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 an epithelial root sheath to fuse on buccal or lingual root surface is claimed to be the main cause of this anatomical 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

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.
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% (170) |
| 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 | 46.75% (86) | 53.25% (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 Hajihassani 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), Helvacioglu-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 Helvacioglu-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), Helvacioglu-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.

CBCT 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
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References
1. Hajihassani N, Roohi N, Madadi K, Bakhshi M, Tofangchiha M. Evaluation of root canal morphology of mandibular first and second premolars using cone beam computed tomography in a defined group of dental patients in Iran. Scientifica (Cairo). 2017;2017:1504341. doi: 10.1155/2017/1504341.
2. Pawar AM, Pawar M, Kfir A, Singh S, Salve P, Thakur B, et al. Root canal morphology and variations in mandibular second molar teeth of an Indian population: an in vivo cone-
beak computed tomography analysis. Clin Oral Investig. 2017;21(9):2801-9. doi: 10.1007/s00784-017-2082-6.

3. Abdalmajedd KD, Mustafa NS, Kashmoola MA, Jabbar OA, Ab Razak LS, Noor SN. The diagnosis and determination of C-shaped canals in lower second molar. J Int Dent Med Res. 2018;11(3):810-8.

4. Alhazour H, Alqelaifia A, Alkhayyal AK, Almobarak AA, Alhusain MF, Martins JNR. Prevalence of C-shaped canal system in mandibular first and second molars in a Saudi population assessed via cone beam computed tomography: a retrospective study. Clin Oral Investig. 2019;23(1):107-12. doi: 10.1007/s00784-018-2415-0.

5. Vega-Lizama EM, Tiesler V, Chi-Keb JR, Ramírez-Salomón M, Hernández-Mejía A, Cucina A. Root canal morphology of the mandibular first premolars in a Yucatecan population using cone beam computed tomography: an in vitro study. Int J Morphol. 2018;36(4):1216-21. doi: 10.4067/s0717-95022018000401216.

6. Duman SB, Duman S, Bayракdar IS, Yasa Y, Gumussoy I. Cone-beam computed tomography evaluation of C-shape canals and longitudinal grooves of mandibular first and second molar teeth. Ann Med Res. 2019;26(12):2853-8. doi: 10.5455/annalsmedres.2019.09.581.

7. Kantilerakis E, Delantoni A, Angelopoulos C, Beltes P. Evaluation of root and root canal morphology of mandibular first and second molars in a Greek population: a CBCT study. Eur Endod J. 2019;4(2):62-8. doi: 10.14744/eiej.2019.19480.

8. Nejaim Y, Gomes AF, Rosado LPL, Freitas DQ, Martins JNR, da Silva E. C-shaped canals in mandibular molars of a Brazilian subgroup: prevalence and root canal configuration using cone-beam computed tomography. Clin Oral Investig. 2020;24(9):3299-305. doi: 10.1007/s00784-020-02320-6.

9. Datta P, Zahir S, Kundu GK, Dutta K. Different methods of studying root canal morphology of human tooth: a review. Bangladesh J Dent Res Educ. 2015;5(2):59-63. doi: 10.3329/bjder.v5i2.24718.

10. Janani M, Rahimi S, Jafari F, Johari M, Nikniaz S, Ghasemi N. Anatomic features of C-shaped mandibular second molars in a selected Iranian population using CBCT. Iran Endod J. 2018;13(11):120-S. doi: 10.22037/iej.v13i11.17286.

11. Kim HS, Jung D, Lee H, Han YS, Oh S, Sim HY. C-shaped root canals of mandibular second molars in a Korean population: a CBCT analysis. Restor Dent Endod. 2018;43(4):e42. doi: 10.5395/edte.2018.43.e42.

12. Martins JNR, Mata A, Marques D, Caramés J. Prevalence of C-shaped mandibular molars in the Portuguese population evaluated by cone-beam computed tomography. Eur J Dent. 2016;10(4):529-35. doi: 10.4103/1305-7456.195175.

13. Fan B, Cheung GS, Fan M, Gutmann JL, Fan W. C-shaped canal system in mandibular second molars: Part II–Radiographic features. J Endod. 2004;30(12):904-8. doi: 10.1097/01. jen.0000136206.73115.93.

14. Jin GC, Lee SJ, Roh BD. Anatomical study of C-shaped canals in mandibular second molars by analysis of computed tomography. J Endod. 2006;32(1):10-3. doi: 10.1016/j. joen.2005.10.007.

15. Zheng Q, Zhang L, Zhou X, Wang Q, Wang Y, Tang L, et al. C-shaped root canal system in mandibular second molars in a Chinese population evaluated by cone-beam computed tomography. Int Endod J. 2011;44(9):857-62. doi: 10.1111/j.1365-2951.2011.04896.x.

16. Helvaciglu-Yigit D, Sinanoglu A. Use of cone-beam computed tomography to evaluate C-shaped root canal systems in mandibular second molar in a Turkish subpopulation: a retrospective study. Int Endod J. 2013;46(11):1032-8. doi: 10.1111/iej.12094.

17. Rahimi S, Shahi S, Lotfi M, Zand V, Abdolrahimi M, Es'haghi R. Root canal configuration and the prevalence of C-shaped canals in mandibular second molars in an Iranian population. J Oral Sci. 2008;50(1):9-13. doi: 10.2334/josnsd.50.9.

18. Sherwood IA, Gutmann IL, Kumar S, Evangelin J, Nivedha V, Sadashivam V. CBCT analysis of the anatomy of C-shaped root canals in mandibular second molars from a southern Indian population in Tamil Nadu. ENDO. 2019;13(1):61-70.

19. Bahammam LA. Prevalence of C-Shaped root canals in mandibular second molars in a sample population of Saudi Arabia. Pak Oral Dent J. 2018;38(3):377-80.

20. Madani ZS, Mehraban N, Moudi E, Bijani A. Root and canal morphology of mandibular molars in a selected Iranian population using cone-beam computed tomography. Iran Endod J. 2017;12(2):143-8. doi: 10.22037/iej.2017.29.

21. Weine FS, Pasiewicz RA, Rice RT. Canal configuration of the mandibular second molar using a clinically oriented in vitro method. J Endod. 1988;14(5):207-13. doi: 10.1016/s0099-2399(88)80171-7.

22. Cooke HG 3rd, Cox FL. C-shaped canal configurations in mandibular molars. J Am Dent Assoc. 1979;99(5):836-9. doi: 10.14219/jada.archive.1979.0402.

23. See MS, Park DS. C-shaped root canals of mandibular second molars in a Korean population: clinical observation and in vitro analysis. Int Endod J. 2004;37(2):139-44. doi: 10.1111/j.0143-2885.2004.00772.x.

24. Mirzaie M, Tork Zaban P, Mohammadi V. Cone-beam computed tomography study of root canals in a Hamadan population in Iran. Avicenna J Dent Res. 2012;4(2):25-31.

25. Nielsen CJ, Shahmohammadi K. The effect of mesio-distal chamber dimension on access preparation in mandibular incisors. J Endod. 2005;31(2):88-90. doi: 10.1097/01. d0000137635.54668.9d.

26. Victorino FR, Bernardes RA, Baldi JV, Moraes IG, Bernardino N, Garcia RB, et al. Bilateral mandibular canines with two roots and two separate canals: case report. Braz Dent J. 2018;29(2):184-9. doi: 10.1590/0103-642020180100015.

27. Sandhya R, Velmurugan N, Kandaswamy D. Assessment of root canal morphology of mandibular first premolars in the Indian population using spiral computed tomography: an in vitro study. Indian J Dent Res. 2010;21(2):169-73. doi: 10.4103/0970-9290.66626.

28. Rwennyonyi CM, Kutesa AM, Buwembo LW, Buwembo W. Root and canal morphology of maxillary first and second permanent molar teeth in a Ugandan population. Int Endod J. 2007;40(9):679-83. doi: 10.1111/j.1365-2951.2007.02165.x.

29. Zare Jahromi M, Meh dizade M, Shirazzadeh Z, Poursaeid E. Evaluation of mandibular premolars root morphology by cone beam computed tomography. Caspian J Dent Res. 2018;7(1):58-63. doi: 10.22088/cjdr.7.1.58. [Persian].

30. Yu X, Guo B, Li KZ, Zhang R, Tian YY, Wang H, et al. Cone-beam computed tomography study of root and canal morphology of mandibular premolars in a western Chinese population. BMC Med Imaging. 2012;12:18. doi: 10.1186/1471-2342-12-18.

31. Liao Q, Han J, Xu X. [Analysis of canal morphology of mandibular first premolar]. Shanghai Kou Qiang Yi Xue. 2011;20(5):517-21.

32. Shetty A, Hegde MN, Taliban MD, Shetty H, Bhat GT, Shetty S. A three-dimensional study of variations in root canal morphology using cone-beam computed tomography of mandibular
33. Khademi A, Mehdizadeh M, Sanei M, Sadeqnejad H, Khazaei S. Comparative evaluation of root canal morphology of mandibular premolars using clearing and cone beam computed tomography. Dent Res J (Isfahan). 2017;14(5):321-5. doi: 10.4103/1735-3327.215964.

34. Jo HH, Min JB, Hwang HK. Analysis of C-shaped root canal configuration in maxillary molars in a Korean population using cone-beam computed tomography. Restor Dent Endod. 2016;41(1):55-62. doi: 10.5395/rde.2016.41.1.55.

35. De Moor RJ. C-shaped root canal configuration in maxillary first molars. Int Endod J. 2002;35(2):200-8. doi: 10.1046/j.1365-2591.2002.00461.x.

36. Yang ZP, Yang SF, Lee G. The root and root canal anatomy of maxillary molars in a Chinese population. Endod Dent Traumatol. 1988;4(5):215-8. doi: 10.1111/j.1600-9657.1988.tb00324.x.

37. Kim SY, Kim BS, Kim Y. Mandibular second molar root canal morphology and variants in a Korean subpopulation. Int Endod J. 2016;49(2):136-44. doi: 10.1111/iej.12437.

38. Seo DG, Gu Y, Yi YA, Lee SJ, Jeong JS, Lee Y, et al. A biometric study of C-shaped root canal systems in mandibular second molars using cone-beam computed tomography. Int Endod J. 2012;45(9):807-14. doi: 10.1111/j.1365-2591.2012.02037.x.

39. von Zuben M, Martins JNR, Berti L, Cassim I, Flynn D, Gonzalez JA, et al. Worldwide prevalence of mandibular second molar C-shaped morphologies evaluated by cone-beam computed tomography. J Endod. 2017;43(9):1442-7. doi: 10.1016/j.joen.2017.04.016.

40. Ladeira DB, Cruz AD, Freitas DQ, Almeida SM. Prevalence of C-shaped root canal in a Brazilian subpopulation: a cone-beam computed tomography analysis. Braz Oral Res. 2014;28:39-45. doi: 10.1590/s1806-832420130005000027.

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