Advances in Dentistry & Oral Health
ISSN: 2472-6389

Juniper Publishers
key to the Researchers

Review Article
Volume 13 Issue 2 - October 2020
DOI: 10.19080/ADOH.2020.13.555859

Adv Dent & Oral Health

C-Shaped Root Canal System– A Review of Literature

Slavena Svetlozarova*

Faculty of Dental Medicine, Medical University-Varna, Bulgaria

Submission: September 21, 2020; **Published:** October 16, 2020

***Corresponding author:** Slavena Svetlozarova, Faculty of Dental Medicine, Medical University-Varna, Bulgaria

Abstract

Proper diagnosis, treatment planning and thorough knowledge of the root canal system morphology and its possible variations are essential for the successful outcome of the endodontic treatment. The aim of this literature review is to describe the incidence of one of the possible variations of the root canal system anatomy – the C-shaped root canal configuration, when analyzed by CBCT. A review of related articles and studies was conducted in order to summarize the incidence and possible diagnostics of this variation. Knowledge of the C-shaped canal configuration is essential for proper management of endodontic cases.

Keywords: CBCT; C-shaped root canal; C-shaped configuration; Mandibular molar; Maxillary molar

Introduction

The main object of endodontic therapy is the chemical and mechanical preparation and finally definitive obturation of the root canal system of the tooth. The root canal system is complex and accessing it to its full extend is mainly considered impossible. Variations in root canal system configuration can lead to difficulties in the proper cleaning and obturation [1]. Different variations can be present, such as multiple foramina, apical deltas, additional root canals, connections between the canals, C-shaped root canals, etc. C-shaped root canals are first reported in 1979 by Cooke & Cox [2]. The authors described three clinical cases of C-shaped mandibular second molars with similar clinical findings such as normal anatomy of the pulp floor and separate orifices of the root canals. The authors also reported the fact, that this variation of the root canal system configuration was not possible to be detected on the preoperative radiographs. C-shaped root canal systems have been reported in maxillary and mandibular molars, although their frequency in mandibular molars is considered higher [3]. As a main ethiological factor for the development of C-shaped root canal system configuration is considered failure of the adhesion of the Hertwig's epithelia root sheath of the root to the buccal and lingual root surfaces [4]. In 1991 Menton et al. [5] suggested the first classification of C-shaped root canal systems. Modification of this classification was suggested by Fan et al. [6]. The authors used a micro-CT in order to classify the morphology of C-shaped root canals in mandibular second molars:

i. C1 – one continuous C-shaped root canal with no separation or dividing

ii. C2 – a comma-shaped root canal, resulting in non-continuous C-shaped root canal

iii. C3 – two or three separate root canals

iv. C4 – only one root canal with a round or oval cross section

v. C5 – absence of any canal cavity; being visible only near the apex [1].

Different techniques have been described to study the internal morphology of root canals such as conventional and digital radiography, injection of dye into the teeth and cleaning [7,8], spiral computed tomography scan [9], micro-CT-scan, CBCT-scan [8]. CBCT is a three-dimensional imaging system which allows more precise visualization and understanding of the internal tooth morphology [10,11]. The three-dimensional visualization allows establishing the exact connection of the tooth to neighboring anatomical structures [12]. CBCT is a non-invasive diagnostic tool which with its 3D-nature overcomes many of the limitations of 2D-radiographic images such as the image superimposition. The information from the CBCT-scan can enormously help not only with the endodontic treatment planning and predicting the treatment outcome, but also with the mechanical preparation of teeth with root canal system variations [13].

Aim

The aim of this review article is to describe and summarize the results of the included in the review studies in order to investigate

the frequency of the C-shaped root canal configuration. The not proper identification of this variation of the root canal system morphology can lead to poor preparation and obturation of the root canal. The identification of this variation using CBCT *in vivo* can significantly enhance the quality of the performed endodontic treatment and can decrease the risk of endodontic mishaps.

Materials and Methods

A search was conducted in electronic databases with the keywords: C-shaped root canal, C-shaped root canal system configuration, root canal system morphology, mandibular molar, maxillary molar, CBCT evaluation of tooth morphology. Related review articles, studies and case reports were evaluated. The selected materials were submitted to analysis. As inclusion criteria were used:

a) In vivo and *in vitro* clinical studies evaluating the frequency and characteristics of C-shaped root canal system configuration based on different populations,

b) Studied, literature reviews and case reports using maxillary first and second molars and mandibular first and second molars as target groups.

Results and Discussion

The C-shaped configuration is characterized by a C-shaped groove that connects one or more root canals. The position of this groove can vary, and it can occur on every level of the root canal system. A C-shaped root canal system can manifest itself in the middle or apical 1/3, while appearing completely normal on the level of the pulp chamber floor [3]. Lynn [3] reported a clinical case of a C-shaped mandibular second molar, which was impossible to be detected radiographically. The communication between the root canals appeared in the apical 1/3. Jo et al. [14] conducted a CBCT study to analyze the C-shaped configuration of maxillary molars in the Korean population. Digitized CBCT images from 911 subjects were obtained in Chosun University Dental Hospital between February 2010 and July 2012 for orthodontic treatment. Among them, a total of selected 3,553 data of maxillary molars were analyzed retrospectively. The authors reported that the fusion between the mesio-buccal and the palatal root canal and between the mesio-buccal and the disto-buccal root canal are the most dominant types. According to the results of the CBCT-study root fusion was present in 3.2% of the first molars and 19.5% of the second molars. C-shaped root canals were present in 0.8% of the first molars and 2.7% of the second molars. The frequency of root fusion and C-shaped canal was significantly higher in the second molar than the first molar in the included in the study Korean population. The results of another study [15] reported clinical cases of C-shape configuration of upper molars resulting from the fusion of the disto-buccal and palatal roots.

The author of the study observed the C-shaped configuration in two out of 2175 root-filled maxillary first molars treated at the Department of Endodontology, Ghent University Hospital, during a 10 year-period. In order to study and visualize this aberration, cross-sections were made. Yilmaz et al. [16] presented a case report of a C-shaped root canal system of maxillary first molar – the C-shaped configuration was in the buccal root. The pulp chamber floor displayed two orifices – 1 leading to the root canal system of the buccal root and one – to the one of the palatal roots. Studies of mandibular second molars, including cross-sectional studies, clinical examination and use of CBCT, proved that C-shaped canals are more frequent in Asian populations than in other ethnical groups [17-20]. The frequency of C-shaped root canals in second mandibular molars was reported 29% according to a CBCT-study [21] investigating Chinese population. Patients who required CBCT radiographic examinations as part of their routine examination, diagnosis and treatment planning, were enrolled in the study. A total of 389 healthy, untreated, fully developed mandibular molars in Chinese individuals were included. Wang et al. [19] reported a frequency of 41% according to a clinical study. Kim et al. [22] reported a frequency of 39,8% of C-shaped root canals of mandibular second molars in a Korean population using CBCT as a diagnostic tool. A total of 542 teeth were evaluated using cone-beam computed tomography (CBCT).

The study showed that the most common configuration type was C2 (45, 6%). Similar findings reported Seo and Park, using *in vivo* analysis with radiographic images and *in vitro* analysis [23]. CBCT – study based on the Turkish population [10] proved that C1 configuration (continuous C-shaped root canal) was the most common configuration. The frequency of C-shaped root canal system of second mandibular molars in Brazilian population [24] was reported by a CBCT-study 3,5%, and another CBCT-study based on the same population reported a frequency of C-shaped root canals of 15,3% [11]. CBCT images of 214 patients (406 teeth) were evaluated for: presence of C-shaped root canals, number of canals and direction of the root grooves (buccal or lingual). The authors of the study concluded that there was a significant prevalence of C-shaped canals in the mandibular second molars of the population studied, the C-shaped canal system varied in configuration, with a higher prevalence of three and two canals. Silva et al. [24] included in their CBCT study 460 healthy, untreated, fully developed mandibular first and second molars. The results of the stydu showed that the incidence of C-shaped canals was 1.7% of first molars and 3.5% of second molars. Rahmi et al. [25] conducted an *in vitro* study on the Iranian population and concluded that the highest frequency of C-shaped root canal configurations was seen in single-rooted mandibular second molars. The study included 139 extracted mandibular second molars, which were injected with India ink and demineralized. They were made clear and transparent with methyl salicylate, and the anatomy of their canals was studied. Among the mandibular second molars, 7.2% had C-shaped canals and these configurations were seen mostly in single-rooted mandibular second molars. Similar findings were obtained by Janani et al. [26] in their CBCT-

How to cite this article: Slavena S. C-Shaped Root Canal System– A Review of Literature. Adv Dent & Oral Health. 2020; 13(2): 555859. DOI: 10.19080/ADOH.2020.13.555859

study based also on an Iranian population. This study consisted of retrospective evaluation of CBCT images from 231 adult patients. The results of the study showed that 21.4% of the molars from 58 patients had a C-shaped root canal configuration.

This variation of inner tooth morphology is common in Asian population, but relatively rare amongst Europeans and Americans [27]. In the described by Lynn [3] clinical case of a C-shaped mandibular second molar the root canal orifices were located approximately 2 mm below the CEJ-level. Micro-CT study concluded that in 98% of all C-shaped molars the orifices are located 1 mm to 3 mm below the CEJ-level. The variation of orifice location and level of the root canal fusion prove molars with C-shape configuration to be particularly difficult for chemo-mechanical preparation and root canal system obturation. The application of CBCT can significantly assist the treatment planning, but also the inspection of the inner morphology of teeth and the connections to neighboring structures and existing periapical lesions [28]. Clinical cases with C-shaped mandibular premolars or maxillary central incisors have also been reported [29,30]. Velmurugan et al. [29] conducted an *in vitro* study with 100 extracted adult mandibular first premolar teeth, which were studied following decalcification and clearing. The results of the study showed that the root canal patterns were classified as Type I (72%), Type II (6%), Type III (3%), Type IV (10%) and Type V (8%) according to Vertucci's classification. C-shaped canals were identified in one tooth (1%). Gu [30] conducted an *in vitro* study investigating lateral incisors. Eleven extracted permanent maxillary lateral incisors with radicular grooves were collected from a native Chinese population and were scanned by micro-CT scans. The results of the study showed that three specimens presented type I grooves (apically not beyond the coronal third of the root); five specimens showed a type II groove (beyond coronal third, corresponding to a normal or simple root canal), and three showed a type III groove (beyond the coronal third, corresponding to a complex root canal system). The C-shaped root canal was observed in specimens with type III grooves.

The C-shape root canal configuration is considered to be complex because of the high incidence of lateral canals, transverse anastomoses, apical deltas and other irregularities [5]. The third root of mandibular molars is often difficult to detect on conventional radiographic images because of the overlapping of the roots. The failure to locate and prepare the additional root canal may result in treatment failure [31]. Different studies have reported the higher chances of C-shaped canal systems in teeth with fused roots [32]. Roy et al. [32] investigated published research articles related to C-shaped canal configuration in mandibular second molars. The results of the review showed a significant variation between the Asian and non-Asian population. The highest incidence of racial predilection was observed in China (Asia) with 93.1%, and the minimum was observed in America with 2.7%. Chhabra et al. [33] during conducting their study investigating the Indian population observed presence of C-shaped root canal system in 78,5% of the mandibular second molars with fused roots. The study was performed *in vitro* and included 42 extracted mandibular second molar teeth with fused roots and longitudinal grooves, which were collected randomly from native Indian population.

The differences between the results of the studies can be explained by the different ethnic background of the examined patients and also by the different methodology of the included *in vivo* and *in vitro* studies. A study conducted by Matherne et al. [34] pointed out the superiority of CBCT over other diagnostic methods. The authors suggested the simultaneous use of CBCT and magnification in order to most precisely conduct an endodontic treatment. Burhley et al. [35] reported the results of an *in vivo* study, proving that the chance of detecting additional root canals increased to 93% when using an operating microscope to examine the pulp chamber floor. Participants that used the microscope or dental loupes located the MB2 canal of maxillary molars with a frequency of 57.4% and 55.3%, respectively. Those using no magnification located the MB2 canal with a frequency of 18.2%. In clinical cases with C-shaped root canals the clinician cannot assume if this shape continuous throughout the length of the root canal or is present only in part of it. The prognosis of such complex root canal anatomy can be improved by simultaneous use of magnification and CBCT [33].

Difficulties to the clinician present not only the chemo-mechanical preparation of the C-shaped root canal system, but also the proper obturation, due to the various anastomoses present. Post-endodontic restoration including intracanal post placement may also be compromised due to the smaller amount of dentin than in clinical cases with separate root canals. The chance of not optimal instrumentation and obturation of the C-shaped root canal system increase in cases when the clinician is not aware of the complex anatomy, especially when the C-shaped configuration is present only in the middle or apical 1/3.

Thorough knowledge of the root canal system internal morphology and proper diagnosis including the use of magnification and CBCT diagnostics when required, are essential for minimizing the risk of iatrogenic intraoperative mishaps, especially in cases with complex anatomy.

Conclusion

The C-shaped root canal configuration is characterized with an ethnic predisposition and a high frequency rate in mandibular second molars. Proper diagnosis and treatment planning, as well as three-dimensional visualization of the root canal system using CBCT, can positively influence the treatment outcome of teeth with more complex root canal system morphology.

References

1. Fan B, Cheung GS, Fan M, Gutmann JL, Bian Z (2004) C-shaped canal system in mandibular second molars: Part I-Anatomical features. J Endod 30(12): 899-903.

2. Cooke HG, Cox FL (1979) C-shaped canal configurations in mandibular molars. J Am Dent Assoc 99(5): 836-839.

How to cite this article: Slavena S. C-Shaped Root Canal System– A Review of Literature. Adv Dent & Oral Health. 2020; 13(2): 555859.
DOI: 10.19080/ADOH.2020.13.555859

3. Lynn EA (2006) Conventional root canal therapy of C-shaped mandibular second molar. A case reports. N Y State Dent J 72(6): 32-34.
4. Zheng Q, Zhang L, Zhou X, Wang Q, Wang Y, et al. (2011) C-shaped root canal system in mandibular second molars in a Chinese population evaluated by cone-beam computed tomography. Int Endod J 44(9): 857-862.
5. Melton DC, Krell KV, Fuller MW (1991) Anatomical and histological features of C-shaped canals in mandibular second molars. J Endod 17(8): 384-388.
6. Fan B, Cheung GS, Fan M, Gutmann JL, Fan W (2004) C-shaped canal system in mandibular second molars: Part II--Radiographic features. J Endod 30(12): 904-908.
7. Fan W, Fan B, Gutmann JL, Fan M (2008) Identification of a C-shaped canal system in mandibular second molars. Part III. Anatomic features revealed by digital subtraction radiography. J Endod 34(10): 1187-1190.
8. Scarfe WC, Farman AG, Sukovic P (2006) Clinical applications of cone-beam computed tomography in dental practice. J Can Dent Assoc 72(1): 75-80.
9. Cimilli H, Cimilli T, Mumcu G, Kartal N, Wesselink P (2005) Spiral computed tomographic demonstration of C-shaped canals in mandibular second molars. Dentomaxillofac Radiol 34(3): 164-167.
10. Helvacioglu-Yigit D, Sinanoglu A (2013) Use of cone-beam computed tomography to evaluate C-shaped root canal systems in mandibular second molars in a Turkish subpopulation: a retrospective study. Int Endod J 46(11): 1032-1038.
11. Ladeira DB, Cruz AD, Freitas DQ, Almeida SM (2014) Prevalence of C-shaped root canal in a Brazilian subpopulation: a cone-beam computed tomography analysis. Braz Oral Res 28: 39-45.
12. Borisova-Papancheva Ts, Papanchev G, Peev St, Georgiev T (2016) Posterior Endodontic Surgery – A Case Report. Medinform 3(1): 389-393.
13. Borisova-Papancheva T (2015) Endodontic Management of an Uncommon Anatomic Variation of Mandibular Second Premolars: A Case Report. T Borisova-Papancheva. Journal of IMAB - Annual Proceeding (Scientific Papers) 21(4): 945-947.
14. Jo HH, Min JB, Hwang HK (2016) Analysis of C-shaped root canal configuration in maxillary molars in a Korean population using cone-beam computed tomography. Restor Dent Endod 41(1): 55–62.
15. De Moor RJ (2002) C-shaped root canal configuration in maxillary first molars. Int Endod J 35(2): 200-208.
16. Yilmaz Z, Tuncel B, Serper A, Calt S (2006) C-shaped root canal in a maxillary first molar: a case report. Int Endod J 39(2): 162-166.
17. Roy A, Astekar M, Bansal R, Gurtu A, Kumar M, et al. (2019) Racial predilection of C-shaped canal configuration in the mandibular second molar. J Conserv Dent 22(2): 133-138.
18. Lu TY, Yang SF, Pai SF (2006) Complicated root canal morphology of mandibular first premolar in a Chinese population using the cross section method.J Endod 32(10): 932-936.
19. Wang Y, Guo J, Yang HB, Han X, Yu Y (2012) Incidence of C-shaped root canal systems in mandibular second molars in the native Chinese population by analysis of clinical methods. Int J Oral Sci 4(3): 161-165.
20. Kim SY, Kim BS, Kim Y (2016) Mandibular second molar root canal morphology and variants in a Korean subpopulation. Int Endod J 49(2):136-144.
21. Zhang R, Wang H, Tian YY, Yu X, Hu T, et al. (2011) Use of cone-beam computed tomography to evaluate root and canal morphology of mandibular molars in Chinese individuals. Int Endod J 44(11): 990-999.
22. Kim HS, Jung D, Lee H, Han YS, Oh S, et al. (2018) C-shaped root canals of mandibular second molars in a Korean population: a CBCT analysis. Restor Dent Endod 43(4): e42.
23. Seo MS, Park DS (2004) C-shaped root canals of mandibular second molars in a Korean population: clinical observation and *in vitro* analysis. Int Endod J 37(2): 139-144.
24. Silva EJ, Nejaim Y, Silva AV, Haiter-Neto F, Cohenca N (2013) Evaluation of root canal configuration of mandibular molars in a Brazilian population by using cone-beam computed tomography: an *in vivo* study. J Endod 39(7): 849-852.
25. Rahimi S, Shahi S, Lotfi M, Zand V, Abdolrahimi M, et al. (2008) Root canal configuration and the prevalence of C-shaped canals in mandibular second molars in an Iranian population. J Oral Sci 50(1): 9-13.
26. Janani M, Rahimi S, Jafari F, Johari M, Nikniaz S, et al. (2018) Anatomic Features of C-shaped Mandibular Second Molars in a Selected Iranian Population Using CBCT. Iran Endod J 13(1): 120-125.
27. Kato A, Ziegler A, Higuchi N, Nakata K, Nakamura H, et al. (2014) Aetiology, incidence and morphology of the C-shaped root canal system and its impact on clinical endodontics. Int Endod J 47(11): 1012-1033.
28. Papanchev G, Borisova-Papancheva T, Georgiev T, Andreeva R (2013) Accuracy of CBCT for Measurement of the Volume, Area and Bone Density of Periapical Lesions. International Journal of Science and Research 5(6): 1697-1702.
29. Velmurugan N, Sandhya R (2009) Root canal morphology of mandibular first premolars in an Indian population: A laboratory study. Int Endod J 42(1): 54-58.
30. Gu Y (2011) A micro-computed tomographic analysis of maxillary lateral incisors with radicular grooves. J Endod 37(6): 789-792.
31. Gulabivala K, Opasanon A, Ng YL, Alavi A (2002) Root and canal morphology of Thai mandibular molars. Int Endod J 35: 56-62.
32. Sutalo J, Simeon P, Tarle Z, Prskalo K, Pevalek J, et al. (1998) C-shaped canal configuration of mandibular second permanent molarColl Antropol 22(1): 179-186.
33. Chhabra S, Yadav S, Talwar S (2014) Analysis of C-shaped canal systems in mandibular second molars using surgical operating microscope and cone beam computed tomography: A clinical approach. J Conserv Dent 17(3): 238-243.
34. Matherne RP, Angelopoulos C, Kulild JC, Tira D (2008) Use of cone-beam computed tomography to identify root canal systems *in vitro*. J Endod 34(1): 87-89.
35. Buhrley LJ, Barrows MJ, BeGole EA, Wenckus CS (2002) Effect of magnification on locating the MB2 canal in maxillary molars. J Endod 28(4): 324-327.

How to cite this article: Slavena S. C-Shaped Root Canal System– A Review of Literature. Adv Dent & Oral Health. 2020; 13(2): 555859.
DOI: 10.19080/ADOH.2020.13.555859

DOI: 10.19080/ADOH.2020.13.555859

How to cite this article: Slavena S. C-Shaped Root Canal System– A Review of Literature. Adv Dent & Oral Health. 2020; 13(2): 555859. DOI: 10.19080/ADOH.2020.13.555859