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DANIEL DE ALMEIDA DECURCIO

Efeito de Materiais Obturadores do Canal Radicular nas Dimensões da Imagem de Tomografia Computadorizada de Feixe Cônico

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Tese de Doutorado apresentada ao Programa de Pós-Graduação em Ciências da Saúde da Universidade Federal de Goiás para obtenção do Título de Doutor em Ciências da Saúde.

Orientador: Prof. Dr. Carlos Estrela

Co-orientadora: Profa. Dra. Ana Helena G. de Alencar

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da Universidade Federal de Goiás

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Dedico este trabalho ao meu filho Gabriel, um verdadeiro anjo que traz paz e muita alegria à minha vida, e que me faz a cada dia, trilhar melhores caminhos...

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SUMÁRIO

TABELAS, FIGURAS E ANEXOS

SÍMBOLOS, SIGLAS E ABREVIATURAS

#	*Number*
%	Porcentagem
=	Igual
®	Marca registrada
µm	Micrômetro
CA	Califórnia
CBCT	*Cone beam computed tomography*
CGP	Cones de Guta-percha
EDTA	Ácido etilenodiamino tetra-acético
et al.	e outros
Ghz	Giga-hertz
GO	Goiás
ISO	*International Organization for Standardization*
kVp	*Kilovoltage Peak*
mA	*Miliampère*
MI	Michigan
mm	Milímetro
nº	Número
OCR	Obturação do canal radicular
PA	Pensylvania
PR	Paraná
RCF	*Root canal filling*
RJ	Rio de Janeiro
SP-2	*Service Pack 2*
TC	Tomografia computadorizada
TCFC	Tomografia computadorizada de feixe cônico
TM	*Trademark*
USA	Estados Unidos da América
WA	Washington
α	Nível de significância

RESUMO

Objetivo: Avaliar a alteração entre as medidas da obturação do canal radicular (OCR) de dentes humanos extraídos e de imagens de Tomografia Computadorizada de Feixe Cônico (TCFC). **Metodologia:** Setenta e dois canais radiculares foram preparados até instrumento K-File de nº 50, aquém 1 mm do forame apical. A seguir, os dentes foram divididos aleatoriamente em 8 grupos: Sealapex®, Sealapex® + cones de guta-percha, Sealer 26®, Sealer 26® + cones de guta-percha, AH Plus™ , AH Plus™ + cones de guta-percha, Endofill®, e Endofill® + cones de guta-percha. Após o preparo e OCR, imagens de TCFC foram adquiridas e os espécimes secionados nos planos axial, sagital ou coronal usando brocas Endo Z em alta rotação. As medidas da OCR das seções transversais dos espécimes foram obtidas por meio de um paquímetro digital, e das imagens da TCFC utilizando o programa do fabricante do tomógrafo. A alteração entre a medida do espécime e das imagens da TCFC foi determinada em diferentes planos e espessuras de corte. Análise de variância (ANOVA) e teste de Tukey foram utilizados para análise estatística. O nível de significância foi de $\alpha = 5\%$. **Resultados:** As medidas da OCR nas imagens da TCFC mostraram-se alteradas em relação às dos espécimes, apresentando aumento dimensional. As maiores alterações foram observadas nos grupos obturados apenas com cimentos, com diferença estatisticamente significante ($p<0,05$). **Conclusão:** A Tomografia Computadorizada de Feixe Cônico apresentou imagens com alterações na dimensão da obturação do canal radicular em relação à do espécime.

ABSTRACT

Objective: To evaluate the change between the measurements of root canal filling (RCF) of extracted human teeth and images of Cone Beam Computed Tomography (CBCT). **Methodology**: Seventy-two root canals were prepared by an instrument in the K-File #50, 1 mm below the foramen. Next, the teeth were randomly divided into eight groups: Sealapex®, Sealapex® + gutta-percha, Sealer 26®, Sealer 26® + gutta-percha, AH Plus™, AH Plus™ + gutta-percha, Endofill®, and Endofill® + gutta-percha. After preparation and RCF, the CBCT images were acquired and the specimens sectioned in axial, coronal or sagittal planes, using Endo Z drills in high speed. Measurements of RCF of the cross sections of specimens were obtained using a caliper and the CBCT images using the software manufacturer's scanner. The change between the specimen and the extent of the CBCT images was determined on different planes and slice thicknesses. Analysis of variance (ANOVA) and Tukey test were used for statistical analysis. The level of significance was $\alpha = 5\%$. **Results**: Measurements of RCF on the images of CBCT proved to be altered when compared to the specimens, with increased dimensional. The largest changes were observed in groups filled only with cement, which was statistically significant ($p<0.05$). **Conclusion**: Cone Beam Computed Tomography images showed an increase in the dimension of the root canal filling.

1 INTRODUÇÃO

O advento da tomografia computadorizada (TC) iniciou uma revolução de informações nos estudos da área da saúde e tem contribuído para o planejamento, diagnóstico, tratamento e prognóstico de diversas patologias[1,12]. A tomografia computadorizada de feixe cônico (TCFC) é uma tecnologia desenvolvida recentemente[3,25] com potencial para aplicação em diferentes áreas da pesquisa e clínica odontológica[6,21,31].

Em endodontia, imagens são rotineiramente utilizadas antes, durante e após o tratamento do canal radicular. Radiografias convencionais promovem uma análise bidimensional de uma estrutura tridimensional, o que pode resultar em erros de interpretação.

Lesões periapicais de origem endodôntica podem estar presentes e não serem visíveis em radiografias convencionais[5,7-9]. Estudos recentes têm demonstrado maior acurácia da TCFC no diagnóstico dessas lesões[3,9]. Novos métodos utilizando TCFC para investigar periodontite apical e reabsorção radicular têm sido propostos[7-9], assim como novas ferramentas de imagem têm sido utilizadas em diversas pesquisas na área endodôntica[10].

Entretanto, as imagens da TCFC são afetadas por materiais com número atômico alto gerando artefatos, os quais originam imagens de baixa qualidade que conduzem à interpretação limitada da imagem tridimensional. Assim, existe uma preocupação com os artefatos, e a busca pela correção do endurecimento do raio (*beam hardening*) tem sido o foco de diversos estudos[4,11,13,15,17-20,22,26-30].

De acordo com Ketcham e Carlson[20] (2001), o endurecimento do raio é o artefato mais frequentemente encontrado nas imagens de TC. O endurecimento do raio leva ao aparecimento de estrias, faixas escuras e sombras na borda do objeto, causado pela absorção preferencial de fótons de baixa energia absorvidos por materiais de alto número atômico (ex. metais). Katsumata *et al*.[17] (2006) relataram que estes artefatos também aparecem nas imagens da TCFC muitas vezes devido a objetos sólidos, não anatômicos, colocados no arco dentário, como hidroxiapatita contendo resina e alumínio, e guias cirúrgicos para instalação de implantes osseointegrados.

O conhecimento de que artefatos de imagens podem ocorrer na TCFC devido à densidade de diferentes materiais, e a escassez na literatura de estudos relacionados evidenciam a necessidade de pesquisas que avaliem a acurácia das imagens da OCR obtidas por TCFC. Alterações na dimensão da imagem da OCR podem induzir a erros de interpretação da condição do remanescente dentinário, levando a diagnósticos falsos de perfurações radiculares e tratamentos não conservadores.

O objetivo do presente estudo foi avaliar a alteração entre as medidas da OCR de dentes humanos extraídos e de imagens de TCFC. A hipótese nula foi de que não havia diferença entre a dimensão da OCR do espécime e da imagem da TCFC.

2 OBJETIVO

O objetivo deste estudo foi avaliar a alteração entre as medidas da obturação do canal radicular de dentes humanos extraídos e de imagens de Tomografia Computadorizada de Feixe Cônico.

3 MATERIAL E MÉTODO

Preparo dos dentes

Setenta e dois dentes anteriores humanos, extraídos por diferentes razões, foram obtidos no Serviço de Urgência da Faculdade de Odontologia da Universidade Federal de Goiás, Goiânia, Brasil. Este estudo foi aprovado pelo Comitê de Ética da Universidade Federal de Goiás, Brasil (Protocolo nº 074/2009). Radiografias pré-operatórias de cada dente foram realizadas para verificar a ausência de calcificações, reabsorções internas ou externas, e a presença de rizogênese completa.

Os dentes foram removidos da solução de armazenamento de timol a 0,2% e imersos em hipoclorito de sódio a 5% (Fitofarma, Goiânia, GO, Brazil) por 30 minutos a fim de se remover tecido orgânico remanescente. As faces dentárias (vestibular, palatina, mesial e distal) foram identificadas, e a seguir as coroas secionadas, utilizando-se brocas Endo Z (Dentsply/Maillefer, Ballaigues, Switzerland) em alta rotação, a fim de se padronizar um comprimento radicular de 13 mm. Este comprimento foi determinado por um paquímetro digital calibrado de 0,01 mm (Fowler/Sylvac Ultra-Cal Mark IV Electronic Caliper, Crissier, Switzerland), medido a partir do ápice radicular. Após as radiografias iniciais e remoção coronária, o terço cervical do canal radicular de cada dente foi preparado utilizando brocas de Gates-Glidden ISO nºs 1 até 3 (Dentsply/Maillefer). A odontometria foi realizada pela visualização da lima tipo

K-file no forame apical seguido de recuo de 1 mm (método visual). Os terços apicais dos canais radiculares foram ampliados até lima K-File ISO nº 50 (Dentsply/Maillefer). Durante o preparo dos canais radiculares, os mesmos foram irrigados com 3 ml de hipoclorito de sódio a 1% (Fitofarma) a cada troca de instrumento. Os canais radiculares foram secos e preenchidos com EDTA a 17% (pH 7,2) (Biodinâmica, Ibiporã, PR, Brazil) por 3 minutos para remoção da *smear layer*. A seguir, os canais foram novamente irrigados com 3 ml de hipoclorito de sódio a 1% e secos com cones de papel absorventes (Dentsply/Maillefer).

Os dentes foram divididos aleatoriamente em 8 grupos experimentais (cada um contendo 9 espécimes), de acordo com o material obturador: Grupo 1 - Sealapex® (Sybron Endo, Glendora, CA, USA); Grupo 2 - Sealapex® + cones de guta-percha (Dentsply/Maillefer); Grupo 3 - Sealer 26® (Dentsply, Petrópolis, RJ, Brazil); Grupo 4 - Sealer 26® + cones de guta-percha; Grupo 5 - AH Plus™ (Dentsply/Maillefer); Grupo 6 - AH Plus™ + cones de guta-percha; Grupo 7 – Endofill® (Dentsply); Grupo 8 – Endofill® + cones de guta-percha.

Após o preparo do canal radicular, os dentes dos grupos 1, 3, 5 e 7 foram obturados com os cimentos endodônticos correspondentes, utilizando espiral Lentulo (Dentsply/Maillefer), preparados de acordo com as recomendações do fabricante. Nos grupos 2, 4, 6 e 8, os dentes foram obturados com os cimentos endodônticos correspondentes e cones de guta-percha, utilizando-se da técnica convencional de condensação lateral ativa.

Aquisição das imagens

Os espécimes foram posicionados no centro de uma plataforma preenchida com água para simular tecidos moles, baseado em modelos de estudo prévios[17,26,30], com as faces dentárias identificadas. As imagens da TCFC foram adquiridas com um aparelho de primeira geração i-CAT Cone Beam 3D Imaging System (Imaging Sciences International, Hatfield, PA, USA). Os volumes foram reconstruídos com voxel isotrópico de 0,2 mm. A voltagem utilizada foi de 120 kVp, a corrente de 3,8 mA, e tempo de exposição de 40 segundos.

Seção das raízes

Após a obtenção das imagens da TCFC, três espécimes de cada grupo foram cuidadosamente secionados no plano axial (corte transversal), três no sagital (direção vestíbulo-lingual) e três no coronal (direção mésio-distal) com brocas Endo Z (Dentsply/Maillefer) em alta rotação e sob abundante refrigeração a água. O corte axial foi obtido a 6,5 mm do ápice radicular, e no corte sagital e no coronal as raízes foram secionadas longitudinalmente, e o centro dos canais radiculares localizado por desgaste (Figura 1). Após o corte dos espécimes, a superfície secionada foi regularizada em toda sua extensão com discos diamantados (KG Sorensen, Cotia, São Paulo, Brasil), em baixa rotação, removendo irregularidades da superfície.

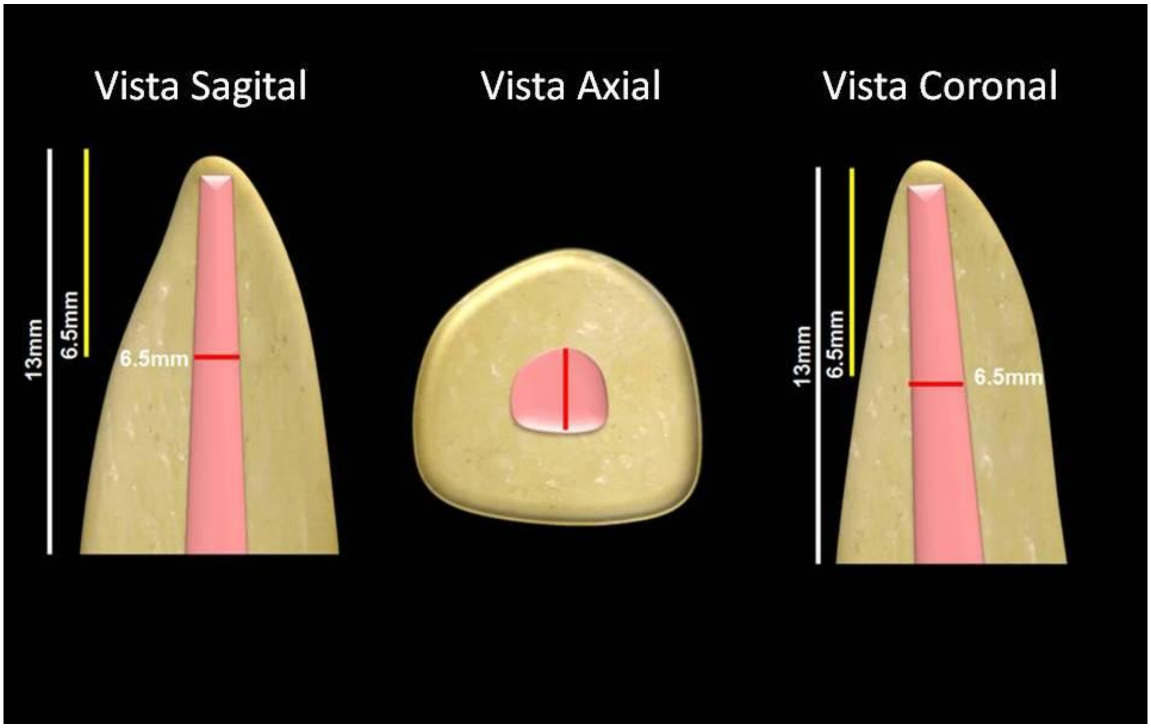

Figura 1. Representação esquemática do corte das raízes, nos planos sagital, axial e coronal.

Medição dos espécimes e das imagens da TCFC

As medidas da dimensão da OCR dos espécimes foram realizadas por dois especialistas em endodontia, calibrados e utilizando um paquímetro digital de 0,01 mm (Fowler/Sylvac Ultra-Cal Mark IV Electronic Caliper, Crissier, Switzerland). Quando não havia consenso, um terceiro examinador, especialista em endodontia, era requerido.

As OCRs nas imagens da TCFC foram mensuradas por dois especialistas em Radiologia, previamente calibrados, utilizando a ferramenta de medição do programa do fabricante do tomógrafo (Xoran 3.1.62; Xoran Technologies, Ann Arbor, MI, USA), em um computador de mesa instalado o Microsoft Windows XP Professional SP-2 (Microsoft Corp, Redmond, WA, USA), com processador Intel® Core™ 2 Duo-6300 1.86 Ghz (Intel Corporation, USA), placa de vídeo NVIDIA GeForce 6200 (NVIDIA Corporation, USA) e monitor EIZO - Flexscan S2000, resolução de 1600x1200 pixels (EIZO NANAO Corporation Hakusan, Japan). Todas as imagens foram reformatadas utilizando-se espessuras de corte de 0,2 mm, 0,6 mm, 1,0 mm, 3,0 mm e 5,0 mm.

As medidas da OCR das imagens de TCFC foram realizadas nos mesmos planos de corte dos espécimes (axial, sagital e coronal). Em todos os cortes, tanto do espécime quanto da imagem da TCFC, as medidas da OCR foram tomadas a 6,5 mm do ápice radicular. Nas imagens axiais, a medida da OCR foi realizada na direção vestíbulo-lingual, nas imagens coronais, na direção mésio-distal, e nas imagens sagitais, na direção vestíbulo-lingual.

A análise de variância (ANOVA) e teste de Tukey foram aplicados para análise estatística. O nível de significância foi de $\alpha = 5\%$.

4 RESULTADOS

As medidas da OCR nas imagens da TCFC mostraram-se alteradas em relação às dos espécimes, apresentando aumento dimensional (Tabela 1). Portanto, a hipótese inicial foi rejeitada. Os grupos obturados apenas com cimentos endodônticos mostraram as maiores alterações, em nível estatisticamente significante em relação aos obturados com cimentos endodônticos e guta-percha (p = 0,0001). As maiores alterações dimensionais ocorreram quando da utilização do cimento Endofill® (69,94%) e AH Plus™ (69,69%), não havendo diferença estatisticamente significante entre ambos. As menores variações de dimensão corresponderam ao Sealer 26® (36,22%), com diferença estatisticamente significante em relação aos outros cimentos (Tabela 2).

Quando a alteração da dimensão da OCR foi avaliada em relação à espessura de corte, independente do material obturador e do plano de orientação, foi observado aumento de 46,16% (corte de 5,0 mm) e de 50,53% (corte de 0,2 mm), no entanto sem diferença estatisticamente significante (p = 0,647). A análise da dimensão da OCR nos diferentes planos de orientação revelou aumento, variando entre 35,48% (sagital) e 59,28% (axial), apresentando nível estatisticamente significante entre os grupos (p = 0,0001). As Figuras 2 e 3 ilustram as imagens de TCFC da OCR com os materiais obturadores utilizados, diferentes espessuras de corte e planos de orientação.

Tabela 1. Aumento (%) na dimensão da OCR na imagem da TCFC em comparação a do espécime, considerando material obturador, espessura de corte e plano de orientação (α=5%).

Material/ Espessura/ Plano	AH Plus™	AH Plus™ + CGP	Sealapex®	Sealapex® + CGP	Endofill®	Endofill® + CGP	Sealer 26®	Sealer 26® + CGP
0,2mm / Axial	81,80	59,79	50,00	49,70	63,60	47,40	33,30	29,73
0,2mm / Coronal	80,00	60,61	42,90	50,37	83,30	37,37	60,00	42,93
0,2mm / Sagital	40,00	33,33	60,00	41,41	60,00	40,10	27,30	29,06
0,6mm / Axial	81,80	59,79	50,00	49,70	63,60	47,40	33,30	29,73
0,6mm / Coronal	80,00	60,61	42,90	50,37	83,30	37,37	60,00	37,37
0,6mm / Sagital	40,00	33,33	60,00	29,80	60,00	40,10	27,30	29,06
1,0mm / Axial	81,80	59,79	50,00	49,70	63,60	47,40	33,30	29,73
1,0mm / Coronal	80,00	60,61	42,90	50,37	83,30	36,87	60,00	37,37
1,0mm / Sagital	40,00	33,33	60,00	24,24	60,00	40,10	27,30	23,93
3,0mm / Axial	100,00	59,79	50,00	49,70	81,80	47,40	33,30	35,28
3,0mm / Coronal	80,00	55,05	28,60	42,96	83,30	31,31	40,00	31,82
3,0mm / Sagital	40,00	27,27	60,00	18,18	40,00	34,04	9,10	18,80
5,0mm / Axial	100,00	59,79	66,70	43,64	100,00	47,40	50,00	51,66
5,0mm / Coronal	80,00	43,43	28,60	36,30	83,30	31,31	40,00	31,82
5,0mm / Sagital	40,00	15,15	40,00	18,18	40,00	27,98	9,10	18,80
Valor de p	*0,001**	*0,014**	*0,001**	0,760	*0,001**	0,879	*0,001**	0,392

*interação entre tipo e espessura de corte foram significantes pelo teste de Tukey.
CGP – Cones de guta-percha.

Tabela 2. Aumento (%) na dimensão da OCR na imagem da TCFC em relação a do espécime, entre os diferentes materiais obturadores, espessuras de corte e planos de orientação (α=5%).

FATOR	GRUPOS							
Material*	Endofill®	AH Plus™	Sealapex®	AH Plus™ + CGP	Sealapex® + CGP	Endofill® + CGP	Sealer 26®	Sealer 26® + CGP
	$69,94^{A}$	$69,69^{A}$	$48,84^{BC}$	$48,12^{BCD}$	$40,31^{BCDE}$	$39,57^{CDE}$	$36,22^{DE}$	$31,82^{E}$
Espessura**	0,2 mm		0,6 mm		1 mm		3 mm	5 mm
	$50,53^{A}$		$49,89^{A}$		$49,48^{A}$		$46,70^{A}$	$46,16^{A}$
Plano***		Axial			Coronal		Sagital	
		$59,28^{A}$			$50,89^{B}$		$35,48^{C}$	

Letras diferentes na horizontal demonstram diferença estatisticamente significante com $p < 0,05$.
*p = 0,0001 pelo teste de ANOVA e p = 0,0001 pelo teste de Tukey;
**p = 0,647 pelo teste de ANOVA e p = 0,272 pelo teste de Tukey;
***p = 0,0001 pelo teste de ANOVA e p = 0,0001 pelo teste de Tukey.
CGP – Cones de guta-percha.

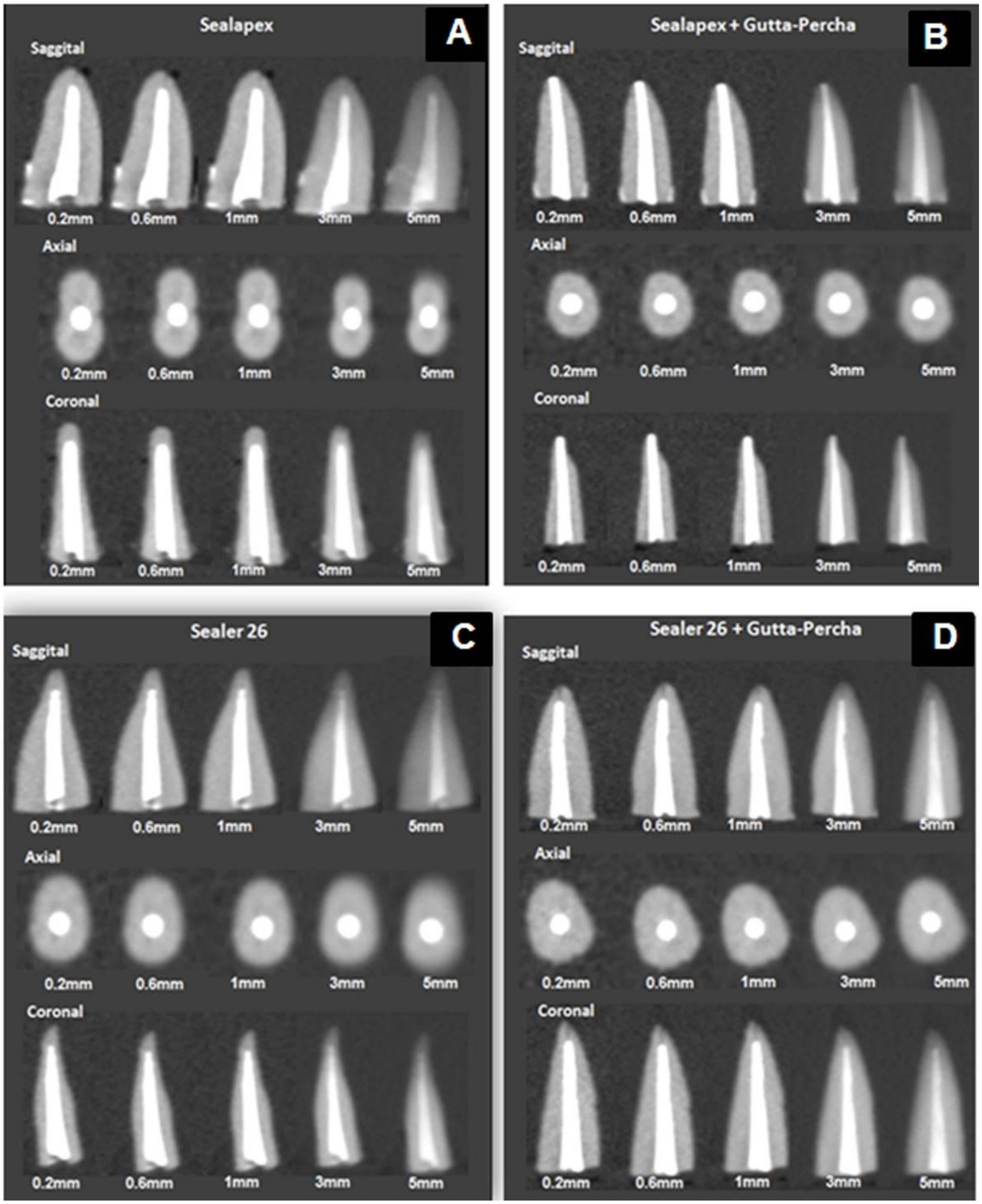

Figura 2. Imagens de TCFC das OCRs com Sealapex® (A), Sealapex® + cones de guta-percha (B), Sealer 26® (C), e Sealer 26® + cones de guta-percha (D) em diferentes espessuras de corte e planos de orientação.

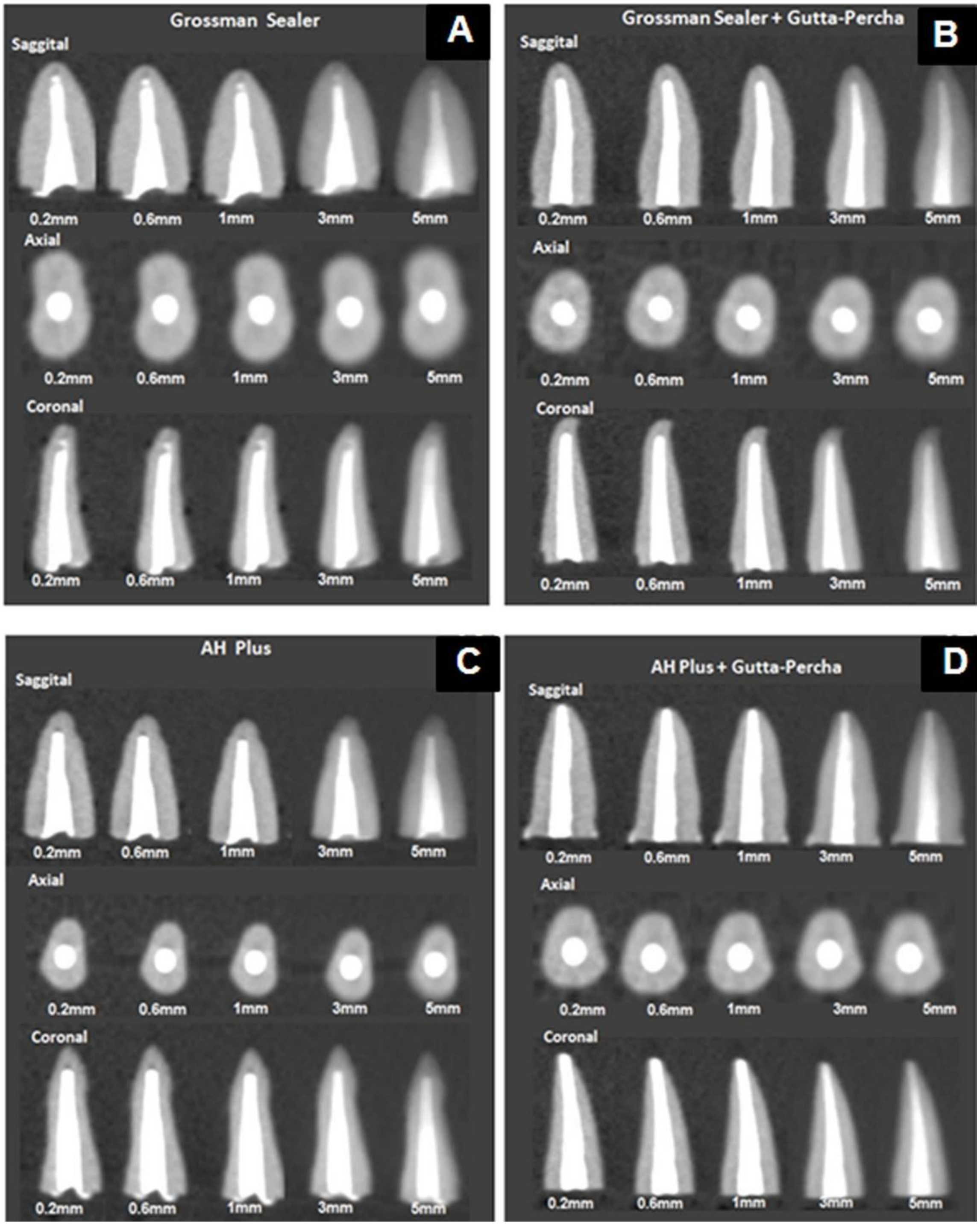

Figura 3. Imagens de TCFC das OCRs com Endofill® (A), Endofill® + cones de guta-percha (B), AH Plus™ (C), e AH Plus™ + cones de guta-percha (D) em diferentes espessuras de corte e planos de orientação.

5 DISCUSSÃO

Durante muitos anos, a qualidade da obturação do canal radicular foi avaliada na prática clínica por imagens bidimensionais de estruturas tridimensionais[5-8]. A imagem radiográfica do dente tratado endodonticamente tem sido utilizada para avaliar a qualidade do selamento endodôntico e indicar a presença de periodontite apical. Entretanto, a avaliação radiográfica como padrão e método de estudo tem demonstrado várias limitações[7-10,21].

Um novo padrão na endodontia moderna foi criado com o advento da Tomografia Computadorizada de Feixe Cônico[3,5-10,21,25,27,28,31]. A TCFC promove uma imagem tridimensional, na qual um novo plano é adicionado: a profundidade. A aplicação clínica resulta numa maior acurácia de imagem, conduzindo a diagnósticos precisos e planos de tratamentos apropriados. A TCFC tem revelado lesões periapicais, canais radiculares e perfurações radiculares não visíveis em radiografias convencionais[9,27].

Recentes estudos utilizando TCFC têm sido realizados na Endodontia para detecção de espaços na obturação do canal radicular[2,14] e avaliação da homogeneidade e comprimento da OCR[32]. Diversas pesquisas evidenciam que as ferramentas de medida da TCFC geram informações precisas sobre distâncias lineares em estruturas anatômicas volumétricas[7-9,16,24,32]. Loubele *et al.*[22] (2008) demonstraram a acurácia da TCFC nas medições lineares de osso mandibular *ex vivo*, e Mischkowski *et al*.[24] (2008) demonstraram a mesma acurácia nas distâncias lineares e volumétricas, em crânios *ex vivo*.

O objetivo do presente estudo foi determinar alterações dimensionais da OCR entre espécimes e imagens, utilizando as ferramentas de medição da TCFC. Os resultados demonstraram que as imagens da OCR na TCFC apresentavam dimensões maiores do que as do espécime. Não foram encontradas pesquisas, na literatura revisada, que avaliassem alterações dimensionais de materiais obturadores em imagens de TCFC.

Os resultados do presente estudo podem ter sido afetados pela densidade dos materiais obturadores utilizados, como ressaltado em outras pesquisas[2,14,32]. Considerando a alta densidade dos materiais de OCR, cimentos endodônticos e cones de guta-percha, artefatos podem ser produzidos nas imagens de TCFC. Portanto, atenção especial deve ser dada à avaliação da obturação de dentes tratados endodonticamente. Mudanças na dimensão da OCR podem favorecer falsa interpretação do remanescente dentinário, e constituem risco em potencial de erro de diagnóstico.

As implicações dos artefatos nos procedimentos diagnósticos parecem ser óbvias[30], e diferentes métodos para correções têm sido investigados[4,11,13,17-20,29,30]. Azevedo *et al*.[4] (2008) estudaram o efeito da incidência da energia de radiação sobre a quantidade e extensão de artefatos de imagem em estruturas anatômicas adjacentes. O uso de mais energia no feixe durante o escaneamento pareceu resultar em menor formação de artefato. Hunter e McDavid[13] (2009) mostraram que o uso de filtro de cobre pode suprimir os artefatos de imagem na TCFC. Em estudo com microtomografia, os efeitos dos artefatos também foram minimizados pela filtração do feixe[23].

Pesquisas têm demonstrado que artefatos também podem ser decorrentes da diferença na densidade relativa entre os tecidos moles linguais e vestibulares, e que, portanto, a diminuição da área escaneada poderia conduzir a uma menor intensidade de artefatos[18,19]. Estudos com imagens tomográficas revelaram uma relação estreita entre densidade óssea e valores da escala de cinza, e sugeriram a calibração simultânea com o paciente para garantir uma acurada imagem[11].

Durante a análise das imagens do presente estudo, pode ser observada falta de homogeneidade da OCR e de definição nas imagens da TCFC. No entanto, Soğur *et al*.[32] (2007) avaliaram o comprimento e a homogeneidade da OCR (adaptação às paredes laterais do canal radicular ou espaços no interior da massa obturadora), e demonstraram que a qualidade das imagens de radiografia convencional, radiografia digital e TCFC foi semelhante. Resultados estes discordantes dos de Huybrechts *et al*.[14] (2009), os quais revelaram que espaços na OCR menores que 350 µm eram detectados de forma mais acurada na radiografia digital do que na radiografia convencional ou imagens de TCFC.

Os resultados do presente estudo demonstraram grandes alterações nas dimensões da OCR nas imagens da TCFC em relação as do espécime, o que pode ter sido causado por artefatos oriundos da densidade do material obturador. A utilização de diversos recursos disponíveis na TCFC, como variações de espessura de corte e de planos de orientação, pareceu não oferecer vantagem para avaliação da OCR.

Poucos estudos investigaram materiais endodônticos por meio de imagens de TCFC[14,32], sendo portanto, necessárias mais pesquisas que avaliem o efeito de variáveis como retentores intrarradiculares e materiais retrobturadores na formação de artefatos. O desenvolvimento de novos programas para reconstrução das imagens da TCFC seguramente reduzirá a formação de artefatos e, consequentemente, as alterações dimensionais. Apesar do avanço tecnológico, a radiografia periapical ainda deve ser utilizada como referência padrão, juntamente com a imagem tomográfica, no diagnóstico endodôntico.

6 CONCLUSÃO

Considerando a metodologia empregada e suas limitações, podemos concluir que a Tomografia Computadorizada de Feixe Cônico apresentou imagens com aumento na dimensão da obturação do canal radicular.

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8 PUBLICAÇÃO

Artigo:

Effect of Root Canal Filling Materials on Dimensions of Cone Beam Computed Tomography Images

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Effect of Root Canal Filling Materials on Dimensions of Cone Beam Computed Tomography Images

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Effect of Root Canal Filling Materials on Dimensions of Cone Beam Computed Tomography Images

Abstract

Objective. To evaluate the discrepancy of root canal fillings (RCF) measurements between specimens cross-sections and Cone Beam Computed Tomography (CBCT) images.

Study design. Seventy-two human maxillary anterior teeth were prepared up to an ISO #50 K-File 1 mm short of the apical foramen. Thus, the teeth were randomly divided into 8 groups, according to the root canal filling material: Sealapex®, Sealapex® + gutta-percha points, Sealer 26®, Sealer 26® + gutta-percha points, AH Plus™ , AH Plus™ + gutta-percha points, Grossman Sealer, and Grossman Sealer + gutta-percha points. After root canal preparation and RCF, CBCT scans were acquired and the specimens were sectioned in axial, sagittal, and coronal planes. The measurements of RCF were obtained in different planes and thicknesses to determine the discrepancy between the specimen RCF measurement (using a digital caliper) and CBCT measurements (using the scanner's proprietary software). One-way analysis of variance and Tukey tests were used for statistical analyses. The significance level was set at $\alpha = 5\%$.

Results. Measurements of different endodontic filling materials image were 9% to 100% greater on CBCT images than they were with corresponding calipter measurements in original specimens. Greater RCF dimensions were found when only sealers were used, with statistically significant difference between the groups.

Conclusions. RCF dimensions were greater on CBCT images than on the original specimen measurements.

Key Words: Cone beam computed tomography. Diagnostic imaging. Artifact. Root canal filling.

Introduction

The advent of computed tomography (CT) has started a revolution of information in health studies and has contributed to planning, diagnosis, treatment, and prognosis of several diseases[11]. Cone beam computed tomography (CBCT) is a recently developed technology[2,25] with potential for applications in different areas of research and clinical dentistry[5,20,29].

In endodontics, images are routinely used before, during, and after root canal treatment. Conventional radiographic images provide a two-dimensional (2D) rendition of a three-dimensional structure, which may result in interpretation errors.

Periapical lesions of endodontic origin may be present but not visible on conventional 2D radiographs[4,6-8]. These lesions are visible on CBCT images, and new methods using CBCT scans to investigate apical periodontitis and root resorption have been developed[6-8], as new imaging tools are now used in several endodontic research areas[9,22].

However, CBCT images are affected by high atomic number materials. Artifacts can cause low image quality and poor image contrast leading to limited interpretation of the 3D volumes. There is a concern with artifacts and the search for beam hardening corrections have been the focus of several studies[3,10,12,14,16-19,21,26-28].

According to Ketcham and Carlson[19] (2001) beam hardening is the most frequently artifact found in Computed Tomography (CT) scanning. Beam hardening causes the edges of an object to appear as cupping, streaks, dark bands, or flare artifacts, and is caused by preferential absorption of low-energy photons by absorbing materials with higher atomic numbers (e.g. metals). Katsumata, et al.[16] (2006) related that the CBCT image defects often appeared in images of solid nonanatomical objects placed on the dental arch, such as diagnostic stents (guide splint) for the accurate positioning of dental implants and rectangular radiopaque reference markers for the assessment of periodontal disease. This was more frequent when radiopaque materials, such as hydroxyapatite containing resin and aluminum, were used.

However, it is essential to understand that image artifacts are likely to occur because of the density of several materials used in root canal treatment. Alterations from true dimension of RCF may offer false interpretation on real dentin remnants.

Thus, evaluating the dimension of endodontic materials on CBCT images may aware the clinicians for the potential risks of misdiagnosis. This study evaluated the discrepancy of RCF measurements between specimens cross-sections and CBCT images.

Material and Methods

Teeth preparation

Seventy-two human maxillary anterior teeth, extracted for different reasons, were obtained from the Dental Urgency Service of the Federal University of Goiás - School of Dentistry, Goiânia - Brazil. This study was approved by the Ethics Committee of the Federal University of Goiás, Brazil. Preoperative radiographs of each tooth were taken to verify the absence of calcified root canal, internal or external resorption, and the presence of a fully formed apex.

The teeth were removed from storage in 0.2% thymol solution and immersed in 5% sodium hypochlorite (Fitofarma, Goiânia, GO, Brazil) for 30 min to remove external organic tissues. The crowns were removed to set the remaining tooth length to a standardized 13 mm from the root apex. After initial radiographs, standard access cavities were prepared, and the cervical third of each root canal was enlarged using ISO # 50 up to # 90 Gates-Glidden drills (Dentsply/Maillefer, Ballaigues, Switzerland). Teeth were prepared up to an ISO # 50 K-File (Dentsply/Maillefer) 1 mm short of the apical foramen. During instrumentation, the root canals were irrigated with 3 ml of 1% NaOCl (Fitofarma) at each change of files. Root canals were dried and filled with 17% EDTA (pH 7.2) (Biodinâmica, Ibiporã, PR, Brazil) for 3 min to remove the smear layer. After that, the root canals were irrigated again with 3 ml of 1% NaOCl, and dried with paper points (Dentsply/Maillefer).

The teeth were randomly divided into 8 experimental groups (each one with 9 specimens), according to different sealers: Group 1 - Sealapex® (Sybron Endo, Glendora, CA, USA); Group 2 - Sealapex® + gutta-percha points (Dentsply/Maillefer); Group 3 - Sealer 26® (Dentsply, Petrópolis, RJ, Brazil); Group 4 - Sealer 26® + gutta-percha points; Group 5 - AH Plus™ (Dentsply/Maillefer); Group 6 - AH Plus™ + gutta-percha points; Group 7 – Grossman Sealer (Endofill, Dentsply); Group 8 – Grossman Sealer + gutta-percha points.

After root canal preparation, teeth groups 1, 3, 5, and 7 were filled with the corresponding sealers using a Lentulo drill, prepared according to the manufacturer's directions. In groups 2, 4, 6, and 8, teeth were filled with the corresponding sealer and gutta-percha points using the conventional lateral condensation technique.

Image Acquiring

Teeth were positioned in the center of a bucket filled with water to simulate soft tissue and supported by a plastic platform, based on the model used in previous studies[16,26,28]. CBCT images were acquired with the first generation i-CAT Cone Beam 3D imaging system (Imaging Sciences International, Hatfield, PA, USA). The volumes were reconstructed with 0.2 mm isometric voxel. The tube voltage was 120 kVp and the tube current 3.8 mA. Exposure time was 40 seconds.

Sectioning Root

After obtaining the CBCT scans, all teeth were carefully sectioned in axial, sagittal or coronal planes using a high-speed Endo Z bur (Dentsply/Maillefer) under water spray cooling. The axial cuts were obtained at 6.5 mm from the root apex; and for sagittal and coronal planes, the roots were sectioned longitudinally, in center of the root canal (Figure 1).

Measurement of specimens and CBCT slices

All measurements of the sectioned roots were made by two endodontic specialists using a digital caliper accurate to 0.01 mm (Fowler/Sylvac Ultra-cal Mark IV Electronic Caliper, Crissier, Switzerland). The calibrated examiners measured all the specimens and CBCT images, and assessed RCF dimensions in the directions described below. When a consensus was not reached a third observer made the final decision.

All the measurements on the CBCT images were acquired by two dental radiology specialists with the scanner's proprietary software (Xoran version 3.1.62; Xoran Technologies, Ann Arbor, MI, USA) in a PC workstation running Microsoft Windows XP professional SP-2 (Microsoft Corp, Redmond, WA, USA), with processor Intel® Core™ 2 Duo-6300 1.86 Ghz (Intel Corporation, USA), NVIDIA GeForce 6200 turbo cache videocard (NVIDIA Corporation, USA) and Monitor EIZO - Flexscan S2000, resolution 1600x1200 pixels (EIZO NANAO Corporation Hakusan, Japan). All CBCT scans were reformatted using 0.2 mm, 0.6 mm, 1.0 mm, 3.0 mm and 5.0 mm slice thickness.

To determine the discrepancy between the specimen RCF measurements and the CBCT image measurements, the same sites were measured on the CBCT images utilizing the same orientation (axial, sagittal and coronal). In all planes, measurements were made at 6.5 mm from the root apex. On axial images, the RCF measurement was made in the buccal/palatal direction; on sagittal images, in the mesial/distal direction; and on coronal images, in the buccal/palatal direction.

One-way analysis of variance (ANOVA) and Tukey tests were used for statistical analyses. The significance level was set at $\alpha = 5\%$.

Results

Results are shown in Tables 1 and 2. The variation of RCF dimensions on CBCT images ranged from 9% to 100%. The lower RCF dimensions (percentage values) corresponded to Sealer 26 and Sealer 26 plus gutta-percha points. Groups that were filled with sealers alone showed the greatest dimensional values in CBCT images when compared with groups filled together with gutta-percha, with statistically significant difference between the groups. When slice thicknesses varying from 0.2 mm to 5.0 mm were measured, an increase of 46.16% to 50.53% in RCF dimensions was noted, with difference not statistically significant. Different visualization planes analysis revealed an increase in RCF dimensions ranging from 35.48% (sagittal slice) to 59.28% (axial slice) (with statistically significant difference). The figures 2-3 illustrate the sagittal, axial and coronal views of the RCF using CBCT.

Discussion

A new standard of contemporary endodontics has been created with the advent of CBCT[2,4-9,20,22,25,29]. For several years, RCF quality was evaluated in clinical practice according to a two-dimensional image of three-dimensional structures[4-8]. The radiographic appearance of the filled root canal space is used to evaluate its sealing quality and to indicate the presence of apical periodontitis. However, the limitations of a radiographic assessment as a reference and study method have been demonstrated in several studies[6-9,20].

There is a possibility of interference from artifact caused by different densities from endodontic materials, which can cause errors of interpretation. Our main purpose was to determine the discrepancy of RCF measurements between specimens cross-sections and CBCT images, and our findings showed that CBCT images of RCF with sealers and sealers plus gutta-percha have greater dimensional values than the original measurements (Table 1 and 2). These results bring important implications for the clinical evaluation of RCF and anatomic dental structures. Special attention should be paid depending on the density of the endodontic material and slice thickness/ orientation which can lead to misdiagnosis.

CBCT measurement tools provide satisfactory information about linear distances within an anatomic volume[6-8,15,22,24,30]. Loubele, et al.[21] (2008) compared the accuracy of CBCT and multislice CT for linear jaw bone measurements, and found that both methods were accurate when used to evaluate an ex vivo specimen. Mischkowski, et al.[24] (2008)

determined the geometric accuracy of CBCT scans in comparison with a multidetector computed tomography (MDCT) scanner. Their results showed that the CBCT devices provide satisfactory information about linear distances and volumes. MDCT scans proved slightly more accurate in both measurement categories, but this difference may be irrelevant for most clinical applications.

Recent studies using CBCT images detected voids in root filling[1,13] and incomplete removal of filling material during endodontic retreatment. Soğur, et al.[30] (2007) showed that image quality of storage phosphor images was subjectively as good as conventional film images and superior to limited-volume CBCT images for the evaluation of both homogeneity and length of root fillings in single-rooted teeth. Huybrechts, et al.[13] (2009) analyzed voids in root fillings using intraoral analogue, intraoral digital and CBCT images. Voids larger than 30 µm were detected by all imaging techniques. For small void detection, all digital intraoral techniques performed better than intraoral analogue and CBCT images.

The difference in density of RCF materials may have affected the results of several studies[1,13,30], and was also found in our specimens. The endodontic sealers and gutta-percha used in our study have different physical and chemical properties because of different radiopaque substances (bismuth oxide, barium sulfate, zinc oxide).

CBCT reconstructions may show higher RCF dimensional values, as well as lack of image homogeneity and definition. Katsumata, et al.[17] (2007) conducted an in vitro study about the effect of projection data discontinuity–related artifacts in limited-volume CBCT imaging of jaws. The effects of artifacts were scored as the difference in relative density between the lingual and buccal soft tissue. The intensity of artifacts increased when more objects were outside the area being imaged. Fewer artifacts were noted in images produced by the particular flat CBCT panel detector used in this investigation. Katsumata, et al.[18] (2009) analyzed the relationship between density values and CBCT volume size using an Alphard CBCT system capable of providing different-size imaging volumes. The authors found that the data discontinuity-related effect was different in limited-volume CBCT scanning.

Considering that the higher density of RCF materials may produce image artifacts, special attention should be paid to the RCF evaluation of endodontically treated teeth. Any change from true dimension of RCT may favor false interpretation on real dentin remnants, and constitute potential risks of misdiagnosis. The implication of density artifacts on diagnostic procedures seems to be obvious[28], and different correction methods have been investigated[3,10,12,16-19,27,28]. Azevedo, et al.[3] (2008) studied the effect of incident radiation energy on the amount and extent of image artifacts over adjacent anatomical structures. The use of a harder energy beam during scanning appears to result in less extensive artifact formation.

A strong correlation between gray scale values on CBCT images and bone densities has been found by Haristoy, et al.[10] (2008). This has implications for potential quantitative radiological approaches to determine bone density from CBCT images. However, given the variation of gray scale values despite normalization, it may be necessary to use calibration phantoms scanned simultaneously with the patient to ensure an accurate determination of bone density[10]. Hunter and McDavid[12] (2009) showed that additional copper filtration suppresses beam hardening artifacts. In micro-computed tomography scanning based on bone mineral density measurements, the effects of beam hardening-induced cupping artifacts may be also minimized by beam filtration[23].

CBCT provides a three-dimensional image, in which a new plane has been added: depth. Its clinical application results in greater accuracy and may be used in nearly all areas of dentistry: surgery, implants, dentistry, orthodontics, endodontics, periodontics, temporomandibular dysfunction, image diagnosis, and so on.

Few studies investigated the dimensional alterations of endodontic materials observed on CBCT images, and further studies should include other variables, such as the effect of artifacts on intracanal post alloys. The evolution of the new softwares, certainly can reduce metallic artifact and dimensional alterations in future reconstructions of CBCT images. Periapical radiographs should be used as a reference standard, together with CBCT image interpretation, when making endodontic diagnoses. This study results showed that RCF dimensions were greater on CBCT images than on the original specimen measurements.

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30. Soğur E, Baksi BG, Gröndahl HG. Imaging of root canal fillings: a comparison of subjective image quality between limited cone-beam CT, storage phosphor and film radiography. Int Endod J. 2007;40:179-85.

Table 1. Percentage (%) of RCF dimension increase from original specimens to CBCT images according to slice thickness and planes for each endodontic material (α=5%).

Materials/ Thickness/Plane	AH Plus	AH Plus + GPP	Sealapex	Sealapex + GPP	Grossman Sealer	Grossman Sealer + GPP	Sealer 26	Sealer 26 + GPP
0.2mm / Axial	81.8	59.79	50.0	49.70	63.6	47.40	33.3	29.73
0.2mm / Coronal	80.0	60.61	42.9	50.37	83.3	37.37	60.0	42.93
0.2mm / Saggital	40.0	33.33	60.0	41.41	60.0	40.10	27.3	29.06
0.6mm / Axial	81.8	59.79	50.0	49.70	63.6	47.40	33.3	29.73
0.6mm / Coronal	80.0	60.61	42.9	50.37	83.3	37.37	60.0	37.37
0.6mm / Saggital	40.0	33.33	60.0	29.80	60.0	40.10	27.3	29.06
1mm / Axial	81.8	59.79	50.0	49.70	63.6	47.40	33.3	29.73
1mm / Coronal	80.0	60.61	42.9	50.37	83.3	36.87	60.0	37.37
1mm / Saggital	40.0	33.33	60.0	24.24	60.0	40.10	27.3	23.93
3mm / Axial	100.0	59.79	50.0	49.70	81.8	47.40	33.3	35.28
3mm / Coronal	80.0	55.05	28.6	42.96	83.3	31.31	40.0	31.82
3mm / Saggital	40.0	27.27	60.0	18.18	40.0	34.04	9.1	18.80
5mm / Axial	100.0	59.79	66.7	43.64	100.0	47.40	50.0	51.66
5mm / Coronal	80.0	43.43	28.6	36.30	83.3	31.31	40.0	31.82
5mm / Saggital	40.0	15.15	40.0	18.18	40.0	27.98	9.1	18.80
p value	*0.001**	*0.014**	*0.001**	0.760	*0.001**	0.879	*0.001**	0.392

*interaction between type of cut and slice thickness significantly by Tukey test. GPP - Gutta-percha points.

Table 2. Percentage (%) of RCF dimension increase from original specimens to CBCT images for each group according to sealers, slice thickness and planes, and statistical analysis (α=5%).

FACTOR	GROUPS							
Materials*	Grossman Sealer	AH Plus	Sealapex	AH Plus + GPP	Sealapex + GPP	Grossman Sealer + GPP	Sealer 26	Sealer 26 + GPP
	69.94^{A}	69.69^{A}	48.84^{BC}	48.12^{BCD}	40.31^{BCDE}	39.57^{CDE}	36.22^{DE}	31.82^{E}
Thickness**	0.2mm	0.6mm	1mm	3mm	5mm			
	50.53^{A}	49.89^{A}	49.48^{A}	46.70^{A}	46.16^{A}			
Planes***	Axial	Coronal	Sagital					
	59.28^{A}	50.89^{B}	35.48^{C}					

Different letters in horizontal demonstrate statistically significant difference with $p < 0.05$.
*p=0.0001 by ANOVA test and p=0.0001 by Tukey test;
**p=0.647 by ANOVA test and p=0.272 by Tukey test;
***p=0.0001 by ANOVA test and p=0.0001 by Tukey test.
GPP - Gutta-percha points.

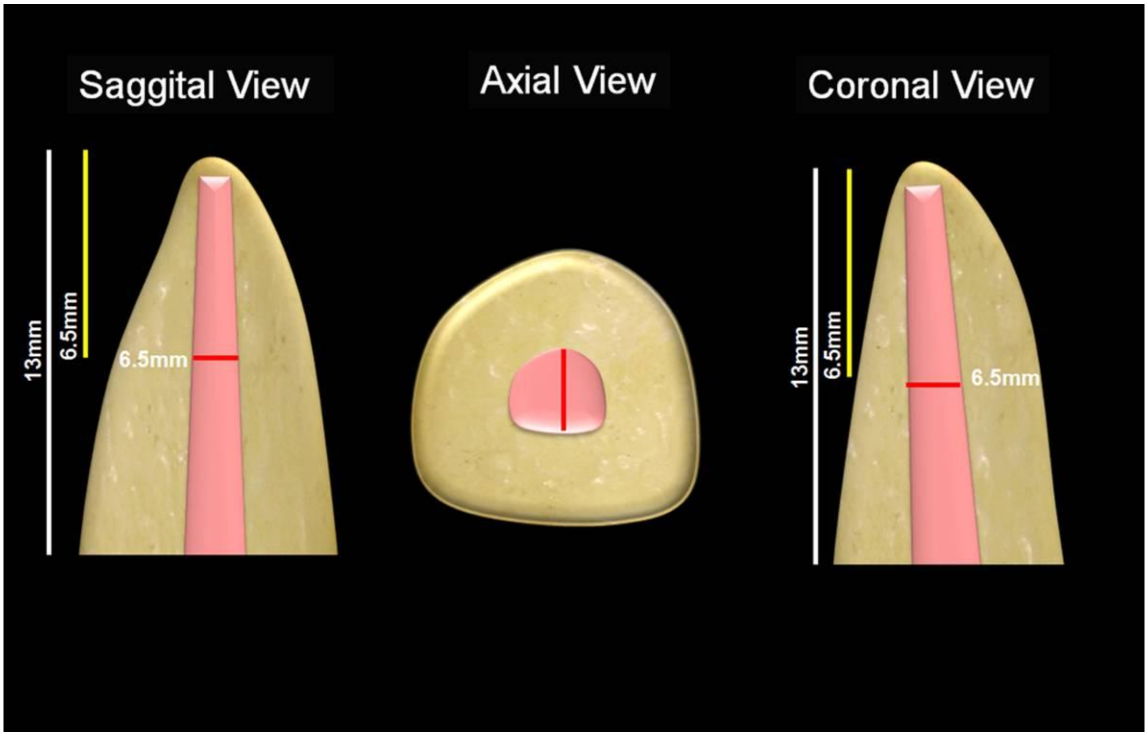

Figure 1. Schematic representation of sectioning root method, showing the saggital, axial, and coronal views.

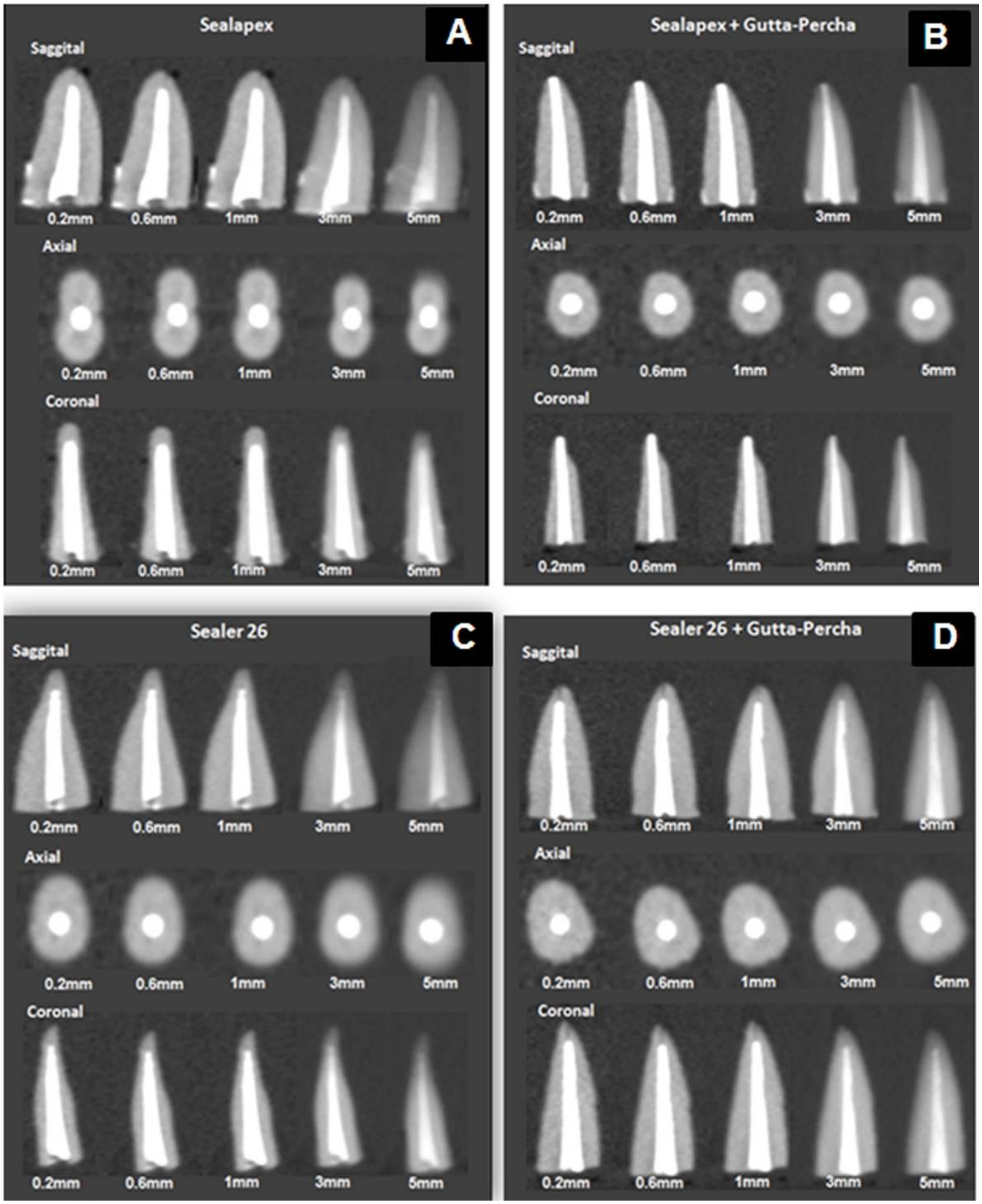

Figure 2. CBCT images of root canal filling with Sealapex (A), Sealapex + gutta-percha (B), Sealer 26 (C), and Sealer 26 + gutta-percha (D) in different slice thickness and planes (saggital, axial and coronal).

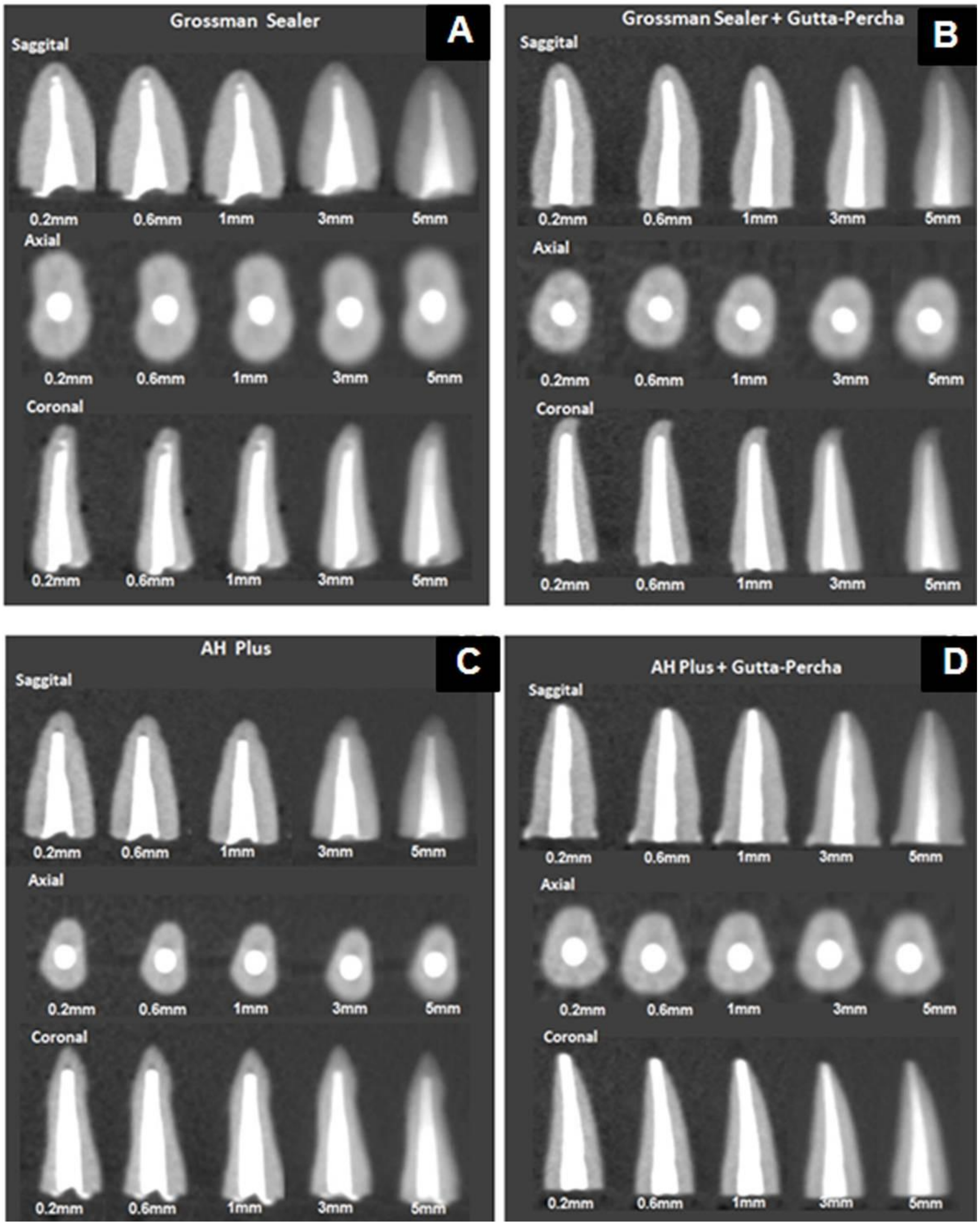

Figure 3. CBCT images of root canal filling with Grossman Sealer (A), Grossman Sealer 26 + gutta-percha (B), AH Plus (C), and AH Plus + gutta-percha (D) in different slice thickness and planes (saggital, axial and coronal).

9 ANEXOS

Anexo 1. Publicações no biênio 2009/2010

Artigos científicos publicados em periódicos nacionais e internacionais, com corpo editorial:

1) Decurcio DA, Crosara MB, Silva JA, Amorim LFG, Estrela CRA Avaliação Antimicrobiana de Cones de Guta-Percha Associados ao Hidróxido de Cálcio ou Clorexidina. ROBRAC (Goiânia. Impresso). , v.18, p.30 - 33, 2010.
2) Carvalho LM, Silva JA, Decurcio DA, Crosara MB, Alencar AHG Avaliação qualitativa do preparo de canais radiculares realizado “in vitro” com instrumentos rotatórios de níquel - titânio RaCe e K3. ROBRAC (Goiânia. Impresso). , v.19, p.132 - 137, 2010.
3) Lopes-Filho LG, Decurcio DA, Silva JA, Lopes LG, Estrela C Capacidade Seladora de Remanescente de Obturação do Canal Radicular Frente a Indicadores Microbianos. ROBRAC (Goiânia. Impresso). , v.18, p.80 - 86, 2010.
4) Peres AVS, Decurcio DA, Silva JA, Morais ALG, Alencar AHG Discrepância entre método convencional de odontometria com referência padrão. ROBRAC (Goiânia. Impresso). , v.19, p.168 - 171, 2010.
5) Estrela CRA, Avila GEG, Decurcio DA, Silva JA, Estrela C Eficácia da clorexidina em infecções endodônticas - Revisão Sistemática. Revista Brasileira de Odontologia. , v.66, p.133 - 141, 2009.
6) Estrela C, Decurcio DA, Silva JA, Mendonça EF, Estrela CRA Persistent apical periodontitis associated with a calcifying odontogenic cyst. International Endodontic Journal. , v.42, p.539 - 545, 2009.
7) Hollanda ACB, Estrela CRA, Decurcio DA, Silva JA, Estrela C Sealing ability of three commercial resin-based endodontic sealers. General Dentistry. , v.57, p.368 - 373, 2009.

Artigos científicos aceitos para publicação em periódicos nacionais e internacionais, com corpo editorial:

1) Estrela C, Bernabé PFE, Decurcio DA, Silva JA, Estrela CRA, Figeuiredo JAP. Microbial leakage of mineral trioxide aggregate, Portland cement, Sealapex and zinc oxide-eugenol as root-end filling materials. Med Oral Patol Oral Cir Bucal (in press).

Capítulo de livro publicado internacionalmente:

1) Estrela C, Pécora JD, Decurcio DA, Toledo AM. Internal anatomy and coronal preparation In: Endodontic Science. 02 ed.São Paulo: Artes Médicas Ltda, 2009, v.01, p. 531-569.

Anexo 2. Normas de publicação do periódico

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The main goal of the **Journal of Applied Oral Science** is to publish results from original research as well as invited case reports and invited reviews in the field of Dentistry and related sciences areas.

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