Objectives: The aim of this study is to determine the prevalence of the first lower molars that have two roots or three roots and the number of the root canals of the mandibular first molars in the Vietnamese subpopulation using cone-beam computed tomography (CBCT).

Materials and Methods: The study was conducted on 166 patients who had CBCT as indicated by dentists in Nguyen Trai Dental CT Center, Ho Chi Minh City using the Picasso Trio (Ewoo Vatech, Korea). The number of root canals of the first lower molars was examined by moving cross-sectional slices from the pulpal floor to the apex. The orifices, middle thirds, and apical thirds of the canals of the first lower molar were observed, and the root canals of each root of the mandibular first molars were observed in three planes.

Results: The prevalence of two, three, and four root canals of the mandibular first molars was 4.5%, 66.8%, and 28.9%, respectively. For the distal roots of these molars, a classification of Vertucci type I was the most common at a rate of 80.8%–97.6%. Whenever these teeth had three roots, a Vertucci type I was the classification of 100% of distolingual roots.

Conclusion: Majority of the mandibular first molars has two roots and three canals. CBCT is appropriate equipment useful in investigating the complex root canal morphology of human teeth.

Keywords: Cone-beam computed tomography, distolingual root, mandibular first molar, Vertucci
number of roots and canals can lead to endodontic failures. In addition, variations in the root canal systems and the characteristic features in different races should be recognized before or during endodontic treatment.\cite{3}

To evaluate the root and root canal morphology of the mandibular first molars, there are numerous techniques that have been developed such as root canal staining, tooth clearing, modified root canal staining technique, radiographic technique or micro-computed tomographic (\(\mu\)CT) technique.\cite{4,8} \(\mu\)CT imaging is a new method for investigating the anatomy of a tooth. This method can provide valuable information on complex root canal systems without destroying the sample. The \(\mu\)CT technique also allows data about the root canal system to be recorded both before and after any intervention with high resolution. However, this method can only be used on extracted teeth, it takes considerable time to obtain data and works on relatively small sample size.\cite{9} Due to the limitations of the \(\mu\)CT technique, other computed tomographic techniques such as medical computed tomography (CT) or cone-beam CT (CBCT) have been used in dental anatomic investigations.

CBCT uses a cone-shaped X-ray beam instead of a fan-shaped beam; this has been designed specifically for use in dentistry. The radiation doses needed for CBCT are significantly lower than those for conventional CT because CT uses only a single sweep of scanning to obtain data for constructing the tomographic image.\cite{4} CBCT produces three-dimensional (3D) images faster than conventional radiography does as the latter must compress the 3D data into two-dimension data. CBCT does not need chemicals, a dark-room and film-like in conventional radiographs. The digital technology of CBCT allows for easier to acquire tomographic images and more convenient manipulation of the image.\cite{9} A cone-shaped beam of X-rays, after passing through the target area, is detected by an amorphous silicon panel. Subsequently, the data are gathered and processed using a personal computer. CBCT can be used for in vivo studies, in which the researchers can link the anatomic configuration with other factors such as race, sex, and age.

The mandibular first molars have complex root and canal anatomy normally with two root and three root canals.\cite{10} There have been many studies investigating the root and root canal anatomy of mandibular first molars in many different races. In Mongoloid races, the prevalence of three-rooted mandibular first molars (one more root in lingual-distal) was rather high, about 20%. However, up to now, no detailed data of the roots and root canal systems of the mandibular first molar in Vietnamese individuals who have had CBCT used for evaluation.

The aim of this study was to investigate the number of roots of the mandibular first molars with two or three roots in the Vietnamese population using CBCT.

**Materials and Methods**

This study was approved by the Research Ethics Committee of the University of Medicine and Pharmacy at Ho Chi Minh City, Vietnam. The approval number of the present study was 2245/QĐ-DHYD-SDH. The study was conducted at Nguyen Trai Dental CT Centre, district 5, Ho Chi Minh City, Vietnam, in the period from October 2010 to June 2016. This was a retrospective analysis of CBCT images obtained from the Vietnamese subpopulation. Informed consent was not acquired for this study based on the university decision. Individuals with both right and left mandibular first molars, full information of age, sex, and date of capture were included in the study. Selected criteria for the mandibular first molars were as follows: maturated, normal position, absence of resorption, absence of periodontitis, absence of apical periodontitis, and absence of endodontic treatment. CBCT images which had appropriate brightness and contrast were included in the study. Exclusion criteria were blurred or distorted CBCT images, previous endodontically treated teeth, posts or crowns, periapical lesions, internal or external root resorptions. The CBCT images of the patients were randomly chosen using the random number table for the patient record number. CBCT images of patients were acquired for reasons not related to the present study such as diagnostic requirements or implant therapy. Sample size was calculated based on the prevalence of three-rooted mandibular first molars of the Thai people in the study by Gulabivala et al., with the formulation:

\[
n = (Z^2_{1-\alpha/2}p (1-p)/d^2) (\alpha = 0.02, Z_{1-\alpha/2} = 2.32, d = 0.06)
\]

at 166 individuals.\cite{11} The CBCT images were captured using a Picasso Trio (Ewoo Vatech, Korea) with a field of the volume of 8 cm × 5 cm, slice thickness of 0.1 mm, captured time of 15 s, and reconstruction time of 29 s.

All patients’ information was recorded into the data collection form. Whenever the data analysis was performed, patient information on the computer screen and the form was covered. CBCT images that were included in the study were observed on a personal computer with 14-inch flat monitor, resolution of 1366 × 768 pixels using EzImplant CD Viewer software from the manufacturer (Ewoo Vatech, Korea). CBCT images were reset to the original situation, by performing the reset all action, at a ×1.5. If needed, the brightness, contrast, and magnification were adjusted for observation and analysis. The positions of the left and right mandibular first molars were recorded. The root
numbers and root canal configuration were analyzed in three planes: axial, coronal, and sagittal ones using the EzImplant CD Viewer software. In each plane, teeth were analyzed to find out the number of roots, number of root canals, and the canal configuration by using the cursor to move the slices downward from pulpal floor to the apex, from the canal orifices to middle and apical thirds. Root canal systems of each root were classified according to the criteria by Vertucci.[12]

Two independent endodontists evaluated the root canal system morphology using the same software from the manufacturer. To evaluate the inter-examiner reliability, 33 CBCT images of patients were randomly chosen to have been reassessed the root canal configuration by the observers. After 2 weeks from the first evaluation of two observers, these same CBCT images were reassessed to measure the intra-examiner reliability.

**Data analysis**

The Kappa coefficient and intraclass correlation coefficient (ICC) were calculated to detect the inter- and intra-examiner reliabilities based on the categories of the data.

Data were statistically analyzed with the appropriate tests using SPSS version 18.0 (Statistical Package for the Social Sciences, IBM, Armonk, New York, USA) and the statistical significance was set at a 95% confidence level.

**Results**

For inter-examiner and intra-examiner reliabilities, the Kappa coefficients were larger than 0.85 (excellent) for canal configuration and the ICCs were larger than 0.8 (good) for number of roots and canals.

**Sample characteristics**

The sample includes CBCT images of 166 individuals, of which 56.6% were male and 43.4% were female [Table 1]. There were 83 individuals in the age group of 30–50 years old; this was twice the number of individuals in the age group of <30 years old and >50 years old.

Each participant had two mandibular first molars studied, 36 and 46, a total of 332 teeth were studied.

**Distribution of the number of roots and the number of root canals**

Of these 332 mandibular first molars, there were 291 molars with two roots and 41 molars with three roots. The prevalence of mandibular first molars with two, three, and four root canals was 4.5%, 66.6%, and 28.9%, respectively. There were no significant differences in the frequency of the number of root canals between position ($P = 0.97$) and sex ($P = 0.56$). Almost all three-rooted mandibular first molars had four root canals, there were only two teeth with three root canals [Table 2].

**Number of root canals in each root**

Of the 291 mesial roots of two-rooted mandibular first molars, there were 275 (94.5%) roots with two root canals and 16 (5.5%) remaining roots had one root canal. Of the 291 distal roots, there were 235 (80.8%) roots with one root canal and the 56 (19.2%) remaining roots had two root canals [Table 3].

Of the 41 mesial roots of the three-rooted mandibular first molars, there were 38 (92.7%) roots with two root canals and the 3 (7.3%) remaining roots had one canal. Of the 41 distobuccal roots of the three-rooted mandibular first molars, there were 40 (97.6%) roots with one root canal and only one (2.4%) root had two root canals. All distolingual roots had one root canal [Table 4].

**Root canal configuration of the mandibular first molars**

Classification by Vertucci was used for analyzing the canal configuration of the mandibular first molars.[12] Of the 291 two-rooted mandibular first molars, in the mesial roots, a Type IV canal was the most frequency pattern (60.8%), followed by Type II (30.6%), Type I (5.5%), Type III (2.1%), and Type VI (1%). Whereas, in the distal roots, a Type I canal was the most frequent with 80.8%, Type IV, III, II, V, and VI was 6.5%, 5.5%, 5.2%, 1.7%, and 0.3%, respectively [Table 5].

Of the 41 three-rooted mandibular first molars, in the mesial root, a Type IV canal was the most frequency pattern (68.3%), followed by Type II (24.4%) and Type I (7.3%). In the distobuccal root, Type I canal was the most frequency with 97.6%, followed by Type III with 2.4%. The most frequent pattern in the distolingual root was a Type I canal [Table 5], it was 100%.

The configuration of the root canal system in two- and three-rooted mandibular first molars by location and sex is presented in Tables 6 and 7. There were no statistically significant differences in root canal configuration between sexes ($P > 0.05$) for both kinds of molars.
Table 2: Number and frequency of the number of roots and number of root canals in mandibular first molars by position and sex

|                              | Left            | Subtotal, n (%) | Right           | Subtotal, n (%) | Total, n (%) |
|------------------------------|-----------------|-----------------|-----------------|-----------------|--------------|
| Mandibular first molars      | Male (n) Female (n) | Male (n) Female (n) | Male (n) Female (n) | Male (n) Female (n) |Male (n) Female (n)|
| Single root                  | - -             | - -             | - -             | - -             | - -          |
| Two separate roots           | 84 66           | 150 (90.4)      | 78 63           | 141 (84.9)      | 291 (87.7)   |
| Three separate roots         | 10 6            | 16 (9.6)        | 16 9            | 25 (15.1)       | 41 (12.3)    |
| Number of root canals        |                 |                 |                 |                 |              |
| 2 canals                     | 1 8             | 9 (5.4)         | 0 6             | 6 (3.6)         | 15 (4.5)     |
| 3 canals                     | 69 44           | 113 (68.1)      | 66 42           | 108 (65.1)      | 221 (66.6)*  |
| 4 canals                     | 24 20           | 44 (26.5)       | 28 24           | 52 (31.3)       | 96 (28.9)    |
| Mandibular first molars with four root canals |                 |                 |                 |                 |              |
| Two separate roots           | 15 14           | 29 (65.9)       | 12 16           | 28 (53.8)       | 57 (59.4)    |
| Three separate roots         | 9 6             | 15 (34.1)       | 16 8            | 24 (46.2)       | 39 (40.6)    |

*Mandibular first molars with three canals were two-third of the sample

Table 3: Number and frequency of the number of root canals in each root of two-rooted mandibular first molars

|                  | 1 canal | 2 canals | Total |
|------------------|---------|----------|-------|
| Mesial root, n (%) | 16 (5.5) | 275 (94.5) | 291 (100) |
| Distal root, n (%)   | 235 (80.8) | 56 (19.2) | 291 (100) |

There was no third canal in the mesial root of two-rooted mandibular first molars

Table 4: Number and frequency of the number of root canals in each root of three-rooted mandibular first molars

|                  | 1 canal | 2 canals | Total |
|------------------|---------|----------|-------|
| Mesial root, n (%) | 3 (7.3)  | 38 (92.7) | 41 (100) |
| Distobuccal root, n (%) | 40 (97.6) | 1 (2.4) | 41 (100) |
| Distolingual root, n (%) | 41 (100.0) | 0 (0.0) | 41 (100) |

There was no third canal in the mesial root of three-rooted mandibular first molars

**DISCUSSION**

In this study, the CBCT images of 166 patients of the Vietnamese subpopulation were analyzed for evaluation of the root and root canal morphology. A half of the sample was in the group of age ranging from 30 to 50. A total of 332 teeth, left and right mandibular first molars were analyzed. The first mandibular molars with three canals were two-third of the sample, and there was no third canal in the mesial root of both two-rooted and three-rooted mandibular first molars. This supports the hypothesis that the prevalence of the third canal in the mesial root of Vietnamese mandibular first molars was very low. Type IV canal configuration was the majority in the mesial root of these molars, and Type I canal configuration was the majority in the distal root or the two-rooted molars and in the distolingual root of the three-rooted molars. This agrees with the hypothesis that the Type I canal configuration was the majority in the distolingual root of the three-rooted molars for many different populations.

This study was conducted on a Vietnamese sample with reasonable sample size. This study was also performed using the high-resolution CBCT images with the small voxel size of 0.1 mm that satisfied the minimum requirement for endodontic research with CBCT, especially in the anatomy dental investigation. However, the study was retrospective one and done at only one CBCT center, therefore, the study could not reflect panoramic picture of the root canal morphology of the Vietnamese population.

There was no C-shaped canal system in the mandibular first molars in this study. This result was not the same as the result of the previous study in the Saudi population.[13]

In the present study, the prevalence of distolingual roots was 12.3%. This result was high and in agreement with the result of the previous study in Malaysia (12%) and Thailand (12.7%);[11,14] however, this was still lower than that in Korea (23.26%) and China (25%).[15,16] The fact that Asian people have more mandibular first molars with three roots than other racial groups was confirmed by this study. However, the prevalence of distolingual roots was 0% in the previous study in the Tanzanian population.[17]

Of the 166 individuals, there were 27 individuals who had at least one three-rooted mandibular first molar. The prevalence of individuals who had three-rooted molars on both sides was 8.5% (14/166), whereas individuals who had three-rooted molars on one side, it was 7.8% (13/166). In this study, there was no significant different between the number of three-rooted molars and sex. This agrees with the result of the previous study.[18]

The results of this study showed that the three-rooted mandibular first molars existed more in the right side than they did in the left side. This is similar to the result
Some other authors concluded that these molars existed in the left side more than they did in the right side. These different results may be due to sample selections and research methods depending on each author.

The prevalence of mandibular first molars with two root canals, three root canals, and four root canals were 4.5%, 66.8%, and 28.9%, respectively. These findings agree with those of the Taiwanese population in one study, the rates were 3.4%, 56.1%, and 40.5%, respectively. In another study, the rates were 6%, 62.5%, and 31.5%, respectively.

| Type | Sex | Two-rooted mandibular first molars | Three-rooted mandibular first molars |
|------|-----|-----------------------------------|-------------------------------------|
|      |     | Mesial root (%) | Distal root (%) | Mesial root (%) | Distobuccal root (%) | Distolingual root (%) |
| I    | Male | 2 | 136 | 2 | 25 | 26 |
|      | Female | 14 | 99 | 1 | 15 | 15 |
|      | Subtotal | 16 (5.5) | 235 (80.8) | 3 (7.3) | 40 (97.6) | 41 (100) |
| II   | Male | 55 | 4 | 6 | 0 | 0 |
|      | Female | 34 | 11 | 4 | 0 | 0 |
|      | Subtotal | 89 (30.6) | 15 (5.2) | 10 (24.4) | 0 (0) | 0 (0) |
| III  | Male | 4 | 8 | 0 | 1 | 0 |
|      | Female | 2 | 8 | 0 | 0 | 0 |
|      | Subtotal | 6 (2.1) | 16 (5.5) | 0 (0) | 1 (2.4) | 0 (0) |
| IV   | Male | 101 | 9 | 18 | 0 | 0 |
|      | Female | 76 | 10 | 10 | 0 | 0 |
|      | Subtotal | 177 (60.8)* | 19 (6.5) | 28 (68.3)* | 0 (0) | 0 (0) |
| V    | Male | 0 | 5 | 0 | 0 | 0 |
|      | Female | 0 | 0 | 0 | 0 | 0 |
|      | Subtotal | 0 (0) | 5 (1.7) | 0 (0) | 0 (0) | 0 (0) |
| VI   | Male | 0 | 0 | 0 | 0 | 0 |
|      | Female | 3 | 1 | 0 | 0 | 0 |
|      | Subtotal | 3 (1) | 1 (0.3) | 0 (0) | 0 (0) | 0 (0) |
| VII  | 0 | 0 | 0 | 0 | 0 |
| VIII | 0 | 0 | 0 | 0 | 0 |
| Others | 0 | 0 | 0 | 0 | 0 |
| Subtotal | Male | 162 | 162 | 26 | 26 | 26 |
|      | Female | 129 | 129 | 15 | 15 | 15 |
|      | Subtotal | 291 | 291 | 41 | 41 | 41 |

*Type I canal was the majority in the mesial root of mandibular first molars

| Type | Mesial root | Distal root |
|------|-------------|-------------|
|      | Male (n) | Female (n) | Subtotal, n (%) | Male (n) | Female (n) | Subtotal, n (%) |
| I    | 2 | 14 | 16 (5.5) | 136 | 99 | 235 (80.8)* |
| II   | 55 | 34 | 89 (30.6) | 4 | 11 | 15 (5.2) |
| III  | 4 | 2 | 6 (2.1) | 8 | 8 | 16 (5.5) |
| IV   | 101 | 76 | 177 (60.8) | 9 | 10 | 19 (6.5) |
| V    | 0 | 0 | 0 (0.0) | 5 | 0 | 5 (1.7) |
| VI   | 0 | 3 | 3 (1.0) | 0 | 1 | 1 (0.3) |
| VII  | 0 | 0 | 0 (0.0) | 0 | 0 | 0 (0.0) |
| VIII | 0 | 0 | 0 (0.0) | 0 | 0 | 0 (0.0) |
| Others | 0 | 0 | 0 (0.0) | 0 | 0 | 0 (0.0) |
| Subtotal | 162 | 129 | 291 | 162 | 129 | 291 |

*Type I canal was the majority of the distal root of the two-rooted mandibular first molars

of the previous study. Some other authors concluded that these molars existed in the left side more than they did in the right side. These different results may be due to sample selections and research methods depending on each author.

Of the two-rooted mandibular first molars, the prevalence of molars with two root canals, three root canals, and four root canals was 4.5%, 66%, and 17.2%, respectively. Of the three-rooted mandibular first molars, the prevalence of molars with three root canals and four root canals was 0.6% and 11.7%, respectively. Almost all three-rooted mandibular first molars had four root canals, only the two remaining molars had three root canals. These findings agree with the results of the previous study in the Taiwanese population. In the mandibular first molars with four root canals, the prevalence of three-rooted molars was more than a half (62.5%–68.3%).
There was not any third canal in the mesial roots of the mandibular first molars in this study. This result was not similar to that of the previous studies in other Asian nations.\textsuperscript{[22-24]}

The result of this study showed that Type I, II, and IV canals were the main anatomic variations; others were rare or absence. The prevalence of anatomic variations of mandibular first molars may change depending on the populations and methods. There are many factors that can affect the distribution of root canal anatomic variations. These factors included different methods, techniques (\textit{in vitro, in vivo,} CBCT, and clearing techniques) or a racial factor.\textsuperscript{[25]} Of the two- or three-rooted mandibular first molars in this study, Type IV canals showed the most variation in the mesial roots.

The most common root canal configuration in the mesial root of mandibular first molars was the Type IV canal with a prevalence of 52.3%, followed by the Type II canal with a prevalence of 35%.\textsuperscript{[10]} In the distal roots of these molars, the prevalence of Type I, II, and IV canals were 62.7%, 14.5%, and 12.4%, respectively.\textsuperscript{[10]} These findings are not like those of the present study.

In the two-rooted mandibular first molars, the prevalence of Type IV canals in the mesial root was 43% in the US, 58.3% in Thailand, and 76.8% in Turkey.\textsuperscript{[4,11,25]} In the three-rooted mandibular first molars, the prevalence of Type IV canals in the mesial root was 66.7% in Thailand and 46.2% in Turkey.\textsuperscript{[11,25]} One study especially showed the very high prevalence of Type IV canals in the mesial roots of two- and three-rooted mandibular first molars at 94%.\textsuperscript{[18]}

In the present study, the most common type of canals was Type I canals with a prevalence of 80.8% in the distal roots of two-rooted molars. In three-rooted molars, it was 97.6% in distal roots and 100% in distolingual roots. Type I canals were also the most common root canal configuration in the previous study.\textsuperscript{[4]}

In this study, in the three-rooted mandibular first molars, the prevalence of Type I canals in the distolingual root was 100%. This finding agrees with the results of other previous studies in Thailand, China, and Turkey.\textsuperscript{[11,18,25]} The C-shaped canal configuration and the middle mesial canal in the mesial root of the mandibular first molars were not detected in the present study. These two characteristics of the root canal system existed in the nearby Asian nations, and therefore, these features might present in the Vietnamese population with the larger sample size of the research.

The prospective, larger sample size, multi-center, and broader range future research would be conducted to collect more valuable data about the Vietnamese root canal configuration of mandibular first molars and provide useful knowledge for clinicians in root canal treatment of these teeth.

**Conclusion**

The prevalence of two, three, and four root canals of the mandibular first molars was 4.5%, 66.8%, and 28.9%, respectively. There were no significant differences in the frequency of number of root canals between position and sex. For the mesial roots of the mandibular first molars, a classification of Vertucci type IV was the most common at a rate of 60.8%–68.3%. The next most common classification was Vertucci type II at a rate of 24.4%–30.6%. For the distal roots of these teeth, a classification of Vertucci type I was the most common at a rate of 80.8%–97.6%. Whenever these teeth had three roots, a Vertucci type I was the classification of 100% of these cases.

Majority of the mandibular first molars has two roots and three canals. CBCT is appropriate equipment useful in investigating the complex root canal morphology of human teeth.

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Nil.

**Conflicts of Interest**

There are no conflicts of interest.

**References**

1. Serene TP, Spolsky VW. Frequency of endodontic therapy in a dental school setting. J Endod 1981;7:385-7.
2. Jung IY, Seo MA, Fouad AF, Spånberg LS, Lee SJ, Kim HJ, et al. Apical anatomy in mesial and mesiobuccal roots of permanent first molars. J Endod 2005;31:364-8.
3. Robinson S, Czerny C, Gahlertner A, Bernhart T, Kainberger FM. Dental CT evaluation of mandibular first premolar root configurations and canal variations. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002;93:328-32.
4. Arai Y, Tammisalo E, Iwai K, Hashimoto K, Shinoda K. Development of a compact computed tomographic apparatus for dental use. Dentomaxillofac Radiol 1999;28:245-8.
5. Katge F, Wakpanjar MM. Root canal morphology of primary molars by clearing technique: An in vitro study. J Indian Soc Pedod Prev Dent 2018;36:151-7.
6. Weng XL, Yu SB, Zhao SL, Wang HG, Mu T, Tang RY, et al. Root canal morphology of permanent maxillary teeth in the Han nationality in Chinese Guanzhong area: A new modified root canal staining technique. J Endod 2009;35:651-6.
7. de Oliveira SH, de Moraes LC, Faig-Leite H, Camargo SE, Camargo CH. In vitro incidence of root canal bifurcation in mandibular incisors by radiovisiography. J Appl Oral Sci 2009;17:234-9.
8. Keles A, Keskin C. Deviations of mesial root canals of mandibular first molar teeth at the apical third: A micro-computed tomographic study. J Endod 2018;44:1030-2.
9. Nair MK, Nair UP. Digital and advanced imaging in endodontics: A review. J Endod 2007;33:1-6.
10. de Pablo OV, Estevez R, Péix Sánchez M, Heilborn C, Cohenca N. Root anatomy and canal configuration of the permanent mandibular first molar: A systematic review. J Endod 2010;36:1919-31.
11. Gulabivala K, Opasanon A, Ng YL, Alavi A. Root and canal morphology of Thai mandibular molars. Int Endod J 2002;35:56-62.
12. Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol 1984;58:589-99.
13. Alfrwaz H, Alqedairi A, Alkhayyal AK, Almobarak AA, Alhusain MF, Martins JN, et al. 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;23:107-12.
14. Deng PU, Halim MS, Masudi SM, Al-Shehadat S, Ahmad B. Cone-beam computed tomography analysis on root and canal morphology of mandibular first permanent molar among multiracial population in East Coast Malaysian population. Eur J Dent 2018;12:410-6.
15. Kim HH, Jo HH, Min JB, Hwang HK. CBCT study of mandibular first molars with a distolingual root in Koreans. Restor Dent Endod 2018;43:e33.
16. Ni N, Cao S, Han L, Zhang L, Ye J, Zhang C. Cone-beam computed tomography analysis of root canal morphology in mandibular first molars in a Chinese population: a clinical study. Evid Based Endod 2018;3:1.
17. Madjapa HS, Minja IK. Root canal morphology of native Tanzanian permanent mandibular molar teeth. Pan Afr Med J 2018;31:24.
18. Wang Y, Zheng QH, Zhou XD, Tang L, Wang Q, Zheng GN, et al. Evaluation of the root and canal morphology of mandibular first permanent molars in a Western Chinese population by cone-beam computed tomography. J Endod 2010;36:1786-9.
19. Song JS, Choi HJ, Jung IY, Jung HS, Kim SO. The prevalence and morphologic classification of distolingual roots in the mandibular molars in a Korean population. J Endod 2010;36:653-7.
20. Huang CC, Chang YC, Chuang MC, Lai TM, Lai JY, Lee BS, et al. Evaluation of root and canal systems of mandibular first molars in Taiwanese individuals using cone-beam computed tomography. J Formos Med Assoc 2010;109:303-8.
21. Yew SC, Chan K. A retrospective study of endodontically treated mandibular first molars in a Chinese population. J Endod 1993;19:471-3.
22. Arayasantiparb R, Wanichwetin W, Banomyoug D. Prevalence and morphology of middle mesial canals in a group of Thai permanent mandibular molars from cone-beam computed tomography images. M Dent J 2017;37:281-7.
23. Alsawi Ram, Abouoq A, Alqabou SS, Alam MK. Three-dimensional cone-beam computed tomography assessment of additional canals of permanent first molars: A Pinocchio for successful root canal treatment. J Int Soc Prev Community Dent 2018;8:259-63.
24. Bansal R, Hegde S, Astekar M. Morphology and prevalence of middle canals in the mandibular molars: A systematic review. J Oral Maxillofac Pathol 2018;22:216-26.
25. Miloglu O, Arslan H, Barutcuigil C, Kantekin K. Evaluating root and canal configuration of mandibular first molars with cone beam computed tomography in a Turkish population. J Dent Sci 2013;8:80-6.