The Diagnosis and Determination of C-Shaped Canal in Lower Second Molar

Kais Raad Abdulmajeed[1], Nazih shaban Mustafa[2]*, Muhanad Ali Kashmoola[2], Omar Abdul Jabbar[2], Liyana Syafiqah Ab Razak[3], Siti Noornadiyana Mohd Noor[3]

1. Specialist Dentist, Qatar.
2. Department of Oral Diagnosis and Oralmaxillofacial Surgery, Kulliyyah of Dentistry, International Islamic University. Malaysia, Selangor, Malaysia.
3. Dentists, Ministry of Health, Malaysia.

Abstract

To determine the frequency of C-shaped canal in mandibular second molar among Malay population by using radiographic and clinical examination and to compare the effectiveness between both methods. Other objectives are to know which classification of C-shaped canal is significant and the relation between number of roots and its occurrence.

86 mandibular second molars teeth were collected from different government clinics in Malaysia. All teeth were cleaned, sterilized and mounted in a mixture of Plaster of Paris and saw-dusts. CBCT images and periapical radiograph were taken for each sample. Access cavity was done and the shape of the canals was evaluated with the aids of Surgical Operating Microscope (SOM). Teeth with C-shaped canal were categorized by using the radiographic classification and Min's method.

C-shaped canals were identified in 49(57.00%) mandibular second molars by periapical radiograph (type I, 18.37%; type II, 75.51%; type III, 6.12%). %). As for CBCT examination, 49(57.00%) exhibited c-shaped canal (type I, 34.69%; type II, 28.57%; type III, 18.37%; type IV, 18.37%). Clinical examination showed that 44(51.16%) cases having C-shaped canal (type I, 36.36%; type II, 27.27%; type III,18.18%; type IV, 18.18%). Kappa statistic between both methods is 0.98. 77.8% of one-rooted sample have C-shaped canal (type I, 85.71%; type II, 0.00%; type III, 14.29%) and 56.8% of two-rooted exhibited c-shaped canal (type I, 7.14%; type II, 88.10%; type III, 4.76%).

Frequency of C-shaped canal in one-rooted mandibular second molar was high in Malay population. The types of C-shaped canal were significant. Both methods of assessment were reliable. Root number has relation with the presence of C-shaped canal.

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Introduction

The main goal of endodontic therapy is to ensure optimal debridement of the root canal system by means of thorough cleaning, shaping, disinfection and three-dimensional obturation of the root canal system. Knowledge, respect and appreciation for anatomy of root canal, in addition to careful, thoughtful and meticulously performed cleaning and shaping procedures are the key roles for successful endodontic therapy.[1]

The complexity of the root canal anatomy becomes one of the clinical challenges during the treatment and therefore, a detailed knowledge of the morphology of root canal is important, or otherwise may lead to treatment failure.[2]

A number of studies have been done and the results have shown different trends in the shapes and number of root canals among different populations. One of the most anatomic variations is the C-shaped canal system in mandibular second molar. The aim of this study was to diagnose and determine the occurrence of C-shaped canal in mandibular second molar among Malay population by using a radiographic

Corresponding author:
Nazih shaban Mustafa
Department of Oral Diagnosis and Oralmaxillofacial Surgery,
Kulliyyah of Dentistry,
International Islamic University Malaysia,
Selangor, Malaysia.
E-mail: drnazih@iium.edu.my

examination and clinical examination, and to evaluate the effectiveness between the two assessment methods used, with the classification and the no of roots and the occurrence of C-shaped canal in mandibular second molar.

Literature review

Anatomical features

The main anatomical feature of C-shaped canal is the presence of a fin or web connecting the root canals, leading to the appearance of a single ribbon-like opening with an 180^o arc linking the canals.[3]

The 180^o arc may appear as either a band or a deep semilunar groove connecting the distal, mesio-buccal and mesio-lingual canals.[4]

The orientation of the concavity of the C shape may be buccally or lingually. From the occlusal view, the orifice may appear as a complete C connecting all the three canals, an incomplete C, with union of the distal and mesio-buccal canals and an isolated mesio-lingual canal and an incomplete C, with union of the distal and mesio-lingual canals and an isolated mesio-buccal canal. Instead of the normal shape of the pulp chamber with three root canals, there is the presence of C-shaped orifice of the root canal in mandibular molar.[5]

The orifice of the C-shaped canal starts from the mesio-lingual line angle of the pulp chamber, curves buccally and ends distally. The convex portion of the C shape is directed vestibullary. Meanwhile, below the level of orifice, there is a wide range of anatomic variations as the canals can be of one, two, three or four separate canals. The teeth are further classified into two basic groups; first of which the single ribbon-like morphology persists from orifice to the apex, and second of which there is the presence of more than one separate canals below the orifice.[5]

There is also varied diameter of the canals ranging from the widest to the smallest. There is also similar evidence that the C shape may be continuous throughout the length of the root, or it can be two or three canals present in the C-shaped groove.[6]

Occurrence

A lot of studies have been done to study the occurrence of C-shaped canal configuration in different population around the world. There is no correlation of C-shaped canal configuration with age, tooth position and gender. However, the issue whether race plays a role in the presence of C-shaped canal configuration remains controversial. According to research done, it is proven that genetic plays a role in C-shaped canal configuration.[7]

There are quite a number of previous studies that had been done to determine the incidence of C-shaped root canals in different populations. For example, the incidence of C-shaped canals in Asian population is higher compared to Caucasian population which has only 12.7% involvement.[8] C-shaped canals occur in Hong Kong Chinese population is about 52.0%, in Taiwan Chinese population is about 31.5% and in Japanese population is about 28.4%.[8.] As to compare the incidence of C-shaped canal configuration among Asian countries, Burmese population showed prevalence of 22.4%, which was higher than the Sri Lankan, Indian and Thai population. Lebanese population has the higher incidence of C-shaped canal configuration which is 19.1%, as compared to other west Asian population such as Saudi Arabian, Jordanian or Iranian.[7]

It is proven that the C-shaped canal configuration not only exists in mandibular second molar only, but there is high frequency of its occurrence in mandibular premolar. Incidence studies in mandibular premolar done in Chinese, Iranian and Indian population reveals that Chinese has the highest frequency to have C-shaped canal configuration in mandibular premolar.[7] It also reported that there is high possibility that the C-shaped canal configuration are bilaterally with percentage of 70-81%.[9]

Due to the great percentage of C-shaped canals occurrence in Asian population, this study has been done because there is still no research done yet to study the prevalence of C-shaped canals in Malay population. The first constitutional requirement for a person to qualify as a Malay is that the person “professes the religion of Islam”. Secondly, the person “habitually speaks the Malay language”. Thirdly, the person “conforms to Malay custom”. The final requirement to qualify as a Malay under the constitution revolves around “Merdeka Day”. To be an official Malay, the person or one of his ancestors have to have been born in Malaysia or Singapore before Merdeka Day or have been a Malaysian or Singaporean resident on the day itself.[10]

Etiology

C-shaped canal is first described by Keith (1908), and later by Keith and Knowles (1913), Pedersen (1949), Tratman (1950), and Cooke and Cox (1979).[11] the C-shaped root canal configuration was first documented in the literature by Cooke and Cox.[12]

Earlier, taurodontism has been linked to the occurrence of C-shaped canal. It has also been reported that C-shaped canal is associated with the result of age changes due to deposition of dentin on the walls of the canal, however this theory is not supported because even in patients under 40 years old, separate canals in roots with C-shaped anatomy has been observed. Root fusion is the most likely determining factor of the occurrence of C-shaped canal. This is because, during teeth development stage, Hertwig's epithelial sheath has failed to develop or fuse in the furcation area either in buccal or lingual aspect, most likely due to genetic origin because of the various documentation of racial predilection.[13] Failure to fuse buccally leads to formation of lingual groove, whereas failure to fuse lingually leads to formation of buccal groove. Failure to fuse on both buccal and lingual sides will result in conical or prism-shaped root to be present.[2]C-shaped canal is a result of irregular fusion of either buccal or lingual aspect of the mesial and distal roots.[5] The irregularity of the fusion is what makes the two roots stay connected by an interradicular ribbon.

Classifications

The clinician should be aware of any possibilities that might happen if a C-shaped canal configuration is identified. Its configuration may vary along the root canal depth so that the appearance of the orifice cannot be used as fixed prediction of canal anatomy and the root structure may also harbor a wide range of anatomic variations below the orifice level. As the canal anatomy of C-shaped tooth is complicated, several classifications have been proposed by earlier researchers. The earliest classification was done by Manning and Melton et al. based on their cross-sectional shapes.

Manning described the presence of a single canal from orifice to apex in a type 1 canal and was later described as a true C-shaped canal by Yang. In other classification proposed by Melton, C-shaped canal configuration can be further classified into 3 categories, depending on the cross-sectional shape of the canal which are[14]: 1). **Category I:** Continuous C-shaped canal running from the pulp chamber to the apex; 2). **Category II:** Semicolon-shaped; 3). **Category III:** Refers to teeth with two or more separate and discrete canals. There are two subdivisions under this category. If the C-shaped orifice in the coronal third that divides into two or more canals that join apically, this belongs to subdivision I. in subdivision II, the C-shaped orifice in the coronal third divides into two or more canals in the mid root to the apex and in subdivision III, C-shaped orifice that divides into two or more canals in the coronal third to the apex.

According to Min, C-shaped canal configuration can be divided into[15]: 1). **Type I:** Peninsula-like floor presenting a continuous C-shaped orifice; 2). **Type II:** A buccal, strip-like dentin connection between the peninsula-like floor and the buccal wall of the pulp chamber separating the C-shaped groove into mesial and distal orifices; 3). **Type III:** A mesial, strip-like dentin connection between the peninsula-like floor and the mesial wall, separating the C-shaped groove into a small mesial-lingual orifice and a large arc-like mesiobuccal distal orifice; 4). **Type IV:** Non C-shaped floors comprising of one distal canal orifice and one oval or two round mesial canal orifices.

Figure 1. Canal Orifice showing Min's Classification of C-shaped canal. (a) Type I, (b) Type II, (c) Type III and (d) Type IV.

Radiographically, Fan's radiographic classification has three basic types of C-shaped classifications which are:[16] 1). Type I: Conical or square root with a vague, radiolucent longitudinal line separating the root into distal and mesial parts; 2). Type II: Conical or square root with a vague, radiolucent longitudinal line separating the root into distal and mesial parts. There was a mesial and distal canal, and the two canals appeared to continue on their own pathway to the apex; 3). Type III: Conical or square root with a vague, radiolucent longitudinal line separating the root into distal and mesial parts. There was a mesial and distal canal: one canal curved to and superimposed on this radiolucent line when running towards the apex and the other canal appeared to continue on its own pathway to the apex.

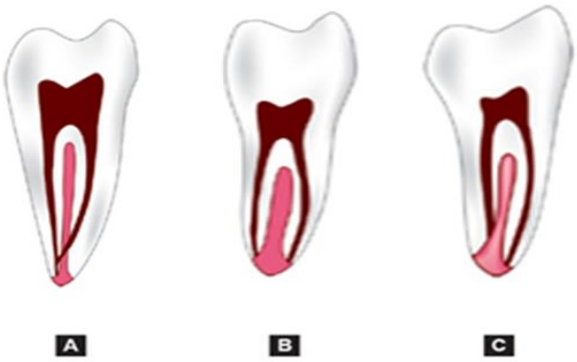

Figure 2: Radiographic types. (A) Type I, (B) Type II and (C) Type III.

There are some critics on Melton's classification proposed before. There has been no clear description of the difference between categories II and III, as well as the clinical significance. Therefore, Min's classification is used in this study, as it is the basic classification of C-shaped clinically and Fan's radiographic classification is used to further classified C-shaped canal tooth via radiographic assessment.

Materials and methods

Statistical analysis

The statistical analysis used was chi square test.

Sampling method

The sampling method of this research was non-probability sampling method (purposive sampling).

Inclusion criteria

The inclusion criteria for the teeth selection are 1). Extracted right or left mandibular second molar, 2). Malay population only.

Exclusion criteria

The exclusion criteria for the teeth selection are 1). Tooth with questionable morphology such as in case of extensive caries to the pulp, extensive restorations and fractured tooth involving the pulp; 2). Fracture root.

Data collection

Collection of teeth

86 mandibular second molar teeth from Malay patients were collected from government clinics in Malaysia after approval from International Islamic University Malaysia Research Ethics Committee (IREC) was obtained. Consent was taken from the patient prior to the teeth selection (Appendix1).

All the teeth collected were washed by tap water immediately after extractions and immersed in antiseptic Dettol solution until the collection was completed. Thereafter, the teeth were washed under tap water and immersed in 2.5% sodium hypochlorite solution for 30 minutes to remove adherent soft tissues and later were autoclaved for sterilization. The calculus and stains were removed using an ultrasonic scaler. The teeth were mounted one by one in mixture of Plaster of Paris and saw-dusts to make the handling easier.

Radiographic technique

The periapical images were taken by using Planmeca Promax 3D Mid operating at 63 kV and 8 mA with an exposure time of 0.05 seconds. The pixel size used was 30 micrometer. The setting of equipment for periapical radiograph is shown in Figure 3. Then, CBCT images were taken by using a Planmeca Promax 3D s operating at 90 kV and 9 mA with an exposure time of 13 seconds. The voxel size used was 200 micrometer and the numbers of slices were 340. The scans were produced according to the manufacturer's recommended protocols. The setting of equipment for CBCT images is shown in Figure 4. All periapical and CBCT exposures were performed by an appropriately licensed radiographer, with the minimum exposure

necessary for adequate image quality. The lowest dose radiation and the smallest field of view were ensured.

Figure 3. Setting of Equipment for Periapical Radiograph of the Samples.

Figure 4. Setting of equipment for CBCT Images of the Samples.

Evaluation of images

The periapical and CBCT images were analyzed with the inbuilt software (Romexis). The contrast and brightness of the images were adjusted using the image processing tool in the software to ensure optimal visualization. The images were evaluated throughout the canal by endodontists to reach a definite interpretation of the radiographic findings.

Access cavity

After taking and evaluating the radiographic images, access cavity was done by endodontists using high speed long shank round and non-end cutting burs with the aids of Surgical Operating Microscope (SOM). Eyepiece magnification of the SOM was set in a range of 10x to 12.5x. The coronal shape of the canal was evaluated with probe No. 9 and photograph of the done cavity was taken by using intraoral camera. Figure 5 shows the access cavity done to the samples.

Evaluation of C-shaped canals

Calibration between the two endodontists was done to prevent bias in the results obtained with kappa value of 0.98. At one time, the collected teeth were given to one of the endodontists to be evaluated clinically and radiographically. However, the endodontists were not aware of the coding of the teeth. The presence or the absence of the C-shaped canals and the type of C-shaped canal was recorded. Then, the same procedures were repeated by the other endodontist.

Figure 5. Access Cavity Done by Endodontist on The Samples.

Results

Frequency of C-shaped canal in mandibular second molar

Based on periapical radiographic classification, of all samples detected to have C-shaped canal, Type II is found to be the highest frequency, followed by Type I and the least is Type III. The type of C-shaped canal system in Malay population is significant as the P value is < 0.05. The radiographic appearances of periapical view are presented in Figure 6.

The clinical examination of 86 samples of mandibular second molar showed the frequency of C-shaped canal system is found to be more than 50%. Among the teeth with C-shaped canal system, according to Min's classification, Type I has the highest frequency, followed by Type II, Type IV and the least is Type III. The type of C-shaped canal system in Malay population is significant as the *P* value is < 0.05. The clinical picture taken presented in Figure 7.

By using Cone Beam Computed Tomography (CBCT), among the teeth found to have C-shaped canal, according to Min's

classification, Type I has the highest frequency, followed by Type II, Type IV and the least is Type III. The type of C-shaped canal system in Malay population is significant as the P value is < 0.05. Table 1 shows the frequency of C-shaped canal system by using the periapical radiograph, clinical and CBCT assessment according to the type of C-shaped canal.

The CBCT images of C-shaped canal are presented in Figure 8 according to its classification.

Relation of root number and occurrence of C-shaped canal

Out of all 86 samples, as presented in Table 2, teeth with two roots have the highest frequency, followed by one-rooted and three-rooted.

Among the one-rooted mandibular second molar collected, more than 50% of the one-rooted mandibular second molar have C-shaped canal system while the frequency of two-rooted mandibular second molar having C-shaped canal is less when compared to one-rooted mandibular second molar. Among the three-rooted mandibular second molar collected, none of them exhibit C-shaped canal system. There was significant relation between root number and the presence of C-shaped canal with *P* value < 0.05.

Methods	Number of teeth with c-shape canal system of different category (percentage)
Clinical examination	44(51.16%)
Type I	16(36.36%)
Type II	12(27.27%)
Type III	8(18.18%)
Type IV	8(18.18%)
Radiographic examination (periapical)	49(57.00%)
Type I	9(18.37%)
Type II	37(75.51%)
Type III	3(6.12%)
Radiographic examination (CBCT)	49(57.00%)
Type I	17(34.69%)
Type II	14(28.57%)
Type III	9(18.37%)
Type IV	9(18.37%)

Table 1. Number of Teeth with C-Shaped Canal System of Different Category (%) In Three Methods.

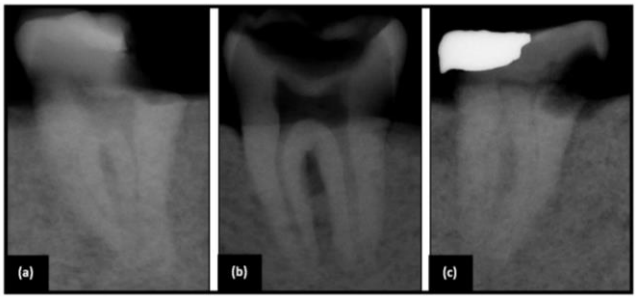

Figure 6. Periapical View of C-Shaped Canal According to its Type; (a) Type I (b) Type II (c) Type III.

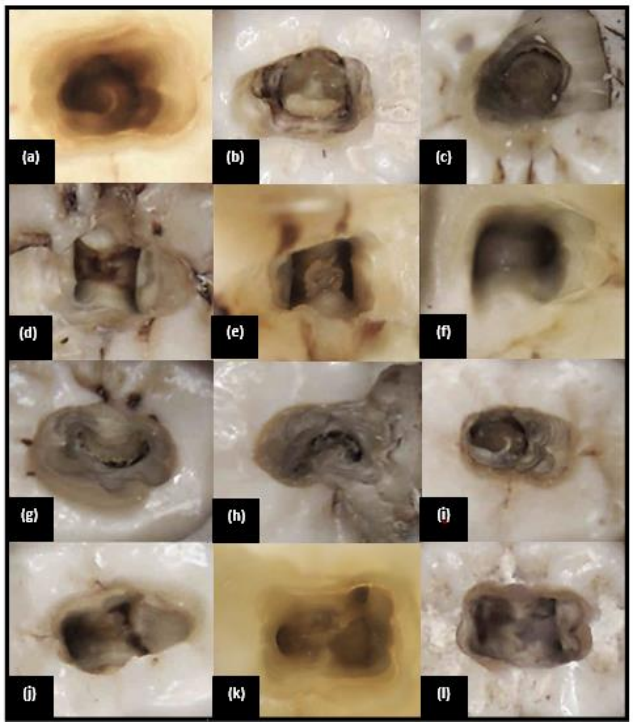

Figure 7. Clinical View of C-Shaped Canal According to Min's Classification; Type I: (a-c), Type II: (d-f), Type III: (g-i), Type IV: (j-l).

The frequency of C-shaped canal in mandibular second molar radiographically (periapical radiograph) is presented in Figure 9.

One-rooted mandibular second molar have highest frequency in Type I followed by Type III and none of one-rooted mandibular second molar have Type II classification. In comparison, Type II classification dominated two-rooted mandibular second molar followed by Type I and Type III as shown in Figure 10.

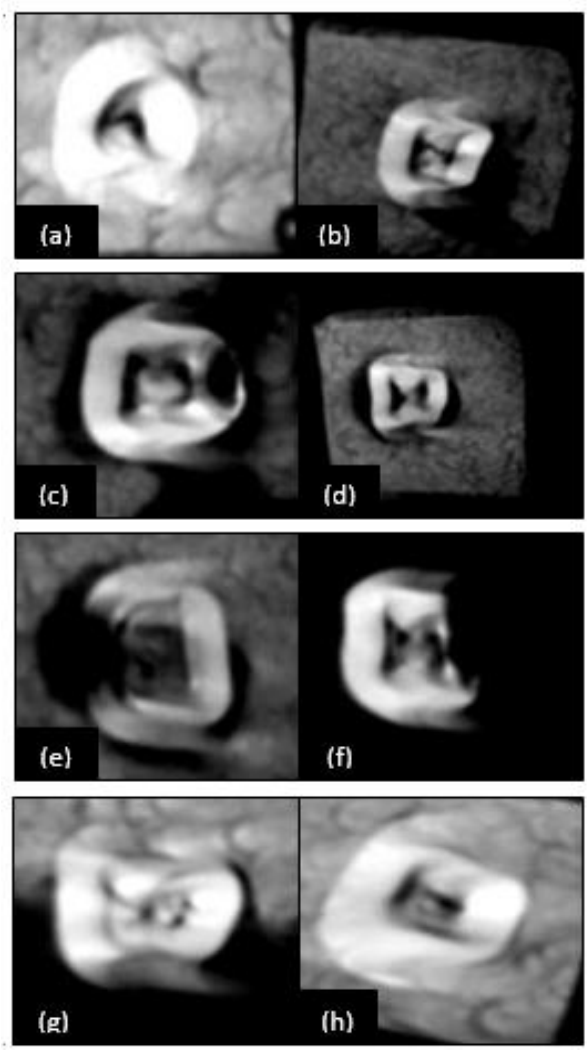

Figure 8. CBCT View of C-Shaped Canal According to Min's Classification; Type I: (a-b) Type II: (c-d): Type III (e-f): Type IV (g-h) Case Report.

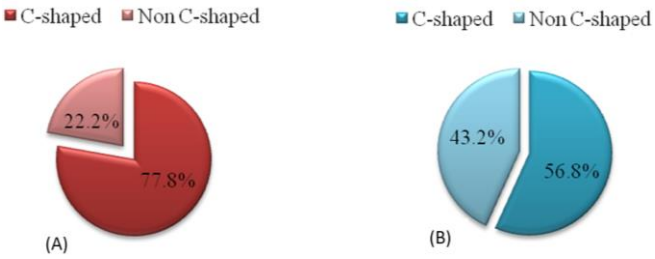

Figure 9. Percentage of C-shaped canal in mandibular second molar by using radiographic classification. (A). Frequency of C-Shaped Canal in One-rooted Mandibular Second Molar Radiographically (periapical); (B). Frequency of C-Shaped Canal in Two-rooted Mandibular Second Molar Radiographically (periapical).

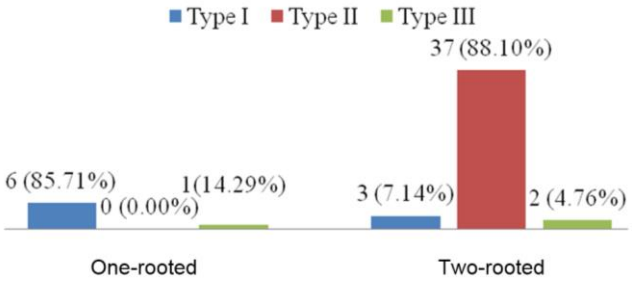

Figure 10. Frequency and Percentage of C-Shaped Canal in Mandibular Second Molar According to their Types By using Radiographic Classification.

Discussion

Frequency of C-shaped Canal in Malay population

C-shaped canal is found to highly occur in Malay population. This is important from clinical point of view because it is the significant group who comes to dental clinic seeking dental treatment. Since determination of C-shaped canal is usually missed during the diagnosis for root canal treatment, an endodontist should take into consideration whenever a Malay patient comes to the clinic for root canal treatment. This result is expected because the previous studies showed that there was also high prevalence of C-shaped canal in Asian population compared to those found in Caucasian population. It is thought that one of the determinant factors of C-shaped canal is the genetic factor, as most population having C-shaped canal is found in Asian population including Malay.

Assessment methods in diagnosing C-shaped canals

C-shaped canal found through radiographic assessment which includes periapical radiograph and CBCT imaging is higher compared to clinical assessment and this is expected, as radiograph provides a better image of the internal structure of the canal compared to clinical examination. Periapical radiograph is the standard investigation method used in root canal therapy since it uses low radiation exposure and less costly. Despite its advantages, this type of conventional 2-dimensional radiograph might be inadequate for diagnostic information, as there is difficulty in

observing the narrow connecting fins.[17] Therefore, CBCT images provide better images compared to periapical radiograph, as CBCT has the ability to provide 3-dimensional images and slices of images. This is useful to diagnose the C-shaped canal, as the occurrence of C-shaped canal can be in any level of the canal system. In addition to that, CBCT can also provide the endodontist with thorough information of the classification of the C-shaped canal; either Type I, Type II, Type III or Type IV. While in clinical assessment, it has its own limitation because there is chance to misdiagnose the presence of C-shaped canal. The assessment is done at the pulpal floor of pulp chamber only, while the C-shaped canal may occur throughout the canal system. Therefore, this will affect the treatment plan and its prognosis.

Classification of C-shaped canal

Type of the C-shape canal found was not significant in this research and this meets the expectation. This is because the age of the tooth is not being considered in this research, while the canal configuration can be influenced by the aging changes in the pulp-dentin complex and might cause changes in the root canal system.[17] Extracted teeth or the teeth demanding root canal treatment might have already undergone many changes, leading to the diverse variation of root canal configuration.

Relation of root number and the presence of C-shaped canal

There is significant correlation between root number and the presence of C-shaped canal. In this research, there is high frequency of C-shaped canal found in one-rooted mandibular second molar. This meets the expectation, as the result is comparable with previous research done in Iranian population. However, it is thought that the canal configuration was not influenced by the root number itself because the internal canal morphology is more significant than the external root morphology.[18] But, the significant relation between root number and the canal configuration can be explained based on the fact that the development of root canal is simultaneously occurred with the development of the root itself. The lateral canal may develop due to premature loss of Hertwig's epithelial root sheath, or when the developing root encounters a blood vessel. Variation in root canal morphologies makes it difficult for cleaning and sealing adequately. This is true in the case of C-shape canal system. The number of canals varies from one to three for continuous C-shape orifice, from one to two canals for oval or flat orifice and there is usually one canal below round orifice.[13]

Conclusions

Malay population has high frequency of C-shaped canal. The variation of root numbers in mandibular second molar has a close relation with the presence of C-shaped canal. C-shaped canal system is well observed by using CBCT images rather than clinical and periapical radiographic assessment alone. Therefore, CBCT images could be used as a useful tool for the diagnosis and determination of C-shaped canal for a better root canal treatment and prognosis. Types of C-shaped canal by Min's classification and Fan's classification are significant in Malay population. The limitation of this research is the shortage of time to classify the samples obtained into different variables, such as age and gender. For further betterment, a more comprehensive study need to be done involving samples with different races, ages, genders and other determinants that could affect the C-shaped canal formation in mandibular second molar.

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Declaration of Interest

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