ORIGINAL RESEARCH

A CBCT Study to Evaluate the Root and Canal Morphology of Permanent Maxillary First Molars in Children

Navin Hadadi Krishnamurthy[1], Athira P[2], Umapathy T[3], Balaji P[4], Sharon Jose[5]

Abstract

Introduction: For the correct diagnosis and endodontic therapy, a complete understanding of root canal morphology is required. One of the causes of endodontic failure is the inability to identify every canal in the root canal system; the second mesiobuccal canal (MB2) in the permanent maxillary first molar is the most commonly missed canal. Studies examining the root canal differences in pediatric Indian populations' permanent maxillary first molars are somewhat uncommon.

Aim: Cone-beam computed tomography (CBCT) will be used to assess the root and canal morphology of permanent maxillary first molars in the pediatric Indian population.

Materials and methods: In the age range of 7–13 years, 25 children's CBCT pictures (50 images) were gathered from the institutional database and private diagnostic facilities. SCANORA® software was used to reconstruct the CBCT pictures, and Statistical Package for the Social Sciences (SPSS) for Windows was used to evaluate and analyze the data.

Results: The roots of each permanent maxillary first molar were distinct. And all of the palatal and distobuccal roots were found to have a single root canal (100%), whereas the mesiobuccal roots were found to have a single root canal in 80% of cases and a double root canal in 20% of cases. The Vertucci type II structure, followed by types IV and V, was the most prevalent in roots with two channels.

Conclusion: Within the constraints of this investigation, we came to the conclusion that the permanent maxillary first molar root canal configuration varied among the patients from the pediatric Indian population.

Keywords: Cone-beam computed tomography, Permanent maxillary first molar, Root canal morphology.

International Journal of Clinical Pediatric Dentistry (2022): 10.5005/jp-journals-10005-2441

Introduction

A successful endodontic procedure requires complete root canal system detection, complete debridement, and obturation of the prepared root canals using an inert filling substance.[1] One of the major factors that contribute to endodontic treatment failure may be the operator's failure to detect the root canal system during the course of the procedure.[1,2] Because of this, doctors need to be well-versed in root canal designs and anatomical differences.[2]

The root canal system is frequently intricate; thus, practitioners need to be conversant with its varied anatomies. The first molars have very intricate root and canal architecture of the maxillary teeth. It is one of the first permanent teeth to sprout into the mouth and it is vulnerable to decay and requires endodontic therapy.[1,2] The maxillary molars' MB2 is one of the most frequently ignored canals during endodontic treatment and has always presented a difficulty for doctors.[3]

There are currently a number of ways to find the MB2 canal. In order to identify the root canal anatomy, common methods include the use of staining agents, radiography techniques, and more recently, CBCT.[1] The limitation of conventional radiography techniques, such as magnification, superimposition, and picture distortion, have led to many problems despite their widespread usage for many years. They produce a two-dimensional (2D) representation.[4] The introduction of CBCT as an effective and promising diagnostic technology has demonstrated that it is the most accurate approach for identifying root canal anatomy.[3,4]

Cone-beam computed tomography, which uses less radiation than conventional computed tomography to produce three-dimensional (3D) maxillofacial images, was created in the 1990s.[5] A particular beam is used by CBCT to create 3D images that reveal intricate anatomical details.[1] The fact that CBCT is noninvasive and enables 3D reconstruction of the root canals gives it a significant edge over other imaging procedures.[1] Using this approach, it is able to see the location of fractured root canal instruments and the amount of periapical diseases, perforations, and obturation. In addition, it works well as a diagnostic instrument for measuring root length and curvature as well as providing a better picture of missing and calcified canals.[4] Traditional periapical films should be replaced with CBCT since it reduces or eliminates the superimposition of the surrounding structures. As a result,

[1–3,5]Department of Pedodontics & Preventive Dentistry, RajaRajeswari Dental College & Hospital, Bengaluru, Karnataka, India

[4]Department of Oral Medicine & Radiology, RajaRajeswari Dental College & Hospital, Bengaluru, Karnataka, India

Corresponding Author: Navin Hadadi Krishnamurthy, Department of Pedodontics & Preventive Dentistry, RajaRajeswari Dental College & Hospital, Bengaluru, Karnataka, India, Phone: +91 9845272314, e-mail: navina30@yahoo.co.in

How to cite this article: Krishnamurthy NH, Athira P, Umapathy T, *et al.* A CBCT Study to Evaluate the Root and Canal Morphology of Permanent Maxillary First Molars in Children. Int J Clin Pediatr Dent 2022;15(5):509–513.

Source of support: Nil

Conflict of interest: None

CBCT is thought to be the best imaging technique for evaluating and determining root canal anatomy.[6]

Therefore, the purpose of this study was to determine the variation in the quantity and shape of the root canals in children's permanent maxillary first molars, as well as the application of CBCT in determining root canal morphology.

Materials and Methods

This retrospective study examined 50 CBCT scans of permanent maxillary first molars taken from the institutional database of RajaRajeswari Dental College & Hospital and other private diagnostic facilities in Bengaluru. The children's ages ranged from 7 to 13 years. The age range was selected because children's permanent first molars have been shown to have considerable caries exposure and may need endodontic therapy. Therefore, it is crucial to understand the structure of the root canals.

The number of roots, the number of root canals per root, and changes in the morphology of the root canals were all determined by analyzing the CBCT pictures. No developmental defects, teeth requiring endodontic treatment with or without periapical lesions, teeth exhibiting multiple surfaces of caries, repaired or shattered teeth, and teeth exhibiting bone loss were excluded from the study.

The formula $N = Z2\ (1-\alpha) \times PQ$, where $Z\ (1-\alpha) = 1.96$, $P = 0.50$, $Q = 1-P$, δ (Margin of Error) = 0.15. $\delta 2$, was used to estimate the sample size. SPSS V22 (IBM, Corp.) for Windows was used to analyze the study's data. The significance threshold was established at $p = 0.05$. Prior to the start of the investigation, the institutional ethics and research committee granted its approval.

Radiographic Techniques

A SCANORA® 3D device was used to capture the CBCT images, which had a field of view of 60 mm and a voxel size of 0.1 mm. The exposure length was 15 seconds, and the slice thickness was 1 mm. All of the scans were performed in accordance with the manufacturer's suggested methodology, and a certified radiologist used the least amount of exposure required to provide acceptable image quality. There was a guarantee of the lowest radiation field and dose.

Evaluation of the Image

Software from OnDemand3D and SCANORA® was used to reconstruct and evaluate the coronal portion of 50 CBCT images [SCANORA® 3D, Soredex, Finland (CBCT machine)]. To achieve optimal visualization, the photos' brightness and contrast were modified using the software's image processing tool. The number of roots, number of canals per root, and variations in root canals were assessed in the photos. The Vertucci classification served as the foundation for the image evaluation criteria.

Vertucci's Classification

- Type I: From the pulp chamber to the apex, a single canal runs (1).
- Type II: Two distinct canals emerge from the pulp chamber and merge into one canal just before the apex (2–1).
- Type III: In the root, a single canal splits into two before merging back into a single canal at the exit (1–2–1).
- Type IV: From the pulp chamber to the apex, there are two unique and separate canals (2).
- Type V: One canal exits the pulp chamber and splits into two different canals with discrete apical foramina just before the apex (1–2).
- Type VI: Two different canals emerge from the pulp chamber, combine in the body of the root, and then split again just before the apex (2–1–2).
- Type VII: A single canal exits the pulp chamber, splits, rejoins, and then redivides into two separate canals just before the apex (1–2–1–2).
- Type VIII: From the pulp chamber to the apex, three independent, distinct canals are present (3) (Fig. 1).

Statistical Analysis

Microsoft Windows SPSS version 22.0 (IBM, Corp.) was used to analyze the study's data. In this paper, categorical variables were used to show the experimental results. With a significance level of $p < 0.05$, the Chi-square test was used to determine and compare the frequency of the number of root and canal procedures.

Results

Fifty permanent maxillary first molars were analyzed using CBCT images. The study comprised people aged 7–13 years; of them, 19 were in the 7–10 years age range, and six were in the 11–13 years age range. Additionally, 17 were men and eight were women (Table 1).

The roots of each permanent maxillary first molar were distinct. And all of the palatal and distobuccal roots were found to have one root canal (100%), but only 80% of mesiobuccal roots were found to have a single root canal and 20% of them to have two (Fig. 2 and Table 2).

The canal configurations of the maxillary first molar roots are listed in Table 3 based on Vertucci's criteria. The palatal and distobuccal roots all (100%) had a configuration of Vertucci type I. Mesiobuccal roots' morphology continues to be rather complicated;

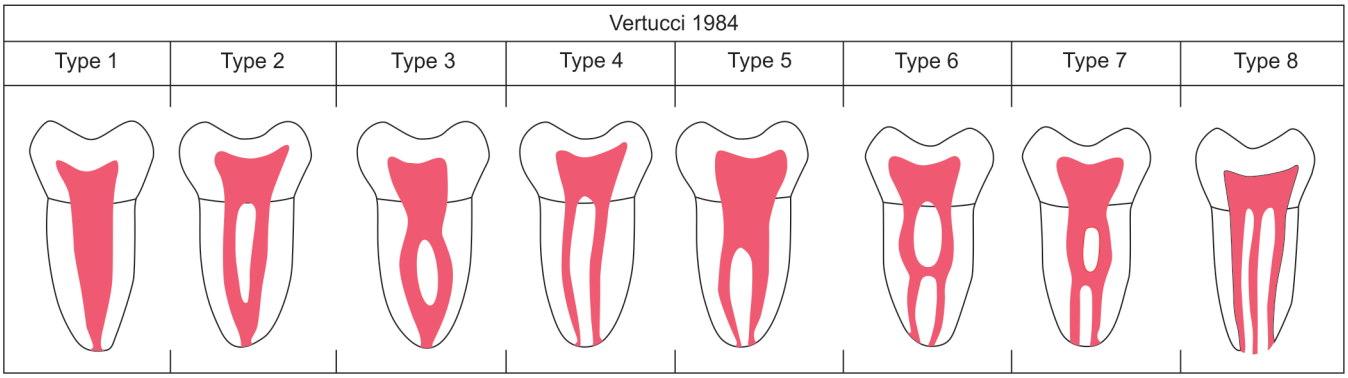

Fig. 1: Vertucci's classification: image for evaluation

Vertucci's type I configuration was seen in 80% of the instances, type II in 16% of the cases, and type IV and type V cases in 2% of the cases (Figs 3 and 4).

Regarding gender, there were no appreciable differences in the root and canal architecture of permanent maxillary first molar teeth.

The distribution of permanent maxillary first molars by gender showed that both males and females had single canals in the palatal and distobuccal canals, while only 70.6% of males and 87.5% of females had single canals in the mesiobuccal root, and 29% of males and 12.5% of females had two canals (Table 4).

Discussion

To perform a successful root canal procedure, one must have a thorough understanding of the root canal anatomy. One of the key reasons endodontic therapy fails is the inability to identify all of the root canals.[5] Vertucci et al. identified eight different canal layouts after studying the intricate root canal architecture of every tooth.[1,2] Since 1925, it has been documented that the permanent maxillary first molar's mesiobuccal root has two distinct canals.[1]

Table 1: Age and gender distribution among study subjects

Variable	*Category*	*N*	*%*
Age	7–10 years	19	76%
	11–13 years	6	24%
Sex	Males	17	68%
	Females	8	32%

Table 2: Distribution of the number of root canals in maxillary first molars in study subjects

Variable	*Category*	*N*	*%*
Palatal	1 canal	50	100%
Distobuccal	1 canal	50	100%
Mesiobuccal	1 canal	40	80%
	2 canals	10	20%

Table 3: Vertucci's criteria to classify the root canal anatomy of the maxillary first molar

Variables	*Category*	*N*	*%*
Palatal	Type I	50	100%
	Type II	0	0%
Distobuccal	Type I	50	100%
	Type II	0	0%
Mesiobuccal	Type I	40	80%
	Type II	8	16%
	Type IV	1	2%
	Type V	1	2%

In several investigations, the prevalence of MB2 canal was estimated to range from 11.53 to 93.7%. The success of the root canal procedure in teeth depends on the detection of the MB2 and full debridement and filling of the root canal system.[5,3]

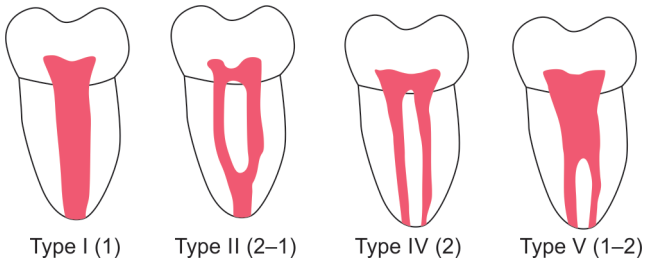

Fig. 2: Vertucci's types noted in this study

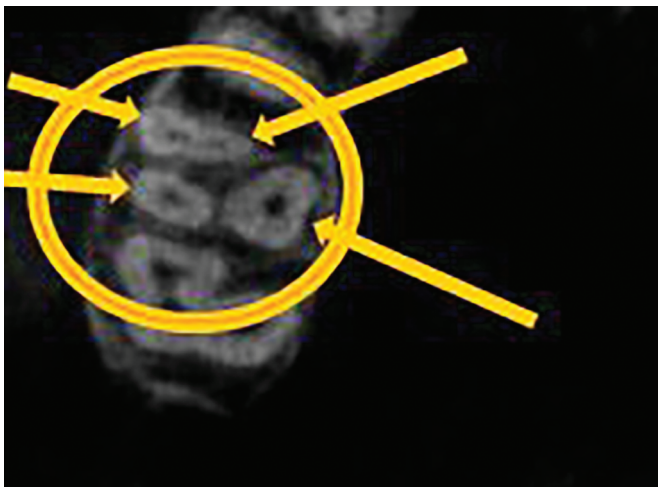

Fig. 3: Maxillary first molar with four canals

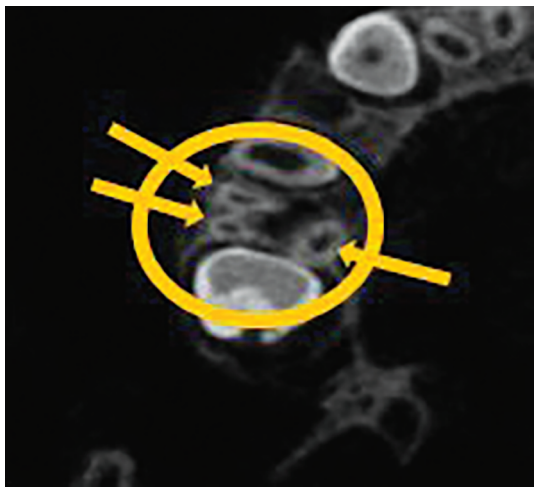

Fig. 4: Maxillary first molar with three canals

Table 4: Comparison of root canals in permanent maxillary first molar based on gender using Chi-square test

		Males		*Females*			
Roots	*Root canals*	*N*	*%*	*N*	*%*	*Chi-square value*	*p-value*
Palatal	1 canal	34	100%	16	100%		
Distobuccal	1 canal	34	100%	16	100%		
Mesiobuccal	1 canal	24	70.6%	14	87.5%	0.853	0.36
	2 canals	10	29.4%	2	12.5%		

Numerous methods have been employed to identify the root canal system, such as conventional and modified tooth staining and cleaning, conventional and digital radiography, contrast media radiography, and computed tomography.[6] The main imaging method in endodontics has always been conventional radiography, but CBCT imaging seems to have better validity and reliability.[7,8] Conventional radiography is 2D; thus, it does not always show how many canals are actually present in a tooth.[8] According to studies, CBCT scanning is a trustworthy technique when compared to the gold standard (sectioning).[2] In the late 1990s, Arai et al. in Japan and Mozzo et al. in Italy independently developed CBCT at the same time.[9] Compared to traditional CT scanning, CBCT has a significantly lower radiation dose and a resolution that is nearly eight times higher.[5]

In the current study, 50 permanent maxillary first molars from 25 subjects aged 7–13 years were examined using CBCT to determine the number of roots and the morphology of the canals. The root canal morphology of permanent first molars has been the subject of numerous research, although very few of these have been conducted in children this age. By the time they emerge, they are 6–7 years old, the maxillary first molars expose the oral cavity to decay and necessitate endodontic therapy. Therefore, in order to provide a successful course of treatment, a pediatric dentist must possess a complete understanding of root canal morphology. In this investigation, the permanent maxillary first molar showed three distinct roots. Rarely were four-rooted and fused-root maxillary first molars discovered. Additionally, it was discovered that all palatal and distobuccal roots only had one root canal, whereas the mesiobuccal root had many canals. Two canals were present in 20% of cases and a single canal was present in 80% of cases in the mesiobuccal root (type I). Only type I was discovered for roots with a single canal, while Vertucci's type II (16%), type IV (2%), and type V (2%) were the next most often encountered types. The root and canal architecture of permanent maxillary first molar teeth showed no discernible gender difference. There were no instances of Vertucci's classification categories III, VI, VII, or VIII.

Around 96.8% of the 220 permanent maxillary first molars examined in an *in vitro* study by Neelakantan et al. had three distinct roots. The mesiobuccal root showed the greatest variety in canal morphology, with type I (58%) being the most prevalent. This finding was consistent with our study, where type I was likewise the most prevalent canal morphology. The distobuccal and palatal roots primarily displayed type I canal morphology, with type IV canal architecture following.[10] Additional canals were found in 86.6% of mesiobuccal roots, with Vertucci's type VI configuration being the most common, followed by type II and type I, according to a research by Naseri et al. on 149 CBCT images. According to the findings of our study, there was no statistically significant variation in the canal layout based on gender or age.[2]

In contrast to our study, which found that every tooth had three distinct roots, Alrahabi et al.'s *in vitro* analysis of 100 permanent maxillary first molars revealed that 94% of the teeth had three separated roots and 6% had four. One root and Vertucci type I configuration were seen in the palatal and distobuccal roots, respectively. Contrary to the findings of our study, where type I canal morphology was the most frequently observed canal morphology, type II was most frequently observed in the mesiobuccal canal (47%), followed by type I (29.4).[1] The prevalence of MB2 canals was observed in 70.2% of cases in a different study by Khademi et al. on 295 CBCT images, and the most prevalent type of Vertucci's classification was type II (53.1%), followed by type I in contrast to our study where type I was most prevalent.[3]

Prior to treatment, knowledge of the tooth's anatomy and canal shape may have aided the doctor in performing root canal therapy.[11] The canal systems of the maxillary molar teeth's mesiobuccal roots varied more in morphology than those of the distobuccal or palatal roots.[12,13] In the current investigation, CBCT was found to be trustworthy and to have exceptional accuracy in identifying the root canal shape, with the potential to enhance the success of endodontic therapy.[3,14] Before beginning treatment, knowledge about the tooth's anatomy and canal shape may be useful to the treating physician.[11] The morphology of the canal system of the maxillary molar teeth's mesiobuccal roots varied more than that of the distobuccal or palatal roots.[12,13] In the current investigation, CBCT was found to be trustworthy and to be extremely accurate in identifying the root canal shape, with the potential to enhance the success of endodontic treatment.[3,14–19] Unquestionably, justification, optimization, and protection—the three fundamental principles of radiation protection—should be adhered to. Therefore, special care should be taken to maintain an adequate diagnostic output while minimizing the radiation burden.[9] It is clear that there is no questioning CBCT's value. But the availability, radiation, and cost must be considered when prescribing CBCT imaging for the patient.[7]

Limitation

The small sample size of this study was one of its limitations. Therefore, more research must be done to pinpoint the differences in root canal morphology that aid pediatric dentists in honing their diagnostic and endodontic treatment abilities.

Conclusion

The changes in the root and canal morphology in children's permanent maxillary first molars were demonstrated in this *in vitro* investigation. Three distinct roots were seen on the permanent maxillary first molars. In the mesiobuccal canal, which had one canal in each of the palatal and distobuccal roots, the changes in canal morphology were the greatest. Compared to conventional radiography, CBCT provides precise and reliable information on the variations in root canal morphology in a 3D image. As a result, clinicians may be able to create effective management plans to address problems that arose during endodontic therapy for permanent maxillary first molars and prevent further complications. This may help clinicians gain a thorough understanding of variations in the root canal morphology of permanent maxillary first molars.

Importance of the Present Study

- In this study, the mesiobuccal canal of the permanent maxillary first molar showed the most differences in canal structure.
- One of the reasons why root canal therapy on these teeth failed is because the MB2 of the first permanent maxillary molar was not detected.
- Research on the root canal morphology of a child's permanent teeth is rather uncommon.
- For assessing root canal morphology, CBCT can be regarded as the best imaging method.

Acknowledgments

The authors would like to acknowledge the Department of Oral Medicine and Radiology for their support in the successful completion of the present study.

Orcid

Athira P https://orcid.org/0000-0003-2248-3616

References

1. Alrahabi M, Zafar MS. Evaluation of root canal morphology of maxillary molars using cone-beam computed tomography. Pak J Med Sci 2015;31(2):426–430. DOI: 10.12669/pjms.312.6753
2. Naseri M, Safi Y, Baghban AA, et al. Survey of anatomy and root canal morphology of maxillary first molars regarding age and gender in an Iranian population using cone-beam computed tomography. Iran Endod J 2016;11(4):298–303. DOI: 10.22037/iej.2016.8
3. Khademi A, Zamani Naser A, Bahreinian Z, et al. Root morphology and canal configuration of first and second maxillary molars in a selected Iranian population: a cone-beam computed tomography evaluation. Iran Endod J 2017;12(3):288–292. DOI: 10.22037/iej.v12i3.13708
4. Mehta V, Ahmad N. Cone-beamed computed tomography in pediatric dentistry: concepts revisited. J Oral Bio Craniofac Res 2020;10(2):210–211. DOI: 10.1016/j.jobcr.2020.03.013
5. Corbella S, Del Fabbro M, Tsesis I, et al. Computerized tomography technique for the investigation of the maxillary first molar mesiobuccal root. Int J Dent 2013;2013:614898. DOI: 10.1155/2013/614898
6. Rouhani A, Bagherpour A, Akbari M, et al. Cone-beam computed tomography evaluation of maxillary first and second molars in Iranian population: a morphological study. Iran Endod J 2014;9(3):190–194.
7. Kiarudi AH, Eghbal MJ, Safi Y, et al. The applications of cone-beam computed tomography in endodontics: a review of literature. Iran Endod J 2015;10(1):16–25. DOI: 10.22037/iej.v10i1.6383
8. Venskutonis T, Plotino G, Juodzbalys G, et al. The importance of cone-beam computed tomography in the management of endodontic problems: a review of the literature. J Endod 2014;40(12):1895–1901. DOI: 10.1016/j.joen.2014.05.009
9. Van Acker JW, Martens LC, Aps JK. Cone-beam computed tomography in pediatric dentistry, a retrospective observational study. Clin Oral Invest 2016;20(5):1003–1010. DOI: 10.1007/s00784-015-1592-3
10. Neelakantan P, Subbarao C, Ahuja R, et al. Cone-beam computed tomography study of root and canal morphology of maxillary first and second molars in an Indian population. J Endod 2010;36(10):1622–1627. DOI: 10.1016/j.joen.2010.07.006
11. Guo J, Vahidnia A, Sedghizadeh P, et al. Evaluation of root and canal morphology of maxillary permanent first molars in a North American population by cone-beam computed tomography. J Endod 2014;40(5):635–639. DOI: 10.1016/j.joen.2014.02.002
12. Silva EJ, Nejaim Y, Silva AI, et al. Evaluation of root canal configuration of maxillary molars in a Brazilian population using cone-beam computed tomographic imaging: an in vivo study. J Endod 2014;40(2):173–176. DOI: 10.1016/j.joen.2013.10.002
13. Zhang R, Yang H, Yu X, et al. Use of CBCT to identify the morphology of maxillary permanent molar teeth in a Chinese subpopulation. Int Endod J 2011;44(2):162–169. DOI: 10.1111/j.1365-2591.2010.01826.x
14. Kim Y, Lee SJ, Woo J. Morphology of maxillary first and second molars analyzed by cone-beam computed tomography in a Korean population: variations in the number of roots and canals and the incidence of fusion. J Endod 2012;38(8):1063–1068. DOI: 10.1016/j.joen.2012.04.025
15. Lee JH, Kim KD, Lee JK, et al. Mesiobuccal root canal anatomy of Korean maxillary first and second molars by cone-beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111(6):785–791. DOI: 10.1016/j.tripleo.2010.11.026
16. Tanvi M, Vimala N, Lalitagauri M. Evaluation of the root morphology of maxillary permanent first and second molars in an Indian subpopulation using cone-beam computed tomography. J Dent Med Sci 2016;15(10):51–56. DOI: 10.9790/0853-1510035156
17. Altunsoy M, Ok E, Nur BG, et al. Root canal morphology analysis of maxillary permanent first and second molars in a southeastern Turkish population using cone-beam computed tomography. J Dent Sci 2015;10(4):401–407. DOI: 10.1016/j.jds.2014.06.005
18. Peeters HH, Suardita K, Setijanto D. Prevalence of a second canal in the mesiobuccal root of permanent maxillary first molars from an Indonesian population. J Oral Sci 2011;53(4):489–494. DOI: 10.2334/josnusd.53.489
19. Blattner TC, George N, Lee CC, et al. Efficacy of cone-beam computed tomography as a modality to accurately identify the presence of second mesiobuccal canals in maxillary first and second molars: a pilot study. J Endod 2010;36(5):867–870. DOI: 10.1016/j.joen.2009.12.023