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Influência do tamanho do FOV e voxel na avaliação da espessura dentinária radicular em molares inferiores: estudo em tomografia computadorizada de feixe cônico

Governador Valadares

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Dissertação apresentada ao Programa de Pós-Graduação em Ciências Aplicadas à Saúde, da Universidade Federal de Juiz de Fora, Campus Governador Valadares, como requisito parcial à obtenção do título de Mestre em Ciências Aplicadas à Saúde.

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"O cientista não é o homem que fornece as verdadeiras respostas; é quem faz as verdadeiras perguntas."

Claude Levi Straus

RESUMO

O conceito de zona de perigo (danger zone - DZ) foi estabelecido em 1980 por Abou-Rass et al., quando este sugeriu a técnica de instrumentação anticurvatura para o preparo de canais curvos. A DZ é uma região específica da raiz mais suscetível à perfuração e rasgos em caso de retirada excessiva de dentina durante o preparo mecânico. O objetivo deste estudo experimental foi verificar se a avaliação da zona de perigo (ZD) dos molares inferiores é afetada pelo tamanho do FOV e voxel em exames de tomografia computadorizada de feixe cônico (TCFC), em comparação com imagens de micro-TC como padrão de referência. Assim, quarenta primeiros e segundos molares inferiores foram selecionados. Os dentes foram escaneados em um dispositivo de microtomografia computadorizada (micro-TC) para estabelecer imagens padrão de referência. Em seguida, eles foram submetidos a varreduras TCFC variando o campo de visão (FOV) (10 x 5,5 cm; 5 x 5,5 cm) e tamanho do voxel (0,4, 0,2, 0,15, 0,075 mm). As imagens foram avaliadas por dois endodontistas quanto à espessura da dentina dos molares inferiores, em cortes axiais a 2, 4 e 6 mm da furca radicular. A menor espessura de dentina dos canais mésio-vestibular e mésio-lingual foi medida na superfície externa distal da raiz mesial. Todas as avaliações foram realizadas em condições padronizadas. Os dados coletados foram analisados por meio de estatística descritiva e inferencial (coeficiente de correlação intraclasse (ICC) e teste T pareado) ($p<0,05$). Como resultado desse estudo encontramos que todas as medidas superestimaram a espessura da dentina radicular em comparação com o padrão de referência ($p<0,001$). Ao usar o tamanho do voxel de 0,4 mm com FOV de 5 x 5,5 cm, o valor da espessura da dentina foi mais superestimado ($p = 0,007$), ao comparar os FOVs. Em contrapartida, a espessura da dentina com tamanho de voxel de 0,075 mm e FOV de 5 x 5,5 cm foi significativamente menor e apresentou o melhor valor de ICC com o padrão de referência (0,936). Diante do exposto concluímos que a TCFC superestima a espessura da dentina da DZ dos molares inferiores, independentemente do FOV e dos tamanhos dos voxels. O FOV de 5 x 5,5 cm apresentou o melhor desempenho com o tamanho do voxel de 0,075 mm, enquanto teve um desempenho ruim com o tamanho do voxel de 0,4 mm.

Palavras-chave: Dentina. Microtomografia computadorizada. Dente molar. Tomografia computadorizada de feixe cônico. Endodontia.

ABSTRACT

The danger zone concept (DZ) was established in 1980 by Abou-Rass et al., when he suggested the anti-curvature instrumentation technique for the preparation of curved root canals. The DZ is a specific region of the root more susceptible to perforation and strips in case of excessive removal of dentin during mechanical preparation. The aim of this experimental study was to verify whether the assessment of the danger zone (ZD) of mandibular molars is affected by the size of the FOV and voxel in cone-beam computed tomography (CBCT) scans, compared to standard micro-CT images. of reference. Thus, forty mandibular first and second molars were selected. Teeth were scanned on a computed microtomography (micro-CT) device to establish reference standard images. Then they underwent CBCT scans varying the field of view (FOV) (10 x 5.5 cm; 5 x 5.5 cm) and voxel size (0.4, 0.2, 0.15, 0.075 mm). The images were evaluated by two endodontists regarding the dentin thickness of the lower molars, in axial sections at 2, 4 and 6 mm from the root furcation. The smallest dentin thickness of the mesiobuccal and mesiolingual canals was measured on the distal outer surface of the mesial root. All assessments were performed under standardized conditions. The collected data were analyzed using descriptive and inferential statistics (intraclass correlation coefficient (ICC) and paired t test) ($p<0.05$). As a result of this study, we found that all measurements overestimated root dentin thickness compared to the reference standard ($p<0.001$). When using a voxel size of 0.4 mm with a FOV of 5 x 5.5 cm, the dentin thickness value was more overestimated ($p = 0.007$) when comparing the FOVs. In contrast, the dentin thickness with voxel size of 0.075 mm and FOV of 5 x 5.5 cm was significantly smaller and presented the best ICC value with the reference standard (0.936). Given the above, we concluded that CBCT overestimates the dentin thickness of the DZ of lower molars, regardless of FOV and voxel sizes. The 5 x 5.5 cm FOV performed best with the voxel size of 0.075 mm, while it performed poorly with the voxel size of 0.4 mm.

Keywords: Dentin. Microtomography. Molar tooth. Cone Beam Computed Tomography. Endodontics.

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1 INTRODUÇÃO

A anatomia complexa do sistema de canais radiculares é uma das causas de acidentes e complicações no tratamento endodôntico. A perfuração é uma dessas complexidades, e pode ser definida como uma comunicação artificial entre um dente ou sua raiz, e os tecidos periodontais (ESTRELA et al., 2018). Exceto por reabsorções ou cáries, as perfurações iatrogênicas são as principais causas de fracassos endodônticos (EGHBAL et al., 2014). A maior complicação decorrente de uma perfuração é uma inflamação periodontal e perda de inserção óssea, o que pode levar a perda do elemento dental (ARAÚJO et al., 2018).

Os dentes com maiores chances de sofrerem esse tipo de complicação são os molares inferiores, pois são os primeiros dentes posteriores que irrompem e os mais propensos a serem afetados por lesão cariosa (ZHOU et al., 2020a). Em consequência, são os dentes mais frequentemente tratados endodonticamente, com uma incidência de até 17,0% (HULL et al., 2003). Geralmente possuem duas ou três raízes, com dois ou três canais nas raízes mesiais (SILVA et al., 2013). Abaixo da bifurcação, as raízes mesiais apresentam maior concavidade na superfície distal, sendo uma região de fina espessura dentinária, conhecida como zona de perigo. Dependendo do grau de curvatura, aumentam as dificuldades na modelagem dos canais que pode resultar em acidentes, como: o desvio do trajeto original do canal, perfurações radiculares, rasgos e degraus (ABOU-RASS et al., 1980; SAUÁIA et al., 2010).

O conceito de zona de perigo (*danger zone* - DZ) foi estabelecido em 1980 por Abou-Rass et al., quando estes sugeriram a técnica de instrumentação anticurvatura para o tratamento endodôntico de canais curvos. A DZ é uma região específica da raiz mais suscetível à perfuração e rasgos em caso de retirada excessiva de dentina durante o preparo mecânico (ABOU-RASS et al.,1980). A principal DZ está localizada na região distal da raiz mesial nos molares inferiores (em direção à região interradicular), especialmente nos primeiros molares (BERUTTI; FEDON, 1992).

A partir de então, vários estudos foram realizados sobre a localização e a espessura mínima de dentina da DZ na raiz mesial dos molares inferiores. Há divergências quanto aos métodos empregados e a região da raiz onde se localiza a DZ. Alguns estudos avaliaram a espessura dentinária a 2 mm da furca e através de cortes seriados (BERUTTI; FEDON, 1992; KEESLER et al., 1983; SAUÁIA et al., 2010; TABRIZIZADEH et al., 2010; DWIVEDI et al., 2014). Outros estudos avaliaram a DZ em 3 e 4 mm da furca e utilizaram a tomografia computadorizada de feixe cônico (TCFC) (AKHLAGHI et al., 2015). No entanto, nos últimos anos, esse conceito foi revisto e a avaliação de centenas de cortes transversais de raízes mesiais de molares inferiores por meio da tecnologia de imagem micro-tomográfica (micro-TC) revelou a DZ localizada até 4 a 7 mm abaixo do nível da furca (DE-DEUS et al., 2019).

Nesse contexto, diversos métodos têm sido sugeridos para a avaliação da espessura dentinária radicular: radiografias periapicais, cortes histológicos, imagens de micro-TC e imagem de TCFC. As radiografias periapicais não são um método confiável para medir a espessura dentinária, pois de acordo com Raiden et al. (2001) as espessuras aparecem sobrestimadas nestes exames. O seccionamento em série (cortes histológicos) é destrutivo, portanto, não pode ser usado *in vivo* e as amostras não podem ser usadas para estudos posteriores (SOUZA et al., 2011). A micro-TC fornece informações detalhadas e precisas sobre a espessura da dentina, morfologia do canal e curvaturas em intervalos micrométricos (HARRIS et al., 2013). No entanto, sua aplicação está restrita à estudos *in vitro*, não sendo possível sua utilização clínica. Já a imagem da TCFC fornece imagens de qualidade, precisas, sendo um exame não destrutivo, útil para informações adequadas e identificação da anatomia do canal radicular interno. Desta forma, apresenta-se como uma ferramenta poderosa no diagnóstico, planejamento de tratamento e acompanhamento endodôntico (PATEL et al., 2019). Além disso, a imagem TCFC permite a realização de mensurações lineares com precisão (ZHOU et al., 2020 e MEHDIZADEH, M. et al., 2022).

O emprego de imagens de TCFC é cada vez mais difundido, tanto na prática clínica, quanto na pesquisa, devido ao seu melhor desempenho no diagnóstico de periodontite apical, fraturas radiculares verticais ou perfurações radiculares, em comparação com as radiografias periapicais (PATEL et al., 2019; TOLENTINO et al., 2018). Segundo a Associação Americana de Endodontia e da Academia Americana de Radiologia Oral e Maxilofacial (2015), a TCFC somente deve ser usada quando os benefícios superam os riscos potenciais da exposição à radiação X, bem como quando as informações necessárias não puderem ser alcançadas por radiografia bidimensional de dose mais baixa (PATEL et al., 2019). Dessa forma, em casos de tratamento endodôntico de dentes com anatomia complexa, a TCFC com campo de visão (*field of view* – FOV) limitado deve ser considerada uma modalidade de imagem de escolha, desde que os critérios citados anteriormente sejam respeitados. Destaca-se que a TCFC não deve ser usada como exame de rotina na Endodontia, sendo individualmente indicada (PATEL et al., 2019).

Para um bom diagnóstico e planejamento em Endodontia faz-se necessária a obtenção de uma boa qualidade de imagem e adequada visualização de estruturas anatômicas na TCFC. Para isso, Hassan et al. (2012) sugerem a indicação de um correto protocolo de aquisição das imagens. Durante a aquisição da imagem, o operador necessita saber as variáveis do protocolo: o FOV, o tamanho do voxel, o tempo de varredura, os parâmetros de mA, de kVp e, também, a imobilização do paciente (SIMÕES; CAMPOS, 2013). O FOV por exemplo, é um fator importante para a visualização dos canais, uma vez que quanto menor o FOV utilizado, maior a resolução espacial da imagem (KAMBUROGLU et al., 2015). Uma das características importantes da TCFC é sua capacidade de otimizar o FOV em relação à região de interesse (MEHDIZADEH et al. 2022). O FOV pode ser modificado de acordo com as configurações do equipamento. De modo geral, FOV menores permitem doses de radiação mais baixas e imagens com menos ruído (DE OLIVEIRA PINTO et al., 2021). O voxel por sua vez, é a menor unidade das imagens TCFC e seu tamanho tem influência direta na resolução espacial das imagens (GANGULY et al., 2016). Reduzir o tamanho do voxel aumenta a resolução espacial das imagens e sem dúvida a precisão das medições nas imagens, no entanto, leva a um aumento da dose de radiação. Assim, os benefícios da aquisição de imagens de alta resolução devem superar os riscos associados a tais procedimentos (GANGULY et al., 2016).

Diante do exposto, a correta avaliação da espessura dentinária na DZ dos molares inferiores é de fundamental importância para o planejamento do tratamento endodôntico, pois fornece ao clínico as informações necessárias para selecionar o procedimento de instrumentação necessário em cada caso específico a fim de evitar perfurações e iatrogenias que possam comprometer a longevidade do dente (AZIMI et al., 2020). No entanto, a literatura é restrita em apresentar estudos que avaliem a espessura dentinária da DZ de molares inferiores em exames de TCFC, considerando diferentes protocolos de aquisição e ainda como padrão de referência a micro-TC. Desta forma, o objetivo do presente estudo foi verificar se a mensuração da DZ em molares inferiores é influenciada por diferentes tamanhos de FOV e voxel em imagens de TCFC, comparada ao padrão de referência em imagens de micro-TC. A hipótese nula testada foi a de que não há diferença na espessura dentinária obtida com imagens de TCFC, independente do tamanho do FOV e do voxel, quando comparada ao padrão de referência (micro-TC).

2 ARTIGO CIENTÍFICO

Artigo científico enviado para publicação no periódico *Journal of Endodontics*, qualis CAPES A1 (2023). A estruturação do artigo baseou-se nas instruções aos autores preconizadas pelo periódico (ANEXO B e C).

Is the assessment of mandibular molars danger zone affected by FOV and voxel sizes in CBCT examinations?

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The authors deny any conflict of interest related to this study.

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Statement of clinical relevance

The correct assessment of dentin thickness in the danger zone of mandibular molars is essential for avoiding errors such as drilling of the root canal wall that can lead to irreversible consequences such as tooth loss.

Abstract
Introduction: The objective of this observational study was to verify if the assessment of mandibular molars danger zone (DZ) is affected by FOV and voxel sizes in cone-beam computed tomography (CBCT) examinations, compared to micro-CT images as reference standard.
Methods: Forty mandibular first and second molars were selected. The teeth were scanned in a micro-computed tomography (micro-CT) device to establish reference standard images. Then they were submitted to CBCT scans varying the field of view (FOV) (10 x 5.5 cm; 5 x 5.5 cm) and voxel size (0.4, 0.2, 0.15, 0.075 mm). The images were evaluated by two Endodontists regarding the dentin thickness of the mandibular molars, in axial slices at 2-, 4- and 6 mm from the root furcation. The smallest dentin thickness of the mesiobuccal and mesiolingual canals was measured at the distal external surface of the mesial root. All evaluations were performed under standardized conditions. The collected data were analysed using descriptive and inferential statistics (Intraclass correlation coefficient (ICC) and paired T test) ($p<0.05$).
Results: All measurements overestimated the root dentin thickness compared to the reference standard ($p<0.001$). When using the 0.4 mm voxel size with 5 x 5.5 cm FOV the dentin thickness value was more overestimated ($p = 0.007$), when comparing the FOVs. Furthermore, the dentin thickness with the 0.075 mm voxel size and 5 x 5.5 cm FOV was significantly smaller and showed the best ICC value with the reference standard (0.936).

Conclusions: CBCT overestimates dentin thickness of the DZ of mandibular molars, regardless of FOV and voxel sizes. The 5 x 5.5 cm FOV showed the best result with the 0.075 mm voxel size whereas a lower performed with the 0.4 mm voxel size.

Keywords: Cone-Beam CT. Dentin. Endodontics. Micro-CT. Lower molar. Root canal preparation.

Introduction

Iatrogenic perforations are the main causes of endodontic failures[1]. The worst complication resulting from a perforation is periodontal inflammation and loss of bone insertion, which can lead to tooth loss[2]. The teeth most likely to suffer this type of complication are the lower molars, especially the first molars, as they are the first posterior teeth to erupt and the most likely to be affected by carious injury[3]. Consequently, these are most frequently treated endodontically teeth, with an incidence of up to 17.0%[4]. In addition, below the bifurcation, the mesial roots present greater concavity in the distal surface, being a region of thin dentin thickness known as danger zone[5,6].

The concept of danger zone (DZ) was established in 1980 by Abou-Rass et al.[5], when they suggested the technique of anti-curvature instrumentation for the endodontic treatment of curved canals. DZ is a specific region of the root more susceptible to perforation in case of excessive dentin removal during mechanical preparation[5]. The correct evaluation of dentin thickness in the DZ of the lower molars is essential for the planning of endodontic treatment, as it provides the clinician with the necessary information to determine instrumentation procedure in each specific case to avoid perforations and iatrogenic that may compromise tooth longevity[7].

Several studies have been conducted on the location and minimum thickness of dentin in the mesial root of the lower molars. However, there are many variations regarding the methods employed and the region of the root where the ZD is located. Some studies have evaluated dentin thickness at 2 mm from the furcation and through serial slices[6, 8- 11]. Other studies evaluated the DZ at 3 and 4 mm from the furcation through cone beam computed tomography (CBCT)[12, 13]. However, in recent years, this concept has been revised and the evaluation of hundreds of cross-sections of lower molars' mesial roots by means of micro-computed tomographic imaging technology (micro-CT) revealed that the DZ located up to 4 to 6 mm below the level of the furcation[14].

Micro-CT provides detailed and accurate information on dentin thickness, root canal morphology, and curvatures at micrometric intervals[15]. However, its application is restricted to *in vitro* studies, and its clinical use is not possible. CBCT is a non-destructive examination offering adequate information for the identification of the anatomy of the root and root canal system with the advantage of high-quality, submillimeter accuracy images. Thus, it is a powerful tool in diagnosis, treatment planning, and endodontic follow-up[16]. In addition, linear measurements obtained from CBCT images were reported to highly correlate with the actual measurements [3,17].

For a standard diagnosis and treatment planning in Endodontics, it is necessary to obtain a CBCT image quality to allow adequate visualization of anatomical structures. Hassan et al.[18] suggested the use of a correct protocol for the acquisition of images. During image acquisition, the operator needs to know the protocol variables such as field of view (FOV), voxel size, scan time, mA, kVp, and patient immobilization[19]. The FOV is an important factor to evaluate the root canals, since the lower the FOV, the higher the spatial resolution of the image[20]. One of the important features of CBCT is its ability to optimize the FOV in relation to the region of interest[17]. In general, smaller FOVs theoretically allow for lower radiation doses and images with less noise[21]. The voxel, in turn, is the smallest unit of CBCT images and its size has a direct influence on the spatial resolution of the images[22]. Reducing the voxel size increases the spatial resolution of the images, however, it leads to an increase in noise and radiation dose. Thus, the benefits of acquiring high-resolution images should outweigh the risks associated with such procedures[22]. In addition, the literature is restricted in presenting studies evaluating the dentin thickness of the DZ of lower molars in CBCT exams, considering different acquisition protocols, and micro-CT as a reference standard. The objective of this research was therefore to verify if the assessment of lower molars DZ is affected by FOV and voxel sizes in CBCT examinations when compared to micro-CT images as reference standard. The null hypothesis tested in this study was that there was no significant difference in the dentin thickness obtained by CBCT images, regardless of the FOV and voxel sizes used, when compared to the reference standard (micro-CT) images.

Materials and Methods

This ex vivo study was previously approved by the local Human Research Ethics Committee, under Protocol No: 54186821.6.0000.5147/2022.

Sample Selection and Sample Size Calculation

To perform this study, 45 lower human molars were obtained from a biorepository. These molars were newly extracted for periodontal reasons. Clinical and radiographic inspections were performed to select molars that were fully developed and had intact roots. Molars with anomalies, previous endodontic treatment, intraradicular posts, resorptions, fractures, or root perforations were excluded.

Initially, a pilot test was conducted using five teeth to faithfully replicate the proposed methodology and calculate the sample size. G*Power Version 3.1.9.7 (Franz Faul, University of Kiel, Germany) software was utilized, considering an effect size of 1.877 (determined from means and standard deviations obtained in the pilot study), an α of 0.05, a test power of 0.80, and an allocation ratio (N2/N1) of 1. The result indicated a sample size of n=5 for each of the tested groups. Since eight groups were to be compared (seven acquisition protocols and the reference standard), a total of 40 teeth were included in the final sample. The teeth used in the pilot test were not included in the final sample.

In order to ensure that evaluators could not identify individual teeth, the crowns of all teeth were sectioned at the cementoenamel junction using a metallographic cutter (ISOMET 1000 Precision Saw, Buehler, Lake Bluff, IL, USA).

Micro-CT acquisition and evaluation (Reference Gold Standard)

After sample preparation, all teeth were submitted to micro-CT Super-Argus PET/CT - Sedecal USA Inc., Madrid, Spain) with the following acquisition protocol: 40 kVp, 140 mA and voxel size of 0.03 mm[21] to determine the reference standard.

Micro-CT scans were evaluated in consensus in the Amide software (*Amide's a Medical Imaging Data Examiner*, available in *amide.sf.net*), by two specialists, one in Oral Radiology (F.S.V.) and another in Endodontics (R. B. J.), with recognized experience in micro-CT images. A 24' LCD monitor (LG *Electronics*, Seoul, South Korea) was used, located in a room with dimmed lighting conditions.

CBCT acquisition and evaluation

For CBCT image acquisition, the teeth were positioned in a dry human jaw, respecting their anatomical location, articulated to a dry human skull, coated with wax for soft tissue simulation. The ProMax 3D Max tomography (Planmeca, Helsinki, Finland) was used, varying FOV and voxels sizes, as described in Table 1. The kilovoltage (kV) was kept fixed, and the milliamperage (mA), scan time (t) and dose area product (DAP) were automatically determined by the device when the voxel size was chosen within each FOV. It should be noted that the CBCT unit only allowed the use of the 0.075 mm voxel size with the 5 x 5.5 cm FOV.

Table 1. Promax 3D Max protocols tested.

FOV (cm)	Voxel (mm)	kV	mA	t (s)	DAP ($mGy.cm^2$)
10 x 5.5	0.4	96	4	6	261
	0.2	96	5.6	12	728
	0.15	96	7.1	15	1153
5 x 5.5	0.4	96	4	6	149
	0.2	96	5.6	12	415
	0.15	96	7.1	15	657
	0.075	96	7.1	15	657

The images were evaluated individually by two Endodontists (D. R. F. and T. M. S. R.), with more than 10 years of experience, and who use CBCT in their clinical routine. The specialists were trained in a pilot session, with faithful reproduction of the proposed methodology, in a small number of images (referring to the five teeth used for this purpose), and that were not used in the final sample. After 15 days, the images of the pilot session were reevaluated to perform the calculation of the intra-examiner agreement. The evaluators were only allowed to start the evaluations of the sample, after obtaining agreement (Intraclass correlation coefficient - ICC) higher than 0.75. Thus, it was ensured that the evaluators were able to analyze the images, without compromising the results of the research.

All images were evaluated for dentin thickness in the distal wall of the mesial root of the lower molars in the DZ region. Initially, the sagittal, coronal, and axial planes were corrected so that they were truly parallel and perpendicular along the axis of the mesial root of the lower molars (FIGURE 1).

Next, the most central sagittal section of the root furcation region was selected (FIGURE 2). In this section, a reference line was drawn tangent to the region of the root furcation in the mesiodistal direction. From this reference line, new lines were drawn parallel to the reference line, at 2-, 4- and 6 mm distance, in the apical direction, to serve as a reference for the location of the axial sections in which the measurements were performed (FIGURE 2)[14].

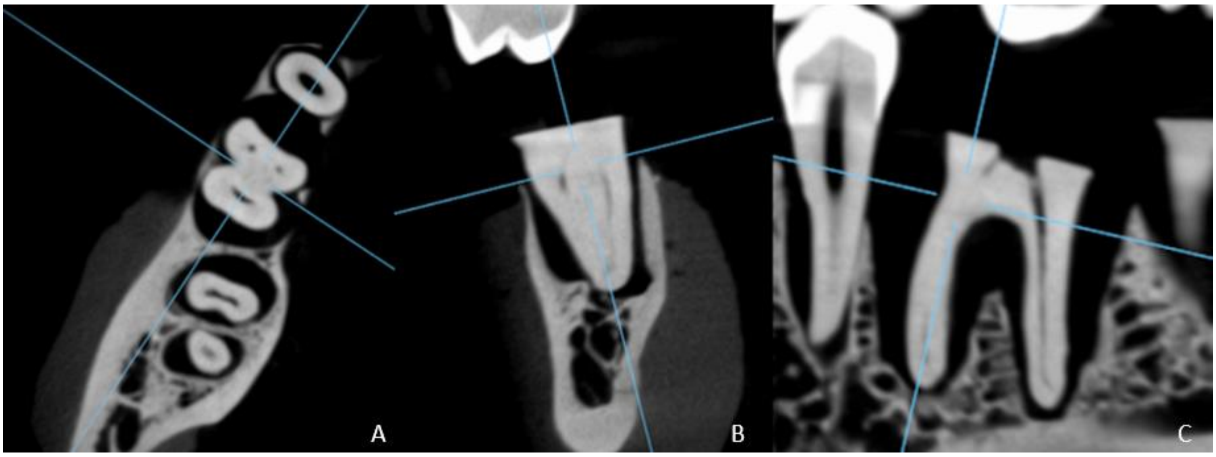

Figure 1 - Corrected axial (A), coronal (B) and sagittal (C) sections of CBCT in relation to the long axis of the mesial root of the lower first molar.

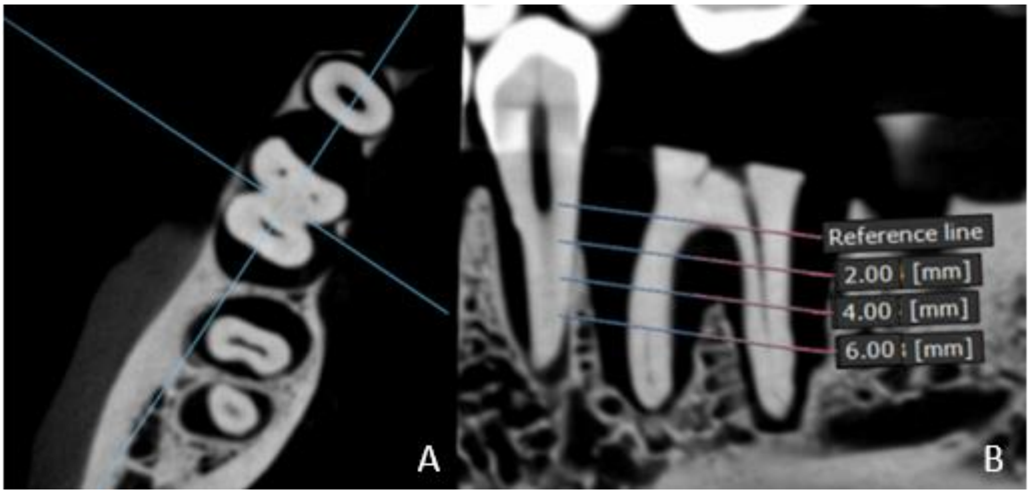

Figure 2 - A) Axial CBCT reference section for the location of the sagittal section of the most central region of the root furcation. B) CBCT sagittal section showing the horizontal reference line tangent to the root furcation region; and lines parallel to the reference line, at 2-, 4- and 6

mm, in the apical direction, to serve as a reference for locating the axial sections in which the measurements would be performed.

In each of the three selected axial sections, the lower dentin thickness was measured in relation to the mesiobuccal (MB) and mesiolingual (ML) canals. It was defined as the shortest perpendicular distance from the center of the MB and ML canals to the distal external surface of the mesial root (FIGURE 3)[14]. The evaluations were performed using the OnDemand3D™ (CybermedInc., South Korea) software. The specialists were instructed to evaluate a maximum of 20 CBCT examinations per day, to avoid visual fatigue and consequent impairment of the evaluations. All evaluations were performed on 24' LCD monitor (LG Electronics, Seoul, South Korea), with a resolution of 1920x1200 pixels and a color depth of 16-bit, in a room with dimmed lightening conditions. All measurements were made with the aid of the zoom tool, with an increase of 4x [3]. At the discretion of the evaluators, brightness and contrast could be used.

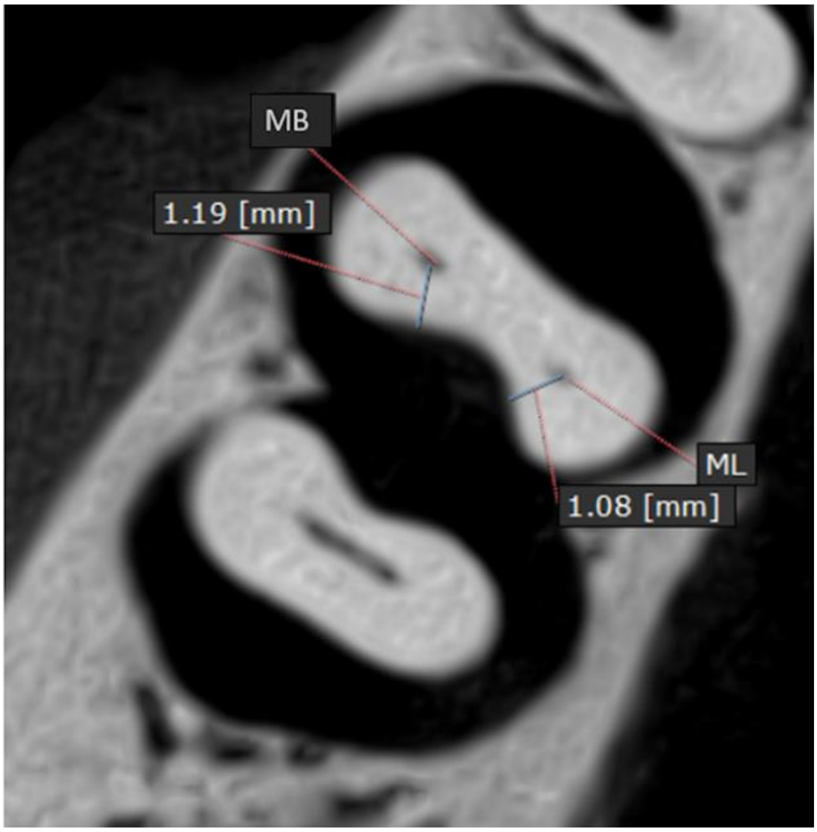

Figure 3 - Measurement of the smallest dentin thickness in relation to the mesiobuccal (MB) and mesiolingual (ML) canals.

Data analysis

To assess the intra- and inter-rater agreement, as well as the agreement between dentin thickness obtained from the reference standard and the tested FOV and voxel sizes, the ICC was employed. The ICC values were interpreted based on the following criteria: <0.5 = poor agreement, 0.5 - 0.75 = moderate agreement, >0.75 - 0.9 = good agreement, >0.9 - 1.0 = excellent agreement[23].

The normality of the data was evaluated using the Shapiro-Wilk test, which indicated a normal distribution. The data were presented by using the mean and standard deviation. To compare dentin thickness, a paired sample T-test was utilized. The significance level was set at 5%. The statistical analysis was performed using The Jamovi Project (2021) software, version 1.6, which can be accessed at https://www.jamovi.org.

Results

Mean and standard deviation of dentin thickness, regardless of the distance from the root furcation, according to the reference standard and the tested FOV and voxel sizes, are presented in Table 3. The dentin thickness was significantly overestimated by all tested protocols when compared to the reference standard ($p < 0.001$) (Table 4).

The interexaminer ICC demonstrated good agreement (ranging from 0.779 to 0.888) for all tested FOV and voxel sizes.

Table 2 presents the mean and standard deviation of dentin thickness obtained from the reference standard images at distances of 2-, 4-, and 6 mm from the root furcation, adjacent to the mesiobuccal and mesiolingual canals. It was observed that the lowest dentin thickness was found 6 mm away from the root furcation, followed by measurements at 4 and 2 mm, for both mesiobuccal and mesiolingual canals, respectively.

When comparing the voxel sizes within the 10 x 5.5 cm FOV, the dentin thickness obtained with the 0.40 mm voxel size exhibited significantly higher values than both 0.2 mm voxel size ($p = 0.036$) and 0.15 mm voxel size ($p = 0.048$) (Table 4). Furthermore, although the ICC between 0.4 mm and 0.2 mm voxel sizes were considered good, it was the lowest value obtained within this FOV (ICC = 0.885). When comparing the voxel sizes within the 5 x 5.5 cm FOV, the dentin thickness obtained with the 0.4 mm voxel size was significantly higher than the other three voxel sizes (p < 0.001) (Table 4). Conversely, the dentin thickness with the 0.075 mm voxel was significantly smaller than all the other voxels and yielded the highest ICC value with the reference standard (Table 4).

Regarding the comparison of dentin thickness between FOV sizes, the only significant difference was found for 0.4 mm voxel size at 5 x 5.5 cm FOV (p = 0.007), where the highest dentin thickness was observed along with the lowest ICC value (Table 4).

Table 2 - Mean (standard-deviation) of dentin thickness from the reference standard at distances of 2- 4- 6- mm from the root furcation, related to mesiobuccal and mesiolingual canals.

Distance from root furcation (mm)	Mesiobuccal canal (mm)	Mesiolingual canal (mm)
2	1.17 (0.19)	1.16 (0.20)
4	1.04 (0.17)	1.02 (0.17)
6	0.95 (0.19)	0.88 (0.14)

Table 3 – Mean (standard deviation) of dentin thickness according to reference standard and the tested FOV and voxels sizes, irrespective of the distance from the root furcation.

		Mean (SD) (mm)
Reference Standard		1.044 (0.20)
FOV (cm)	Voxel (mm)	
10 x 5.5	0.4	1.259 (0.23)
	0.2	1.239 (0.21)
	0.15	1.244 (0.21)
5 x 5.5	0.4	1.288 (0.21)
	0.2	1.240 (0.21)
	0.15	1.233 (0.21)
	0.075	1.217 (0.20)

Table 4 - Pairwise comparison of mean* dentin thickness and intraclass correlation coefficient (ICC) values between groups.

FOV (cm)	VOXEL (mm)	COMPARED TO	P value**	ICC
10 x 5.5	0.4	Reference Standard	< 0.001	0.865
	0.2	Reference Standard	< 0.001	0.904
	0.15	Reference Standard	< 0.001	0.917
5 x 5.5	0.4	Reference Standard	< 0.001	0.901
	0.2	Reference Standard	< 0.001	0.913
	0.15	Reference Standard	< 0.001	0.911
	0.075	Reference Standard	< 0.001	0.936
10 x 5.5	0.4	0.2†	0.036	0.885
	0.4	0.15†	0.046	0.906
	0.2	0.15†	0.529	0.937
5 x 5.5	0.4	0.2†	< 0.001	0.922
	0.4	0.15†	< 0.001	0.926
	0.4	0.075†	< 0.001	0.920
	0.2	0.15†	0.422	0.937
	0.2	0.075†	0.001	0.941
	0.15	0.075†	0.003	0.958
10 x 5.5	0.4	5 x 5.5‡	0.007	0.873
	0.2	5 x 5.5‡	0.961	0.908
	0.15	5 x 5.5‡	0.165	0.940

* Mean exhibited in table 3.
† Voxel size (mm)
‡ FOV size (cm)
*P value - t test for paired samples

Discussion

The present study aimed to compare FOV and voxels sizes of CBCT in the evaluation of dentin thickness in the mesial roots of lower molars, in comparison to micro-CT images as the reference standard. The null hypothesis was rejected since all tested protocols differed from the reference standard. There are many divergences in the literature about the location and actual size of DZ. This is due to the great variation of the internal anatomy of the lower molars. Thus, the wall thickness of curved canals may be irregular, and variable as shown by Silva et al.[24] and Vertucci[25]. In addition, variations in the results can be observed because the researchers use different methods to measure dentin thickness in the DZ and select different intervals to analyze this region[6, 8, 10, 12, 14].

Several authors described an area from 2 to 4 mm below the entrance of the canals as the more susceptible site for perforation of the lower molar’s mesial roots[3]. However, current studies such as De Deus et al.[14], using micro-CT as the reference standard, suggested that DZ was located in the middle third of the root (4 to 7 mm below the furcation). Thus, we preferred to measure the dentin thickness at 2, 4, and 6 mm away from the root furcation, in the apical direction, and the lowest values were found at 6 mm distance.

According to the studies by Hassan et al.[18] and De Oliveira Pinto et al.[21] several scanning and reconstruction factors, including FOV and voxel size, the number of base projections and imaging artifacts have a significant influence on the image quality in CBCT. The selection of FOV and voxel sizes influences spatial and contrast resolution. A larger FOV provides less resolution and contrast compared to small ones, and this directly influences the visibility of subtle anatomical structures in CBCT[18, 21]. This may explain the highest ICC values when smallest FOV and voxel sizes were used. With the best image quality, the evaluators achieved better visibility and were able to perform the measurements of the dentin thickness with high agreement.

There are studies in the literature comparing CBCT acquisition protocols in different situations, but to the best of our knowledge, this is the first study evaluating the influence of FOV and voxel size in the measurement of dentin thickness around the DZ. Hassan et al.[18] conducted a study that evaluated the influence of several CBCT imaging protocols on the visibility of the root canal and they found that both the selection of FOV and the number of projections had a significant influence on the visibility of the root canal[18]. They concluded that the lowest FOV available should always be used for endodontic applications. However, according to the authors, using standard scanning mode instead of high resolution did not negatively influence the visibility of root canal space and therefore could be used. In the present study, when considering the FOV size, the 5 x 5.5 cm performed significantly worse (overestimating the DZ more) than 10 x 5.5 when using the voxel size of 0.04 cm.

Kamburoğlu et al.[26] evaluated, the use of two different CBCT equipments, with different FOVs and voxel sizes, for the detection of small, simulated root resorptions in an ex vivo setting. They found that ultra- and high-resolution CBCT images performed similarly and/or better than low-resolution images in detecting simulated internal resorption[26]. In that study, the objective was to detect simulated root resorption and not to perform measurements of the cavities. Instead, the present study was aimed at measuring the dentin thickness in DZ and was limited to a single CBCT device. Therefore, caution should be exercised when extrapolating current results to other CBCT systems.

In another study, Kamburoğlu et al.[20] evaluated CBCT images with different voxel sizes in the detection of furcal perforations. No differences were found with different voxel sizes of CBCT. Also, the actual width of the perforation was highly correlated with the measurements made on the CBCT images. The authors stated that low-resolution CBCT imaging might be preferred for the diagnosis of furcal perforation due to its low dose and reliable diagnostic result which contradicts with our findings[19]. It is obvious that it is easier to measure simply simulated well bordered furcal perforations when compared to danger zone measurements conducted on natural anatomy of extracted teeth.

In this study, we observed that voxel size plays a significant role in evaluating dentin thickness in the danger zone. Specifically, the 0.4 mm voxel size resulted in a significant overestimation of dentin thickness, particularly when used with a small FOV. Therefore, it is not recommended for this purpose. On the other hand, the 0.2 mm and 0.15 mm voxel sizes performed similarly, regardless of the FOV size. Considering that the 10 x 5.5 cm FOV had a higher DAP (Table 1), the smaller FOV should be preferred. Although the 0.075 mm voxel size also differed from the reference standard, it exhibited the least overestimation of dentin thickness measurements and demonstrated the highest concordance values.

The results of the present study are in accordance with previous recommendations that the smallest FOV and voxel sizes, with the lowest possible milliamperage, should be used for the evaluation of endodontic cases, in which clinical signs and symptoms and radiographic techniques are insufficient to provide accurate information[16, 27-30]. As the correct evaluation of DZ cannot be performed in periapical radiographs, CBCT with the lowest FOV and voxel available should be performed. However, it is important that the endodontist should use caution when planning the case and be aware that the measurement of DZ would be overestimated, if performed according to the methodology of the present study. This of paramount importance as millimetric differences in dentin thickness may present a cause for root perforation with consequent condemnation of the tooth.

Ganguly et al.[22] investigated the effect of several resolutions of CBCT images on the accuracy of linear measurements of edentulous areas of human cadavers compared to the gold standard (caliper). The images were acquired by using two CBCT equipment varying the FOV (13 × 16 cm; 5 x 8 cm) and the voxel size (0.3 mm, 0.2 mm, and 0.16 mm). Despite being a study that evaluated larger thicknesses, the authors concluded that there were no significant differences between the protocols evaluated[22]. However, there were differences between CBCT and gold standard measurements, analogous to our findings.

In the present study, micro-CT was utilized as the reference standard as it's a non-destructive method that provides highly detailed three-dimensional information with extra high radiation doses incompatible for clinical use[31]. For clinical practice, CBCT should be the method of choice, especially in clinical situations where periapical radiography is inconclusive[16]. Hence, conducting studies like the present one is crucial to identify the optimal approach for acquiring CBCT images, thereby enabling a reliable evaluation comparable to that of micro-CT. However, compared to the reference standard, all measurements of dentin thickness performed in the CBCT images were significantly overestimated. Likewise, in a study focused on comparing the root canal area of three-rooted upper premolars by using micro-CT and CBCT, authors found that CBCT also overestimated the areas in all thirds of the roots[32]. The study by Tolentino et al.[31] also found that there was no agreement between micro-CT and CBCT for detection of root isthmus, even using the higher resolution settings available in the CBCT equipment[31]. As those are evaluations of very subtle structures, it is believed that this difference can be explained by the partial volume averaging effect, which occurs when a voxel lies on the borders of two objects of different densities. This voxel will then reflect the average density of both objects rather than the true value of either object and could impair the ability to distinguish two objects of similar densities and in proximity[33].

According to a systematic review by Borges et al.[34], CBCT overcomes some of the disadvantages of micro-CT, such as scan time, radiation dose, high cost, as well as wide use in clinical practice. However, CBCT may fail to detect some minimal morphological characteristics, such as accessory root canals, and be inadequate for the evaluation and identification of particular types of root canal morphology[34]. Although the authors did not mention analysis of DZ, based on the results of the present study, it is possible to state that the quantitative evaluation of DZ in CBCT exams is also a challenge.

Some limitations of the present study should be taken into consideration when assessing our results. First, sources of noise and artifacts, such as patient movement or hyperdense materials were not an issue in our ex vivo setting. Second, only a single CBCT unit was utilized. Therefore, considering the importance of accurate evaluation of DZ, further research should be encouraged, particularly in adverse situations such as measuring DZ in the presence of metallic artifacts by using various units and settings available.

In conclusion, CBCT overestimated the dentin thickness of the DZ of mandibular molars, regardless of FOV and voxel sizes. The 5 x 5.5 cm FOV showed the best result with a voxel size of 0.075 mm, whereas it had a lower result with a voxel size of 0.4 mm.

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Figure Legends

Figure 1 - Corrected axial, coronal and sagittal sections of CBCT in relation to the long axis of the mesial root of the lower first molar.

Figure 2 - A) Axial CBCT reference section for the location of the sagittal section of the most central region of the root furcation. B) CBCT sagittal section showing the horizontal reference line tangent to the root furcation region; and lines parallel to the reference line, at 2-, 4- and 6 mm, in the apical direction, to serve as a reference for locating the axial sections in which the measurements would be performed.

Figure 3 - Measurement of the smallest dentin thickness in relation to the mesiobuccal (MB) and mesiolingual (ML) canals.

3 CONCLUSÃO

Dentro das limitações deste estudo ex vivo, concluiu-se que a TCFC superestima a espessura da dentina da DZ dos molares inferiores, independentemente do FOV e dos tamanhos dos voxels. O FOV de 5 x 5,5 cm teve um desempenho ruim com o tamanho do voxel de 0,4 mm. Por outro lado, apresentou o melhor desempenho com o tamanho do voxel de 0,075 mm. Nesse sentido, recomendamos ao cirurgião-dentista, leve em consideração essa superestimação na avaliação e planejamento do tratamento endodôntico ao escolher o sistema de instrumentação mais adequado para cada situação clínica.

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ANEXOS

ANEXO A – Aprovação do Comitê de Ética em Pesquisa com Seres Humanos

COMITÊ DE ÉTICA EM PESQUISA COM SERES HUMANOS | ufjf

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Plataforma Brasil

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Influência de diferentes protocolos de aquisição de imagem de TCFC na avaliação da espessura dentinária radicular em molares inferiores

Pesquisador: DANIELLA RIBEIRO FERRARI

Área Temática:

Versão: 4

CAAE: 54186821.6.0000.5147

Instituição Proponente: UNIVERSIDADE FEDERAL DE JUIZ DE FORA UFJF

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 5.658.788

Apresentação do Projeto:

O presente estudo será realizado após a aprovação do Comitê de Ética em Pesquisa com Seres Humanos da Universidade Federal de Juiz de Fora.

O objetivo neste estudo observacional será verificar a acurácia de diferentes protocolos de aqui-sição de imagens de TCFC para avaliação da

espessura dentinária nas raízes mesiais de molares inferiores. Serão utilizadas imagens de microtomografia computadorizada (micro-TC) e

tomografia computadorizada de feixe cônico (TCFC) de dentes molares inferiores, pertencentes ao setor de Radiologia Odontológica da UFJF/GV.

Os exa-mes serão avaliados por dois especialistas em Endodontia, membros da equipe da pesquisa. Todas as imagens serão avaliadas quanto à

espessura dentinária na pare-de distal da raiz mesial dos molares inferiores, em cortes axiais 2, 4 e 6 mm, abaixo da região da furca radicular. Em

cada corte axial deverá ser realizada a mensuração da menor espessura dentinária em relação aos canais mésio-vestibular (MV) e mésio-lingual

(ML) à superfície externa distal, da raiz mesial. Todas as avaliações serão rea-lizadas sob condições padronizadas. Os dados coletados serão

analisados por meio de estatística descritiva e inferencial, a 5%. A escolha dos testes estatísticos seguirá baseando-se no tipo das variáveis

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coletadas e na distribuição dos dados. Espera-se que os resultados encontrados possam contribuir para um melhor esclarecimento so-bre qual o
melhor protocolo de aquisição de imagem de TCFC para avaliação da es-pessura dentinária na zona de perigo em molares inferiores.

Objetivo da Pesquisa:
Objetivo Primário:
Verificar a acurácia de diferentes protocolos de aquisição de imagens de TCFC para avaliação da espessura dentinária nas raízes mesiais de
molares inferiores.
Objetivo Secundário:
1. Verificar a influência de diferentes materiais intra-canais na avaliação da espessura dentinária das raízes mesiais de molares inferiores;2.
Verificar a influência da ferramenta redutora de artefatos metálicos na avaliação da espessura dentinária das raízes mesiais de molares inferiores.

Avaliação dos Riscos e Benefícios:
Riscos:
O desenvolvimento desta pesquisa oferece risco mínimo aos participantes relacionados à quebra de sigilo das imagens. Para reduzir ainda mais as
chances disso acontecer e garantir o sigilo, as imagens serão codificadas pelo pesquisador responsável, para que nenhum avaliador ou outro
membro da equipe tenha acesso à identificação dos participantes. Ressalta-se ainda que a espessura dentinária não está relacionadas ao princípio
da unicidade forense, desta forma, esta medida não permite a identificação de nenhum indivíduo. O pesquisador responsável garante que manterá
sigilo total.
Benefícios:
Os benefícios desta pesquisa estão relacionados aos resultados que serão en-contrados, que poderão contribuir para um melhor esclarecimento
sobre qual o me-lhor protocolo de aquisição de imagem de TCFC para avaliação da zona de perigo dentinária em molares inferiores. Contribuindo
assim para melhor planejamento de tratamento, minimizando as chances de complicações durante o tratamen-to/retratamento endodôntico.

Comentários e Considerações sobre a Pesquisa:

O projeto está bem estruturado, delineado e fundamentado, sustenta os objetivos do estudo em sua metodologia de forma clara e objetiva, e se apresenta em consonância com os princípios éticos norteadores da ética na pesquisa científica envolvendo seres humanos elencados na resolução 466/12 do CNS e com a Norma Operacional Nº 001/2013 CNS.

Considerações sobre os Termos de apresentação obrigatória:

O protocolo de pesquisa está em configuração adequada, apresenta FOLHA DE ROSTO devidamente preenchida,com o título em português, identifica o patrocinador pela pesquisa, estando de acordo com as atribuições definidas na Norma Operacional CNS 001 de 2013 item 3.3 letra a; e 3.4.1 item 16. Apresenta o TERMO DE CONSENTIMENTO LIVRE ESCLARECIDO em linguagem clara para compreensão dos participantes, apresenta justificativa e objetivo, campo para identificação do participante, descreve de forma suficiente os procedimentos, informa que uma das vias do TCLE será entregue aos participantes, assegura a liberdade do participante recusar ou retirar o consentimento sem penalidades, garante sigilo e anonimato, explicita riscos e desconfortos esperados, indenização diante de eventuais danos decorrentes da pesquisa, contato do pesquisador e do CEP e informa que os dados da pesquisa ficarão arquivados com o pesquisador pelo período de cinco anos, de acordo com as atribuições definidas na Resolução CNS 466 de 2012, itens: IV letra b; IV.3 letras a, b, d, e, f, g e h; IV. 5 letra d e XI.2 letra f. Apresenta o INSTRUMENTO DE COLETA DE DADOS de forma pertinente aos objetivos delineados e preserva os participantes da pesquisa. O Pesquisador apresenta titulação e experiência compatível com o projeto de pesquisa, estando de acordo com as atribuições definidas no Manual Operacional para CEPs. Apresenta DECLARAÇÃO de infraestrutura e de concordância com a realização da pesquisa de acordo com as atribuições definidas na Norma Operacional CNS 001 de 2013 item 3.3 letra h.

Conclusões ou Pendências e Lista de Inadequações:

Todas as pendências apontadas pelo relator foram atendidas e portanto, o projeto está aprovado. Diante do exposto, o projeto está aprovado, pois está de acordo com os princípios éticos norteadores da ética em pesquisa estabelecido na Res. 466/12 CNS e com a Norma Operacional Nº 001/2013 CNS. Data prevista para o término da pesquisa: dezembro de 2024.

Considerações Finais a critério do CEP:

Diante do exposto, o Comitê de Ética em Pesquisa CEP/UFJF, de acordo com as atribuições

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Continuação do Parecer: 5.658.788

definidas na Res. CNS 466/12 e com a Norma Operacional Nº001/2013 CNS, manifesta-se pela APROVAÇÃO do protocolo de pesquisa proposto. Vale lembrar ao pesquisador responsável pelo projeto, o compromisso de envio ao CEP de relatórios parciais e/ou total de sua pesquisa informando o andamento da mesma, comunicando também eventos adversos e eventuais modificações no protocolo.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1858881.pdf	25/08/2022 23:00:35		Aceito
Projeto Detalhado / Brochura Investigador	projetodetalhado_V3.pdf	25/08/2022 22:59:47	DANIELLA RIBEIRO FERRARI	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE.pdf	25/08/2022 22:59:29	DANIELLA RIBEIRO FERRARI	Aceito
Folha de Rosto	folhaDeRosto.pdf	06/12/2021 14:36:43	FRANCIELLE SILVESTRE	Aceito
Outros	planilha_coleta_dados.xlsx	06/12/2021 14:35:43	FRANCIELLE SILVESTRE	Aceito
Declaração de concordância	declaracaobancodedados.pdf	17/11/2021 01:17:54	DANIELLA RIBEIRO FERRARI	Aceito
Declaração de Instituição e Infraestrutura	declaracaoinfra.pdf	17/11/2021 01:16:49	DANIELLA RIBEIRO FERRARI	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

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JUIZ DE FORA, 22 de Setembro de 2022

Assinado por:
Patrícia Aparecida Baumgratz de Paula
(Coordenador(a))

ANEXO B – Instruções aos autores preconizadas pelo periódico *Journal of Endodontics*

JOURNAL OF ENDODONTICS
Official journal of the American Association of Endodontists

AUTHOR INFORMATION PACK

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ISSN: 0099-2399

DESCRIPTION

The *Journal of Endodontics*, the official journal of the American Association of Endodontists, publishes scientific articles, case reports and comparison studies evaluating materials and methods of **pulp conservation** and **endodontic treatment**. Endodontists and general dentists can learn about new concepts in **root canal treatment** and the latest advances in techniques and instrumentation in the one journal that helps them keep pace with rapid changes in this field.

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INTRODUCTION

The *Journal of Endodontics* is owned by the American Association of Endodontists. Submitted manuscripts must pertain to endodontics and may be original research (eg, clinical trails, basic science related to the biological aspects of endodontics, basic science related to endodontic techniques, case reports, or review articles related to the scientific or applied aspects of endodontics). Clinical studies using CONSORT methods (http://www.consort-statement.org/consort-statement/) or systematic reviews using meta-analyses are particularly encouraged. Authors of potential review articles are encouraged to first contact the Editor during their preliminary development via e-mail at *JEndodontics@UTHSCSA.edu*. Manuscripts submitted for publication must be submitted solely to *JOE*. They must not be submitted for consideration elsewhere or be published elsewhere.

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If the work involves the use of human subjects, the author should ensure that the work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. The manuscript should be in line with the

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Declaration of interest

All authors must disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work. Examples of potential competing interests include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. Authors must disclose any interests in two places: 1. A summary declaration of interest statement in the title page file (if double anonymized) or the manuscript file (if single anonymized). If there are no interests to declare then please state this: 'Declarations of interest: none'. 2. Detailed disclosures as part of a separate Declaration of Interest form, which forms part of the journal's official records. It is important for potential interests to be declared in both places and that the information matches. More information.

Submission declaration and verification

Submission of an article implies that the work described has not been published previously (except in the form of an abstract, a published lecture or academic thesis, see 'Multiple, redundant or concurrent publication' for more information), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. To verify compliance, your article may be checked by Crossref Similarity Check and other originality or duplicate checking software.

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Reporting sex- and gender-based analyses

Reporting guidance

For research involving or pertaining to humans, animals or eukaryotic cells, investigators should integrate sex and gender-based analyses (SGBA) into their research design according to funder/sponsor requirements and best practices within a field. Authors should address the sex and/or gender dimensions of their research in their article. In cases where they cannot, they should discuss this as a limitation to their research's generalizability. Importantly, authors should explicitly state what definitions of sex and/or gender they are applying to enhance the precision, rigor and reproducibility of their research and to avoid ambiguity or conflation of terms and the constructs to which they refer (see Definitions section below). Authors can refer to the Sex and Gender Equity in Research (SAGER) guidelines and the SAGER guidelines checklist. These offer systematic approaches to the use and editorial review of sex and gender information in study design, data analysis, outcome reporting and research interpretation - however, please note there is no single, universally agreed-upon set of guidelines for defining sex and gender.

Definitions
Sex generally refers to a set of biological attributes that are associated with physical and physiological features (e.g., chromosomal genotype, hormonal levels, internal and external anatomy). A binary sex categorization (male/female) is usually designated at birth ("sex assigned at birth"), most often based solely on the visible external anatomy of a newborn. Gender generally refers to socially constructed roles, behaviors, and identities of women, men and gender-diverse people that occur in a historical and cultural context and may vary across societies and over time. Gender influences how people view themselves and each other, how they behave and interact and how power is distributed in society. Sex and gender are often incorrectly portrayed as binary (female/male or woman/man) and unchanging whereas these constructs actually exist along a spectrum and include additional sex categorizations and gender identities such as people who are intersex/have differences of sex development (DSD) or identify as non-binary. Moreover, the terms "sex" and "gender" can be ambiguous—thus it is important for authors to define the manner in which they are used. In addition to this definition guidance and the SAGER guidelines, the resources on this page offer further insight around sex and gender in research studies.

Author contributions
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a. The paragraph is the ideal unit of organization. Paragraphs typically start with an introductory sentence that is followed by sentences that describe additional detail or examples. The last sentence of the paragraph provides conclusions and forms a transition to the next paragraph. Common problems include one-sentence paragraphs, sentences that do not develop the theme of the paragraph (see also section "c," below), or sentences with little to no transition within a paragraph.

b. Keep to the point. The subject of the sentence should support the subject of the paragraph For example, the introduction of authors' names in a sentence changes the subject and lengthens the text. In a paragraph on sodium hypochlorite, the sentence, "In 1983, Langeland et al, reported that sodium hypochlorite acts as a lubricating factor during instrumentation and helps to flush debris from

the root canals" can be edited to: "Sodium hypochlorite acts as a lubricant during instrumentation and as a vehicle for flushing the generated debris (Langeland et al, 1983)." In this example, the paragraph's subject is sodium hypochlorite and sentences should focus on this subject.

c. Sentences are stronger when written in the active voice, that is, the subject performs the action. Passive sentences are identified by the use of passive verbs such as "was," "were," "could," etc. For example: "Dexamethasone was found in this study to be a factor that was associated with reduced inflammation," can be edited to: "Our results demonstrated that dexamethasone reduced inflammation." Sentences written in a direct and active voice are generally more powerful and shorter than sentences written in the passive voice.

d. Reduce verbiage. Short sentences are easier to understand. The inclusion of unnecessary words is often associated with the use of a passive voice, a lack of focus, or run-on sentences. This is not to imply that all sentences need be short or even the same length. Indeed, variation in sentence structure and length often helps to maintain reader interest. However, make all words count. A more formal way of stating this point is that the use of subordinate clauses adds variety and information when constructing a paragraph. (This section was written deliberately with sentences of varying length to illustrate this point.)

e. Use parallel construction to express related ideas. For example, the sentence, "Formerly, endodontics was taught by hand instrumentation, while now rotary instrumentation is the common method," can be edited to "Formerly, endodontics was taught using hand instrumentation; now it is commonly taught using rotary instrumentation." The use of parallel construction in sentences simply means that similar ideas are expressed in similar ways, and this helps the reader recognize that the ideas are related.

f. Keep modifying phrases close to the word that they modify. This is a common problem in complex sentences that may confuse the reader. For example, the statement, "Accordingly, when conclusions are drawn from the results of this study, caution must be used," can be edited to "Caution must be used when conclusions are drawn from the results of this study."

g. To summarize these points, effective sentences are clear and precise, and often are short, simple and focused on one key point that supports the paragraph's theme.

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Gmail **Francielle Verner <franverner08@gmail.com>**

Submission Confirmation for Is the assessment of mandibular molars danger zone affected by FOV and voxel sizes in CBCT examinations?
1 mensagem

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