Prevalence of C-Shaped Canals and their Variations in Mandibular First Premolars and Second Molars

Dewa Ayu Nyoman Putri Artiningsih[1]*, Marceline Olivia[2], Kamizar Nazar[1]

1. Department of Conservative Dentistry, Faculty of Dentistry, Universitas Indonesia, Jakarta, Indonesia.
2. Faculty of Dentistry, Universitas Indonesia, Jakarta Indonesia.

Abstract

Knowledge about the presence and anatomy of c-shaped canals in the root is essential for endodontic treatment. Identification of the presence of a c-shaped canal and its classification might help the clinician to modify the treatment protocol.

The aim of this study was to determine the prevalence of c-shaped canals and to evaluate the variations in these canals in mandibular first premolars and second molars.

Sixty first premolars and 32 second molars from the mandible were scanned using micro-computed tomography (CT) at a resolution of 50 µm. Transverse sections were obtained from each root and categorized. Alterations in the configurations of the c-shaped canals were noted.

The prevalence of c-shaped canals in the mandibular first premolars was 17% and in the mandibular second molars was 16,67%. Alterations in configuration were observed all along the root canal.

The dentist should be aware of the presence of c-shaped canals and the possibility of alterations in the shape of these canals while performing endodontic treatment. In cases where a c-shaped root canal is suspected, radiographic examinations should be performed to detect alterations in the configurations so that successful treatment can be provided.

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Introduction

It is extremely important to examine and have adequate knowledge about the anatomy of the tooth owing to variations in the shape of the root canal, one of which is the c-shape.[1] The c-shaped canal is an anatomical variation caused by the inability of the Hertwig's Epithelial Root Sheath (HERS) to fuse in the lingual or buccal surface.[2] It has an ethnic predilection;[3] this variation is rarely found among the white population, but commonly found in Asia.[4–7] C-shaped canals are mostly found in the mandibular second molar (4,6%–40%), followed by the mandibular first premolar (2,3%).[4,8,9]

The C-shaped configuration of the canal varies along the root[10]. This complex anatomy (isthmus and variation along the root) leads to a questionable prognosis[11] owing to difficulties in carrying out adequate debridement and obturation. Hence, it is advised that individuals who present with this kind of configuration be referred to the endodontist for proper treatment.[1]

A thorough identification of the c-shaped canal and its classification should be done before the treatment so that modifications to the protocol can be considered in order to obtain perfect results from the endodontic treatment. The classification of the canal alone could help in predicting the anatomy of the canal.[12]

There are many ways to analyze the presence of a c-shaped canal. It can be evaluated using various laboratory techniques such as clearing, cross-sectioning, and using a polyester resin model. In addition, conventional X-rays, Cone-beam Computed Tomography (CBCT) and Micro-CT can be used.[5]

Information about the probability of a c-shaped canal is very important.[5,12] The aim of this study was to determine the statistical predominance of and variations in c-shaped

Corresponding author:
Dewa Ayu Nyoman Putri Artiningsih,
Department of Conservative Dentistry
Faculty of Dentistry, Universitas Indonesia.
E-mail: dewaayunpa@yahoo.co.id

canals in the second molars and first premolars of the mandible.

Materials and methods

Sixty mandibular first premolars and 32 mandibular second molars were examined in this study. The teeth were obtained without considering the age, ethnicity, and gender of the patients. The inclusion criteria for the teeth were complete root development, closed apex, no restoration, no signs of root fracture or resorption, and no endodontic treatment.

The samples were cleaned and stored in saline water (0,9% NaCl) and then examined by micro-CT. The samples were placed on a wax block and scanned using a micro-CT (SkyScan 1173; Bruker, Kontich, Belgium) sensor flat panel, Kontich Belgium, at an isotopic resolution of 50 µm (medium), scanning vial of 130 kV and 60 µA, and exposure time of 295 ms. Each specimen was scanned at 360^0 around the tooth axis with a pixel size of 71.25 µm.

After carrying out the scanning and the reconstruction procedure, cross-sectional images of the root canal were taken at five different levels according to the study by Fan et al. (2008): cemento-enamel junction (**CEJ**)-2 (2 mm below the CEJ); CM (junction between the coronal and middle thirds—1/3 of the distance between the CEJ and apex); M (middle of the root—½ the distance between the CEJ and apex); AM (junction between the middle and apical thirds); and A+2 (2 mm coronal to the apex; Figure 1a). Furthermore, as described in another study by Fan et al. (2004), cross-sectional images of the second molar were taken at the following five levels: O (orifice); CM (junction between coronal and middle thirds—1/3 of the distance between the orifice and the apex); OM (middle of the root—½ the distance between the orifice and apex); AM; and A+2 (Figure 1b).

The root canal in each cross-sectional image was classified based on the classification model for mandibular first premolars described by Fan et al. (2008) as follows: C1 (complete “c” without separation); C2 (semi columnar in shape because of discontinue “c” outline); C3 (two or three separated round, oval, or flat canal); C4 (only one round, oval, or flat canal); C5 (three or more separated round or oval canal); and C6 (no canal lumen; Figure 2). The tooth was determined as a mandibular first premolar with a c-shaped canal if it had an external groove on the root and at least one type C1 or C2 image.

For the second molar, the cross-sectional image was categorized based on the classification model described by Fan et al. (2004) as follows: C1(complete “C”-shaped canal without separation); C2 (semi columnar canal, where one of the angles (α or β) was less than 60); C3 (two or three separated canals with α and β less than 60°); C4 (only one round or oval canal in the cross-section of the root); and C5 (no canal lumen). The tooth was tagged as a mandibular first premolar with a c-shaped canal if the root were fused with one longitudinal groove on the buccal/lingual surface and at least canal of type C1, C2, or C3 was observed on the cross-sectional image.

Results

Thirty mandibular second molars and 59 mandibular first premolars could be analyzed in this study. The prevalence of a c-shaped canal was 17% in the first premolars (10/ 59) and 16.67% in the second molars (5/ 30). The distribution of the c-shaped canals in the mandibular first premolars and second molars are shown in Tables 1 and 2.

From all teeth that was determined as c-shaped canal teeth, we lined out alteration of configuration classification as shown in Table 3 and Table 4.

Classification	Mandibular First Premolar				
	CEJ-2	CM	M	AM	A+2
C1	-	-	2 20%	-	-
C2	-	-	5 50%	9 90%	4 40%
C3	-	-	2 20%	1 10%	4 40%
C4	10 100%	10 100%	1 10%	-	-
C5	-	-	-	-	2 20%
C6	-	-	-	-	-

Table 1. Distribution of c-shaped canals in the mandibular first premolars.
Cemento-enamel junction (CEJ)-2, 2 mm below CEJ; CM, junction of coronal third and middle third (1/3 distance between CEJ and apex); M, middle of the root (1/2 distance between CEJ and apex); AM, the junction of middle and apical thirds; A+2, 2 mm coronal to the apex.

Classification	Mandibular Second Molar				
	O	CM	OM	AM	A+2
C1	4 80%	3 60%	4 80%	3 60%	3 60%
C2	-	2 40%	1 20%	1 20%	-
C3	1 20%	-	-	-	-
C4	-	-	-	1 20%	2 40%
C5	-	-	-	-	-
C6	-	-	-	-	-

Table 2. Distribution of c-shaped canals in the mandibular second molars.

O, orifice; CM, junction of coronal third and middle third (1/3 of the distance between orifice and apex); OM, middle of the root (1/2 the distance between orifice and apex); AM, junction of middle and apical thirds; A+2, 2 mm coronal to the apex.

Tooth Code	CEJ-2	CM	M	AM	A+2	Number of Alterations
A1	C4	C4	C2*	C2	C2	1
A2	C4	C4	C2*	C2	C2	1
A17	C4	C4	C4	C2*	C3*	2
P2	C4	C4	C3*	C2*	C3*	3
P3	C4	C4	C1*	C3*	C3	2
P6	C4	C4	C2*	C2	C5*	2
P7	C4	C4	C1*	C2*	C2	2
P31	C4	C4	C2*	C2	C5*	2
P34	C4	C4	C3*	C2*	C3*	3
P42	C4	C4	C2*	C2	C2	1
Number of Alteration in Each Sectioning Level	0	0	9	5	5	19

Table 3. Alterations in the shape of the c-shaped canal in the mandibular first premolars.

Note: Mark (*) shows alterations in the shape of the canal. Sectioning Level: CEJ-2, 2 mm below CEJ; CM, the junction of coronal third and middle third (1/3 distance between CEJ and apex); M, middle of the root (1/2 distance between CEJ-apex); AM, the junction of middle third and apical third; A+2, 2 mm coronal to the apex.

Tooth Code	O	CM	OM	AM	A+2	Number of alteration
B2	C1	C1	C1	C1	C1	0
B4	C1	C2*	C1*	C1	C1	2
B5	C3	C2*	C2	C2	C4*	2
B6	C1	C1	C1	C1	C1	0
B15	C1	C1	C1	C4*	C4	1
Number of alteration in Each Sectioning Level	0	2	1	1	1	5

Table 4. Alterations in the c-shaped canals in the mandibular second molars.

Note: Mark (*) shows alterations in the shape of the canal. Sectioning Levels: O, orifice; CM, the junction of coronal and middle thirds (1/3 of the distance between the orifice and the apex); OM, middle of the root (1/2 distance between orifice-apex); AM, the junction of middle and apical thirds; A+2, 2 mm coronal to the apex.

Three alterations were observed and it occurred mostly in the middle of the root (M). A crosstab analysis was performed to assess the possibility of locating the c-shaped canal in the various sectioning levels. The odds ratio (OR) for this test was 1.07, which indicated that the tendency for locating a c-shaped canal was 1.07 times higher at level M than at levels AM and A+2.

Table 4 shows that the number of alterations in the second molar was two and the sectioning level with most alteration was CM (junction between the coronal and middle thirds of the root). Crosstab calculation showed that OR was 0.53, which indicated that the tendency for locating a c-shaped canal was 0.53 times higher at level AM than at level A+2.

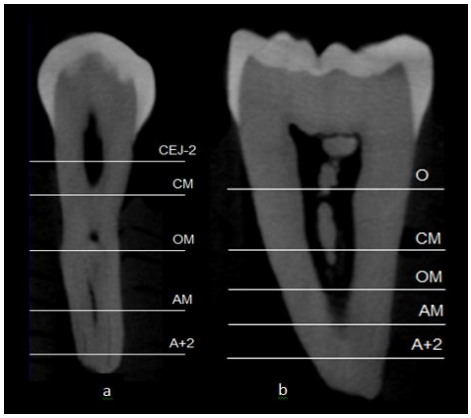

Figure 1. Levels of sectioning in the mandibular first premolar (a) and second molar (b).

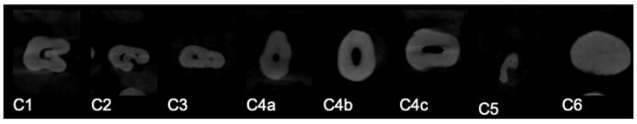

Figure 2. Cross-sectional images of the canal configurations in the mandibular first premolar based on the classification by Fan et al. (2008).

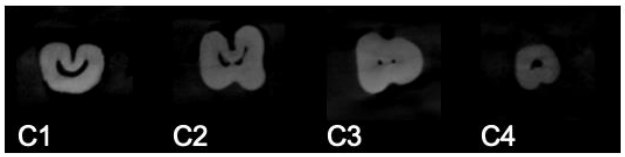

Figure 3. Cross-sectional images of the c-shaped canals in the mandibular second molars based on the classification by Fan et al. (2004).

Discussion

A non-invasive radiographic method (micro-CT) was used to evaluate the root canal anatomy in this study. This method provides

clear cross-sectional images of the canal along the root without damaging the tooth.[17] Root canal can be analyzed in detail using a micrometer.[15] Mandibular first premolars and second molars were selected for this study because of the high prevalence of c-shaped canals in these teeth.[4,6,8,9,16–18]

In this study, the prevalence of c-shaped canal in the first premolar was 17%, which was higher than the global prevalence (2.3% of 1123 mandibular first premolars) reported in the study by Martins et al. (2017).[9] On the other hand, the statistical population of both canals used in this study (17%) was relatively lower than that used by Lu et al. (2006) and Fan et. al (2008), which included samples from patients from different ethnicities or regions (18–24%).[19,20]

The number of c-shaped canals in the second molar in the current study (16,67%) was relatively lower than that reported in some countries in East Asia, such as China and Korea, which was about 29%–42.6% in approximately 96–528 samples.[4–7,21] Furthermore, it was lower than that reported in Myanmar (22.4% of the total sample of 134 teeth), which is located within the same region where the current study was conducted (South East Asia).[22] These differences may be attributed to racial differences. Moreover, genetic variations in each population could be affected by different dynamic processes such as mutation, methods of survival in different environments, reproduction, and gene flow within the population.[23] Different geographic conditions can lead to adaptations to the environment resulting in genetic differentiation.[24] Additionally, differences in the methods used in the various studies may also account for the differences in the results.[16] Some of the previous studies used hundreds to thousands of samples[5] whereas, in some studies, the ethnicity of the patient was taken into consideration.

Alterations in the c-shaped configuration were observed all along the roots of the teeth examined in this study; as stated in previous studies, variations in the anatomy of the c-shaped canals were seen.[6,10,14,25] The dentist should be careful while performing endodontic treatments in teeth with c-shaped canals and should be aware of the possibility of alterations in the shape of these canals from the orifice to the apex.[14]

In cases where a c-shaped root canal is suspected, radiographic examinations should be conducted to facilitate the ability to detect alterations in the configurations of these canals so that successful treatment can be provided. CBCT is the correct method to examine these types of teeth because it can provide three-dimensional imaging for evaluation. Thus, the operator can be made aware of the shape, position, and size of the canal.[8,13]

This study also explains the tendency for the appearance of variations in the configuration of the c-shaped root canals at some of the sectioning levels in the mandibular teeth. In the mandibular first premolar, the c-shaped canal begins to appear in the middle third of the root (M) and the tendency for the appearance at this level was 1.07 times higher than those at levels AM and A+2. In the second molar, the tendency for the appearance of a c-shaped canal at the AM level was 0.53 times higher than that at the A+2 level. This information is important, particularly during endodontic treatment; the operator should be aware of these alterations in these sectioning levels.

This study had some limitations. The age, ethnicity, and gender of the patients were not taken into consideration. The sample size was small as this study was conducted as a pilot study to evaluate the prevalence of c-shaped root canals in the Indonesian population.

Conclusions

The prevalence of c-shaped canals was 17% in the first premolars and 16.67% in the second molars. The clinician should be aware that the configuration of the c-shaped canal varies along the root in both these mandibular teeth. Additional studies using larger sample sizes are required to confirm these findings in the Indonesian population.

Declaration of Interest

The authors report no conflict of interest.

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