigation
Writing - original draft: DM
Writing - review & editing: EM, DM

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