Evaluation of the number of root canals of mandibular incisors using cone beam computed tomography

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ABSTRACT

Introduction: The study of root and rood canal anatomy is relevant for endodontic treatment. Therefore, knowledge of the root canal morphology is essential to achieve an endodontic that results in success. However, the professional has limited information of this knowledge and difficult access to the place of performance. **Objective:** The present study aimed to evaluate the number of the canals of the mandibular incisors, since studies carried out on the subject present a high rate of mandibular incisors with two canals. **Methods:** In order to evaluate in detail the internal anatomy of the roots of incisors, the accuracy of the cone beam computed tomography in the observation of the root canals in human permanent teeth was evidenced in this study. We analized 97 tomographic images obtained using ORTHOPANTOMOGRAPH OP 300 (Instrumentarium, Tuusula, FI) of patients who underwent the diagnostic procedure for several reasons. All dental groups were analyzed individually and the morphology was determined according Vertucci Classification (1984). **Results:** The results observed the Chi-Square statistical test presented higher frequency of Types I and III (Vertucci Criterion) in relation to the other types ($p<0.001$). **Conclusion:** It was concluded that computed tomography is the viable resource to aid endodontic practice, especially in complex cases, such as the location of the root canals. The occurrence of more than one canal in central and lateral lower incisors was 23,71% in this study performed in the Brazilian population.

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

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Introduction

There are anatomical variations in each dental type. It may be the result of differences in terms of ethnic origin, age and sex of the population investigated.[1] Variations in the number of canals, configuration, curvature and presence of accessory roots can present both diagnostic and clinical challenges.[2-3] Awareness and understanding of the root canal anatomy are essential to facilitate the assessment of endodontic risk and to design the treatment plan. Conventional periapical radiography is considered the best clinical practice for preoperative evaluation of the root canal anatomy.[4] A two-dimensional image only provides us the dentition view in the mesiodistal plane (height and width). The root canal system (RCS) of permanent human teeth has been described in eight different morphological types according to the number of canals and the location of their divisions. This classification system is still the most frequently used in internal anatomy studies[5] (Fig 1).

In recent years, significant advances in the field of imaging have been introduced in dentistry such as digital radiography and computed tomography. Conic beam computed tomography (CBCT) overcomes the limitations of conventional periapical radiographs. It enables the visualization of the third dimension eliminating, thus, the overlapping of the overlying alveolar anatomy. Information from a CBCT scan provides the clinician with a deeper understanding of the root canal systems true morphology (including anatomical aberrations).[6-7]

The endodontic treatment aims to recover the shape and function of the tooth through a chemical-mechanical preparation of the pulp cavity and root canal filling.[8-9] To provide this treatment succesfully, the professional must identify, and properly treat, all the canals. Root canals can vary in number, size, diameter. They can also display specificities such as fusions or bifurcations. As endodontic therapy requires manipulation of the pulp cavity and root canals, the dental surgeon has to know the internal anatomy of the root canals and their possible variations. This will be key to perform a good clinical and radiographic evaluation as well as chemical-mechanical preparation.

In the endodontic clinic, it is essential to have (i) a general understanding of the three-dimensional morphological characteristics of the RCS and (ii) a good comprehension of the changes made during the endodontic treatment. Those knowledges enable to complement the information available during the treatment. Thus, thanks to the results provided by the CBCT, we may expect an evolution in the investigation of internal morphology for the acquisition of valuable information that will enable a better planning and execution of the endodontic treatment. Since the lower incisors have considerable variation in the number of canals, a study that seeks to elucidate such anatomy through Cone Beam Computed Tomography becomes relevant.

Material and methods

The research was approved by the Ethics and Research Committee under registration number at CEP 2.071.215. A total of 97 lower incisor teeth (45 central and 52 lateral incisors) were used in this descriptive observational study. The sample size calculation was based on the Cochran Method.[10] All images were obtained through the database of the Faculty Radiological Center. The reason why patients undergo CBCT include procedures for therapeutic planning for orthodontics, injury research and evaluation of fractures of dental organs. Inclusion and exclusion criteria were used to select these images.

Inclusion criteria

» a. Patients without distinction of sex, but aged between 18 and 30 years old;

» b. Healthy teeth, with a fully formed apex, uniradicular, without the presence of orthodontic appliances or any other material that could create artifacts in the tomographic examination;

» c. Teeth without presence of bone rarefaction in the periapex.

Exclusion criteria

» a. Patients under the age of 18 and over 30;

» b. Images that presented artifacts that could interfere with the observation of the studied tooth (leaving its evaluation in doubt). The artifacts observed were: root canal filling material, intraradicular pins, metallic crown restorations, orthodontic retaining and dental implants in adjacent teeth;

» c. Presence of any image that suggested periapical injury.

The images were acquired through the ORTHOPANTOMOGRAPH OP 300 cone beam computed tomography (Instrumentarium, Tuusula, FI) (Fig 2). This device enables to get high resolution images with maximum details of structures and sharpness with the following acquisition protocol: field of view with (FOV) 5 cm high x 5 cm wide in the Endo module; 0.085 mm voxel; 89 KVp working regime and a range of 6 to 8 mA; acquisition time of 6 seconds; 360 degrees of rotation. The images obtained were selected according to the inclusion criteria using the On Demand TM 3D software (USA OnDemand3D Technology Inc.1382 Valencia Ave. #B, Tustin, CA 92780, USA) (Fig 3). The data were stored in DICOM (digital imaging communication medicine) format. Using the software, the lower central and lower lateral incisors were evaluated: axial sections (section thickness of 1.0 mm) (Fig 4) to analyze the number of roots, canals and apical foramina. They were observed in three parts: cervical, middle and apical thirds; sagittal, coronal and axial sections (section thickness 1.0 mm) and 3D reconstruction to assist in determining the number of roots and configuration of the canals according to the Vertucci criterion. Each image was identified with a numeric code to maintain patients' anonymity. As general data, the following information was collected: sex and age. Three trained evaluators (two radiologists and one endodontist) performed the images observations separately and at two different times. The data were submitted to the Chi-square test for proportions, using an MS-Excel spreadsheet. The database is composed of spreadsheets related to the types of teeth (42, 41, 32, 31). At first, descriptive statistics were performed, showing the quantities and frequencies of the types of teeth evaluated and the characteristics of each type of group.

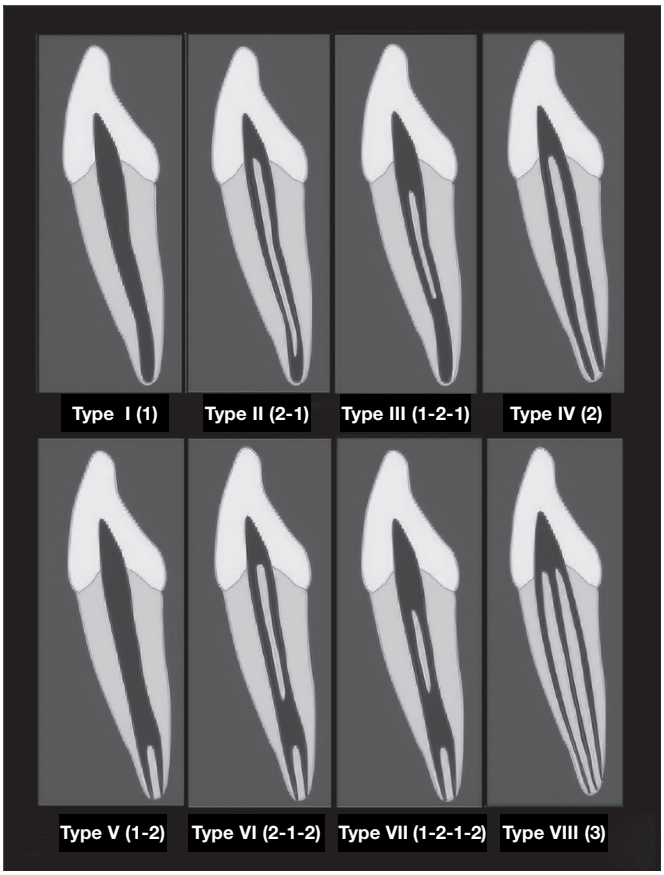

Figure 1. The root canal system (RCS) of permanent human teeth described in eight different morphological types.

Figure 2. 3 in 1 Instrumentarium OP300 CT scanner.

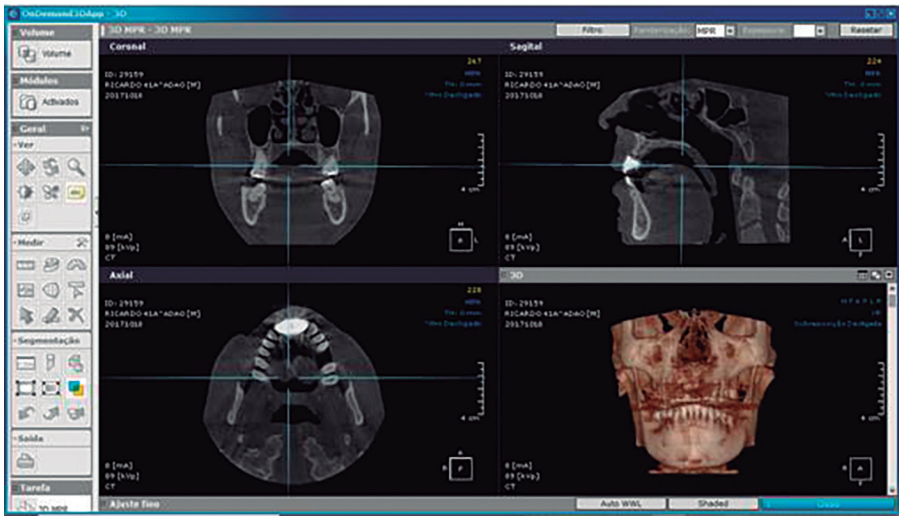

Figure 3. Screen with the OnDemand software in multiplanar reconstruction mode (MPR).

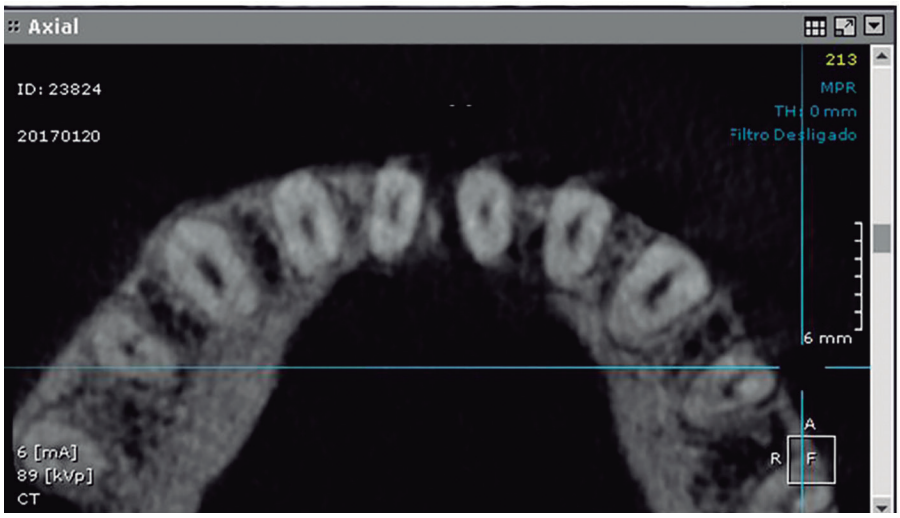

Figure 4. Axial section showing the use of the OnDemand software. Central and lateral incisors with a conduit.

Results

97 images, classified into eight types (numbered from I to VIII) and four teeth (41, 42, 31 and 32), were considered. A total of 46 central and 51 lateral incisors were evaluated. We obtained the following results:

a) All the comparisons of the representation percentages between the four teeth (in each of the eight types studied) are statistically non-significant (the teeth are statistically similar);
b) All the comparisons of the representation percentages between the eight types, in each tooth considered, present significant difference. This result was expected as several types were not found for some teeth (null frequency). Only three types were found in teeth 32 and 42, and only two types were found in teeth 31 and 41.

The data were submitted to the Chi-square test for proportions, using an MS-Excel spreadsheet. The distribution of these incisors is shown in table 1. The configuration of the root canals showed a higher frequency of Types I and III (Vertucci criterion, 1984) in relation to the other types. Comparing the frequency of Type I with Type III, there was a higher incidence with a significant difference in teeth 41, 42 and 32 ($p < 0.05$). In tooth 31, there was no significant difference when comparing Type I with Type III ($p > 0.05$). The incidence of a second canal in lower incisors was 23.71%. The configuration of the root canals showed a higher frequency of Types I and III (Vertucci criterion, 1984) in relation to the other types ($p < 0.001$).

Below, the frequency statistical results of tooth and type distribution. Summary table of observed frequencies:

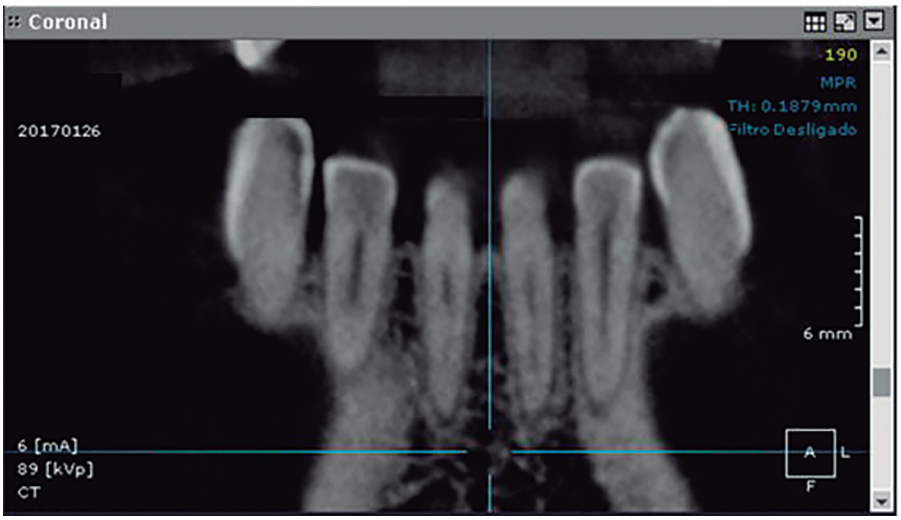

Figure 5. Coronal cut of lower incisors with a conduit.

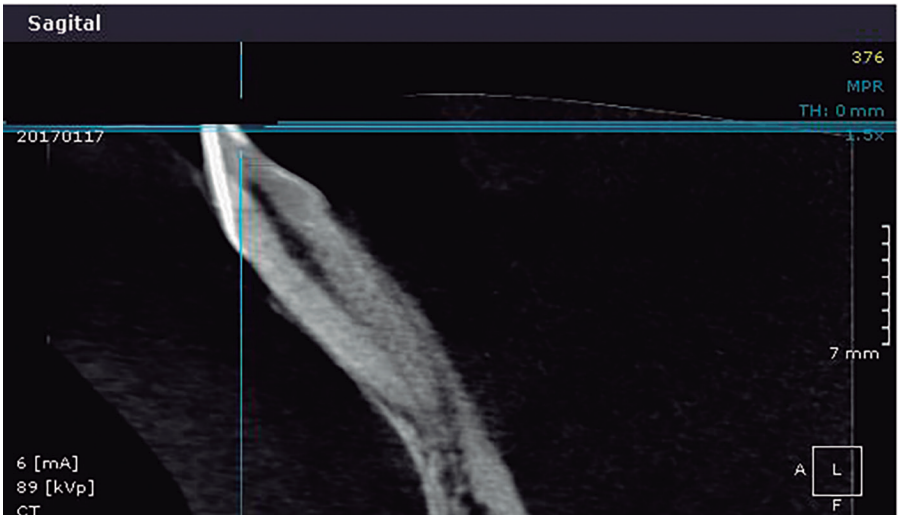

Figure 6. Type I inferior incisor sagittal cut (tooth 41).

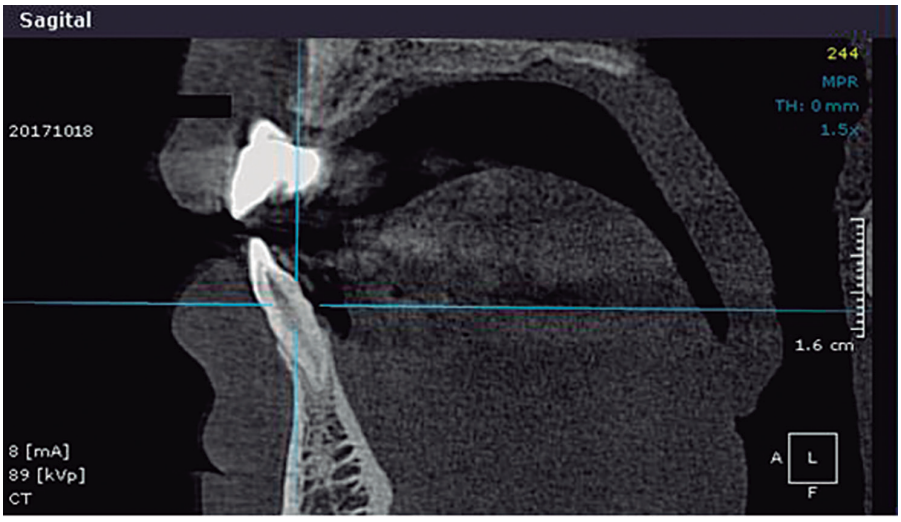

Figure 7. Image of a Type I incisive sagittal cut (tooth 42).

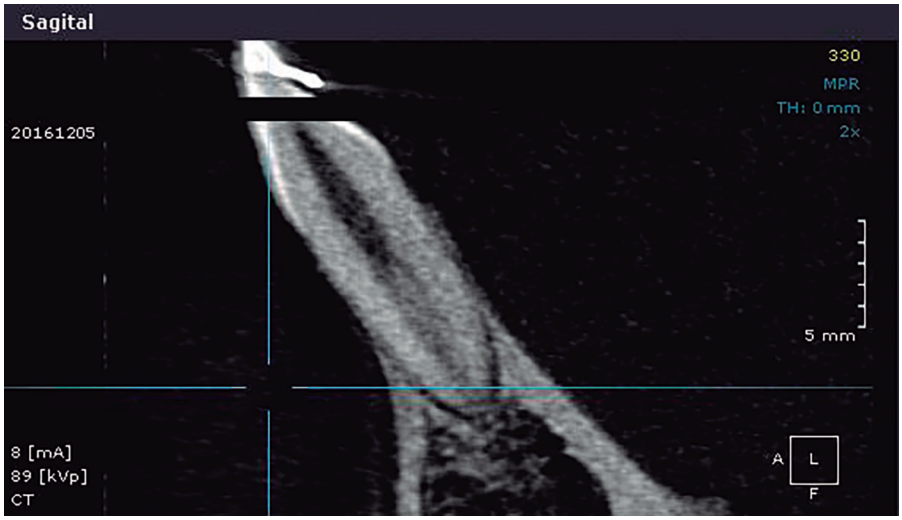

Figure 8. Type III incisor sagittal section (tooth 41).

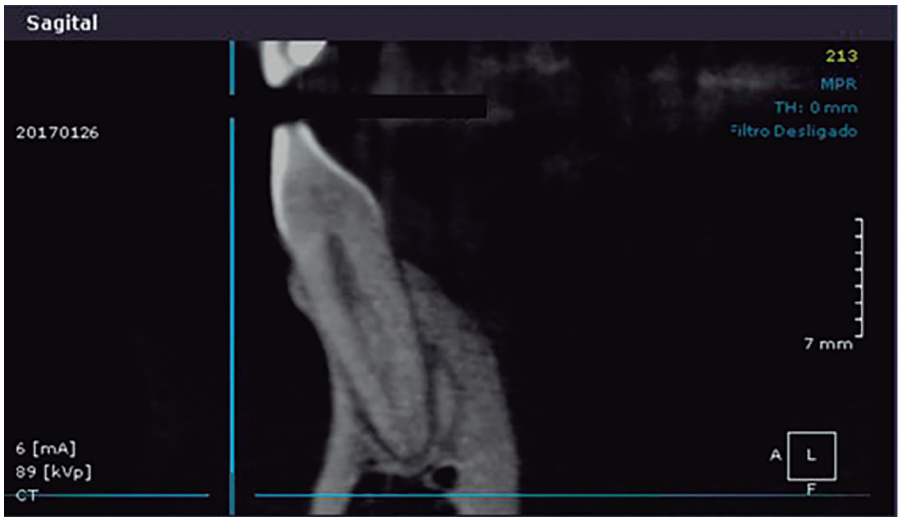

Figure 9. Sagittal view Image Type III lower lateral incisor (tooth 42).

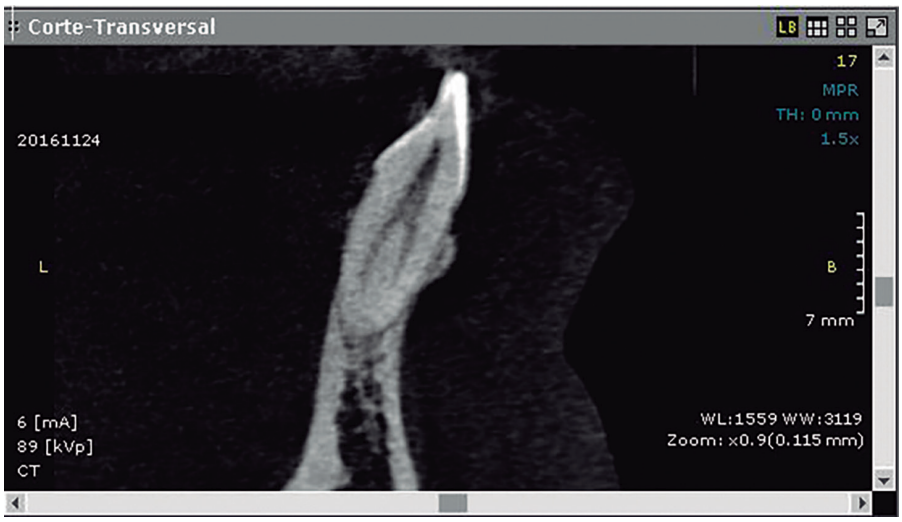

Figure 10. Type V left lower left incisor.

Table 1. Summary table of the observed frequency for each analyzed tooth.

TYPE	TEETH 41	TEETH 42	TEETH 32	TEETH 31	TOTAL
I	19	20	21	14	74
II	0	0	0	0	0
III	7	3	3	5	18
IV	0	0	0	0	0
V	0	3	2	0	5
VI	0	0	0	0	0
VII	0	0	0	0	0
VIII	0	0	0	0	0
TOTAL	**26**	**26**	**26**	**19**	**97**

Table 2. Statistical application of the Chi-Square Test for the four types of teeth evaluated.

TYPE	TEETH 41	TEETH 42	TEETH 32	TEETH 31	Sig (p)
I	73.08%	76.92%	80.77%	73.68%	0.206
II	0.00%	0.00%	0.00%	0.00%	>0.999
III	26.92%	11.54%	11.54%	26.32%	0.234
IV	0.00%	0.00%	0.00%	0.00%	>0.999
V	0.00%	11.54%	7.69%	0.00%	0.195
VI	0.00%	0.00%	0.00%	0.00%	>0.999
VII	0.00%	0.00%	0.00%	0.00%	>0.999
VIII	0.00%	0.00%	0.00%	0.00%	>0.999

Table 3. Statistical application of the Chi-Square Test for eight types of Vertucci.

TYPE	TEETH 41	TEETH 42	TEETH 32	TEETH 31
I	25.68%	27.03%	28.38%	18.92%
II	0.00%	0.00%	0.00%	0.00%
III	38.89%	16.67%	16.67%	27.78%
IV	0.00%	0.00%	0.00%	0.00%
V	0.00%	60.00%	40.00%	0.00%
VI	0.00%	0.00%	0.00%	0.00%
VII	0.00%	0.00%	0.00%	0.00%
VIII	0.00%	0.00%	0.00%	0.00%
Sig (p)	**< 0.001**	**0.011**	**0.014**	**0.015**

Discussion

As lower incisors anatomical complexity is important (this group of teeth display many specificities), a great knowledge of the internal anatomy is key to increase the endodontic treatment probability of success. Several methods have been used to investigate the number of canals in the lower incisors. Reports have shown that the computerized microtomography and the diaphanization technique provide accurate information about the root canal system. Nevertheless, they can only be used on extracted teeth. In the present study, we used CBCT, a non-invasive technique, on live teeth. This technique provides three-dimensional images in axial, sagittal and coronal sections. Although a tomography exam has usually higher radiation level than a periapical exam, the OP 300 tomograph (used in this study) is among one of the most technologically advanced tomographs in its category and enables to have a minimal radiation level with maximum contrast. The image is not distorted and its size is real (1:1). The chosen patients were young (between 18 and 30 years old), with teeth that did not suffer any wear, trauma or dentin deposition over time. Thus, as the dental anatomy was intact and preserved, the results were even more reliable. The tomography method avoids geometric distortions and anatomical overlapping.[11] However, the images of the CBCT may be compromised by the presence of metals in the oral cavity. This could lead to images with artifacts and with a lower quality than impages provided by periapical radiographs.[12-14] The high quality images acquired in this study and the possibilities of obtaining different types of cuts helped the observers'evaluations. Only high quality images were used as the presence of artifacts was considered an exclusion criteria. The On Demand 3D software enabled the analysis of images with extreme quality, showing us one of the main advantages of working with the CBCT. This software allowed us to manipulate the image, being able to handle brightness and contrast for better.

In addition, the reduced FOV of 5x5 provided us a better image quality. The image quality can be deteriorated when using devices that have a larger field of view. The tomograph used in the study provided us with a high resolution Endo module, to which all patients were directed. This feature enables us to get more accurate and reliable results. It is the first time that an anatomy research has been carried out with this CT scanner. The incidence of a second canal in lower incisors in this study was 23.71%. This is coherent with results found in other studies.[5,15] Regarding anatomical variations, ethnicity is a predisposing factor, such as the number of roots and canals.[16] However, there is a difficulty in establishing a pattern in the Brazilian population due to miscegenation.[17] In fact, the Brazilian population has one of the highest rates of ethnic diversity. This difficulty is evidenced by the relatively low amount of work on the morphological assessment of roots and canals through the CBCT (compared with other population).[18-20] The CBCT enables to locate a larger number of root canals than the radiographs (including in teeth already submitted to endodontics).[21] The CBCT has a reduced radiation dose but still present risks. Therefore, it is up to the clinician to select the cases in which this type of examination could be convenient. A tomographic examination with a reduced FOV of 5 x 5 performed by the OP 300 scanner from Instrumentarium has approximately the same radiation level as a periapical radiograph. In the majority of the studies, they observed that Vertucci Type III predominates when the number of canals in the lower incisors is analyzed (same observation as the one made in our study). However, some studies were carried out in populations where miscegenation was not significant. Therefore, the results are more reliable when compared to the Brazilian population where there is a high ethnic diversity. The lower incisors can present: one canal, two canals and one foramen, two canals and two foramens, and up to three canals, with the presence of two canals and two foramens being less frequent. However, normally, they have a single root with flattening in the mesiodistal direction and elongation in the vestibulolingual direction, mostly with rectilinear canals. The difficulty in locating and properly treating the second canal requires to perform radiographs at different angles and a thorough visual inspection. This is useful to prevent any anatomical variations.[22]

Conclusion

There is a prevalence of lower incisors with two canals in this study (23.71%). This is coherent with the results obtained by Vertucci (27.5%). In this study, the use of Cone Beam Computed Tomography proved to be an important auxiliary resource for endodontic practice. This is true especially in complex cases such as a case in which the second root canals is located in lower incisors.

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