

UNIVERSIDADE DE SÃO PAULO  
FACULDADE DE ODONTOLOGIA DE BAURU

GERMAN DIAZ ESPINOZA

**Evaluation of the presence of lateral canals in lower molars by  
means of computed tomography: Longitudinal study in a new  
software**

**Avaliação da presença de canais laterais em molares inferiores  
por meio de tomografia computadorizada: Estudo longitudinal em  
um novo software**

BAURU  
2022

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Dissertação constituída por artigo apresentada à Faculdade de Odontologia de Bauru da Universidade de São Paulo para obtenção do título de Mestre em Ciências no Programa de Ciências Odontológicas Aplicadas, na área de concentração Endodontia.

Orientador: Prof. Dr. Rodrigo Ricci Vivan

BAURU

2022

Diaz, German

Avaliação da presença de canais laterais em molares inferiores por meio de tomografia computadorizada: Estudo longitudinal em um novo software /German Diaz Espinoza. -- Bauru, 2022. 44 p.: il; 31 cm.

Dissertação (mestrado) -- Faculdade de Odontologia de Bauru, Universidade de São Paulo, 2022.

Orientador: Prof. Dr. Rodrigo Ricci Vivan

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Assinatura:

Data:

Comitê de Ética da FOB-USP  
Protocolo nº: 43490721600005417  
Data: 21 de julho de 2021

Universidade de São Paulo  
Faculdade de Odontologia de Bauru  
Assistência Técnica Acadêmica  
Serviço de Pós-Graduação



## FOLHA DE APROVAÇÃO


Dissertação apresentada e defendida por  
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em 01 de junho de 2022.





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# ERRATA

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## DEDICATÓRIA

Dedico esse trabalho com muito amor e gratidão, aos meus pais Mireya e Gerardo, meu irmão Gerardo, a minha esposa Belén e a toda minha família que com muito carinho e apoio não mediram esforços para lutar por minha educação.

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## **AGRADECIMENTOS**

Ao meu orientador Prof. Dr. Rodrigo Ricci Vivan, pela parceria, empenho, ensinamentos, suporte e correções dedicadas à elaboração deste trabalho. Muito obrigado por acreditar em mim e me inspirar a conquistar a excelência tanto no pessoal quanto no acadêmico.

Ao Conselho Nacional de Desenvolvimento científico e tecnológico CNPq pelo apoio financeiro fornecido para a realização da pesquisa envolvida na elaboração deste trabalho.

Ao Dr. Marco Antônio Húngaro Duarte pelo apoio, ensinamentos e incentivos para a elaboração deste trabalho.

À minha família, pelo apoio incondicional. Vocês são as pessoas mais importantes da minha vida.

Aos meus sogros Jose e Cecilia pelo apoio e o suporte incondicional que me brindaram nesta importante etapa da minha vida.

À minha esposa pela parceria e incentivo para alcançar meus sonhos sem importar os momentos difíceis.

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*“A persistência é o melhor caminho do êxito”*

**Charles Chaplin**

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## RESUMO

No presente estudo se utilizaram TCFC do banco de dados da Faculdade de Odontologia de Bauru. Foram selecionadas imagens tomográficas com alta resolução de pacientes atendidos no período compreendido entre (2014 a 2019). A análise das imagens foi realizada em um computador equipado com um processador Intel Core 2 Duo-6300 de 1,86 GHz, uma placa de vídeo turbo de cache NVIDIA GeForce 6200 e um monitor EIZO-Flexscan S2000 com uma resolução de 1600 x 1200 pixels e Windows XP SP-2 profissional. Um total de 100 molares inferiores foi visualizado em 2 softwares diferentes, sendo G1: e-Vol DX, e G2: 3D Accuitomo 170 J Morita. Para o escaneamento das imagens se realizaram 1024 visualizações seguindo o padrão: 3D, espessura de 0,100 mm, dimensões de 1,170 x 1,570 x 1,925 mm, campo de visão de 56,00 mm, tamanho de voxel de 0,100 mm e tempo de exposição de 33,5 segundos, a voltagem do tubo será de 90 kVp e a corrente do tubo será de 4 mA. Para a análise de dados quanto a localização do canal lateral na raiz mesial vestibular RMV nos terços cervical, médio e apical tanto para o G1 software e-Vol DX quanto para G2 software 3D Accuitomo 170 foi utilizado o teste fisher exact e quanto localização do canal lateral na raiz mesial lingual RML, e na raiz RD nos terços cervical, médio, apical foram avaliados pelo teste chi-square. No G1 conseguiu-se detectar e localizar com maior precisão o canal lateral na RMV no terço cervical (30,11%), na RML no terço médio (46,99%), e na RD no terço apical (23,53%). No G2 a localização do canal lateral na RMV foi em terço cervical (3,45%), na RML no terço médio (10,20%), e na RD no terço apical (13,64%). Por meio do e-Vol DX foi analisado que a distância da RM dos 1MI em relação ao canal mandibular foi de 5,14mm (desvio padrão de 1,99), enquanto que da RD até o canal mandibular foi de 4,41mm (desvio padrão de 1,98). Quanto aos 2MI, a RM apresentou uma distância média de 3,32 mm em relação ao canal mandibular (desvio padrão de 1,71 mm) e uma distância média de 2,99 mm da RD em relação ao canal mandibular (desvio padrão de 1,75 mm). Em conclusão o software e-Vol DX (Software CDT, Bauru, SP, Brasil) foi capaz de localizar com maior precisão e eficacia a presença do canal lateral tanto na RMV, RML e RD. Além de localizar a distância que existe entre a RM e RD dos primeiros e segundos molares inferiores permanentes em relação ao canal mandibular. **Palavras-chave:** Endodontia, TCFC, canais laterais.

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## ABSTRACT

### **Evaluation of the presence of lateral canals in lower molars by means of computed tomography: Longitudinal study in a new software**

In the present study, CBCT from the database of the Bauru Dental School was used. High resolution tomographic images of patients treated in the period between (2014 to 2019) were selected. For the evaluation of the images a computer equipped with a processor Intel Core 2 Duo-6300 with 1.86 GHz, an NVIDIA GeForce 6200 cache turbo graphics card and an EIZO-Flex scan S2000 monitor with a resolution of 1600 x 1200 pixels and Windows XP SP-2 professional was used. The sample number was 200 teeth divided into 2 groups for analysis: G1: 100 (e-Vol DX software, CDT software, Bauru, SP, Brazil) and G2: 100 (3D software Accuitomo 170 J. Morita, Kyoto, Japan) and for scanning the images, 1024 views were performed following the pattern: 3D, thickness of 0.100 mm, dimensions of 1.170 x 1.570 x 1.925 mm, field of view of 56.00 mm, voxel size of 0.100 mm and exposure time 33.5 seconds, the tube voltage will be 90 kVp and the tube current will be 4 mA. For the analysis of data regarding the location of the lateral canal in the mesial buccal root MBR in the cervical, middle and apical thirds for both the G1 software e-Vol DX and the G2 software 3D Accuitomo 170, the fisher exact test was used and for the location of the canal. lateral in the mesial lingual root LRM, and in the root DR in the cervical, middle, apical thirds were evaluated by chi-square test. In G1, it was possible to detect and locate the lateral canal with greater precision in the MBR in the cervical third (30.11%), in the LRM in the middle third (46.99%), and in the DR in the apical third (23.53%). In G2, the location of the lateral canal in the MBR was in the cervical third (3.45%), in the LRM in the middle third (10.20%), and in the DR in the apical third (13.64%). Using the e-Vol DX, it was analyzed that the distance from the MR of the LM1 in relation to the mandibular canal was 5.14 mm (standard deviation of 1.99), while from the DR to the mandibular canal it was 4.41 mm (standard deviation of 1.99). default of 1.98). As for the LM2, the MR showed an average distance of 3.32 mm in relation to the mandibular canal (standard deviation of 1.71 mm) and an average distance of 2.99 mm of the DR in relation to the mandibular canal (standard deviation of 1.75 mm). In conclusion, the e-Vol DX software (Software CDT, Bauru, SP, Brazil) was able to more accurately and efficiently locate the presence of the lateral canal in both MBR, LRM and DR. In addition to locating the distance that exists between the

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MR and DR of the first and second permanent lower molars in relation to the mandibular canal.

**Keywords:** Endodontics, CBCT, lateral canals.

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## LISTA DE ABREVIATURA E SIGLAS

AF	Forâmen apical
dpi	Dots per inch (pontos por polegada)
DICOM	Digital Imaging and Communications in Medicine
G1	Grupo1
G2	Grupo2
1MI	Primer molar inferior
2MI	Segundo molar inferior
MPR	Replicação de posições multiplanares
RM	Raiz mesial
RD	Raiz distal
RMV	Raiz mesial vestibular
RML	Raiz mesial lingual
TCFC	Tomografia computadorizada de feixe cônico

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## LISTA DE SIMBOLOS

GHz

Giga hertz

mA

mil amperes

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# 1 INTRODUÇÃO

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## 1 INTRODUÇÃO

A terapia endodôntica tem como objetivo reduzir a carga bacteriana durante o limiar da infecção para dessa forma evitar manifestações clínicas, radiográficas e tomográficas procurando que o organismo tenha condições de promover o reparo dos tecidos periapicais. <sup>1</sup> Para atingir este propósito é necessária a remoção de restos pulpares e microrganismos do sistema de canais radiculares, buscando a limpeza e a antissepsia o mais completa possível. <sup>2</sup>

O fracasso endodôntico está associado a muitos fatores, incluindo diversidade e virulência dos microrganismos, resposta imune do hospedeiro, <sup>2</sup> infiltrações coronária, e da complexidade do sistema de canais radiculares <sup>3,4,5</sup> A anatomia da região apical e seus tecidos periapicais adjacentes limitam o acesso do instrumento endodôntico. Dessa forma, as estratégias de tratamento, muitas vezes, não são suficientes para redução da carga microbiana abaixo do limiar para cura <sup>2,3,5,6</sup>

A área mais constricta (limite CDC) frequentemente encontrada próxima à junção cimento dentinária é considerada uma referência apical para o limite de preparo e obturação. O forame apical é a abertura do canal radicular para o periodonto apical, onde os vasos e fibras nervosas suprem a polpa e o ligamento periodontal. <sup>7</sup>Clinicamente na maioria dos casos a localização do forame não coincide com o ápice radicular. Além disso, a localização da junção cimento dentinária não pode ser determinada por meio de radiografias periapicais, por ser uma imagem bidimensional, apresentando limitações <sup>8,9,10,11</sup>

Arnold et al.<sup>12</sup> (2013) relatam que a causa da periodontite apical ou a perpetuação da mesma pode se dar por uma infecção bacteriana em forma de biofilme localizada dentro de ramificações apicais, avaliaram o número de forames e foraminas em incisivos e caninos superiores por meio de microscópio clínico e microscopia eletrônica de varredura. Concluíram que a média de forames e foraminas são 6 para cada dente. Diante disso, há necessidade de formas de descontaminação dessa área, sabendo do seu impacto no sucesso clínico.<sup>18</sup>

Estudos clássicos da literatura endodôntica classificam os canais laterais, secundários e acessórios, da seguinte maneira: canal lateral é aquele que sai do

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canal principal e desemboca no periodonto lateral, localizado nos terços cervical, médio e apical da raiz <sup>14</sup>

WU et al.<sup>15</sup>(2000) relatam que a terminação apical do tratamento endodôntico é considerada um fator importante no sucesso do tratamento assim em casos de biopulpectomias foi relatada grande taxa de sucesso principalmente quando os procedimentos terminaram 2 a 3 mm aquém do ápice radiográfico por outro lado em casos de necropulpectomia demonstra-se grande sucesso quando a obturação se realiza entre 0 e 2 mm do ápice radiográfico (0 a 2 mm).

A tomografia computadorizada de feixe cônico (TCFC) tem sido uma ferramenta de diagnóstico importante na prática clínica endodôntica devido a que permite identificar com precisão estruturas anatômicas de maior complexidade e lesões periapicais difíceis de serem visualizadas nas radiografias convencionais <sup>16,17,18,19,20,21</sup> existem softwares 3D assim como o Accuitomo 170 (J. Morita, Kyoto, Japan) com uma espessura de 0,100 mm, dimensões de 1,170 x 1,570 x 1,925 mm, campo de visão de 56,00 mm, tamanho de voxel de 0,100 mm que ajudam na visualização de algumas estruturas anatômicas, porém este software tem grandes limitações devido a que não consegue fornecer imagens em alta resolução <sup>22</sup> necessárias para o diagnóstico adequado, um dos grandes desafios para o clínico é a obtenção de imagens tomográficas de alta qualidade com redução de artefatos de alta densidade produzidos por obturações ou pinos metálicos intra canais, visto que estes artefatos ou materiais podem limitar a interpretação e induzir a grandes erros de diagnóstico, <sup>23</sup> em razão disso e no intuito de minimizar estes erros, diferentes fabricantes desenvolveram vários aparelhos de TCFC cada um acompanhado por um software específico, com a finalidade de obter imagens de alta qualidade, de fácil visualização de estruturas anatômicas complexas e precisão na identificação de lesões ocultas ou possivelmente não detectadas facilitando a resolução de situações clínicas complexas e aumentando o índice de sucesso no tratamento endodôntico. <sup>21</sup> Com o propósito de superar estes aspectos e apoiar no diagnóstico, planejamento e monitoramento de casos clínicos endodônticos, surgiu o e-Vol DX (Software CDT, Bauru, SP, Brasil), que devido a navegação dinâmica de imagens em vários planos, tamanhos submilimétricos do voxel, e capacidade de alterar os parâmetros de volume como espessura de corte, intervalos de corte, correção de dados por meio de filtros de imagem, e manipulação do brilho e do contraste fornece imagens em alta resolução

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para utilização na Endodontia, além disso a navegação e análise de imagens de tomografia computadorizada de feixe cônico (TCFC) por este novo software (e-Vol DX) permite determinar a posição do forame apical (AF) em relação às superfícies radiculares do dente permanente com uma eficácia maior do que outros softwares.<sup>19</sup>

Entre as principais vantagens do e-Vol DX com outros softwares contam a compatibilidade com todos os scanners de TCFC atuais, capacidade de exportar dados DICOM, ajuste de brilho e contraste mais abrangente comparado a outros aplicativos em que os ajustes são limitados e geralmente não suportam todos os recursos da faixa dinâmica DICOM, ajuste de espessura de corte personalizado, ajuste de nitidez, algoritmo avançado de redução de ruído que melhora a qualidade da imagem, filtros de imagem predefinidos, filtros para a análise de volume do canal radicular com a capacidade de ampliar a imagem em mais de 1000x em reconstruções em 3D sem perda de resolução, personalização de parâmetros de imagem automática e captura com resolução da tela de 192 dpi tendo a opção de 384 dpi, em contraste com os 96 dpi das aplicações similares.<sup>21</sup>

Conforme mencionado anteriormente o presente estudo tem a finalidade de analisar imagens de TCFC usando estratégias de navegação multidimensional tanto com o novo software e-Vol DX (Software CDT, Bauru, SP, Brasil) quanto com o software Accuitomo 170 (J. Morita, Kyoto, Japan) para determinar a presença canais laterais na RMV, na RML e na RD, por outro lado, também pretende-se identificar com o software e-Vol DX (Software CDT, Bauru, SP, Brasil) a distância que existe entre a RM e RD dos primeiros e segundos molares inferiores em relação ao canal mandibular.

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## **2 ARTIGO**

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## 2 ARTIGO

The article presented in this Dissertation was written according to the Journal of Endodontics and guidelines for article submission

(<https://www.aae.org/specialty/publications-research/journal-of-endodontics/joe-authors/guidelines-publishing-papers-joe/>)

**Title:** Evaluation of the presence of lateral canals in lower molars by means of computed tomography: Longitudinal study in a new software.

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### **Acknowledgements**

To the National Council for Scientific and Technological Development CNPq for the financial support provided to carry out the research involved in the preparation of this work.

**Abstract**

**Introduction:** In the present study, CBCT from the database of the Bauru Dental School was used. High resolution tomographic images of patients treated in the period between (2014 to 2019) were selected. For the evaluation of the images a computer equipped with a processor Intel Core 2 Duo-6300 with 1.86 GHz, an NVIDIA GeForce 6200 cache turbo graphics card and an EIZO-Flex scan S2000 monitor with a resolution of 1600 x 1200 pixels and Windows XP SP-2 professional was used. The sample number was 200 teeth divided into 2 groups for analysis: G1: 100 (e-Vol DX software, CDT software, Bauru, SP, Brazil) and G2: 100 (3D software Accuitomo 170 J. Morita, Kyoto, Japan) and for scanning the images, 1024 views were performed following the pattern: 3D, thickness of 0.100 mm, dimensions of 1.170 x 1.570 x 1.925 mm, field of view of 56.00 mm, voxel size of 0.100 mm and exposure time 33.5 seconds, the tube voltage will be 90 kVp and the tube current will be 4 mA. For the analysis of data regarding the location of the lateral canal in the mesial buccal root MBR in the cervical, middle and apical thirds for both the G1 software e-Vol DX and the G2 software 3D Accuitomo 170, the fisher exact test was used and for the location of the canal. lateral in the mesial lingual root LRM, and in the root DR in the cervical, middle, apical thirds were evaluated by chi-square test. In G1, it was possible to detect and locate the lateral canal with greater precision in the MBR in the cervical third (30.11%), in the LRM in the middle third (46.99%), and in the DR in the apical third (23.53%). In G2, the location of the lateral canal in the MBR was in the cervical third (3.45%), in the LRM in the middle third (10.20%), and in the DR in the apical third (13.64%). Using the e-Vol DX, it was analyzed that the distance from the MR of the LM1 in relation to the mandibular canal was 5.14 mm (standard deviation of 1.99), while from the DR to the mandibular canal it was 4.41 mm (standard deviation of 1.99). default of 1.98). As for the LM2, the MR showed an average distance of 3.32 mm in relation to the mandibular canal (standard deviation of 1.71 mm) and an average distance of 2.99 mm of the DR in relation to the mandibular canal (standard deviation of 1.75 mm). In conclusion, the e-Vol DX software (Software CDT, Bauru, SP, Brazil) was able to more accurately and efficiently locate the presence of the lateral canal in both MBR, LRM and DR. In addition to locating the distance that exists between the MR and DR of the first and second permanent lower molars in relation to the mandibular canal.

**Keywords:** Endodontics, CBCT, lateral canals.

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## 1 Introduction

Endodontic therapy aims to reduce the bacterial load during the threshold of infection in order to avoid clinical, radiographic and tomographic manifestations, seeking for the organism to be able to promote the repair of periapical tissues.<sup>1</sup> To achieve this purpose, it is necessary to remove pulp residues and microorganisms from the root canal system, seeking the most complete cleaning and antiseptics possible.<sup>2</sup>

Endodontic failure is associated with many factors, including diversity and virulence of microorganisms, host immune response,<sup>2</sup> coronary infiltration, and the complexity of the root canal system;<sup>3,4,5</sup> The anatomy of the apical region and its adjacent periapical tissues limit the access of the endodontic instrument. Thus, treatment strategies are often not sufficient to reduce the microbial load below the threshold for cure.<sup>2,3,5,6</sup>

The most constricted area (CDC boundary) often found near the dentin cement junction is considered an apical reference for the preparation and filling boundary. The apical foramen is the opening of the root canal to the apical periodontium, where the vessels and nerve fibers supply the pulp and the periodontal ligament.<sup>7</sup> Clinically, in most cases, the location of the foramen does not coincide with the root apex. Furthermore, the location of the dentin cement junction cannot be determined by means of periapical radiographs, as it is a two-dimensional image, presenting limitations<sup>8,9,10,11</sup>

Arnold et al.<sup>12</sup> (2013) report that the cause of apical periodontitis or its perpetuation may be a bacterial infection in the form of a biofilm located within apical branches, evaluated the number of foramina and foramina in maxillary incisors and canines using clinical microscope and scanning electron microscopy.<sup>13</sup> They concluded that the average number of foramina and foramina is for each tooth. Therefore, there is a need for ways to decontaminate this area, knowing its impact on clinical success. Classic studies in the endodontic literature classify the lateral, secondary and accessory canals as follows: lateral canal is the one that leaves the main canal and opens into the lateral periodontium, located in the cervical, middle and apical thirds of the root.<sup>14</sup>

WU et al.<sup>15</sup>(2000) report that the apical termination of endodontic treatment is considered an important factor in the success of the treatment. On the other hand, in cases of necropulpectomy, great success is demonstrated when the obturation is performed between 0 and 2 mm from the radiographic apex (0 to 2 mm).

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Cone-beam computed tomography (CBCT) has been an important diagnostic tool in endodontic clinical practice because it allows the precise identification of more complex anatomical structures and periapical lesions that are difficult to visualize on conventional radiographs<sup>16,17,18,19,20</sup> there are 3D software such as the Accuitomo 170 (J. Morita, Kyoto, Japan) with a thickness of 0.100 mm, dimensions of 1.170 x 1.570 x 1.925 mm, field of view of 56.00 mm, 0.100 mm voxel size that help in the visualization of some anatomical structures, however this software has major limitations due to the fact that I was not able to provide high resolution images<sup>21</sup> necessary for proper diagnosis, one of the great challenges for the clinician is to obtain high quality tomographic images with reduced of high-density artifacts produced by intra-canal fillings or metallic posts, as these artifacts or materials can limit interpretation and induce large diagnostic errors<sup>22</sup>, As a result and in order to minimize these errors, different manufacturers have developed several CBCT devices, each one accompanied by a specific software, in order to obtain high quality images, easy visualization of complex anatomical structures and precision in the identification of hidden lesions. or possibly undetected, facilitating the resolution of complex clinical situations and increasing the success rate in endodontic treatment<sup>20</sup> In order to overcome these aspects and support the diagnosis, planning and monitoring of endodontic clinical cases, the e-Vol DX (Software CDT, Bauru, SP, Brazil) emerged, which, due to the dynamic navigation of images in several planes, submillimeter sizes of voxel, and the ability to change volume parameters such as slice thickness, slice intervals, data correction through image filters, and brightness and contrast manipulation provide high resolution images for use in Endodontics, in addition to Navigation and analysis of Cone Beam Computed Tomography (CBCT) images by this new software (e-Vol DX) allows determining the position of the apical foramen (AF) in relation to the root surfaces of the permanent tooth with greater efficiency than other software.<sup>18</sup>

Among the main advantages of e-Vol DX with other software are compatibility with all current CBCT scanners, ability to export DICOM data, more comprehensive brightness and contrast adjustment compared to other applications where adjustments are limited and generally not supported. full DICOM dynamic range features, custom slice thickness adjustment, sharpness adjustment, advanced noise reduction algorithm that improves image quality, predefined image filters, filters for root canal volume analysis with the ability to magnifying the image by more than 1000x in 3D

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reconstructions without loss of resolution, automatic image parameter customization and capture with a screen resolution of 192 dpi with the option of 384 dpi, in contrast to the 96 dpi of similar applications.<sup>20</sup>

As previously mentioned, the present study aims to analyze CBCT images using multidimensional navigation strategies both with the new e-Vol DX software (Software CDT, Bauru, SP, Brazil) and with the Accuitomo 170 software (J. Morita, Kyoto, Japan) to determine the presence of lateral canals in the RMV, RML and RD, on the other hand, it is also intended to identify with the e-Vol DX software (Software CDT, Bauru, SP, Brazil) the distance between the MRI and DR of lower first and second molars in relation to the mandibular canal.

## **2 Material and methods**

### **2.1 Ethics Committee**

As a previous requirement, this study was approved by the Ethics Committee in Research on Human Beings of the Bauru Dental School (CAAE: 43490721600005417).

### **2.2. sample selection**

In this study, pre-existing CBCT in the database of the Bauru School of Dentistry of patients treated in the period between (2014 to 2019) were evaluated, only high-resolution images were considered to ensure analytical accuracy. Inclusion criteria were tomographic images showing teeth without endodontic treatment, without the presence of crowns or calcified root canals, without internal or external root resorption, without a history of orthodontic treatment and with a fully formed apex. Third molars were excluded from the study. The sample was 100 lower molars analyzed into 2 softwares: G1: e-Vol DX software, and G2: 3D software Accuitomo 170 J. Morita.

### **2.3. Data collects**

High resolution images of patients seen in the last 5 years were selected, all CT scans followed the same scanning pattern: 3D Accuitomo 170 (J. Morita, Kyoto, Japan), thickness of 0.100 mm, dimensions of 1,170 x 1,570 x 1,925 mm, 56.00 mm field of view, 0.100 mm voxel size, and 33.5 second exposure time (1024 views). The tube voltage will be 90 kVp and the tube current will be 4 mA. Images will be examined on a computer equipped with a 1.86 GHz Intel Core 2 Duo-6300 processor (Intel Corp, Santa Clara, CA), an NVIDIA GeForce 6200 cache turbo graphics card (NVIDIA Corporation, Santa Clara, CA), an EIZO-Flexscan S2000 monitor with a resolution of

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1600x 1200 pixels (EIZO NANAO Corp, Hakusan, Japan) and Windows XP SP-2 Professional (Microsoft Corp, Redmond, WA).

For the identification of the lateral canals in the CBCT images regarding the root surfaces, it was determined longitudinally through axial, sagittal and coronal cuts of 0.1 mm / 0.1 mm from the pulp orifice to the root apex and from the apex to the coronal region. The dynamics of reading the CBCT will be the same as in previous studies.<sup>3,14</sup> When necessary, images will be oriented perpendicularly to correct parallelism errors. The axial cut will be individualized for each canal. As these are mandibular molars, it started at the mesial root and then at the distal root. Regarding the position of the lateral canals in relation to the mesial-buccal, mesial-lingual and distal root surfaces, the lateral canal measurements were performed dynamically by traversing the image of the apical foramen up to the upper 5 mm with the new software (e-Vol DX; CDT Software, Bauru, SP, Brazil).

#### 2.4. Statistical analysis

For data analysis on the location of the lateral canals in the MBR in the software G1 e-Vol DX and in the software G2 Accuitomo 170 3D, the fisher exact test was used, and the location of the lateral canal in the LRM and in the distal root DR were used. evaluated by the chi-square test. Statistical analysis was performed with a significance level of 5%.

### 3 Results

#### 3.1. Data Collection

In this study, 48 CBCT cointaing 100 lower molars were selected from pre-existing high-resolution tomographic images from the database of patients treated in the last 5 years at the Bauru School of Dentistry were evaluated. G1 teeth were evaluated with the e-Vol DX software (Software CDT, Bauru, SP, Brazil) while G2 teeth were evaluated with the Accuitomo 170 3D software (J. Morita, Kyoto, Japan).

#### 3.2. Statistical Analysis

After performing the descriptive and comparative analysis regarding the location of the lateral canal in the mesiobuccal root MBR in the cervical third, it was possible to detect and locate with greater precision the presence of the lateral canal in the teeth of G1 than in the teeth of G2. As shown in Table 1.

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Table 1. Location of the lateral canal MBR in the cervical third G1, G2.

<b>Mesio-buccal Root MBR</b>	<b>Presence in the cervical third</b>	<b>Not presence in the cervical third</b>
<b>Software</b>	Yes	Not
<b>G1 Software e-Vol DX</b>	30,11%	69,89%
<b>G 2 Software Morita</b>	3,45%	96,55%

After performing a descriptive and comparative analysis regarding the location of the lateral canal in the mesial lingual root LRM in the middle third, it was possible to detect and locate with greater precision the presence of the lateral canal in the teeth of G1 than in the teeth of G2. As shown in Table 2.

Table 2. Location of the lateral canal in the LRM in the middle third G1, G2.

<b>Mesial Lingual Root LRM</b>	<b>Presence in the middle third</b>	<b>Not presence in the middle third</b>
<b>Software</b>	Yes	Not
<b>G1 Software e-Vol DX</b>	46,99%	53,01%
<b>G 2 Software Morita</b>	10,20%	89,80%

After performing a descriptive and comparative analysis regarding the location of the lateral canal in the distal root DR in the apical third, it was possible to detect and locate with greater precision the presence of the lateral canal in the teeth of G1 than in the teeth of G2. As shown in Table 3.

Table 3. Location of the lateral canal in the DR in the apical third G1, G2.

<b>Distal Root DR</b>	<b>Presence in the apical third</b>	<b>Not presence in the apical third</b>
<b>Software</b>	Yes	Not
<b>G1 Software e-Vol DX</b>	23,53%	76,47%
<b>G 2 Software Morita</b>	13,64%	86,36%

After performing the descriptive and comparative analysis regarding the distance of the RM and the DR of the lower first molars LM1 in relation to the mandibular canal with the e-Vol DX software, it was possible to detect and locate the mean and standard deviation. As shown in Table 4.

Table 4. Distance of MR and DR in lower first molars LM1.

<b>Lower first molars</b>	<b>Mesial Root MR</b>	<b>Distal Root DR</b>
<b>Average</b>	5,14 mm	4,41 mm
<b>Standard deviation</b>	1,99 mm	1,98 mm

After performing the descriptive and comparative analysis regarding the distance of the MR and the DR of the lower second molars LM2 in relation to the mandibular canal with the e-Vol DX software, it was possible to detect and locate the mean and standard deviation. As shown in Table 5.

Table 5. Distance of MR and DR in lower second molars LM2

<b>Lower second molars</b>	<b>Mesial Root MR</b>	<b>Distal Root DR</b>
<b>Average</b>	3,32 mm	2,99 mm
<b>Standard deviation</b>	1,71 mm	1,75 mm

#### 4 Discussion

In endodontic practice, the accurate identification of the anatomical structures as well as the internal anatomy of the root canal system is of great importance to achieve the removal of pulp debris and microorganisms from the canal system during endodontic therapy.<sup>2</sup> the inadequate identification of these anatomical structures could lead to root canal treatment failure because some areas could remain affected or without biomechanical preparation, which is why the identification of these anatomical complexities is still a great challenge for the clinician<sup>23, 24</sup> However, the use of CBCT together with the use of software allows the identification of more complex anatomical structures and periapical lesions that are difficult to visualize on conventional radiographs<sup>26, 16,17,18</sup>

There is 3D software such as the Accuitomo 170 (J. Morita, Kyoto, Japan) that help in visualizing some anatomical structures, but this software has major limitations because I was unable to provide high resolution images<sup>21</sup> necessary for diagnosis and adequate planning in endodontic treatments.

Contrary to the Accuitomo 170 3D software (J. Morita, Kyoto, Japan) the new e-Vol software has emerged. DX (Software CDT, Bauru, SP, Brazil) that provides better quality and resolution images, with more comprehensive adjustment of brightness and contrast in line with other software where adjustments are limited and generally do not

support all DICOM dynamic range features, In addition, it also allows for custom sharpening and slice thickness adjustment and predefined image filters for root canal volume analysis with the ability to magnify the image by more than 1000x in 3D reconstructions without loss of resolution.<sup>20</sup>

In view of the above, the study aimed to compare the e-Vol DX and Accuitomo 170 J Morita software regarding the identification of lateral canals in lower molars. Each software was able to detect lateral canals in different thirds of the lower molar roots. However, with the e-Vol DX software there were more canals identified along the roots, due to its tools, filters and adjustments, without losing image resolution.

The results showed that during the analysis of the CBCT images of the teeth evaluated with the e-Vol DX software and the Accuitomo 170 3D software, the presence of the lateral canal was identified in the MRV, LRM and DR in the cervical, middle and apical thirds. However, in teeth evaluated with the e-Vol DX software, the presence of lateral canals was more accurately and effectively identified.

After presenting the best results with the e-Vol DX software, this software was also used to measure the distance between the mesial and distal roots of the lower molars in relation to the mandibular canal. The data are obtained from great efforts for the clinician to follow the evolution through the foramen, to obtain the possibility of material leakage, as well as to serve as a guide for paraendodontic surgeries.

In conclusion, the e-Vol DX software (Software CDT, Bauru, SP, Brazil) was able to more accurately and efficiently locate the presence of the lateral canal in both the buccal mesial root VRM, mesial lingual root LRM and distal root DR. In addition to allowing to locate the distance that exists between the MR and DR of the first and second permanent lower molars in relation to the mandibular canal.

### **Acknowledgements**

To the National Council for Scientific and Technological Development CNPq for the financial support provided to carry out the research involved in the preparation of this work.

### **Conflict of interest**

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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## **3 DISCUSSÃO**

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### **3 DISCUSSÃO**

Na prática endodôntica a identificação apurada das estruturas anatômicas assim como da anatomia interna do sistema de canais radiculares é de grande importância para conseguir a remoção de restos pulpares e microrganismos do sistema de canais durante a terapia endodôntica <sup>2</sup> no entanto a identificação não adequada destas estruturas anatômicas poderia levar ao insucesso do tratamento de canal devido a que algumas áreas poderiam permanecer afetadas ou sem preparo biomecânico motivo pelo qual a identificação de estas complexidades anatômicas ainda é um grande desafio para o clínico. <sup>24,25</sup> Porém a utilização de TCFC somada ao uso de softwares permite a identificação de estruturas anatômicas de maior complexidade e lesões periapicais difíceis de serem visualizadas nas radiografias convencionais. <sup>16,17,18,19</sup>

Existem softwares 3D assim como o Accuitomo 170 (J. Morita, Kyoto, Japan) que ajudam na visualização de algumas estruturas anatômicas, porém este software tem grandes limitações devido a que não conseguiu fornecer imagens em alta resolução, <sup>22</sup> necessárias para o diagnóstico e planejamento adequado nos tratamentos endodônticos.

Contrariamente ao software 3D Accuitomo 170 (J. Morita, Kyoto, Japan) surgiu o novo software e-Vol. DX (Software CDT, Bauru, SP, Brasil) que fornece imagens de melhor qualidade e resolução, com ajuste de brilho e contraste mais abrangente conforme a outros softwares em que os ajustes são limitados e geralmente não suportam todos os recursos da faixa dinâmica DICOM, além disso também permite o ajuste de espessura de corte e nitidez personalizado e filtros de imagem predefinidos para a análise de volume do canal radicular com a capacidade de ampliar a imagem em mais de 1000x em reconstruções em 3D sem perda de resolução. <sup>21</sup>

Diante do exposto o estudo teve como finalidade comparar os softwares e-Vol DX e Accuitomo 170 J Morita quanto a identificação de canais laterais em molares inferiores. Ambos os softwares foram capazes de detectar canais laterais em diferentes terços das raízes dos molares inferiores. No entanto, com o software e-Vol

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DX houveram mais canais identificados ao longo das raízes, devido às suas ferramentas, filtros e ajustes, sem perder resolução de imagem.

Após apresentar melhores resultados com o software e-Vol DX, utilizou-se este software também para mensurar a distância entre as raízes mesial e distal dos molares inferiores em relação ao canal mandibular. Os dados obtidos são de grande relevância para que o clínico possa acompanhar a evolução de lesões perirradiculares, para se atentar quanto a possibilidade de extravasamento de materiais via forame, assim como servir de orientação para cirurgias paraendodônticas.

Em conclusão, o software e-Vol DX (Software CDT, Bauru, SP, Brasil) foi capaz de localizar com maior precisão e eficácia a presença de canal lateral nas raízes RMV, RML, RD dos molares inferiores. Além disso, este software também permitiu mensurar a distância que existe entre o RM e DR do primeiro e segundo molares inferiores permanentes em relação ao canal mandibular.

### **Agradecimentos**

Ao Conselho Nacional de Desenvolvimento Científico e Tecnológico CNPq pelo apoio financeiro para a realização da pesquisa envolvida na elaboração deste trabalho.

### **Conflito de interesses**

Os autores declararam explicitamente que não há conflitos de interesse em relação a este artigo.

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# **ANEXOS**

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FIGURAS



Figure1. Software 3D Accuitomo 170 (J. Morita, Kyoto, Japão)

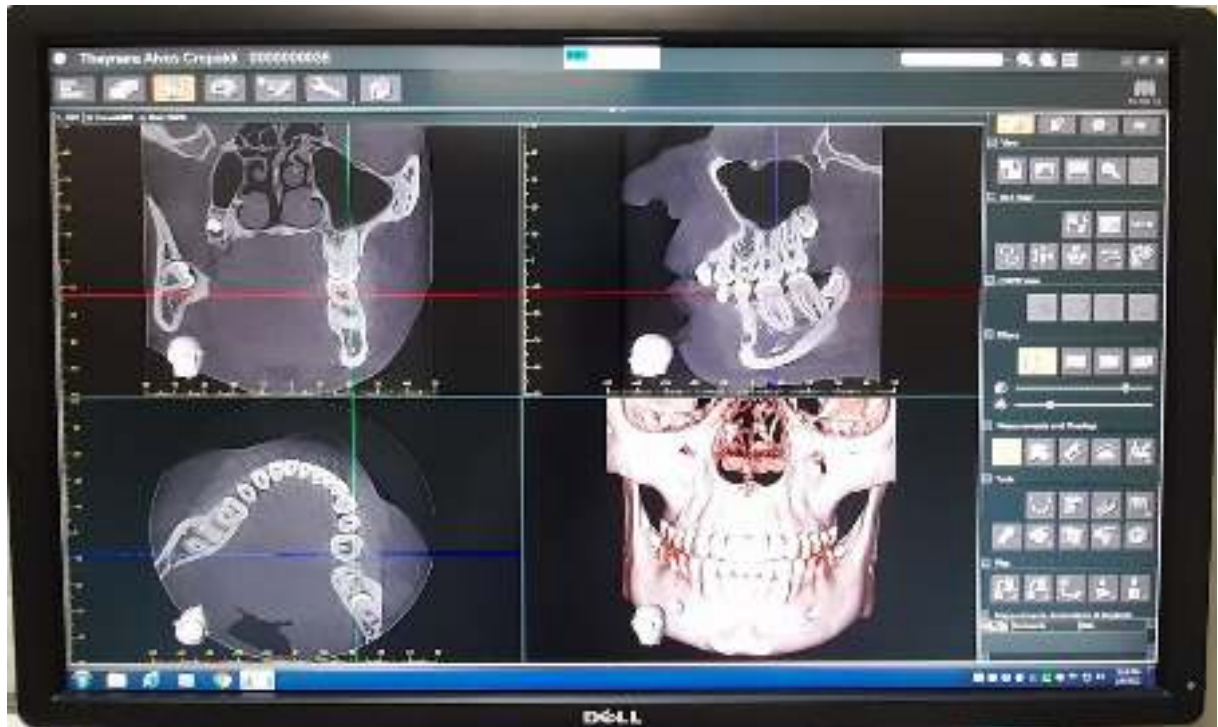


Figure 2. Monitor EIZO-Flexscan S2000 Resolução de 1600 x 1200 pixels (EIZO NANA O Corp, Hakusan, Japão) e Windows XP SP-2 Professional (Microsoft Corp, Redmond, WA).



Figure 3. Representação reconstrutiva da localização do canal lateral utilizando o software e-Vol DX (Software CDT, Bauru, SP, Brasil)



Figura 4. Representação reconstrutiva da localização da distância entre a raiz mesial (RM) e a raiz distal (RD) em relação ao canal mandibular com o software e-Vol DX (Software CDT, Bauru, SP, Brasil)