CBCT assessment of mandibular incisors anatomy in a population from Southeastern Brazil

Danilo De Luca **CAMPOS**[1]
Walber Shiniti **MAEDA**[1]
Wayne Martins **NASCIMENTO**[1]
João Paulo **DRUMOND**[1]
Francine Kuhl **PANZARELLA**[2]
Adriana de Jesus **SOARES**[3]
Marcos Roberto dos Santos **FROZONI**[1]

DOI: https://doi.org/10.14436/2358-2545.11.2.049-055.oar

ABSTRACT

Objective: Evaluate the root canal morphology of permanent mandibular incisors, through the use of cone bean computed tomography (CBCT) in a population of Brazilian southeast region and its relationship with patient age and sex. **Methods:** A total of 1,484 mandibular incisors of 371 male and female patient`s medical records were analyzed using CBCT. The tomographic images were by the orthopantomograph OP300 tomograph, with voxel of 0.20 mm. The morphology of the teeth was evaluated according to the classification of VERTUCCI, and the effects of sex and age of the patients on the variation in the morphology of these teeth were investigated. **Results:** All evaluated teeth had only one root. A single canal (Vertuccis type I) was detected in 80.7% of mandibular incisors. The second canal was present in 19.3% of the cases, with rates of 1.1% for Type II, 18.1% for Type III, 0.1% for Type IV, and 0.1% for Type V. According to sex, there was no statistical difference (p = 0.890) in mandibular incisor morphology. Within the analyzed age group, individuals aged under 18 years and individuals between 40 and 49 years (28.2% and 26,8% respectively) were statistically significant (p = 0.001) when compared to the other age groups. **Conclusions:** The most prevalent morphology was Type I of VERTUCCI, followed by Type III, without difference between sex and with a higher prevalence of morphological variation in individuals with less than 18 years and between 40 and 49 years.

Keywords: Cone-Beam Computed Tomography. Incisor. Anatomy & histology.

How to cite: Campos DL, Maeda WS, Nascimento WM, Drumond JP, Panzarella FK, Soares AJ, Frozoni MRS. CBCT assessment of mandibular incisors anatomy in a population from Southeastern Brazil. Dental Press Endod. 2021 May-Aug;11(2):49-55.
DOI: https://doi.org/10.14436/2358-2545.11.2.049-055.oar

[1] São Leopoldo Mandic, Departamento de Endodontia (Campinas/SP, Brazil).
[2] São Leopoldo Mandic, Departamento de Radiologia (Campinas/SP, Brazil).
[3] Universidade Estadual de Campinas, Departamento de Dentística Restauradora, Divisão de Endodontia (Piracicaba/SP, Brazil).

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Submitted: July 11, 2019. Revised and accepted: February 27, 2020.

Contact address: Danilo De Luca Campos
E-mail: danilo_campos17@hotmail.com - danilodelucacampos@gmail.com

Introduction

Knowledge of root and canal morphologies and of their variations is important for confirming the successful outcome in endodontic treatment.[1,2] Ethnicity, geographical location, and sex are some of the factors that affect root canal anatomy.[3] The presence of a single root canal was assumed in all cases regarding mandibular anterior teeth.[4] However, the first studies by Vertucci et al.[5] in 1974, which used staining and clearing techniques on extracted teeth, indicated different morphologies. Studies have shown a prevalence of a second canal in incisor teeth, ranging from 11.5% to 45%.[6,7] Despite the various methods available to demonstrate canal anatomy, such as radiographic examination, root sectioning, and staining and clearing techniques, they are often regarded as destructive techniques.[8,9] In the clinical setting, conventional periapical radiographs are a complementary technique of choice throughout endodontic treatment, providing two-dimensional images with inevitable geometric distortion and anatomical noise.[10] The cone-beam computed tomography (CBCT) designed for dental use is a noninvasive method that can provide three-dimensional morphological evaluations of the dental and maxillofacial anatomy.[2] Several CBCT studies of the root canal morphology of permanent mandibular incisors have been conducted, mainly in China, Turkey, and India,[11-14] but there is a shortage of data regarding the Brazilian population. The purpose of this study was to use CBCT scanning to investigate the root and canal morphology of mandibular anterior teeth in a Brazilian southeast region.

Materials and methods

Sample selection

A total of 1.484 CBCT images of mandibular anterior teeth (two central and lateral incisors) were collected from 371 patients who accepted CBCT projection as a preoperative assessment for various specialties at the Center of Radiology of the School of Dentistry in Campinas, State of São Paulo, Brazil, between January 2017 and August 2018. The present study was approved by the Research Ethics Committee of São Leopoldo Mandic School (protocol number 2.655.476). CBCT images were selected based on the following criteria: mandibular high-quality images of anterior teeth with complete root formation, absence of root canal treatment, absence of orthodontic treatment, absence of coronal or post-coronal restorations, absence of root resorption or of periapical lesions, and high-quality CBCT images.

Image acquisition

CBCT images were acquired using an ORTHOPANTOMOGRAFH OP 300 (Kavo, Brazil) CBCT device, 15 x 13 cm³ FOV, 89 kvp, with an exposure time of 8 seconds. The voxel size of the images was 0.20 mm, and the slice thickness was 1.0 mm. The images were acquired by an experienced radiologist according to the manufacturer's recommendations, with minimum exposure necessary for adequate image quality.

Image evaluation

The scans were analyzed with On-demand 3D software (South Korea) in a dimly lit room by two endodontists with more than 6 years of experience in CBCT. With the intention of calibrating the evaluations, kappa agreement coefficient was applied and reaching a consensus about the interpretation of the radiographic findings, all the images were analyzed simultaneously by the evaluators.[15]

The following information was recorded and analyzed:

1. Tooth position - 32, 31, 41, and 42,
2. Root number - 1 or 2,
3. Number of canals: 1 or 2.
4. Canal configuration according to the method proposed by Vertucci[9] (Fig 1).

Pearson's chi-square test was used for the statistical analysis using SPSS 21.0 software (SPSS Inc, Chicago, IL, USA). The level of significance level adopted was 5% ($p < 0,05$).

Each evaluator received a table, identifying the sex and age of each patient, and the age was separated into age groups, such as: under 18 years, 19 to 29 years, 30 to 39 years, 40 to 49 years, 50 to 59 years and over 60 years.

Results

We analyzed CBCT images of 123 men and 248 women. The patients' ages ranged from 10 to 75 years (mean age of 44.8 years). Individuals aged 50-59 years

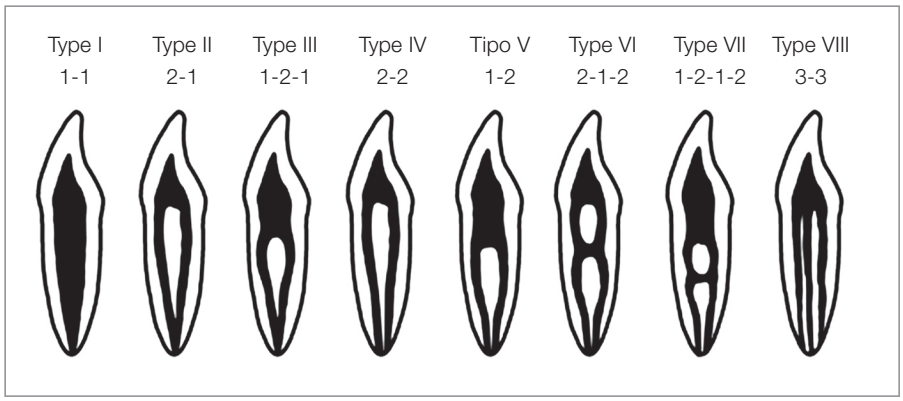

Figure 1. Vertucci's classification of canal configuration.

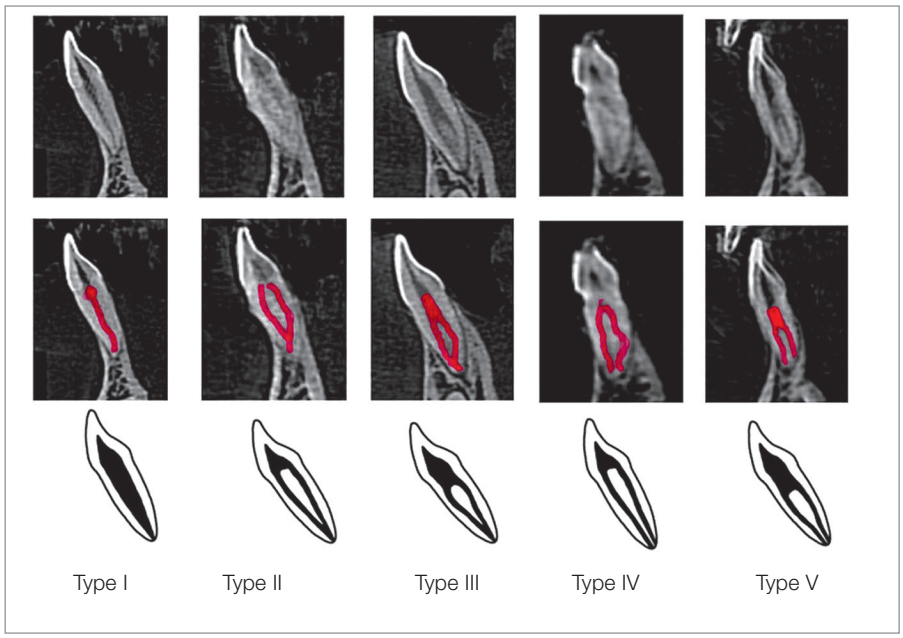

Figure 2. Illustration and cone-beam computed tomography images showing the five variants in permanent mandibular incisors.

were the most prevalent (26.7%), followed by those in the 40-49-year group (22.6%). All the scanned were single-rooted teeth (100%). A single canal (Vertucci's type I) was detected in 80.7% (1,197) of mandibular incisors. The prevalence of two canals was 19.3% (n = 287), and type III was the most common root canal morphology, accounting for 18.1% (n = 269). The prevalence of the other configuration types was as follows: 1.1 % (n = 16) for type II, 0.1 % (n = 1) for type IV, and 0.1 % (n = 1) for type V (Table 1).

The relationship between the morphology of root canals of mandibular incisor teeth and patient sex did not reveal any statistical difference (p = 0.890) with the prevalence of a second canal of 19.4% (n = 192) for females and of 19.3% (n = 95) for males (Table 2).

The relationship between root canal morphology and patient age was statistically significant (p <0.001) in cases of patients aged under 18 years and between 40 and 49 years with 28.2 % (n = 44) and 28.6 % (n = 90), respectively, of presence of a second canal when compared to the other age groups (Table 3).

Considering the prevalence of a second canal in relation to tooth number, there was no significant difference (p = 0.138): 22.4% for the mandibular left lateral incisor (MLLI) (32), 21 % for the mandibular right lateral incisor (MRLI) (42), 17 % for the mandibular right central incisor (MRCI) (41), and 17 % for the mandibular left central incisor (MLCI) (31) (Fig 3).

Table 1. Characterization of the sample of permanent mandibular incisors.

Variables	n = 1.484
Age group (years)	**n (%)**
≤ 18	156 (10.5)
19 – 29	164 (11.1)
30 – 39	140 (9.4)
40 – 49	336 (22.6)
50 – 59	396 (26.7)
≥ 60	292 (19.7)
Number of roots	
1	1.484 (100)
Number of canals	
Single canal	1.197 (80.7)
Presence of a second canal	287 (19.3)
Vertucci's classification	
Type I: A single canal appears from the pulp chamber to the apex	1.197 (80.7)
Type II: Two separate canals leave the pulp chamber but merge into one at the exit	16 (1.1)
Type III: One canal leaves the pulp chamber, divides into two within the root, and then merges at the exit	269 (18.1)
Type IV: Two distinctly separate canals are present from the pulp chamber to the apex	1 (0.1)
Type V: A single canal leaves the pulp chamber but divides into two	1 (0.1)

Table 2. Association between the root canal morphology of mandibular incisor teeth according to sex.

	Male (n = 492)	Female (n = 992)	p
Vertucci's classification	**n (%)**	**n (%)**	
Single canal	397 (80.7)	800 (80.6)	0.890
Presence of a second canal	95 (19.3)	192 (19.4)	

Table 3. Morphology of the root canals of mandibular incisor teeth according to age.

	≤ 18 years (n = 156)	19-29 years (n = 164)	30-39 years (n = 140)	40-49 years (n = 336)	50-59 years (n = 396)	≥ 60 years (n = 292)	p
Vertucci's classification	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	
Single canal	112 (71,8)	144 (87,8)*	120 (85,7)	246 (73,2)	328 (82,8)	247 (84,6)	< 0,001
Presence of a second canal	44 (28,2)*	20 (12,2)	20 (14,3)	90 (26,8)*	68 (17,2)	45 (15,4)	

* Statistically significant association by residual analysis adjusted to 5% of significance.

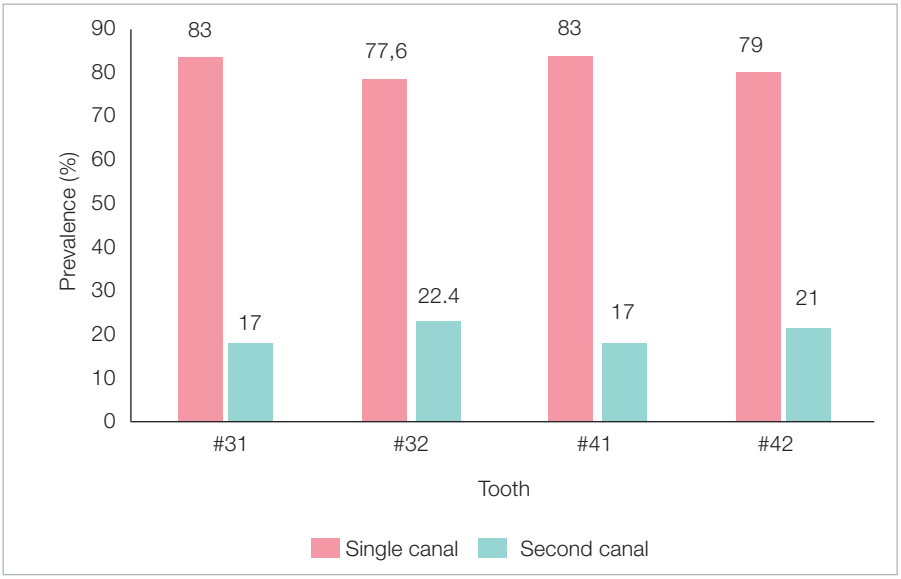

Figure 3. Prevalence of a second canal according to tooth type.

Discussion

In clinical practice, failure to locate a second canal is the main reason for root canal treatment failure, because it leads to incomplete debridement and obturation of the second root canal.[16] In the present study, 66.8% (n = 248) of the patients were female and 33.2% (n = 123) were male. Nonetheless, some studies corroborate the findings of the present study.[17,18,19] The mean age in the present study was 44.8 years, whereas Lin et al.[12] in 2014 obtained a mean age of 34.5 years. All 1,484 mandibular incisors analyzed had a single root, in line with Geduk et al.,[2] Lin et al.,[12] Han et al.,[11] and Zhao et al.,[20] who also evaluated the morphology of mandibular incisors using CBCT. In relation to the number of canals, 80.7% (1197) of mandibular incisors in the present study had a single canal (Vertucci's type 1), similar to other studies, such as those by Altunsoy et al.,[14] Saati et al.,[4] and Kayaoglu et al.,[21] with respective rates of 82.7%, 81.0%, and 82.8%. However, Silva et al.[15] and Shemesh et al.[22] found lower rates - 62.5% and 60.8%, respectively.

Different canal identification techniques, study designs, sample sizes, and genetic and ethnic factors may be responsible for the discrepancies in the prevalence of anatomical variation in mandibular incisors. One of the limitations of the present study concerns the failure to collect genetic/ethnic data.[15] This study also shows that a second canal was observed in 19.3% (287) of the teeth studied, as described by Al-Qudah et al.,[23] Kayaoglu et al.,[21] Altunsoy et al.,[14] Han et al.,[11] and Saati et al.[4] Mandibular incisors with two canals, according to Vertucci's classification, had the following morphology: type II in 1.1% (16), type III in 18.1% (269), type IV in 0.1% (1), and type V in 0.1% (1), without statistical significance. Silva et al.[15] in 2016 demonstrated the presence of type II in 0.5% (1), type III in 43.5% (87), type V in 26.5% (53), type VI in 0.5% (1), and type VII in 4% (8) of the cases, with similar findings, but with some variations in the morphological results for the other types classified by Vertucci. Conversely, Altunsoy et al.[14] found a higher prevalence of type V in 11% (353) and of type III in 0.9% (28) of the cases. Genetic differences between the studied populations may be contributing to the differences observed.[24] The study by Lin et al.[12] in 2014 found a higher prevalence of type III in 12.7% (180) of the cases, followed by type II in 3.0% (43) and finally type V in only 0.5% (7), in line with the results, suggesting that the eastern ethnicity bears a more genetic resemblance to the studied Brazilian population.

We did not identify an association between root canal morphology and patient sex and similar results were observed by Aminsobhani et al.,[13] Geduk et al.,[2] and Liu et al.[25] These data suggest that sex is not a relevant factor for the increase in the number of morphological variations in mandibular incisors. Considering the association of root canal morphology of mandibular incisors with age range, individuals under 18 years or between 40 and 49 years had a statistically significant association of second canal prevalence, as compared to other age groups. Similar results were obtained by Kayaoglu et al.[21] in 2015, who found statistical difference in the prevalence of second root canal in individuals aged 10 to 35 years and 36 to 55 years, when compared to individuals older than 56 years. Human aging results in physiological changes within the pulp, such as continuous deposition of secondary dentin, which consequently causes a decrease in the root canal lumen,[26] justifying the findings of this and other studies, given the lower prevalence of a second channel in age groups over 55 years.

By analyzing tooth by tooth, there was no statistical difference in the prevalence of a single canal among the teeth studied, where MLLI (32) had a single canal in 77.6% of the cases, MLCI (31) and MRCI (41) had a single canal in 83%, and MRLI (42) in 79%. This is in line with the study by Liu et al.[25] in 2014, in which a single canal was detected in 91.1% of mandibular central incisors and in 86.8% of mandibular lateral incisors, suggesting a higher prevalence, albeit nonsignificant, of single canals in mandibular central incisors. At odds with the findings of the present study, Çaliskan et al.[27] in 1995 detected a single canal in 68.63% of both mandibular central incisors and mandibular lateral incisors after subjecting the root canal system in extracted teeth to staining and clearing techniques. This discrepancy may possibly be explained by the differences in the techniques for the detection of root canal morphology.[28]

Looking at the presence of a second canal and at each mandibular incisor, MLLI (32) showed the highest prevalence (22.4%), followed by its homologue - MRLI (42) - with a prevalence rate of 21%, without statistical difference, but there was a higher prevalence of a second canal in mandibular lateral incisors as compared to mandibular central incisors. Interestingly, the prevalence of a second canal was similar among homologous teeth, as observed by Shemesh et al.[22] in 2017, who found bilateral incidence of a second canal in 69.8% of central incisors and in 68.7% of lateral incisors, whereas Zhao et al.[20] in 2014 found 58.7% for central incisors and 76.1% for lateral incisors, demonstrating that the presence of a second canal in MLLI, for example, increases the chance of this same morphology in MRLI. In a study by Verma et al.[16] in 2017, there was a prevalence of 33.5% for a second canal in MRCI (41), 30% in MLCI (31), 33.5% in MLLI (32), and 36.5% in MRLI (42), corroborating the findings of the present study. Difference in the morphology of mandibular incisors and in the studied population is scarcely investigated in the scientific literature; therefore, new studies on this subject are needed.

Conclusion

In the present study, the most prevalent morphology was type I of VERTUCCI with 80.7% of cases, followed by type III with 18.1%, without difference between sex and with a higher prevalence of morphological variation in individuals with less than 18 years and between 40 and 49 years.

References

1. Daokar SG, Kalekar AS, Ghunawat DB, Kakde DD. All the mandibular incisors with double canals in a single patient: a rare case. J Int Oral Health. 2015;7(2):46-9.
2. Geduk G, Deniz Y, Zengin AZ, Eroglu E. Cone-beam computed tomography study of root canal morphology of permanent mandibular incisors in a Turkish sub-population. J Oral Maxillofac Radiol. 2015;3(1):7-10.
3. Gaurav V, Srivastava N, Rana V, Adlakha VK. A study of root canal morphology of human primary incisors and molars using cone beam computerized tomography: an in vitro study. J Indian Soc Pedod Prev Dent. 2013;31(4):254-9.
4. Saati S, Shokri A, Foroozandeh M, Poorolajal J, Mosleh N. Root morphology and number of canals in mandibular central and lateral incisors using cone beam computed tomography. Braz Dent J. 2018;29(3):239-44.
5. Vertucci FJ. Root canal anatomy of the mandibular anterior teeth. J Am Dent Assoc 1974;89(2):369-71.
6. Kartal N, Yamkoglu FÇ. Root canal morphology of mandibular incisors. J Endod. 1992;18(11):562-4.
7. Benjamin KA, Dowson J. Incidence of two root canals in human mandibular incisor teeth. Oral Surg Oral Med Oral Pathol. 1974;38(1):122-6.
8. Cleghorn BM, Christie WH, Dong CCS. Anomalous mandibular premolars: a mandibular first premolar with three roots and a mandibular second premolar with a C-shaped canal system. Int Endod J. 2008;41(11):1005-14.
9. Vertucci FJ, Fla G. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol. 1984;58(5):589-99
10. Zhang R, Wang H, Tian YY, Yu X, Hu T, Dummer PMH. Use of cone-beam computed tomography to evaluate root and canal morphology of mandibular molars in chinese individuals. Int Endod J. 2011;44(11):990-9.
11. Han T, Ma Y, Yang L, Chen X, Zhang X, Wang Y. A study of the root canal morphology of mandibular anterior teeth using cone-beam computed tomography in a Chinese subpopulation. J Endod. 2014;40(9):1309-14.
12. Lin Z, Hu Q, Wang T, Ge J, Liu S, Zhu M, et al. Use of CBCT to investigate the root canal morphology of mandibular incisors. Surg Radiol Anat. 2014;36(9):877-82.
13. Aminsobhani M, Sadegh M, Meraji N, Razmi H, Kharazifard MJ. Evaluation of the root and canal morphology of mandibular permanent anterior teeth in an Iranian population by cone-beam computed tomography. J Dent (Tehran). 2013;10(4):358-66.
14. Altunsoy M, Ok E, Nur BG, Aglarci OS, Gungor E, Colak M. A cone-beam computed tomography study of the root canal morphology of anterior teeth in a Turkish population. Eur J Dent. 2014;8(3):302-6.
15. Silva EJNL, Castro RWQ, Nejaim Y, Silva AIE, Haiter-Neto F, Silberman A, et al. Evaluation of root canal configuration of maxillary and mandibular anterior teeth using cone beam computed tomography: an in vivo study. Quintessence Int. 2016;47(1):19-24.
16. Verma GR, Bhadage C, Bhoosreddy AR, Vedpathak PR, Mehrotra GP, Nerkar AC, et al. Cone beam computed tomography study of root canal morphology of permanent mandibular incisors in Indian subpopulation. Pol J Radiol. 2017;82:371-5.
17. Arslan H, Ertas H, Ertas ET, Kalabalik F, Saygib G, Capar ID. Evaluating root canal configuration of mandibular incisors with cone-beam computed tomography in a Turkish population. J Dent Sci. 2015;10(4):359-64.
18. Camargo MBJ, Dumith SC, Barros AJD. Regular use of dental care services by adults: patterns of utilization and types of services. Cad Saúde Pública. 2009;25(9):1894-1906.
19. Araújo MEA, Silva MT, Andrade KRC, Galvão TF, Pereira MG. Prevalence of health services utilization in Brazil: a systematic review and meta-analysis. Epidemiol Serv Saúde. 2017;26(3):589-604.
20. Zhao Y, Dong Y, Wang X, Wang Z, Li G, Liu M, et al. Cone-bean Computed tomography analysis of root canal configuration of 4674 mandibular anterior teeth. Beijing Da Xue Xue Bao Yi Xue Ban. 2014;46(1):95-9.
21. Kayaoglu G, Peker I, Gumusok M, Sarikir C, Kayadugun A, Ucok O. Root and canal symmetry in the mandibular anterior teeth of patients attending a dental clinic: CBCT study. Braz Oral Res. 2015;29:S1806-83242015000100283.
22. Shemesh A, Kavalerchik E, Levin A, Itzbak JB, Levinson O, Lvovsky A, et al. Root canal morphology evaluation of central and lateral mandibular incisors using cone-beam computed tomography in an Israeli population. J Endod. 2017;44(1):51-5.
23. Al-Qudah AA, Awawdeh LA. Root canal morphology of mandibular incisors in a Jordanian population. Int Endod J. 2006;39(11):873-7.
24. Brook AH, Griffin RC, Townsend G, Levisianos Y, Russel J, Smith RN. Variability and patterning in permanent tooth size of four human ethnic groups. Arch Oral Biol. 2009;54(Suppl 1):79-85.
25. Liu J, Luo J, Dou L, Yang D. CBCT study of root and canal morphology of permanent mandibular incisors in a Chinese population. Acta Odontol Scand. 2014;72(1):26-30.
26. Luukko K, Kettunem P, Fristad I, Berggreen E. Structure and functions of the pulp tooth complex. In: Hargreaves, KM, Cohen S. Pulp paths. 10a ed. Elsevier. Rio de Janeiro; 2011. p. 463.
27. Çaliskan MK, Pehlivan Y, Sepetçioglu F, Turkun M, Tuncer SS. Root canal morphology of human permanent teeth in a Turkish population. J Endod. 1995;21(4):200-4.
28. Kajan ZD, Taramsari M, Fard NK, Kanani M. Accuracy of cone-beam computed tomography in comparison with standard method in evaluating root canal morphology: an in vitro study. Iran Endod J. 2018;13(2):181-7.