Study of root canal morphology of mandibular first premolars using computed tomography

Estudo da morfologia do canal radicular dos primeiros pré-molares inferiores por meio de tomografia computadorizada

Estudio de la morfología del conducto radicular de los primeros premolares mandibulares mediante tomografía computarizada

Silvia Letícia Sena Ferreira[1], Carlos Sampaio de Santana Neto[2], Viviane Almeida Sarmento[3], Joana Dourado Martins Cerqueira[4]

How to cite: Ferreira SLS, Neto CSS, Sarmento VA, Cerqueira JDM. Study of root canal morphology of mandibular first premolars using computed tomography. REVISA. 2024; 13(Esp2): 1142-51. Doi: https://doi.org/10.36239/revisa.v13.nesp2.p1142a1151

REVISA

1. State University of Feira de Santana, Department of Health. Feira de Santana, Bahia, Brazil. https://orcid.org/0000-0001-9535-4298

2. State University of Feira de Santana, Department of Health. Feira de Santana, Bahia, Brazil. https://orcid.org/0000-0003-3864-2992

3. State University of Feira de Santana, Department of Health. Feira de Santana, Bahia, Brazil. https://orcid.org/0000-0003-4403-3659

4. State University of Feira de Santana, Department of Health. Feira de Santana, Bahia, Brazil. https://orcid.org/0000-0001-8606-0220

Received: 23/07/2024
Accepted: 12/09/2024

RESUMO

Objetivo: avaliar a morfologia do canal radicular dos primeiros pré-molares inferiores por meio de tomografia computadorizada. **Método**: dois observadores analisaram 311 imagens tomográficas e 486 dentes foram avaliados. As variáveis estudadas foram o sexo, os tipos de dentes, o número de raízes, o formato da raiz, o número e formato de cada canal nos terços cervical, médio e apical, o comprimento do dente, a classificação de Vertucci e a presença de C- canais em forma. **Resultados:** Canal único foi encontrado em 74,9% da amostra, sendo Vertucci tipo I o mais frequente. As bifurcações ocorreram nos terços médio (19,5%) e apical (17,1%) e a ocorrência de canais "C" foi rara (0,4%). **Conclusão**: a presença de mais de um canal teve associação estatisticamente significativa com o formato do canal e o sexo. A anatomia interna desses dentes é complexa, o que pode dificultar o tratamento endodôntico.

Descritores: Anatomia; Endodontia; Pré-Molar; Canal Radicular; Tomografia.

ABSTRACT

Objective: evaluate the root canal morphology of mandibular first premolars using Computed Tomography scans. **Method:** Two observers analyzed 311 tomographic images, and 486 teeth were evaluated. The variables studied were the sex, the types of teeth, the number of roots, the root shape, the number and shape of each canal in the cervical, middle and apical thirds, the tooth length, the Vertucci's classification and the presence of C-shaped canals. **Results:** A single canal was found in 74.9% of the sample, with Vertucci type I being the most frequent. Bifurcations occurred in the middle thirds (19.5%) and apical (17.1%) and the occurrence of "C" canals was rare (0.4%). **Conclusion:** The presence of more than one canal had a statistically significant association with the canal format and the sex. The internal anatomy of these teeth is complex, which can make endodontic treatment difficult.

Descriptors: Anatomy; Endodontics; Premolar; Root Canal; Tomography.

RESUMEN

Objetivo: evaluar la morfología del conducto radicular de los primeros premolares mandibulares mediante tomografía computarizada. **Método:** Dos observadores analizaron 311 imágenes tomográficas y se evaluaron 486 dientes. Las variables estudiadas fueron el sexo, los tipos de dientes, el número de raíces, la forma radicular, el número y forma de cada conducto en los tercios cervical, medio y apical, la longitud de los dientes, la clasificación de Vertucci y la presencia de C-canales con forma. **Resultados**: Se encontró conducto único en el 74,9% de la muestra, siendo el tipo I de Vertucci el más frecuente. Las bifurcaciones ocurrieron en los tercios medio (19,5%) y apicales (17,1%) y la aparición de conductos en "C" fue rara (0,4%). **Conclusión:** La presencia de más de un conducto tuvo asociación estadísticamente significativa con el formato del conducto y el sexo. La anatomía interna de estos dientes es compleja, lo que puede dificultar el tratamiento endodóntico.

Descriptores: Anatomía; Endodoncia; Premolar; Conducto Radicular; Tomografía.

ORIGINAL

Introduction

The root canal of the mandibular first premolar (MFP) is generally ample and accessible, oval shaped, and grooves are often found on proximal faces in cervical-apical direction, which rarely go deep enough to split the apex [1,2,3,4].

Anatomical variations including a high relation between mandibular premolars and C-shaped canals are also observed in these teeth, increasing the difficulty of cleaning the root canal system during endodontic treatment [5].

Many resources have been used to study the root anatomy of teeth, which are the conventional and digital radiographs, cross-section, diaphanization, computed tomography, Cone Beam Computed Tomography and the computed microtomographs, this latter one is considered the gold standard for clinical research and investigation [5,6.]

These resources have contributed to facilitate the evaluation of anatomical variations of roots and dental canals, Computed Tomography (CT) is one of the methods used in cases of suspected variations [7,8].

Studies with CT in MFP have been performed showing the most common anatomical variations, most of the time, the presence of a single canal is found. However, teeth with more than one canal were also observed, bifurcations of canals occur in the different root thirds [9].

The failures of endodontic treatment, cleaning or filling the root canals, most of the time, are due a poor knowledge of morphology and the variation potential that they may present [8,10]. Therefore, it is essential the study of internal teeth anatomy of teeth in different populations using different diagnostic methods, since the incidence, position and morphology of root canal system may vary in different ethnicities or regional populations and this knowledge is crucial to the success of endodontic treatment [11].

Thus, the aim of this study was to evaluate the root canal morphology of mandibular first premolars using Computerized Tomography scans.

Methods

This is a cross-sectional study using data from medical records of patients treated at University Hospital Professor Roberto Santos of Federal University of Bahia (HUPES-UFBA) from 2015 to 2018.

The research was submitted to the Research Ethics Committee of State University of Feira de Santana and approved with CAAE 83229918.2.0000.0053 and assent nº 2,688,074.

Study group

A convenience sample was selected, consisting of 311 mandibular Computed Tomography scans from the HUPES-UFBA collection, during the established period and the exams were randomly chosen. The inclusion criteria was: examinations performed during the described period, presence of at least one MFP on CT, examination performed from axial slice parallel to mandible base, maximum 1 mm thick, FOV maximum 30 mm. The exclusion criteria was: absence of MFP on CT, non-observation of the entire MFP, presence of metallic

artifacts that made the analysis unfeasible, teeth with open apex, and the presence of supernumerary teeth or root defects and no previous endodontic treatmen.

Definition of variables

In this study, the patient's demographic variables and dental clinics were evaluated. For the sociodemographic variable only the sex was evaluated, since there was no access to patients' records, only to CT scans. And as clinical variables were analyzed: the dental unit, the number of roots, the shape of roots, the number and the format of each canal in the cervical, middle and apical thirds, the length of tooth, the presence of C-shaped canal and Vertucci classification.

For Vertucci classification were considered: Type I- Single canal runs from orifice to apex; Type II- Two canals arises from pulp chamber which unite in its course into one; Type III- One canal arises from pulp chamber and during its course splits into two, these two canals again unite into one before exiting from apex; Type IV- Two canals run separately from orifice to apex; Type V- One canal arises from floor of pulp chamber and during its course divides into two; Type VI- Two canals start from pulp chamber, during its course, they unite into one and then again divide into two before exiting from root apex; Type VII- One canal leave the pulp chamber which divide and again unite into in its course and finally divide into two before exiting from apex; Type VIII- Three canals leave the pulp chamber and run independently towards the apex (11).

Image Collect Procedure

The tomographic images of patients archived at HUPES-UFBA were transferred to an external Hard Disc (HD) for analysis by two examiners at State University of Feira de Santana;.Analysis of tomographic slices- Image preparation

The exams- filed on electronic media in Digital Imaging and Communications in Medicine (DICOM) format- were opened in the Dental Converter® Program (BioParts, Brasília, Brazil) and converted into (BPT) format and archived again. They were opened in the DentalSlice® Program (BioParts, Brasília, Brazil) for analysis. Imaging Evaluation

Images were evaluated by two previously calibrated independent observers. At each examination, the evaluator analyzed each axial slices and panoramic and para-axial reformatting obtained from both sides of the mandible, and analyzed the anatomy of MFP, observing the possible existing of anatomical variations, recording them in data extraction files. In the event of divergence of atings, a third reviewer was called to establish the most appropriate rating.

Data analysis

After tabulation, the data were submitted to descriptive frequency analysis of the variables: the sex, the types of teeth, the number of roots, the

number and shape of the canals in the cervical, middle and apical thirds, the presence of C-shaped canal and Vertucci classification. The association of variations found between canal number, root shape and sex was estimated by the non-parametric Chi-square and Fisher test, 5% probability of error. The confidence interval was established in 95% of confidence level. Statistical analysis was performed with aid of Statistical Package for the Social Sciences (SPSS), version 20.

Inter examiner agreement was assessed using the Kappa coefficient of agreement and classified according to Landis and Koch parameters (1977), (12) considering: no agreement (<0); poor agreement (0 to 0.19); reasonable agreement (0.20 to 0.39); moderate agreement (0.40 to 0.59); substantial agreement (0.60 to 0.79), and excellent agreement (0.80 to 1.00).

Results

Two different examiners evaluated the images independently with inter-examiner agreement being 0.64, it's considered a substantial agreement. As from the analysis 486 MFP tomographic images of 311 patients, 69.6% were female and 30.4% male, with 247 left and 239 right MFP (Table 1).

Most of the teeth evaluated had only one root (91.4%), oval was the most frequent shape (96.7%) (Figure 1). In general, only one canal was found (74.9%) (Figure 1), this result remained when observed the three thirds: cervical, middle and apical (99.4%, 80.5%, 82.9%, respectively). When analyzing the shape of canals according to thirds, there was a higher frequency of circular canal in cervical and apical third, 51.6% and 69.9% respectively, oval type was the more found in middle third with 71.6% (Figure 2). A very small amount of C-shapped canals was observed (0.4%) (Table 1).

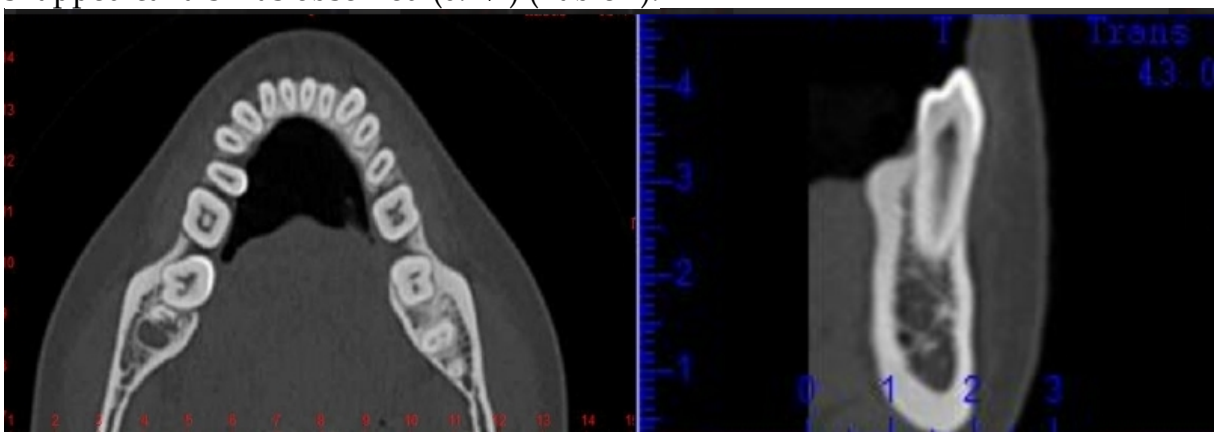

Figure 1 - Oval shape of roots in teeth 3.4 and 4.4 (left). Presence of a single canal and root (Type I Vertucci) (right).

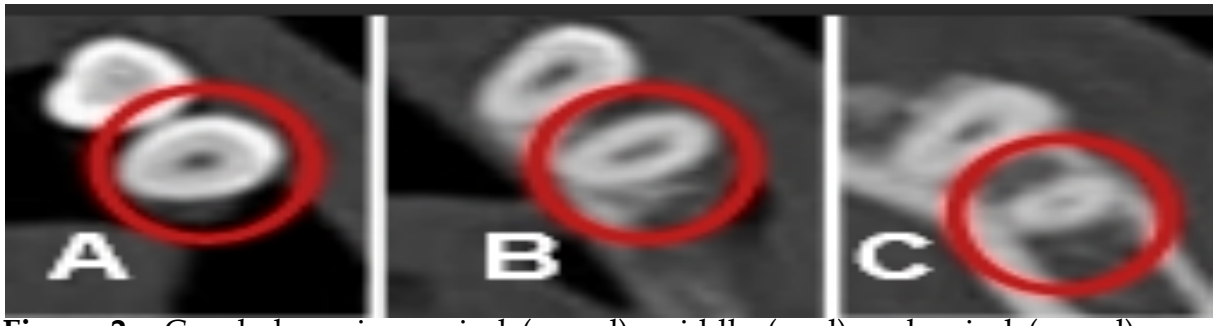

Figure 2 - Canal shape in cervical (round), middle (oval) and apical (round) thirds of same.

The analysis of internal configuration of according to the Vertucci classification demonstrated: types I (74.9%), V (16.9%) and III (7.8%) were more common (Figure 3) (Table 1).

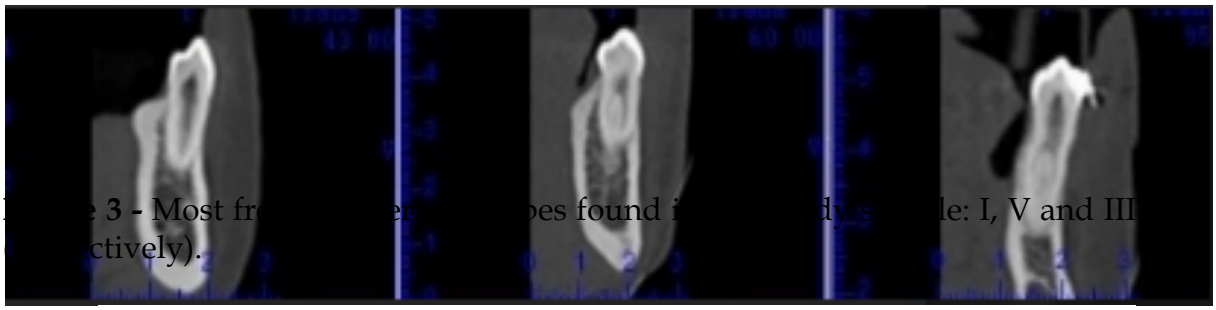

Figure 3 - Most frequent types found in study sample: I, V and III (respectively).

In present study, a statistically significant association was observed between the root shape and the number of canals, both for oval [CI: 1.22-1.30] and circular shape [CI: 1.02-1.07] (Table 2).

Table 2 - Analysis of association between root shape and number of canals (n = 486).

	Number of canals			
	01 canal	02 canals	Total	Confidence interval
Root shape				
Oval	348	122	470	1,22-1,30*
Circular	16	0	16	1,02-1,07*
Total	364	122	486	

* Statistically significant difference (Fisher's test, p value = 0.016)

Regarding the association between the sex and the number of canals, it was significant. In both sexes, the presence of only one canal was the most frequent situation, 67.5% of men [CI: 1.22-1.43] and 79.8% of women [CI: 1.14-1.26] had this morphological configuration (Table 3). The average length of analyzed teeth was 20.00 mm and the standard deviation was 2.46 mm.

Table 3 - Analysis of association between sex and number of canals (n = 486).

	Number of canals			
	01 canal	02 canals	Total	Confidence interval
Gender				
Male	54	26	80	1,22-1,43*
Female	146	37	183	1,14-1,26*
Total	200	63	263	

* Statistically significant difference (Pearson's X2 test, p value = 0.032)

Discussion

When evaluating the root canal morphology of MFM, through computed tomography slices, the presence of a single canal was observed in most cases, represented by type I of Vertucci Classification. The most common root shape was oval. Bifurcations appeared more in middle third. Regarding the shape of canals in root thirds, the most frequent were circular, oval and circular, in the cervical, middle and apical thirds, respectively. The frequency of C-shapped canal format was low.

The number and classification of canal system morphology, according to Vertucci, found in the sample (single canal and Type I) corroborate with results found in literature using other analysis methods in different populations [13, 14, 15]. Despite the large occurrence of a single canal in MFP, bifurcations in the middle third were found and in some teeth there was a fusion of canals in apical third, 19.5% of sample had two canals in middle third, 17.1% in apical third and only 0.6% had bifurcation in the cervical third. According to Baisden (1992), [16] these bifurcations can occur in different thirds of root. For Fan (2008), [17] bifurcations happen more frequently in middle and apical thirds, corroborating with this study.

The number of C-shapped canals found in this study was small (0.4%) and very close to the amount found by Velmurugan and Sandhya (2009) (1%)

and Sandhya, Velmurugan, Kandaswamy (2010) (2%) in an Indian population using the diaphanization and CT analysis methods, respectively. [9,18] In another study using cone beam computed tomography (CBCT), the incidence of these canals was 2.3% [15]. With microtomography analysis, studies showed even greater amounts of C-shapped canals, 24% in a Chinese population and 67.5% in a Brazilian population [17, 19].

Regarding the internal morphology of root canals, it was found that the most common types were types I (74.9%), V (16.9%) and III (7.8%), according to the Vertucci classification. However, some studies have found type V to be the most frequent in their samples using microtomography or CBCT in different populations [2,3,19]. However, Sandhya, Velmurugan and Kandaswamy (2010) [9] and Ferreira (2012) [20] using CT in Indian population and CBCT in Brazilian population, respectively, found similar results to the present study, where Type I was the most frequent.

The format of MFP can present differences depending on of root third analyzed, the most common type is oval (51%) and circular shape (40%) [16]. In this study, oval shape prevailed in middle third (71.6%) and circular in cervical (51.6%) and apical (69.9%). These results are close to those found by Khedmat (2010) [11], the most of the canals morphology was oval in cervical third, circular or oval in middle third, and circular in apical third.

The association between the root shape and the number of canals has been evaluated. Studies have shown that the oval shape may be related to flattening in mesio-distal direction of root, the presence of root grooves and the presence of more than one canal [1,2,21, 22, 23]. The results of this paper agree with those found in studies by Chourasia et al. (2017)[14,] Ordinola-Zapata et al. (2015) [17] and Fan et al. (2008)[19].

The presence of a single root is quite common in MFP. Chourasia et al. (2017) [14] and Ordinola-Zapata et al. (2015)[19], found 97.6% and 98% of MFP with unique roots, respectively. These results are like those obtained in present study.

The average length of teeth in this study was 20.00 mm, similar to that found by Abraham and Gopinath (2015) [24] in an Emirati population using extracted teeth, an average length of 19.90 mm was found. However, Awawdeh and Al-Qudah (2008) [25] obtained the mean length in their study of 22.60 mm in a Jordanian population and Çaliskan (1995) [26] 21.22 mm in a Turkish population, both with extracted teeth. Sandhya, Velmurugan, Kandaswamy (2010) [9] found the average length of 21.60 mm in an Indian population with CT. These differences can be explained by the fact that different populations are evaluated, using different study methods.

The differences in variations reported in literature regarding MFP may be correlated to the racial divergence of samples and methodologies involved.[13,16,27,28] The Brazilian population is very mixed and can present high morphological variation in configuration of MFP canals. However, studies with populations that present a more homogeneous ethnic derivation, such as the Asian one, bring results with less anatomical variation.[27]

Sert and Bayirli (2004)[28] reported that there are differences between the morphological characteristics of male and female MFP. However, Ferreira (2012) [20] results are not in agreement with the previous study, showing that

there are no differences in anatomy of MFP between the sexes. This study agrees with the results found by Sert and Bayirli (2004)[28], where there was a statistically significant difference between male and female MFP. However, sex analysis alone can yield inaccurate results, since other variables such as ethnicity may influence more than sex.

The use of CT for internal root canal anatomy analysis has been reported in literature. However, it may have some disadvantages regarding CBCT, including less sharpness, longer scan time and higher radiation dose, image changes due to metallic objects such as restorations and implants [30]. However, Neelakantan; Subbaraon; Subbarao (2010)[6] demonstrated in their study that CT has a 95% agreement with the CBCT imaging findings. In the present study, CT was used and no difficulties were found in analysis of the anatomy of the MFP, because images that had alterations due to presence of metallic objects were excluded from sample. However, further studies are suggested to use Cone Beam Computed Tomography and Microtomography in different populations.

Although there were some limitations to the study, it can be inferred that the most common root canal morphological configuration in mandibular first premolars is a single channel, corresponding to type I of the Vertucci classification. However, bifurcations in different root thirds and the presence of a C-shapped canal may occur. Root shape and sex can interfere with the number of canals.

Acknowledgment

This study was funded by the authors themselves

References

1. Boschetti E, Silva-Sousa YTC, Mazzi-Chaves JF, *et al*. Micro-CT evaluation of root and canal morphology of mandibular first premolars with radicular grooves. Braz Dent J. 2017;28(5):597–603.

2. Shemesh A, Lalum E, Itzhak JB, Levy DH, Lvovsky A, Levinson O, Solomonov M. Radicular Grooves and Complex Root Morphologies of Mandibular Premolars Among Israeli Population. JOE. 2020; 46(9): 1241-1247.

3. Sousa TO, Haiter-Neto F, Nascimento EHL, Peroni LV, Freitas DQ, Hassan B. Diagnostic Accuracy of Periapical Radiography and Cone-beam Computed Tomography in Identifying Root Canal Configuration of Human Premolars. JOE. 2017;43(7):1176–1179.

4. Dhaimy, S., Dhoum, S., Diouri, M., Bedida, L., Elmerini, H., & Benkiran, I. (2021). Cone-beam computed tomography evaluation of the root morphology of the maxillary and mandibular premolars in a Moroccan subpopulation: Canal configurations and root curvatures (Part 2). Saudi Endodontic Journal. 2021; 11(2): 162.

5. Neelakantan P, Subbarao C, Subbarao C V. Comparative evaluation of modified canal staining and clearing technique, cone-beam computed tomography, peripheral quantitative computed tomography, spiral computed

tomography, and plain and contrast medium-enhanced digital radiography in studying root c. JOE. 2010;36(9):1547–51.

6. Sachdeva GS, Ballal S, Gopikrishna V, Kandaswamy D. Endodontic Management of a Mandibular Second Premolar with Four Roots and Four Root Canals with the Aid of Spiral Computed Tomography: A Case Report. JOE. 2008;34(1):104–7.

7. Portela CP, Baratto Filho F, Tomazinho FSF, Correr GM, Moro A, Moresca RC. Estudo da anatomia interna dos pré-molares – Revisão de literatura. Odonto. 2011;19(37):63–72.

8. Sandhya R, Velmurugan N, Kandaswamy D. Assessment of root canal morphology of mandibular first premolars in the Indian population using spiral computed tomography. Indian J Dent Res. 2010;21(2):169–73.

9. Parekh V, Shah N, Joshi H. Root canal morphology and variations of mandibular premolars by clearing technique: An in vitro study. JCDP. 2011;12(4):318–21.

10. Khedmat S, Assadian H, Saravani AA. Root Canal Morphology of the Mandibular First Premolars in an Iranian Population Using Cross-sections and Radiography. JOE. 2010;36(2):214–7.

11. Landis JR, Koch GG. The Measurement of Observer Agreement for Categorical Data. Biometrics. 1977;33(1):159–74.

12. Rahimi S, Shahi S, Yavari HR, Manafi H, Eskandarzadeh N. Root Canal Configuration of Mandibular First and Second Premolars in an Iranian Population. JODDD. 2007;1(2):59–64.

13. Chourasia HR, Boreak N, Tarrosh MY, Mashyakhy M. Root canal morphology of mandibular first premolars in Saudi Arabian southern region subpopulation. Saudi Endod J. 2017;7(2):77–81.

14. Martins JNR, Francisco H, Ordinola-Zapata R. Prevalence of C-shaped Configurations in the Mandibular First and Second Premolars: A Cone-beam Computed Tomographic In Vivo Study. JOE. 2017;43(6):890–895.

15. Baisden MK, Kulild JC, Weller RN. Root canal configuration of the mandibular first premolar. JOE. 1992;18(10):505–8.

16. Fan B, Yang J, Gutmann JL, Fan M. Root Canal Systems in Mandibular First Premolars with C-shaped Root Configurations. Part I: Microcomputed Tomography Mapping of the Radicular Groove and Associated Root Canal Cross-sections. JOE. 2008;34(11):1337–41.

17. Velmurugan N, Sandhya R. Root canal morphology of mandibular first premolars in an Indian population: A laboratory study. Int Endod J. 2009;42:54–8.

18. Ordinola-Zapata R, Monteiro Bramante C, Gagliardi Minotti P, *et al*. Micro-CT evaluation of C-shaped mandibular first premolars in a Brazilian subpopulation. Int Endod J. 2015;48:807–13.

19. Ferreira FP. Estudo da anatomia dental por meio da tomografia computadorizada de feixe- cônico de indivíduos residentes em São Paulo. 2012.

20. Pinheiro Júnior EC, Leite APP, Silva RG, Pecora JD. Relação entre sulcos radiculares e número de canais em pré-molares inferiores. Estudo "in vitro". Rev ABO Nac. 1994;2(4):265–9.

21. Vier FV, Só MVR, Mattuella LG, Oliveira F, Bozza K, Oliveira EPM de. Correlation between radiographic exam and clearing technique in the determination of canal number in first lower premolar presenting or not root longitudinal grooves. Odontol Clín-Científ. 2004;3(1):39–48.

22. Chen J, Li X, Su Y, *et al.* A micro-computed tomography study of the relationship between radicular grooves and root canal morphology in mandibular first premolars. Clin Oral Invest. 2015;19(2):329–34.

23. Abraham SB, Gopinath VK. Root canal anatomy of mandibular first premolars in an Emirati subpopulation: A laboratory study. Eur J Dent. 2015;9(4):476–82.

24. Awawdeh LA, Al-Qudah AA. Root form and canal morphology of mandibular premolars in a Jordanian population. Int Endod J. 2008;41(3):240–248.

25. Çaliskan MK, Pehlivan Y, Sepetçioglu F, Türkün M, Tuncer SS. Root Canal Morphology of Human Permanent Teeth in a Turkish Population. JOE. 1995;21(4):200–4.

26. Lu TY, Yang SF, Pai SF. Complicated Root Canal Morphology of Mandibular First Premolar in a Chinese Population Using the Cross Section Method. JOE. 2006;32(10):932–6.

27. Tian YY, Guo B, Zhang R, *et al*. Root and canal morphology of maxillary first premolars in a Chinese subpopulation evaluated using cone-beam computed tomography. Int Endod J. 2012;45:996–1003.

28. Sert S, Bayirli GS. Evaluation of the root canal configurations of the mandibular and maxillary permanent teeth by gender in the Turkish population. JOE. 2004;30(6):391-8.

Correspondent Author
Joana Dourado Martins Cerqueira
Universidade Estadual de Feira de Santana
Av. Transnordestina, s/n. ZIP:44036-900- Novo Horizonte.
Feira de Santana, Bahia, Brazil.
cerqueirajdm@gmail.com