UNIVERSIDADE FEDERAL DE JUIZ DE FORA
FACULDADE DE ODONTOLOGIA
PPG EM CLÍNICA ODONTOLÓGICA

DÉBORA DE MARTIN E SILVA

DIAGNÓSTICO DE FRATURAS RADICULARES VERTICAIS MÉSIO-DISTAIS EM DENTES COM PINO METÁLICO: INFLUÊNCIA DA APLICAÇÃO DE FILTROS EM IMAGENS DE TCFC DE DIFERENTES RESOLUÇÕES

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Dissertação apresentada ao Programa de Pós-graduação em Clínica Odontológica, da Faculdade de Odontologia da Universidade Federal de Juiz de Fora, como requisito parcial para obtenção do título de Mestre em Clínica Odontológica. Área de concentração em Clínica Odontológica.

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Juiz de Fora

2016

SILVA, D. D. M. Diagnóstico de fraturas verticais mésio-distais em dentes com pino metálico: influência da aplicação de filtros em imagens de TCFC de diferentes resoluções. Juiz de Fora (MG), 2016. 66f. Dissertação (Curso de Pós-Graduação *Stricto Sensu* – Mestrado em Clínica Odontológica). Faculdade de Odontologia, Universidade Federal de Juiz de Fora, Juiz de Fora (MG).

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RESUMO

O objetivo nesse estudo foi avaliar a influência da aplicação de filtros em imagens de tomografia computadorizada de feixe cônico (TCFC), de diferentes resoluções, obtidas para diagnóstico de fraturas radiculares verticais (FRV) mésio-distais, associadas a dentes com pinos metálicos. Quarenta dentes foram tratados endodonticamente e vinte receberam pinos metálicos. Dez dentes sem pino e dez dentes com pino foram submetidos à FRV no sentido mésio-distal. A amostra foi submetida a radiografias periapicais e a exames de TCFC com voxel de 0,25 e 0,30 mm. Com o objetivo de reduzir a influência do artefato metálico nas imagens tomográficas, as mesmas foram avaliadas com e sem a aplicação de filtros ("*Sharpen" e "Hard"*). As imagens foram avaliadas por dois radiologistas que deveriam identificar a presença da FRV. Valores de acurácia (curva ROC) para as diversas variáveis foram comparados por meio de análise de variância e teste t. Não foi observada diferença entre as imagens com e sem a aplicação dos filtros (p = 0,860). Imagens obtidas com voxel de 0,25 mm foram mais acuradas (p = 0,001). A presença do pino metálico reduziu a acurácia do diagnóstico de FRV (p = 0,001) e as imagens tomográficas mostraram resultados superiores quando comparadas à radiografia periapical (p = 0,005). Pode-se concluir que a presença de pino metálico e o tamanho do voxel interferem significativamente no diagnóstico de FRV. Independente da formação de artefatos metálicos associados aos pinos metálicos, a aplicação de filtros não melhorou o diagnóstico. Para FRV mésio-distais, as imagens de TCFC são superiores às periapicais.

ABSTRACT

The aim of this study was to evaluate the influence of applying filters in cone beam computed tomography (CBCT) images at different resolutions. These CBCT images were obtained for diagnosing mesiodistal vertical root fractures (VRF) in teeth with metal posts. Forty teeth were treated endodontically, and twenty received metal posts. Ten teeth without posts and ten teeth with posts were subjected to VRF in the mesiodistal direction. The sample was submitted to periapical radiographs and CBCT exams with a voxel of 0.25 and 0.30 mm. In order to reduce the influence of the metal artifact in the CT images, the teeth were evaluated with and without the application of filters ("Sharpen" and "Hard"). The images were evaluated by two radiologists who had to identify the presence of VRF. Accuracy values (ROC curves) for the different variables were compared using an analysis of variance and *t*-test. No difference was observed between images with and without filter application ($p = 0.860$). Images obtained with a 0.25 mm voxel were more accurate ($p = 0.001$). The presence of the metal post reduced the accuracy of the diagnosis of VRF ($p = 0.001$), and the CT images showed superior results compared to periapical radiographs ($p = 0.005$). It can be concluded that the presence of a metal post and the voxel size significantly interfere with the diagnosis of VRF. Independent of the formation of metal artifacts associated with metallic cores, applying filters did not improve the diagnosis. For mesiodistal VRF, the CBCT images are superior to the periapical radiographs.

SUMÁRIO

1 INTRODUÇÃO

Fraturas radiculares são complicações relativamente comuns na clínica diária que podem levar a perda do dente. Estudos que investigaram as indicações de extrações dentárias relatam que 7,7 a 32,1% das exodontias são decorrentes de fraturas radiculares (MAJORANA *et al.*, 2002; CHEN *et al*., 2008). As fraturas que acometem as raízes dentárias podem ocorrer em diferentes localizações e com orientações variadas. Quando a fratura radicular é vertical, caracterizada por uma linha de fratura incompleta ou completa que se estende ao longo eixo do comprimento da raiz, torna-se difícil de ser detectada em exames radiográficos convencionais, especialmente quando acontece no sentido mésio-distal (HASSAN *et al.*, 2009; WENZEL *et al.*, 2009; HASSAN *et al.*, 2010; ZOU *et al.*, 2011; METSKA *et al.*, 2012; FERREIRA *et al.*, 2013). Embora, com o passar do tempo, ocorra a formação de bolsa periodontal e perda óssea, esses sinais não são específicos para diagnosticar uma fratura radicular (ZOU *et al.*, 2011).

Poucos são os estudos que identificam o sentido da linha de fratura em suas metodologias ou que utilizam essa variável na avaliação dos resultados (HASSAN *et al.*, 2009; KAMBUROGLU *et al.*, 2010; VARSHOSAZ *et al.*, 2010; KAMBUNGTON *et al.*, 2012; JUNQUEIRA *et al.*, 2013; MELO *et al.*, 2013). Vale ressaltar que a imagem radiográfica de uma fratura radicular vertical apresenta-se como uma linha radiolúcida, mas se o feixe de raios X não passar diretamente pela linha de fratura ou a um pequeno ângulo da mesma, sua visualização pode ser dificultada, tornando-se improvável o diagnóstico de uma fratura vertical mésio-distal por meio de um sistema radiográfico bidimensional (TSESIS *et al.*, 2008; ÖZER, 2011; KAJAN e TAROMSARI, 2012; FERREIRA *et al.*, 2013). Portanto, apesar de o exame radiográfico periapical possibilitar a visualização de detalhes, ser acessível, de baixo custo e demandar uma baixa dose de radiação, é uma técnica bidimensional e, por esse motivo, dependendo do plano de orientação da fratura, pode dificultar ou até impossibilitar o diagnóstico (TSESIS *et al.*, 2008). Isso pode ser agravado nas fases iniciais, quando a fratura está sob a forma de uma fina fenda e seus fragmentos ainda aparecem unidos.

Já o exame de tomografia computadorizada de feixe cônico (TCFC) nos permite a visualização tridimensional das estruturas, sem sobreposição de imagens, aumentando a possibilidade de um diagnóstico preciso. Diversos estudos tem

demostrado a superior eficácia da TCFC para o diagnóstico de fraturas radiculares em dentes sem materiais de preenchimento intracanal (WANG *et al.*, 2011; DA SILVEIRA *et al.*, 2013; NEVES *et al.*, 2014). No entanto, nos casos em que existe preenchimento das raízes com materiais de alta densidade, como por exemplo, a guta-percha e objetos metálicos associados aos dentes envolvidos, tais como pinos e núcleos metálicos fundidos, artefatos podem aparecer nas imagens tomográficas, dificultando a interpretação do exame (HASSAN *et al.*, 2009; FERREIRA *et al.*, 2013; JUNQUEIRA *et al.*, 2013; MELO *et al.*, 2013; JAKOBSON *et al.*, 2014; MOHAMMADPOUR *et al.*, 2014; DE REZENDE *et al.*, 2015; FERREIRA *et al.*, 2015).

Artefatos afetam a qualidade da imagem e podem dificultar substancialmente o diagnóstico das fraturas radiculares (BECHARA *et al.*, 2013). A formação dos artefatos acontece em consequência das diferenças de atenuação e absorção dos feixes de raios X quando entram em contato com materiais de alta densidade física. Essa interação provoca um efeito chamado de “endurecimento” do feixe (*beam-hardening*). A imagem resultante é alterada com a formação de bandas hipodensas (*dark bands*), estrias hiperdensas (*white streaks*) e distorção dos objetos metálicos (*cupping artefacts*). Esses artefatos vão interferir negativamente na qualidade das imagens, tornando-as, em alguns casos, inutilizáveis para o diagnóstico. Para a detecção de fraturas, a associação dos dentes envolvidos com objetos metálicos pode levar a resultados falso-positivos e falso-negativos (HASSAN *et al.*, 2009; HASSAN *et al.*, 2010; SCHULZE *et al.*, 2011; PATEL *et al.*, 2013).

Alguns estudos têm sido realizados na tentativa de minimizar esses efeitos no diagnóstico de fraturas radiculares aplicando-se filtros digitais de melhoramento da imagem e algoritmos de redução de artefatos metálicos, no entanto, poucos são esses estudos e com resultados bastante divergentes (BARRETT e KEAT, 2004; VAN DER BOM *et al.*, 2013; BALLHAUSEN *et al.*, 2014). Algumas variáveis relacionadas ao protocolo de aquisição das imagens tomográficas também podem infuenciar significativamente na qualidade das imagens, como por exemplo, o tamanho do voxel, que tem sido associado a alterações no contraste e resolução das imagens (HASSAN *et al.*, 2010), podendo interferir no diagnóstico de fraturas radiculares (WENZEL *et al.*, 2009; ÖZER, 2011).

Provavelmente, essa variação nos resultados dos diversos estudos que envolvem o diagnóstico de fraturas radiculares pode estar associada a variações

metodológicas, como o sentido das linhas de fraturas, os equipamentos tomográficos utilizados, os protocolos de aquisição das imagens tomográficas e aos diferentes filtros e algoritmos aplicados. Dessa forma, diante da divergência dos resultados encontrados na literatura e da importância de um correto diagnóstico de fratura radicular para o prognóstico de um dente, o objetivo nesse estudo foi avaliar a influência da aplicação de filtros digitais em imagens de TCFC, de diferentes resoluções, obtidas para diagnóstico de fraturas radiculares verticais mésio-distais associadas a dentes com tratamento endodôntico e pinos metálicos intracanais.

2 PROPOSIÇÃO

O objetivo no presente estudo foi avaliar a influência de filtros digitais em imagens de TCFC obtidas para diagnóstico de fraturas radiculares verticais mésio-distais em dentes com tratamento endodôntico, comparando a acurácia de:

- Radiografias periapicais e imagens de TCFC com e sem pinos metálicos intracanais;
- Imagens de TCFC submetidas a diferentes filtros;
- Imagens de TCFC obtidas com diferentes resoluções.

3 MATERIAL E MÉTODOS

3.1 DESENHO DO ESTUDO

Trata-se de um estudo experimental transversal de caso-controle.

3.2 COMITÊ DE ÉTICA

Este estudo foi aprovado pelo Comitê de Ética em Pesquisa da Universidade Federal de Juiz de Fora (CEP/UFJF, Juiz de Fora, Minas Gerais, Brasil), sob o parecer n. 996.011, em dezenove de março de 2015 (ANEXO A).

3.3 DESCRIÇÃO DA AMOSTRA

Foram selecionados 40 dentes unirradiculares humanos (incisivos e caninos), provenientes do banco de dentes da Faculdade de Odontologia da Universidade Federal de Juiz de Fora (FO/UFJF, Juiz de Fora, Minas Gerais, Brasil). Os dentes, conservados em água destilada, foram inspecionados com lente de aumento (2x) para confirmar a ausência de fraturas e reabsorções radiculares e a integridade radicular. Em seguida, foram submetidos à raspagem e alisamento radicular para eliminação de cálculo dentário. Foram excluídos os dentes que apresentaram raiz previamente fraturada, com cárie ou desgaste/reabsorção. Após a seleção, os dentes mantiveram-se armazenados em água destilada.

3.4 PREPARO DA AMOSTRA

3.4.1Tratamento endodôntico

Os dentes selecionados tiveram suas coroas seccionadas na junção cemento-esmalte com disco de carborundum (Dentorium Inc., Nova Iorque, NY, EUA) acionado em baixa rotação com peça de mão (Kavo, Joinville, SC, Brasil). Em seguida, foram feitos os acessos aos canais radiculares e a odontometria foi realizada com lima tipo K #10 (Dentsply-Maillefer, Ballaigues, Suíça), sendo o comprimento de trabalho padronizado em 1 mm aquém do ápice radicular. Os

canais radiculares foram preparados endodonticamente com uso do sistema rotatório Protaper (Dentsply Maillefer, Ballaigues, Suíça) na sequência: SX, S1, S2, F1, F2 e F3. A cada troca de instrumento, o processo de irrigação-aspiração do canal radicular foi realizado com água destilada. Concluído o preparo biomecânico, os canais radiculares foram obturados por meio da técnica de termoplastificação mecânica, com compactadores de McSpadden 21 mm n° 55 (Dentsply Maillefer, Ballaigues, Suíça), utilizando cones de guta percha principal e acessórios (Dentsply Maillefer, Ballaigues, Suíça) e cimento obturador Sealer 26 (Dentsply Maillefer, Ballaigues, Suíça), manipulado em placa de vidro com espátula flexível n° 24 (Golgran, São Paulo, SP, Brasil), de acordo com as recomendações do fabricante. Ao término da termoplastificação, os excessos foram removidos com condensador vertical aquecido (Odous de Deus, Belo Horizonte, MG, Brasil). Em seguida, os dentes foram selados provisoriamente com Coltosol (Vigodent, Rio de Janeiro, RJ, Brasil). Os dentes foram radiografados nos sentidos vestíbulo-lingual e mésio-distal para avaliação da qualidade da obturação.

3.4.2 Cimentação de pinos intracanais pré-fabricados

Após o tratamento endodôntico, foram selecionados, aleatoriamente, 20 dentes que receberam pinos pré-fabricados metálicos. Foram utilizados kits de Reforpost I Metálico (Angelus, Londrina, Paraná, Brasil). A desobstrução do conduto foi realizada com broca Largo nº 2 (Angelus, Londrina, Paraná, Brasil), pertencente ao “kit”, atingindo 11 mm de comprimento. Para cimentação do pino foi utilizado cimento fosfato de zinco (SS White, Rio de Janeiro, RJ, Brasil) manipulado em placa de vidro com espátula flexível n° 24 (Golgran, São Paulo, SP, Brasil) de acordo com as recomendações do fabricante. Na fixação do pino foi aplicado cimento na peça e no interior do canal, sendo mantida uma pressão vertical sobre o pino pelo tempo de um minuto após a sua inserção.

3.4.3 Fratura radicular vertical

Vinte dentes, sendo dez com pinos metálicos e dez sem os pinos metálicos, foram selecionados aleatoriamente e induzidos à fratura radicular vertical no sentido mésio-distal (Figura 1), aplicando força mecânica ao dente, por meio de um cinzel e martelo. Os vinte dentes restantes foram mantidos sem fratura. Foi utilizado um dispositivo de madeira com uma canaleta em forma de cunha para manutenção do dente em posição durante a fratura, garantindo a estabilização do dente e uma melhor padronização da orientação da fratura. Em seguida, as raízes foram cobertas uniformemente por uma camada de aproximadamente 0,3 mm de cera 7 (Epoxiglass, São Paulo, Brasil) para simular o aspecto radiográfico do espaço do ligamento periodontal.

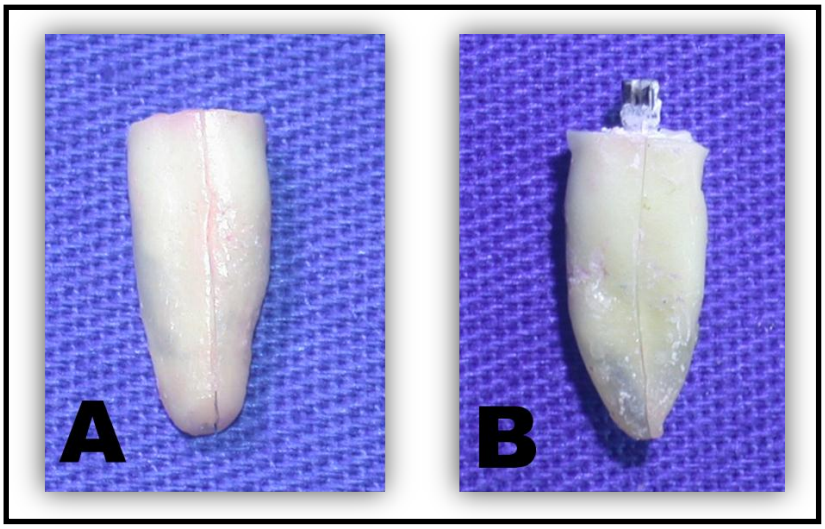

Figura 1 - A. Fratura radicular vertical mésio-distal em um dente com tratamento endodôntico e sem pino intracanal. **B**. Fratura radicular vertical mésio-distal em um dente com tratamento endodôntico e com pino intracanal
Fonte: O autor.

3.4.4 Montagem dos dentes em mandíbula

Os dentes foram montados em uma mandíbula humana seca, proveniente do Laboratório de Anatomia da UFJF, para a aquisição dos exames por imagem. A mandíbula foi recoberta na face vestibular por 3 mm de cera 7 (Epoxiglass, São Paulo, Brasil) para atenuação do feixe de raios X, simulando os tecidos moles mandibulares (Figura 2).

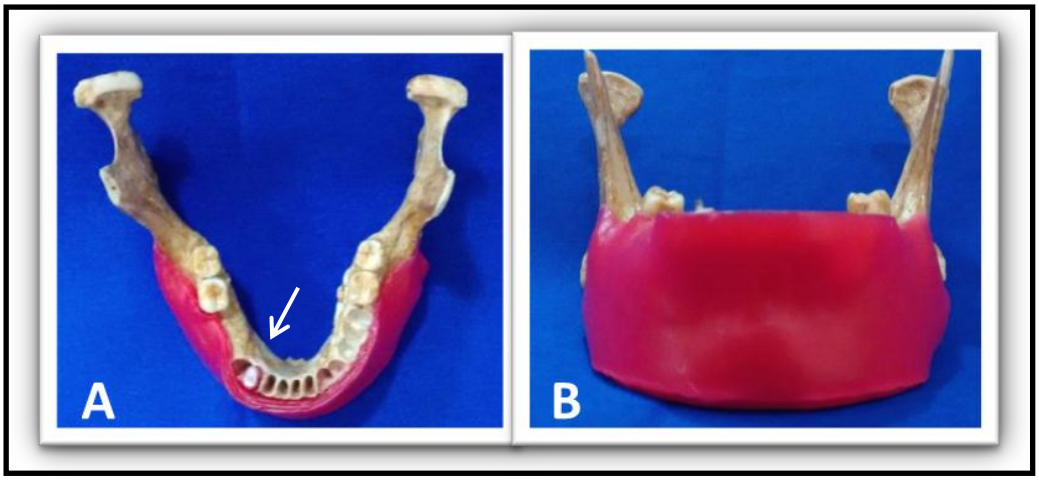

Figura 2 - Dente montado em uma mandíbula seca revestida por três camadas de cera.
A. Vista superior. **B**. Vista frontal
Fonte: O autor.

3.5 GRUPOS DE ESTUDO

A amostra foi dividida em quatro grupos compostos por dez dentes cada, distribuídos da seguinte maneira:

Grupo A (n = 10): sem pino intracanal e sem fratura;

Grupo B (n = 10): sem pino intracanal e com fratura;

Grupo C (n = 10): com pino intracanal e sem fratura;

Grupo D (n = 10): com pino intracanal e com fratura.

3.6 EXAMES POR IMAGEM

Todos os dentes foram submetidos a radiografias periapicais digitais, sendo realizadas três incidências (ortorradial, mesiorradial e distorradial - técnica de Clark). Para realização das radiografias digitais, foi utilizado o aparelho de raios X periapical Gendex Expert DC® (Gendex, Des Plaines, EUA), operando a 7 mA, 65 kVp e 0,5 s. A distância foco-sensor foi fixada em 40 cm, e a variação da angulação horizontal foi de 15°, definida com auxílio de um transferidor. Para aquisição das imagens radiográficas, foi utilizado o sistema de radiografia digital direta Micro Imagem (Micro Imagem, Indaiatuba, SP, Brasil).

Em seguida essa mesma amostra foi submetida a exames de TCFC utilizando-se o tomógrafo I-Cat® Next Generation (Imaging Sciences International,

Hatfield, Pennsylvania, EUA) com FOV (*field of view* - campo de visão) de 6 x 23 cm, 5 mA e 120kV. Foram utilizadas duas diferentes resoluções: voxel de 0,25 mm e voxel de 0,30 mm.

3.7 APLICAÇÃO DOS FILTROS

Foram utilizados, para cada um dos exames de TCFC obtidos, três padrões de imagem disponíveis no programa i-Cat Vision (Imaging Sciences International, Hatfield, Pensilvânia, EUA): imagem sem aplicação de filtro ("Normal"), um filtro de suavização ("*Sharpen*") e um filtro de intensificação ("*Hard*").

3.8 AVALIAÇÃO DOS EXAMES POR IMAGEM

As radiografias periapicais de cada dente foram organizadas em *slides* no programa Microsoft Office® Power Point. Cada *slide* apresentou as três incidências (orto, mesio e distorradial) do mesmo dente. A sequência dos dentes nos *slides* foi aleatória e desconhecida dos examinadores. Já as imagens tomográficas, com e sem a aplicação dos filtros foram analisadas por meio do programa i-Cat Vision (Imaging Sciences International, Hatfield, Pensilvânia, EUA). Uma sequência aleatória também foi definida em relação aos exames e aos filtros para utilização dos examinadores.

Dois examinadores, especialistas em Radiologia Odontológica, com experiência em imagens tomográficas, avaliaram as imagens de forma independente. As imagens foram classificadas quanto à ocorrência de fratura radicular, utilizando cinco escores:

1. fratura definitivamente presente
2. fratura provavelmente presente
3. incerteza
4. fratura provavelmente ausente
5. fratura definitivamente ausente

As avaliações, tanto das imagens periapicais quanto das tomografias, foram realizadas em um único computador, localizado em uma sala com luz reduzida (penumbra). As imagens tomográficas puderam ser avaliadas nos cortes sagitais,

axiais e coronais. As condições de brilho e contraste foram padronizadas pela aplicação da ferramenta: “reiniciar todas as janelas/níveis”. Foi permitido aplicar zoom nas imagens. Após três semanas da primeira avaliação, uma segunda avaliação foi realizada em 20% da amostra para definir a concordância intraexaminador.

3.9 ANÁLISE DOS DADOS

Para a definição da acurácia, foram calculadas as áreas sob as curvas ROC (*receiver operator characteristic*) de cada um dos exames avaliados (periapical, tomografia com os diferentes filtros e resoluções), para os dentes com e sem pino intracanal. Foi aplicada uma análise de variância (ANOVA) para a comparação das áreas sob as curvas ROC entre os filtros e teste t para comparação das áreas entre os examinadores, resoluções e presença/ausência de pino. O coeficiente kappa foi utilizado para o cálculo das concordâncias intra e interexaminadores, interpretado da seguinte maneira: < 0,10, sem concordância; 0,10-0,40, concordância baixa; 0,41-0,60, concordância moderada; 0,61-0,80, concordância forte e de 0,81 a 1,00, concordância excelente. Para a definição dos valores de kappa os cinco escores utilizados na avaliação foram reclassificados em três novos escores. Os escores 1 e 2 foram reclassificados em escore 1 e os escores 4 e 5 foram reclassificados em escore 2. O escore 3 foi mantido, indicando os casos de incerteza. Foi utilizado o programa SPSS versão 15.0 (SPSS Inc, Chicago, EUA), e o nível de significância considerado foi de 5% ($p \leq 0,05$).

4 ARTIGO

O artigo abaixo está apresentado nas normas do periódico *International Endodontic Journal*, classificado no Qualis da CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior), na Área de Avaliação de Odontologia, como A1 (ANEXOS B e C).

Diagnosis of mesiodistal vertical root fractures in teeth with metal posts: influence of applying filters in CBCT images at different resolutions

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Running title: “Diagnosis of mesiodistal root fractures”

Keywords: cone beam computed tomography, image enhancement filters, metal artifact, vertical root fracture, voxel resolution.

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Abstract

Aim: To evaluate the influence of applying filters in cone beam computed tomography (CBCT) images at different resolutions. These CBCT images were obtained for diagnosing mesiodistal vertical root fractures (VRF) in teeth with metal posts.

Methodology: Forty teeth were treated endodontically, and twenty received metal posts. Ten teeth without posts and ten teeth with posts were subjected to VRF in the mesiodistal direction. The sample was submitted to periapical radiographs and CBCT exams with a voxel of 0.25 and 0.30 mm. In order to reduce the influence of the metal artifact in the CT images, the teeth were evaluated with and without the application of filters ("Sharpen" and "Hard"). The images were evaluated by two radiologists who had to identify the presence of VRF. Accuracy values (ROC curves) for the different variables were compared using an analysis of variance and *t*-test.

Results: No difference was observed between images with and without filter application ($p = 0.860$). Images obtained with a 0.25 mm voxel were more accurate ($p = 0.001$). The presence of the metal post reduced the accuracy of the diagnosis of VRF ($p = 0.001$), and the CT images showed superior results compared to periapical radiographs ($p = 0.005$).

Conclusion: The presence of a metal post and the voxel size significantly interfere with the diagnosis of VRF. Despite the formation of metal artifacts associated with metallic cores, applying filters did not improve the diagnosis. For mesiodistal VRF, the CBCT images are superior to the periapical radiographs.

Diagnosis of Mesiodistal Vertical Root Fractures in Teeth with Metal Posts: Influence of Applying Filters in CBCT Images at Different Resolutions

Introduction

Root fractures are relatively common complications in daily clinical practice, which can lead to tooth loss. Studies investigating the indications of dental extractions report that 7.7% to 32.1% of extractions are due to root fractures (Majorana *et al.* 2002, Chen *et al.* 2008). The fractures that afflict dental roots can occur in different locations with a variety of orientations. When the root fracture is vertical and characterized by an incomplete or complete fracture line extending along the axis of the root's length, it becomes difficult to detect the root fracture by conventional radiographic exams, especially when it occurs in the mesiodistal direction (Hassan *et al.* 2009, Wenzel *et al.* 2009, Hassan *et al.* 2010, Metska *et al.* 2012, Ferreira *et al.* 2013). This difficulty can be compounded in the early stages when the fracture is in the form of a thin crack, with its fragments still appearing to be together and without an associated bone loss.

In such cases, a cone beam computed tomography (CBCT) exam is indicated, which allows three-dimensional visualization of the structures, without superimposed images. Various studies have demonstrated the superior accuracy of CBCT for diagnosing root fractures in teeth without intracanal filling material (Wang *et al.* 2011, da Silveira *et al.* 2013). However, in cases where the roots are filled with high-density materials, such as posts and molten metal cores, artifacts can appear in the tomography images, making the exam difficult to interpret (Junqueira *et al.* 2013).

Some studies have been undertaken to minimize these effects in the diagnosis of root fractures by applying digital image enhancement filters and metal artifacts reduction algorithms; however, such studies are few and have quite divergent results (Barrett & Keat 2004, Ballhausen *et al.* 2014). Furthermore, some variables in the tomographic image acquisition protocol may also influence image quality, such as voxel size, which is correlated

with image resolution (Hassan *et al.* 2010) and can interfere in the diagnosis of root fractures (Wenzel *et al.* 2009, Özer 2011, Corbella *et al.* 2014).

This variation in the results of various studies may be associated with methodological variations, such as the direction of the fracture lines, the tomographic equipment used, the tomographic image acquisition protocols, and the different filters and algorithms applied. Thus, given the divergence of the findings in the literature and the importance of a correct diagnosis of root fracture for the prognosis of a tooth, the objective in this study was to evaluate the application of digital filters in CBCT images at different resolutions; these CBCT images were obtained for diagnosing mesiodistal vertical root fractures (VRF) associated with teeth with endodontic treatment and intracanal metal posts.

Material and methods

Teeth selection

After approval of this study by the Research Ethics Committee of the Federal University of Juiz de Fora (UFJF, Juiz de Fora, Minas Gerais, Brazil; Opinion No. 996.011/2015), 40 single-rooted human teeth (incisors and canines) were selected from the tooth bank of the School of Dentistry, UFJF (Juiz de Fora, Minas Gerais, Brazil). The teeth, which were preserved in distilled water, were inspected with a magnifying lens (2x) to confirm the absence of radicular fractures and resorptions and root integrity. Next, they underwent scaling and root planing to remove dental calculus. Teeth with fractured roots, decay or wear /resorption were excluded.

Teeth Preparation

The crowns of the selected teeth were sectioned at the cementoenamel junction. Root canals were prepared endodontically by an endodontist using Protaper rotary system finishing (Dentsply Maillefer, Ballaigues, Switzerland) and filled via mechanical thermoplastic technique using gutta-percha points (Dentsply Maillefer, Ballaigues, Switzerland) and Sealer 26 endodontic cement (Dentsply Maillefer, Ballaigues, Switzerland). The teeth were

radiographed in the buccolingual and mesiodistal directions to evaluate filling quality. After endodontic treatment, 20 teeth were randomly selected to receive prefabricated metal posts (*Reforpost I Metálico*, Angelus, Londrina, Paraná, Brazil) and cemented with zinc phosphate cement (SS White, Rio de Janeiro, RJ, Brazil).

Twenty teeth (ten with metal posts and ten without metal posts) were randomly selected and subjected to vertical root fractures in the mesiodistal direction by applying mechanical force to the tooth using a chisel and hammer. The remaining twenty teeth were not subjected to a fracture. A wooden device with a wedge-shaped channel was used to hold the tooth in position during the fracture, ensuring stabilization of the tooth and better standardization of the fracture orientation. Next, the roots were covered uniformly with a layer of approximately 0.3 mm of *cera 7* (Epoxiglass, São Paulo, Brazil) to simulate the radiographic aspect of the periodontal ligament space. The teeth were randomly assembled on a dry human mandible for imaging exam acquisition. The mandible was covered on the labial face with 3 mm of *cera 7* (Epoxiglass, São Paulo, Brazil) for attenuation of the x-ray beam, simulating mandibular soft tissues.

Periapical radiographs

All teeth were submitted to digital periapical radiographs, with three incidences obtained (orthoradial, mesioradial and distoradial). To produce the digital radiographs, the Gendex Expert DC® (Gendex, Des Plaines, USA) periapical X-ray apparatus was used with the following parameters: 7 mA, 65 kVp, and 0.5 s. The focus-sensor distance was set at 40 cm, and the variation of the horizontal angle was 15° and defined with the aid of a protractor. For radiographic image acquisition, the *Micro Imagem* (Micro Imagem, Indaiatuba, SP, Brazil) direct digital radiography system was used.

Cone Beam Computed Tomography

The same sample was submitted to CBCT exams using the I-Cat® Next Generation scanner (Imaging Sciences International, Hatfield, Pennsylvania, USA) with a 6 x

23 cm FOV (field of view), 5 mA, and 120 kV. Two different resolutions were used: 0.25 mm voxel and 0.30 mm voxel.

For each of the CBCT scans obtained, three images available in the i-CAT Vision software (Imaging Sciences International, Hatfield, Pennsylvania, USA) were used: an image without a filter application ("Normal"), an image with a smoothing filter ("Sharpen"), and an image with an intensifying filter ("Hard").

Imaging exams evaluation

The periapical radiographs of each tooth were organized into slides in Microsoft Office® Power Point. Each slide presented three incidences (ortho-, mesio-, and disto-radial) of the same tooth. The sequence of the teeth on the slides was random and unknown by the examiners. The tomographic images, with and without the applied filters, were analyzed using i-Cat Vision software (Imaging Sciences International, Hatfield, Pennsylvania, USA). A random sequence was also defined in relation to the exams and the filters for the examiners' use.

Two examiners (Dental Radiology specialists with expertise in tomographic images) evaluated the images independently. The images were classified according to the occurrence of root fracture using five scores:

- 1: fracture definitely present
- 2: fracture probably present
- 3: uncertain
- 4: fracture probably absent
- 5: fracture definitely absent

The evaluations of the periapical images and the CT scans were performed on a single computer located in a room with low light (darkened). The tomographic images could be evaluated in the sagittal, axial, and coronal sections. It was possible to zoom in on the

images. Three weeks after the first assessment, a second assessment was performed on 20% of the sample to determine intra-examiner agreement.

Data analysis

To determine accuracy, the areas under the ROC (receiver operator characteristic) curves were calculated for each of the exams (periapical, tomography with different filters and resolutions) for the teeth with and without root canal posts. To compare the values of the areas under the ROC curve, an analysis of variance (ANOVA) was performed for the comparison between filters, and a *t*-test was performed for comparisons between examiners, resolutions, and presence / absence of a post. The kappa coefficient was used to calculate intra- and inter-examiner agreement, which was interpreted as follows: <0.10, no agreement; 0.10-0.40, low agreement; 0.41-0.60, moderate agreement; 0.61-0.80, strong agreement; and 0.81-1.00, excellent agreement. For the definition of the kappa values, the five scores used in the evaluation were reclassified into three new scores. Scores of 1 and 2 were reclassified as a score of 1, and scores of 4 and 5 were reclassified as a score of 2. A score of 3 was retained, indicating cases of uncertainty. SPSS software version 15.0 (SPSS Inc., Chicago, USA) was used, and the level of significance was 5% ($p \leq 0.05$).

Results

The intra- and inter-examiner reliability exhibited moderate average agreement (Table 1).

Table 1

The distribution of examiner responses among the five scores are presented in Table 2. For the teeth without metal posts, the scores related to the "certainties" (scores 1 and 5) were the most frequent. For the teeth with metal posts, the most prominent was a score of 3 (uncertainty).

Table 2

Table 3 presents the accuracy values (areas under the ROC curves) for each radiographic technique for teeth with and without a metal post. Comparing the values of the areas under the ROC curves that were obtained by the two examiners, there was no statistically significant difference (paired *t*-test; p = 0.110). Comparing the areas obtained for "Normal" images with those for the "Sharpen" and the "Hard" filters, no significant differences (ANOVA; p = 0.860) were obtained. When the areas obtained for the 0.25 mm and 0.30 mm voxel images were compared, the accuracy of the images obtained with the smaller voxel (0.25 mm) was significantly higher (paired *t*-test; p = 0.001), regardless of the presence of the metal post. Comparing the Az values between teeth with and without metal posts, the accuracy of the images without posts was significantly increased (*t*-test; p = 0.001). Comparing the tomographic and periapical images, the accuracy of the CBCT was significantly increased (paired *t*-test / p = 0.005).

Table 3

Figures 1 and 2 illustrate the periapical images and CBCT images with different filters and voxel sizes for one case without a post (Figure 1) and one case with a post (Figure 2).

Figure 1

Figure 2

Discussion

VRF extend longitudinally from the apex of the root to the tooth crown (Varshosaz *et al.* 2010). The detection of VRF are quite a challenging task given that a false negative diagnosis can lead to periodontal disease, initially subclinical, with the potential to exacerbate over time, and a false positive diagnosis can result in unnecessary extraction of the tooth (Kajan & Taromsari, 2012). Moreover, it is difficult to arrive at a definitive diagnosis exclusively based on signs and symptoms because they are not specific to fractures and are very similar to those of periodontal and endodontic diseases. VRF may be iatrogenic and occur more frequently during the vertical compression of endodontic root filling material or after the insertion of intracanal posts or cores (Bechara *et al.* 2013).

Previous studies that compared the detection of root fractures in teeth with and without root canal filling concluded that the presence of endodontic treatment reduces the accuracy of the diagnosis (Hassan *et al.* 2009, de Rezende Barbosa *et al.* 2016). The sensitivity and accuracy values for teeth with metal intracanal retainers are even lower (metal cores and intracanal posts) (Ferreira *et al.* 2013, Junqueira *et al.* 2013, Melo *et al.* 2013, Jakobson *et al.* 2014, Mohammadpour *et al.* 2014, Ferreira *et al.* 2015, de Rezende Barbosa *et al.* 2016). The results of the present study correspond with previous results, as the accuracy values were significantly lower for teeth with intracanal metal posts.

The reason for this reduction in accuracy is that high-density objects, such as intracanal metal retainers, cause artifacts in the tomographic images displayed as radiopaque and / or radiolucent striations that may overlap with tooth roots, simulating a non-existent fracture or covering up a real fracture (Wenzel *et al.* 2009, Wang *et al.* 2011, Metska *et al.* 2012, Bechara *et al.* 2013). This phenomenon causes a reduction in the CBCT sensitivity and specificity values (Wenzel *et al.* 2009, Wang *et al.* 2011, Metska *et al.* 2012).

Artifacts, which impair the quality of the images, can only be partially corrected by means of software or specific algorithms given that the density of the metal is beyond the normal range that can be corrected by a computer, resulting in incomplete attenuation profiles and a persistent loss of detail around the tissue / metal interface, which is often the

principal area of interest (Barrett & Keat 2004). Although some studies reported an improvement in the quality of CBCT images with the use of metal artifact reduction algorithms (Bechara *et al.* 2012, Ballhausen *et al.* 2014), others have not reported any difference in images with and without application of the algorithm (de Rezende Barbosa *et al.* 2016). In the study by Bechara *et al.* (2013), the accuracy for fracture diagnosis was reduced after applying the artifact reduction algorithm.

Other tools, such as digital filters, can also be used as an option to reduce the influence of these artifacts, improving the quality of the tomographic images. Previous studies have evaluated the effect of filters on CBCT images for detecting root fractures (Wenzel *et al.* 2009, Nascimento *et al.* 2014, Ferreira *et al.* 2015). Wenzel *et al.* (2009) observed a significant improvement in CBCT sensitivity using the "Angio Sharpen" filter. Nascimento *et al.* (2014) also observed that the "Angio Sharpen" ("Angio Sharpen Medium 5 x 5" and "Angio Sharpen High 5 x 5") and "Sharpen" ("Sharpen" and "Sharpen 3 x 3") filters showed better results than the original images. However, these studies were conducted on teeth without endodontic treatment, which makes interpretation of the images easier due to the absence of artifacts. Few studies have applied image enhancement filters for diagnosing fractures in endodontically treated teeth with intracanal posts. Ferreira *et al.* (2015) analyzed original CBCT images and those with the application of the following filters: "S9", "Smooth", "Smooth 3 x 3", "Sharpen", "Sharpen-Mild", and "Sharpen 3 x 3". Regarding accuracy, the "Sharpen-Mild" filter proved superior. Regarding specificity, the original images and the "S9" and "Smooth" filters had higher values. However, there was no significant improvement in the diagnosis of VRF in teeth with metal posts. In the present study, two filters with very distinct performance were chosen (a smoothing filter ("Sharpen") and an intensifying filter ("Hard")), and no significant difference was observed between images obtained using filters and the original images ("Normal") regardless of the presence of the metallic post.

Parameters related to the tomographic image acquisition protocol may also affect final image quality. Voxel size has been reported in the literature as a variable that can influence the detection of radicular fractures (Kamburoglu *et al.* 2010, Costa *et al.* 2012). The

voxel size defines the resolution of the images. Depending on the CBCT equipment used and the different imaging protocols, differences in the resolution are noted (Costa *et al.* 2012). In a systematic review, Corbella *et al.* (2014) found that voxel size appears to be the most important CBCT parameter for determining the accuracy of a VRF diagnosis. Wenzel *et al.* (2009) evaluated tomographic images with two resolutions: 0.125 mm voxel and 0.25 mm voxel. The smaller voxel promotes an increase in sensitivity without compromising specificity. Other studies comparing different resolutions (voxel sizes) also reported increased accuracy values related to smaller voxel sizes (Kamburoglu *et al.* 2010, Edlund *et al.* 2011, da Silveira *et al.* 2013). However, Talwar *et al.* (2016) observed that voxel size had no impact on the diagnosis of root fracture, although their study was conducted on teeth without endodontic treatment. In the present study, the 0.25 mm voxel was significantly superior to the 0.30 mm voxel regardless of the presence of the metal post. Although we know that the smaller the voxel, the greater the radiation dose, in cases of suspected VRF, especially in the presence of metal posts, the importance of the accuracy of the diagnosis must be considered, with higher resolution images being more appropriate. Using lower FOVs can compensate for the dosages in these cases.

Given the less satisfactory results from CBCT in the presence of metallic artifacts, one could question the application of CT in cases of suspected fractures in teeth with metal posts and indicate the use of periapical radiographs that, despite the two-dimensionality, present images rich in detail. This can be confirmed in several studies that have not observed, in any comparisons, significant differences between CBCT images and periapical radiographs (Wenzel *et al.* 2009, Kambungton *et al.* 2012, Junqueira *et al.* 2013).

However, the vast majority of studies involving a diagnosis of VRF do not identify the direction of the fracture line (Tsesis *et al.* 2008, Edlund *et al.* 2011, Özer 2011, Metska *et al.* 2012, Bechara *et al.* 2013, da Silveira *et al.* 2013, Ferreira *et al.* 2013, Patel *et al.* 2013, Chavda *et al.* 2014, Mohammadpour *et al.* 2014, Moudi *et al.* 2014, Nascimento *et al.* 2014, de Rezende Barbosa *et al.* 2016, Ferreira *et al.* 2015, Moudi *et al.* 2015), which can directly influence its detection. Vertical fractures in the buccolingual direction can be identified in

periapical radiographs. However, if VRF are in the mesiodistal direction, two-dimensional radiographic diagnosis can become unlikely (Tsesis *et al.* 2008, Özer 2011, Kajan & Taromsari 2012, Ferreira *et al.* 2013). Among the studies that identify the fracture line, most studies use fractures predominantly in the buccolingual direction (Hassan *et al.* 2009, Kamburoglu *et al.* 2010, Varshosaz *et al.* 2010, Kambungton *et al.* 2012, Junqueira *et al.* 2013, Melo *et al.* 2013), which may explain the high accuracy values observed for the periapical radiographs in previous studies, often similar to those observed for CBCT images.

In this study, the mean value for accuracy of periapical radiographs was low (0.49) and was likely attributed to the direction of the fracture. In contrast, other studies have observed higher values ranging from 0.53 to 0.93 (Varshosaz *et al.* 2010, da Silveira *et al.* 2013, Junqueira *et al.* 2013, Chavda *et al.* 2014). For VRF detection using periapical radiography, Hassan *et al.* (2009) observed a sensitivity of 51.4% for fractures in the buccolingual direction and 7.7% for those in the mesiodistal direction. For CBCT images, the sensitivity was 87% for buccolingual fractures and 63.5% for mesiodistal fractures. However, only 32.5% of their samples were fractures in the mesiodistal direction, suggesting that the sensitivity values for periapical radiographs could have been even lower if there were more fractures in this direction. Kambungton *et al.* (2012) evaluated VRF using CBCT, digital and conventional periapical radiography. Only three teeth with fractures in a sample of 30 teeth were in the mesiodistal direction. The authors concluded that almost all the lines of fractures that can be detected by two-dimensional X-rays are buccolingual fractures. The authors stated that if the number of mesiodistal fractures were larger, the accuracy of the CBCT images could have been significantly better than that of the periapical radiographs for detecting VRF.

Thus, studies that do not identify the direction of the fracture line should be interpreted with caution, as the result will depend directly on the orientation of the fracture. Factors, such as the presence of metal posts and voxel size, also significantly interfere with the diagnosis of VRF. Despite the formation of metal artifacts associated with metallic cores,

the application of digital filters showed no significant difference in the accuracy of VRF diagnosis.

Conclusions

The presence of a metal post and the voxel size significantly interfere with the diagnosis of VRF. Despite the formation of metal artifacts associated with metallic cores, applying filters did not improve the diagnosis. For mesiodistal VRF, the CBCT images are superior to the periapical radiographs.

Acknowledgments

There are no conflicts of interest regarding this study, or any funding source.

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Table 1 Kappa Values (95% CI) for intra- and inter-examiner agreement

Examiner	1	2
1	0.58 (0.35-0.89)	0.49 (0.23-0.89)
2		0.60 (0.36-0.79)

CI: confidence interval

Table 2 Mean frequency (%) of examiner responses for each radiographic technique, with and without the presence of metal posts

	Without metal posts						
	CBCT						Periapical
	Voxel 0.25 mm			Voxel 0.30 mm			
Score	Normal	*Sharpen*	*Hard*	Normal	*Sharpen*	*Hard*	
1	27.50	35.00	32.50	5.00	15.00	17.50	5.00
2	7.50	10.00	12.50	12.50	12.50	15.00	17.50
3	2.50	0.00	5.00	17.50	22.50	22.50	12.50
4	22.50	20.00	10.00	37.50	30.00	27.50	37.50
5	40.00	35.00	40.00	27.50	20.00	17.50	27.50
	With metal posts						
	CBCT						Periapical
	Voxel 0.25 mm			Voxel 0.30 mm			
Score	Normal	*Sharpen*	*Hard*	Normal	*Sharpen*	*Hard*	
1	25.00	27.50	27.50	5.00	10.00	15.00	2.50
2	12.50	17.50	10.00	7.50	7.50	7.50	15.00
3	40.00	42.50	50.00	52.50	57.50	72.50	30.00
4	17.50	10.00	7.50	30.00	25.00	5.00	37.50
5	5.00	2.50	5.00	5.00	0.00	0.00	15.00

Table 3 Area under the ROC curve (Az) for each radiographic technique, for teeth with and without a metal post

				Examiner 1			Examiner 2		
Radiographic technique	Metal post	Voxel (mm)	Filter	Az	SE	CI 95%	Az	SE	CI 95%
CBCT	Without	0.25	Normal	0.92	0.05	0.81-1.00	0.89	0.08	0.72-1.00
		0.25	*Sharpen*	0.98	0.02	0.92-1.00	0.91	0.07	0.76-1.00
		0.25	*Hard*	0.99	0.01	0.95-1.00	0.97	0.03	0.91-1.00
		0.30	Normal	0.81	0.10	0.61-1.00	0.80	0.10	0.59-1.00
		0.30	*Sharpen*	0.83	0.09	0.65-1.00	0.94	0.04	0.85-1.00
		0.30	*Hard*	0.84	0.08	0.67-1.00	0.89	0.08	0.73-1.00
	With	0.25	Normal	0.58	0.14	0.29-0.86	0.78	0.11	0.55-1.00
		0.25	*Sharpen*	0.74	0.11	0.51-0.96	0.73	0.12	0.48-0.97
		0.25	*Hard*	0.58	0.13	0.31-0.84	0.68	0.12	0.44-0.92
		0.30	Normal	0.54	0.13	0.27-0.80	0.62	0.13	0.35-0.89
		0.30	*Sharpen*	0.60	0.13	0.33-0.86	0.52	0.13	0.26-0.79
		0.30	*Hard*	0.65	0.12	0.40-0.89	0.62	0.12	0.36-0.87
Periapical	Without	-	-	0.59	0.13	0.33-0.84	0.68	0.12	0.44-0.92
	With	-	-	0.36	0.12	0.11-0.61	0.35	0.12	0.10-0.60

Az: area under the ROC curve

SE: standard error

CI: confidence interval

Figure Legends

Figure 1 Images from CBCT and periapical radiography of single fractured tooth without metal post. (a-f) Parasagittal and axial sections from CBCT with 0.25-mm voxel. (a-b) Without filter. (c-d) “Sharpen” filter. (e-f) “Hard” filter. (g-i) Periapical radiographs with variation of horizontal angulation. (g) Mesioradial. (h) Orthoradial. (i) Distoradial. (j-o) Parasagittal and axial sections from CBCT with 0.30-mm voxel. (j-k) Without filter. (l-m) “Sharpen” filter. (n-o) “Hard” filter.

Figure 2 Images from CBCT and periapical radiography of single fractured tooth with metal post. (a-f) Parasagittal and axial sections from CBCT with 0.25-mm voxel. (a-b) Without filter. (c-d) “Sharpen” filter. (e-f) “Hard” filter. (g-i) Periapical radiographs with variation of horizontal angulation. (g) Mesioradial. (h) Orthoradial. (i) Distoradial. (j-o) Parasagittal and axial sections from CBCT with 0.30-mm voxel. (j-k) Without filter. (l-m) “Sharpen” filter. (n-o) “Hard” filter.

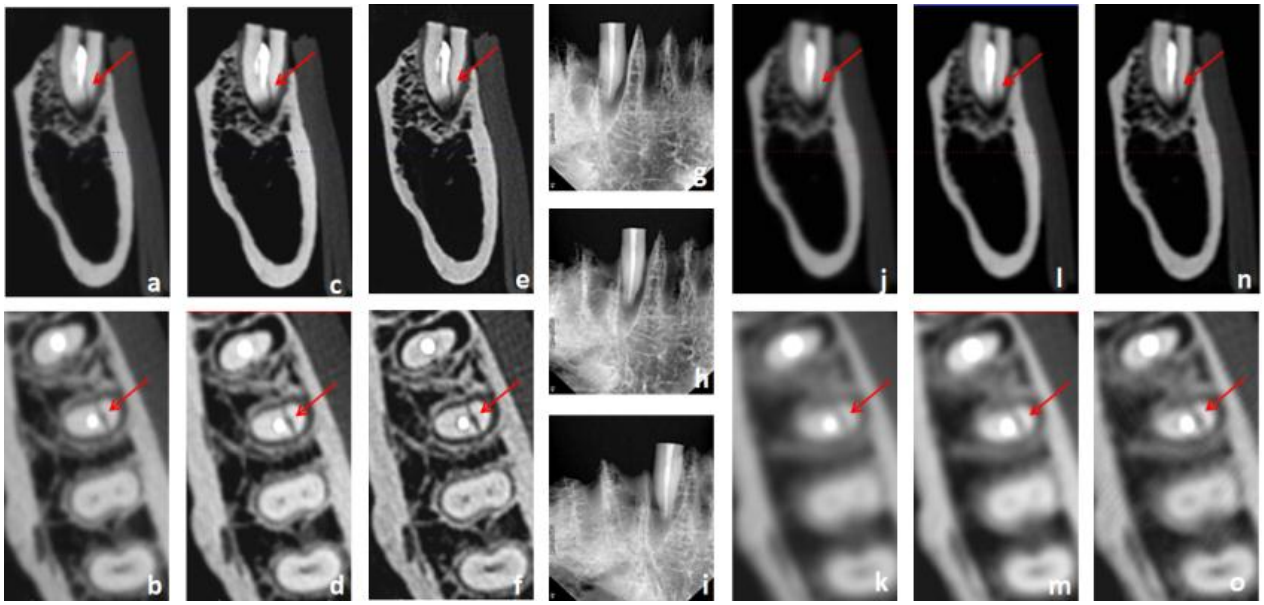

Figure 1 Images from CBCT and periapical radiography of single fractured tooth without metal post. (a-f) Parasagittal and axial sections from CBCT with 0.25-mm voxel. (a-b) Without filter. (c-d) “Sharpen” filter. (e-f) “Hard” filter. (g-i) Periapical radiographs with variation of horizontal angulation. (g) Mesioradial. (h) Orthoradial. (i) Distoradial. (j-o) Parasagittal and axial sections from CBCT with 0.30-mm voxel. (j-k) Without filter. (l-m) “Sharpen” filter. (n-o) “Hard” filter.

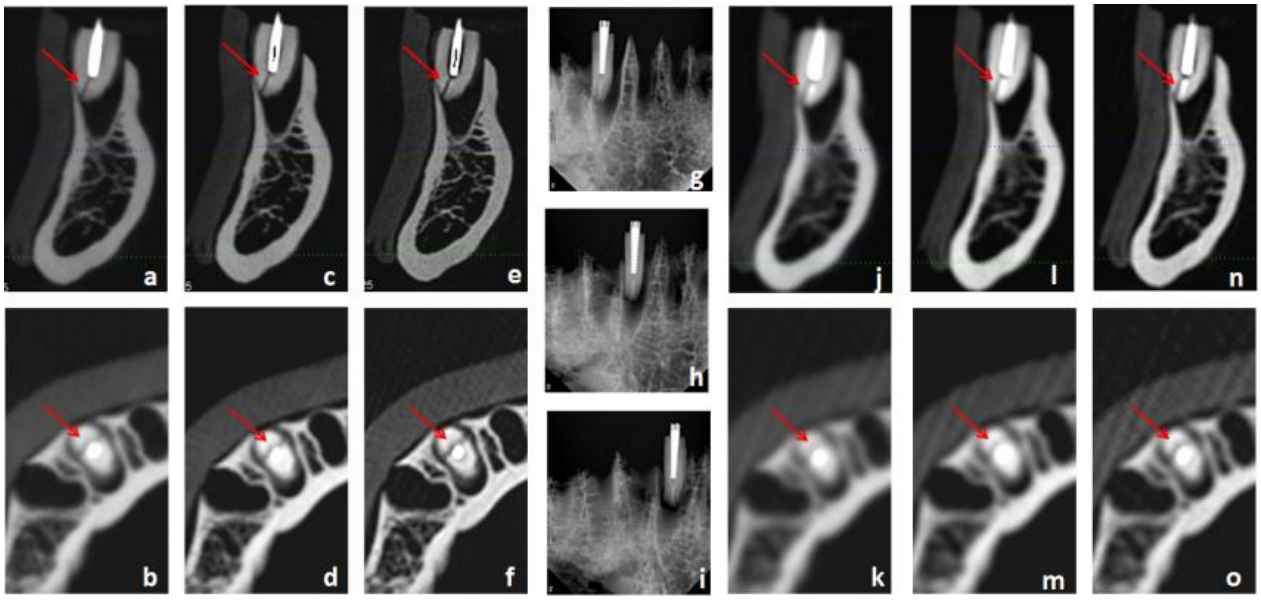

Figure 2 Images from CBCT and periapical radiography of single fractured tooth with metal post. (a-f) Parasagittal and axial sections from CBCT with 0.25-mm voxel. (a-b) Without filter. (c-d) “Sharpen” filter. (e-f) “Hard” filter. (g-i) Periapical radiographs with variation of horizontal angulation. (g) Mesioradial. (h) Orthoradial. (i) Distoradial. (j-o) Parasagittal and axial sections from CBCT with 0.30-mm voxel. (j-k) Without filter. (l-m) “Sharpen” filter. (n-o) “Hard” filter.

5 CONSIDERAÇÕES FINAIS

A partir da metodologia aplicada e dos resultados obtidos, pode-se concluir que:

- a presença de pino metálico interfere significativamente no diagnóstico de FRV, reduzindo a acurácia dos exames periapicais e da TCFC;

- para o diagnóstico de FRV mésio-distal, as imagens de TCFC são superiores às periapicais;

- apesar da formação de artefatos metálicos associados aos pinos metálicos, a aplicação de filtros não melhorou o diagnóstico da FRV;

- o tamanho do voxel interfere significativamente no diagnóstico de FRV, sendo que imagens de TCFC obtidas com maior espessura de corte são menos acuradas.

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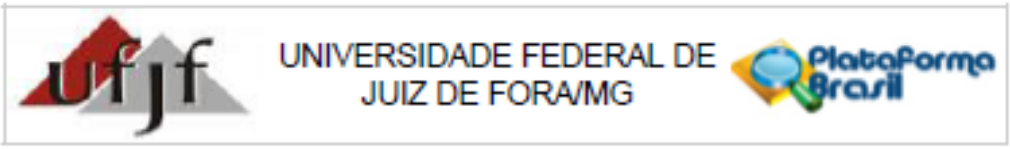
ANEXO A – Parecer Comitê de Ética



PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Detecção de fraturas radiculares verticais: comparação entre radiografia periapical e tomografia computadorizada de feixe cônico

Pesquisador: Karina Lopes Devito

Área Temática:

Versão: 1

CAAE: 42185115.3.0000.5147

Instituição Proponente: FACULDADE DE ODONTOLOGIA

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 996.011

Data da Relatoria: 19/03/2015

Apresentação do Projeto:

Apresentação dentro das normas.

Objetivo da Pesquisa:

Voltado ao ensino Odontológico, bem definido.

Avaliação dos Riscos e Benefícios:

O risco que o projeto apresenta é caracterizado como risco mínimo, considerando que os dados obtidos na pesquisa somente serão utilizados para o projeto vinculado, os quais serão mantidos em sigilo, em conformidade com o que prevê os termos da resolução 466/12 CNS, com amplo benefício acadêmico.

Comentários e Considerações sobre a Pesquisa:

Só comporta elogios pelas finalidades.

Considerações sobre os Termos de apresentação obrigatória:

Atendem perfeitamente às exigências.

Conclusões ou Pendências e Lista de Inadequações:

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

Endereço: JOSE LOURENCO KELMER S/N
Bairro: SAO PEDRO **CEP:** 36.036-900
UF: MG **Município:** JUIZ DE FORA
Telefone: (32)2102-3788 **Fax:** (32)1102-3788 **E-mail:** cep.propesq@ufjf.edu.br

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CNS 001/2013. Data prevista para o término da pesquisa:Junho de 2016.

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

Considerações Finais a critério do CEP:
Diante do exposto, o Comitê de Ética em Pesquisa CEP/UFJF, de acordo com as atribuições 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.

JUIZ DE FORA, 24 de Março de 2015

Assinado por:
Francis Ricardo dos Reis Justi
(Coordenador)

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ANEXO B – Normas do periódico "International Endodontic Journal"

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The official journal of the British Endodontic Society and the European Society of Endodontology

International Endodontic Journal

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1. GENERAL

International Endodontic Journal publishes original scientific articles, reviews, clinical articles and case reports in the field of Endodontology; the branch of dental sciences dealing with health, injuries to and diseases of the pulp and periradicular region, and their relationship with systemic well-being and health. Original scientific articles are published in the areas of biomedical science, applied materials science, bioengineering, epidemiology and social science relevant to endodontic disease and its management, and to the restoration of root-treated teeth. In addition, review articles, reports of clinical cases, book reviews, summaries and abstracts of scientific meetings and news items are accepted.

Please read the instructions below carefully for details on the submission of manuscripts, the journal's requirements and standards as well as information concerning the procedure after a manuscript has been accepted for publication in *International Endodontic Journal*. Authors are encouraged to visit Wiley Author Services for further information on the preparation and submission of articles and figures.

2. ETHICAL GUIDELINES

International Endodontic Journal adheres to the below ethical guidelines for publication and research.

2.1. Authorship and Acknowledgements

Authors submitting a paper do so on the understanding that the manuscript has been read and approved by all authors and that all authors agree to the submission of the manuscript to the Journal.

International Endodontic Journal adheres to the definition of authorship set up by The International Committee of Medical Journal Editors (ICMJE). According to the ICMJE, authorship criteria should be based on 1) substantial contributions to conception and design of, or acquisiation of data or analysis and interpretation of data, 2) drafting the article or revising it critically for important intellectual content and 3) final approval of the version to be published. Authors should meet conditions 1, 2 and 3.

Acknowledgements: Under acknowledgements please specify contributors to the article other than the authors accredited. Please also include specifications of the source of funding for the study and any potential conflict of interests if appropriate. Please find more information on the conflict of interest form in section 2.6.

2.2. Ethical Approvals

Experimentation involving human subjects will only be published if such research has been conducted in full accordance with ethical principles, including the World Medical Association Declaration of Helsinki (version 2008) and the additional requirements, if any, of the country where the research has been carried out. Manuscripts must be accompanied by a statement that the experiments were undertaken with the understanding and written consent of each subject and according to the above mentioned principles. A statement regarding the fact that the study has been independently reviewed and approved by an ethical board should also be included. Editors reserve the right to reject papers if there are doubts as to whether appropriate procedures have been used.

When experimental animals are used the methods section must clearly indicate that adequate measures were taken to minimize pain or discomfort. Experiments should be carried out in accordance with the Guidelines laid down by the National Institute of Health (NIH) in the USA regarding the care and use of animals for experimental procedures or with the European Communities Council Directive of 24 November 1986 (86/609/EEC) and in accordance with local laws and regulations.

All studies using human or animal subjects should include an explicit statement in the Material and Methods section identifying the review and ethics committee approval for each study. The authors MUST upload a copy of the ethical approval letter when submitting their manuscript. Editors reserve the right to reject papers if there is doubt as to whether appropriate procedures have been used.

2.3 Clinical Trials

2.3.1 Randomised control clinical trials

Randomised control clinical trials should be reported using the guidelines available at www.consort-statement.org. A CONSORT checklist and flow diagram (as a Figure) should also be included in the submission material. The *International Endodontic Journal* asks that authors submitting manuscripts reporting from a clinical trial to register the trials in any of the following public clinical trials registries: www.clinicaltrials.gov, https://www.clinicaltrialsregister.eu/, http://isrctn.org/. Other primary registries if named in the WHO network will also be considered acceptable. The clinical trial registration number and name of the trial register should be included in the Acknowledgements at the submission stage.

2.3.2 Epidemiological observational trials

Submitting authors of epidemiological human observations studies are required to review and submit a 'strengthening the reporting of observational studies in Epidemiology' (STROBE) checklist and statement. Compliance with this should be detailed in the materials and methods section. (www.strobe-statement.org)

2.4 Systematic Reviews
Systematic reviews should be reported using the PRISMA guidelines available at http://prisma-statement.org/. A PRISMA checklist and flow diagram (as a Figure) should also be included in the submission material.

2.5 DNA Sequences and Crystallographic Structure Determinations
Papers reporting protein or DNA sequences and crystallographic structure determinations will not be accepted without a Genbank or Brookhaven accession number, respectively. Other supporting data sets must be made available on the publication date from the authors directly.

2.6 Conflict of Interest and Source of Funding
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It is the responsibility of the corresponding author to have all authors of a manuscript fill out a conflict of interest disclosure form, and to upload all forms together with the manuscript on submission. The disclosure statement should be included under Acknowledgements. Please find the form below:

Conflict of Interest Disclosure Form

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3.1 MANUSCRIPT SUBMISSION PROCEDURE

Manuscripts should be submitted electronically via the online submission site http://mc.manuscriptcentral.com/iej. The use of an online submission and peer review site enables immediate distribution of manuscripts and consequentially speeds up the review process. It also allows authors to track the status of their own manuscripts. Complete instructions for submitting a paper is available online and below. Further assistance can be obtained from iejeditor@cardiff.ac.uk.

3.2. Getting Started

• Launch your web browser (supported browsers include Internet Explorer 5.5 or higher, Safari 1.2.4, or Firefox 1.0.4 or higher) and go to the journal's online Submission Site:
http://mc.manuscriptcentral.com/iej
• Log-in, or if you are a new user, click on 'register here'.
• If you are registering as a new user.
- After clicking on 'register here', enter your name and e-mail information and click 'Next'. Your e-mail information is very important.
- Enter your institution and address information as appropriate, and then click 'Next.'
- Enter a user ID and password of your choice (we recommend using your e-mail address as your user ID), and then select your areas of expertise. Click 'Finish'.
• If you are registered, but have forgotten your log in details, please enter your e-mail address under 'Password Help'. The system will send you an automatic user ID and a new temporary password.
• Log-in and select 'Author Centre '

3.3. Submitting Your Manuscript

• After you have logged into your 'Author Centre', submit your manuscript by clicking on the submission link under 'Author Resources'.
• Enter data and answer questions as appropriate. You may copy and paste directly from your manuscript and you may upload your pre-prepared covering letter.

• Click the 'Next' button on each screen to save your work and advance to the next screen.
• You are required to upload your files.
- Click on the 'Browse' button and locate the file on your computer.
- Select the designation of each file in the drop down next to the Browse button.
- When you have selected all files you wish to upload, click the 'Upload Files' button.
• Review your submission (in HTML and PDF format) before completing your submission by sending it to the Journal. Click the 'Submit' button when you are finished reviewing.

3.4. Manuscript Files Accepted

Manuscripts should be uploaded as Word (.doc) or Rich Text Format (.rft) files (not write-protected) plus separate figure files. GIF, JPEG, PICT or Bitmap files are acceptable for submission, but only high-resolution TIF or EPS files are suitable for printing. The files will be automatically converted to HTML and PDF on upload and will be used for the review process. The text file must contain the abstract, main text, references, tables, and figure legends, but no embedded figures or Title page. The Title page should be uploaded as a separate file. In the main text, please reference figures as for instance 'Figure 1', 'Figure 2' etc to match the tag name you choose for the individual figure files uploaded. Manuscripts should be formatted as described in the Author Guidelines below.

3.5. Blinded Review

Manuscript that do not conform to the general aims and scope of the journal will be returned immediately without review. All other manuscripts will be reviewed by experts in the field (generally two referees). International Endodontic Journal aims to forward referees´ comments and to inform the corresponding author of the result of the review process. Manuscripts will be considered for fast-track publication under special circumstances after consultation with the Editor.
International Endodontic Journal uses double blinded review. The names of the reviewers will thus not be disclosed to the author submitting a paper and the name(s) of the author(s) will not be disclosed to the reviewers.
To allow double blinded review, please submit (upload) your main manuscript and title page as separate files.
Please upload:
• Your manuscript without title page under the file designation 'main document'
• Figure files under the file designation 'figures'
• The title page and Acknowledgements where applicable, should be uploaded under the file designation 'title page'
All documents uploaded under the file designation 'title page' will not be viewable in the html and pdf format you are asked to review in the end of the submission process. The files viewable in the html and pdf format are the files available to the reviewer in the review process.

3.6. Suspension of Submission Mid-way in the Submission Process

You may suspend a submission at any phase before clicking the 'Submit' button and save it to submit later. The manuscript can then be located under 'Unsubmitted Manuscripts' and you can click on 'Continue Submission' to continue your submission when you choose to.

3.7. E-mail Confirmation of Submission

After submission you will receive an e-mail to confirm receipt of your manuscript. If you do not receive the confirmation e-mail after 24 hours, please check your e-mail address carefully in the system. If the e-mail address is correct please contact your IT department. The error may be caused by some sort of spam filtering on your e-mail server. Also, the e-mails should be received if the IT department adds our e-mail server (uranus.scholarone.com) to their whitelist.

3.8. Manuscript Status

You can access ScholarOne Manuscripts any time to check your 'Author Centre' for the status of your manuscript. The Journal will inform you by e-mail once a decision has been made.

3.9. Submission of Revised Manuscripts

To submit a revised manuscript, locate your manuscript under 'Manuscripts with Decisions' and click on 'Submit a Revision'. Please remember to delete any old files uploaded when you upload your revised manuscript.

4. MANUSCRIPT TYPES ACCEPTED

Original Scientific Articles: must describe significant and original experimental observations and provide sufficient detail so that the observations can be critically evaluated and, if necessary, repeated. Original Scientific Articles must conform to the highest international standards in the field.

Review Articles: are accepted for their broad general interest; all are refereed by experts in the field who are asked to comment on issues such as timeliness, general interest and balanced treatment of controversies, as well as on scientific accuracy. Reviews should generally include a clearly defined search strategy and take a broad view of the field rather than merely summarizing the authors´ own previous work. Extensive or unbalanced citation of the authors´ own publications is discouraged.

Mini Review Articles: are accepted to address current evidence on well-defined clinical, research or methodological topics. All are refereed by experts in the field who are asked to comment on timeliness, general interest, balanced treatment of controversies, and scientific rigor. A clear research question, search strategy and balanced synthesis of the evidence is expected. Manuscripts are limited in terms of word-length and number of figures.

Clinical Articles: are suited to describe significant improvements in clinical practice such as the report of a novel technique, a breakthrough in technology or practical approaches to recognised clinical challenges. They should conform to the highest scientific and clinical practice standards.

Case Reports: illustrating unusual and clinically relevant observations are acceptable but they must be of sufficiently high quality to be considered worthy of publication in the Journal. On rare occasions, completed cases displaying non-obvious solutions to significant clinical challenges will be considered. Illustrative material must be of the highest quality and healing outcomes, if appropriate, should be demonstrated.

Supporting Information: *International Endodontic Journal* encourages submission of adjuncts to printed papers via the supporting information website (see submission of supporting information below). It is encouraged that authors wishing to describe novel procedures or illustrate cases more fully with figures and/or video may wish to utilise this facility.

Letters to the Editor: are also acceptable.

Meeting Reports: are also acceptable.

5. MANUSCRIPT FORMAT AND STRUCTURE

5.1. Format

Language: The language of publication is English. It is preferred that manuscript is professionally edited. A list of independent suppliers of editing services can be found at http://authorservices.wiley.com/bauthor/english_language.asp. All services are paid for and arranged by the author, and use of one of these services does not guarantee acceptance or preference for publication

Presentation: Authors should pay special attention to the presentation of their research findings or clinical reports so that they may be communicated clearly. Technical jargon should be avoided as much as possible and clearly explained where its use is unavoidable. Abbreviations should also be kept to a minimum, particularly those that are not standard. The background and hypotheses underlying the study, as well as its main conclusions, should be clearly explained. Titles and abstracts especially should be written in language that will be readily intelligible to any scientist.

Abbreviations: International Endodontic Journal adheres to the conventions outlined in Units, Symbols and Abbreviations: A Guide for Medical and Scientific Editors and Authors. When non-standard terms appearing 3 or more times in the manuscript are to be abbreviated, they should be written out completely in the text when first used with the abbreviation in parenthesis.

5.2. Structure

All manuscripts submitted to *International Endodontic Journal* should include Title Page, Abstract, Main Text, References and Acknowledgements, Tables, Figures and Figure Legends as appropriate

Title Page: The title page should bear: (i) Title, which should be concise as well as descriptive; (ii) Initial(s) and last (family) name of each author; (iii) Name and address of department, hospital or institution to which work should be attributed; (iv) Running title (no more than 30 letters and spaces); (v) No more than six keywords (in alphabetical order); (vi) Name, full postal address, telephone, fax number and e-mail address of author responsible for correspondence.

Abstract for Original Scientific Articles should be no more than 250 words giving details of what was done using the following structure:

• **Aim**: Give a clear statement of the main aim of the study and the main hypothesis tested, if any.
• **Methodology**: Describe the methods adopted including, as appropriate, the design of the study, the setting, entry requirements for subjects, use of materials, outcome measures and statistical tests.
• **Results**: Give the main results of the study, including the outcome of any statistical analysis.
• **Conclusions**: State the primary conclusions of the study and their implications. Suggest areas for further research, if appropriate.

Abstract for Review Articles should be non-structured of no more than 250 words giving details of what was done including the literature search strategy.

Abstract for Mini Review Articles should be non-structured of no more than 250 words, including a clear research question, details of the literature search strategy and clear conclusions.

Abstract for Case Reports should be no more than 250 words using the following structure:

• **Aim**: Give a clear statement of the main aim of the report and the clinical problem which is addressed.
• **Summary**: Describe the methods adopted including, as appropriate, the design of the study, the setting, entry requirements for subjects, use of materials, outcome measures and analysis if any.
• **Key learning points**: Provide up to 5 short, bullet-pointed statements to highlight the key messages of the report. All points must be fully justified by material presented in the report.

Abstract for Clinical Articles should be no more than 250 words using the following structure:

• **Aim:** Give a clear statement of the main aim of the report and the clinical problem which is addressed.
• **Methodology:** Describe the methods adopted.
• **Results:** Give the main results of the study.
• **Conclusions:** State the primary conclusions of the study.

Main Text of Original Scientific Article should include Introduction, Materials and Methods, Results, Discussion and Conclusion

Introduction: should be focused, outlining the historical or logical origins of the study and gaps in knowledge. Exhaustive literature reviews are not appropriate. It should close with the explicit statement of the specific aims of the investigation, or hypothesis to be tested.

Material and Methods: must contain sufficient detail such that, in combination with the references cited, all clinical trials and experiments reported can be fully reproduced.

(i) Clinical Trials should be reported using the CONSORT guidelines available at www.consort-statement.org. A CONSORT checklist and flow diagram (as a Figure) should also be included in the submission material.

(ii) Experimental Subjects: experimentation involving human subjects will only be published if such research has been conducted in full accordance with ethical principles, including the World Medical Association Declaration of Helsinki (version 2008) and the additional requirements, if any, of the country where the research has been carried out. Manuscripts must be accompanied by a statement that the experiments were undertaken with the understanding and written consent of each subject and according to the above mentioned principles. A statement regarding the fact that the study has been independently reviewed and approved by an ethical board should also be included. Editors reserve the right to reject papers if there are doubts as to whether appropriate procedures have been used.

When experimental animals are used the methods section must clearly indicate that adequate measures were taken to minimize pain or discomfort. Experiments should be carried out in accordance with the Guidelines laid down by the National Institute of Health (NIH) in the USA regarding the care and use of animals for experimental procedures or with the European Communities Council Directive of 24 November 1986 (86/609/EEC) and in accordance with local laws and regulations.

All studies using human or animal subjects should include an explicit statement in the Material and Methods section identifying the review and ethics committee approval for each study, if applicable. Editors reserve the right to reject papers if there is doubt as to whether appropriate procedures have been used.

(iii) Suppliers: Suppliers of materials should be named and their location (Company, town/city, state, country) included.

Results: should present the observations with minimal reference to earlier literature or to possible interpretations. Data should not be duplicated in Tables and Figures.

Discussion: may usefully start with a brief summary of the major findings, but repetition of parts of the abstract or of the results section should be avoided. The Discussion section should progress with a review of the methodology before discussing the results in light of previous work in the field. The Discussion should end with a brief conclusion and a comment on the potential clinical relevance of the findings. Statements and interpretation of the data should be appropriately supported by original references.

Conclusion: should contain a summary of the findings.

Main Text of Review Articles should be divided into Introduction, Review and Conclusions. The Introduction section should be focused to place the subject matter in context and to justify the need for the review. The Review section should be divided into logical sub-sections in order to improve readability and enhance understanding. Search strategies must be described and the use of state-of-the-art evidence-based systematic approaches is expected. The use of tabulated and illustrative material is encouraged. The Conclusion section should reach clear conclusions and/or recommendations on the basis of the evidence presented.

Main Text of Mini Review Articles should be divided into Introduction, Review and Conclusions. The Introduction section should briefly introduce the subject matter and justify the need and timeliness of the literature review. The Review section should be divided into logical sub-sections to enhance readability and understanding and may be supported by up to 5 tables and figures. Search strategies must be described and the use of state-of-the-art evidence-based systematic approaches is expected. The Conclusions section should present clear statements/recommendations and suggestions for further work. The manuscript, including references and figure legends should not normally exceed 4000 words.

Main Text of Clinical Reports and Clinical Articles should be divided into Introduction, Report, Discussion and Conclusion,. They should be well illustrated with clinical images, radiographs, diagrams and, where appropriate, supporting tables and graphs. However, all illustrations must be of the highest quality

Acknowledgements: *International Endodontic Journal* requires that all sources of institutional, private and corporate financial support for the work within the manuscript must be fully acknowledged, and any potential conflicts of interest noted. Grant or contribution numbers may be acknowledged, and principal grant holders should be listed. Acknowledgments should be brief and should not include thanks to anonymous referees and editors. See also above under Ethical Guidelines.

5.3. References
It is the policy of the Journal to encourage reference to the original papers rather than to literature reviews. Authors should therefore keep citations of reviews to the absolute minimum.

We recommend the use of a tool such as EndNote or Reference Manager for reference management and formatting. The EndNote reference style can be obtained upon request to the editorial office (iejeditor@cardiff.ac.uk). Reference Manager reference styles can be searched for here: www.refman.com/support/rmstyles.asp

In the text: single or double authors should be acknowledged together with the year of publication, e.g. (Pitt Ford & Roberts 1990). If more than two authors the first author followed by *et al.* is sufficient, e.g. (Tobias *et al.* 1991). If more than 1 paper is cited the references should be in year order and separated by "," e.g. (Pitt Ford & Roberts 1990, Tobias *et al.* 1991).

Reference list: All references should be brought together at the end of the paper in alphabetical order and should be in the following form.

(i) Names and initials of up to six authors. When there are seven or more, list the first three and add *et al.*
(ii)Year of publication in parentheses
(iii) Full title of paper followed by a full stop (.)
(iv) Title of journal in full (in italics)
(v) Volume number (bold) followed by a comma (,)
(vi) First and last pages

Examples of correct forms of reference follow:

Standard journal article
Bergenholtz G, Nagaoka S, Jontell M (1991) Class II antigen-expressing cells in experimentally induced pulpitis. *International Endodontic Journal* **24**, 8-14.

Corporate author
British Endodontic Society (1983) Guidelines for root canal treatment. *International Endodontic Journal* **16**, 192-5.

Journal supplement
Frumin AM, Nussbaum J, Esposito M (1979) Functional asplenia: demonstration of splenic activity by bone marrow scan (Abstract). *Blood* **54** (Suppl. 1), 26a.

Books and other monographs

Personal author(s)
Gutmann J, Harrison JW (1991) *Surgical Endodontics*, 1st edn Boston, MA, USA: Blackwell Scientific Publications.

Chapter in a book
Wesselink P (1990) Conventional root-canal therapy III: root filling. In: Harty FJ, ed. *Endodontics in Clinical Practice*, 3rd edn; pp. 186-223. London, UK: Butterworth.

Published proceedings paper
DuPont B (1974) Bone marrow transplantation in severe combined immunodeficiency with an unrelated MLC compatible donor. In: White HJ, Smith R, eds. Proceedings of the Third Annual Meeting of the International Society for Experimental Rematology; pp. 44-46. Houston, TX, USA: International Society for Experimental Hematology.

Agency publication
Ranofsky AL (1978) Surgical Operations in Short-Stay Hospitals: United States-1975. DHEW publication no. (PHS) 78-1785 (Vital and Health Statistics; Series 13; no. 34.) Hyattsville, MD, USA: National Centre for Health Statistics.8

Dissertation or thesis
Saunders EM (1988) In vitro and in vivo investigations into root-canal obturation using thermally softened gutta-percha techniques (PhD Thesis). Dundee, UK: University of Dundee.

URLs

Full reference details must be given along with the URL, i.e. authorship, year, title of document/report and URL. If this information is not available, the reference should be removed and only the web address cited in the text.

Smith A (1999) Select committee report into social care in the community [WWW document]. URL http://www.dhss.gov.uk/reports/report015285.html
[accessed on 7 November 2003]

5.4. Tables, Figures and Figure Legends

Tables: Tables should be double-spaced with no vertical rulings, with a single bold ruling beneath the column titles. Units of measurements must be included in the column title.

Figures: All figures should be planned to fit within either 1 column width (8.0 cm), 1.5 column widths (13.0 cm) or 2 column widths (17.0 cm), and must be suitable for photocopy reproduction from the printed version of the manuscript. Lettering on figures should be in a clear, sans serif typeface (e.g. Helvetica); if possible, the same typeface should be used for all figures in a paper. After reduction for publication, upper-case text and numbers should be at least 1.5-2.0 mm high (10 point Helvetica). After reduction, symbols should be at least 2.0-3.0 mm high (10 point). All half-tone photographs should be submitted at final reproduction size. In general, multi-part figures should be arranged as they would appear in the final version. Reduction to the scale that will be used on the page is not necessary, but any special requirements (such as the separation distance of stereo pairs) should be clearly specified.

Unnecessary figures and parts (panels) of figures should be avoided: data presented in small tables or histograms, for instance, can generally be stated briefly in the text instead. Figures should not contain more than one panel unless the parts are logically connected; each panel of a multipart figure should be sized so that the whole figure can be reduced by the same amount and reproduced on the printed page at the smallest size at which essential details are visible.

Figures should be on a white background, and should avoid excessive boxing, unnecessary colour, shading and/or decorative effects (e.g. 3-dimensional skyscraper histograms) and highly pixelated computer drawings. The vertical axis of histograms should not be truncated to exaggerate small differences. The line spacing should be wide enough to remain clear on reduction to the minimum acceptable printed size.

Figures divided into parts should be labelled with a lower-case, boldface, roman letter, a, b, and so on, in the same typesize as used elsewhere in the figure. Lettering in figures should be in lower-case type, with the first letter capitalized. Units should have a single space between the number and the unit, and follow SI nomenclature or the nomenclature common to a particular field. Thousands should be separated by a thin space (1 000). Unusual units or abbreviations should be spelled out in full or defined in the legend. Scale bars should be used rather than magnification factors, with the length of the bar defined in the legend rather than on the bar itself. In general, visual cues (on the figures themselves) are preferred to verbal explanations in the legend (e.g. broken line, open red triangles etc.)

Figure legends: Figure legends should begin with a brief title for the whole figure and continue with a short description of each panel and the symbols used; they should not contain any details of methods.

Permissions: If all or part of previously published illustrations are to be used, permission must be obtained from the copyright holder concerned. This is the responsibilty of the authors before submission.

Preparation of Electronic Figures for Publication: Although low quality images are adequate for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit EPS (lineart) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented programmes. Scans (TIFF only) should have a resolution of 300 dpi (halftone) or 600 to 1200 dpi (line drawings) in relation to the reproduction size (see below). EPS files should be saved with fonts embedded (and with a TIFF preview if possible). For scanned images, the scanning resolution (at final image size) should be as follows to ensure good reproduction: lineart: >600 dpi; half-tones (including gel photographs): >300 dpi; figures containing both halftone and line images: >600 dpi.

Further information can be obtained at Wiley Blackwell's guidelines for figures:
http:/authorservices.wiley.com/bauthor/illustration.asp.

Check your electronic artwork before submitting it:
http://authorservices.wiley.com/bauthor/eachecklist.asp.

5.5. Supporting Information

Publication in electronic formats has created opportunities for adding details or whole sections in the electronic version only. Authors need to work closely with the editors in developing or using such new publication formats.

Supporting information, such as data sets or additional figures or tables, that will not be published in the print edition of the journal, but which will be viewable via the online edition, can be submitted. It should be clearly stated at the time of submission that the supporting information is intended to be made available through the online edition. If the size or format of the supporting information is such that it cannot be accommodated on the journal's website, the author agrees to make the supporting information available free of charge on a permanent Web site, to which links will be set up from the journal's website. The author must advise Wiley Blackwell if the URL of the website where the supporting information is located changes. The content of the supporting information must not be altered after the paper has been accepted for publication.

The availability of supporting information should be indicated in the main manuscript by a paragraph, to appear after the References, headed 'Supporting Information' and providing titles of figures, tables, etc. In order to protect reviewer anonymity, material posted on the authors Web site cannot be reviewed. The supporting information is an integral part of the article and will be reviewed accordingly.

Preparation of Supporting Information: Although provision of content through the web in any format is straightforward, supporting information is best provided either in web-ready form or in a form that can be conveniently converted into one of the standard web publishing formats:

• Simple word-processing files (.doc or .rtf) for text.
• PDF for more complex, layout-dependent text or page-based material. Acrobat files can be distilled from Postscript by the Publisher, if necessary.
• GIF or JPEG for still graphics. Graphics supplied as EPS or TIFF are also acceptable.
• MPEG or AVI for moving graphics.

Subsequent requests for changes are generally unacceptable, as for printed papers. A charge may be levied for this service.

Video Imaging: For the on-line version of the Journal the submission of illustrative video is encouraged. Authors proposing the use such media should consult with the Editor during manuscript preparation.

6. AFTER ACCEPTANCE

Upon acceptance of a paper for publication, the manuscript will be forwarded to the Production Editor who is responsible for the production of the journal.

6.1. Figures

Hard copies of all figures and tables are required when the manuscript is ready for publication. These will be requested by the Editor when required. Each Figure copy should be marked on the reverse with the figure number and the corresponding author's name.

6.2 Proof Corrections

The corresponding author will receive an email alert containing a link to a web site. A working email address must therefore be provided for the corresponding author. The proof can be downloaded as a PDF (portable document format) file from this site. Acrobat Reader will be required in order to read this file. This software can be downloaded (free of charge) from the following Web site: www.adobe.com/products/acrobat/readstep2.html. This will enable the file to be opened, read on screen, and printed out in order for any corrections to be added. Further instructions will be sent with the proof. Hard copy proofs will be posted if no e-mail address is available; in your absence, please arrange for a colleague to access your e-mail to retrieve the proofs. Proofs must be returned to the Production Editor within three days of receipt. As changes to proofs are costly, we ask that you only correct typesetting errors. Excessive changes made by the author in the proofs, excluding typesetting errors, will be charged separately. Other than in exceptional circumstances, all illustrations are retained by the publisher. Please note that the author is responsible for all statements made in his work, including changes made by the copy editor.

6.3 Early Online Publication Prior to Print

International Endodontic Journal is covered by Wiley Blackwell's Early View service. Early View articles are complete full-text articles published online in advance of their publication in a printed issue. Early View articles are complete and final. They have been fully reviewed, revised and edited for publication, and the authors' final corrections have been incorporated. Because they are in final form, no changes can be made after online publication. The nature of Early View articles means that they do not yet have volume, issue or page numbers, so Early View articles cannot be cited in the traditional way. They are therefore given a Digital Object Identifier (DOI), which allows the article to be cited and tracked before it is allocated to an issue. After print publication, the DOI remains valid and can continue to be used to cite and access the article.

6.4 Online Production Tracking
Online production tracking is available for your article through Blackwell's Author Services. Author Services enables authors to track their article - once it has been accepted - through the production process to publication online and in print. Authors can check the status of their articles online and choose to receive automated e-mails at key stages of production. The author will receive an e-mail with a unique link that enables them to register and have their article automatically added to the system. Please ensure that a complete e-mail address is provided when submitting the manuscript. Visit http://authorservices.wiley.com/bauthor/ for more details on online production tracking and for a wealth of resources including FAQs and tips on article preparation, submission and more.

6.5 Author Material Archive Policy
Please note that unless specifically requested, Wiley Blackwell will dispose of all hardcopy or electronic material submitted two months after publication. If you require the return of any material submitted, please inform the editorial office or production editor as soon as possible.

6.6 Offprints
Free access to the final PDF offprint of your article will be available via Author Services only. Please therefore sign up for Author Services if you would like to access your article PDF offprint and enjoy the many other benefits the service offers.

Additional paper offprints may be ordered online. Please click on the following link, fill in the necessary details and ensure that you type information in all of the required fields: Offprint Cosprinters. If you have queries about offprints please email offprint@cosprinters.com

The corresponding author will be sent complimentary copies of the issue in which the paper is published (one copy per author).

6.7 Author Services
For more substantial information on the services provided for authors, please see Wiley Blackwell Author Services

6.8 Note to NIH Grantees: Pursuant to NIH mandate, Wiley Blackwell will post the accepted version of contributions authored by NIH grant-holders to PubMed Central upon acceptance. This accepted version will be made publicly available 12 months after publication. For further information, see www.wiley.com/go/nihmandate

7 Guidelines for reporting of DNA microarray data
The *International Endodontic Journal* gives authors notice that, with effect from 1st January 2011, submission to the *International Endodontic Journal* requires the reporting of microarray data to conform to the MIAME guidelines. After this date, submissions will be assessed according to MIAME standards. The complete current guidelines are available at http://www.mged.org/Workgroups/MIAME/miame_2.0.html. Also, manuscripts will be published only after the complete data has been submitted into the public repositories, such as GEO (http://www.ncbi.nlm.nih.gov/geo/) or ArrayExpress (http://www.ebi.ac.uk/microarray/submissions_overview.html), in MIAME compliant format, with the data accession number (the identification number of the data set in the database) quoted in the manuscript. Both databases are committed to keeping the data private until the associated manuscript is published, if requested.

Prospective authors are also encouraged to search for previously published microarray data with relevance to their own data, and to report whether such data exists. Furthermore, they are encouraged to use the previously published data for qualitative and/or quantitative comparison with their own data, whenever suitable. To fully acknowledge the original work, an appropriate reference should be given not only to the database in question, but also to the original article in which the data was first published. This open approach will increase the availability and use of these large-scale data sets and improve the reporting and interpretation of the findings, and in increasing the comprehensive understanding of the physiology and pathology of endodontically related tissues and diseases, result eventually in better patient care.

ANEXO C – Comprovante de submissão do artigo

Assunto	**International Endodontic Journal - Manuscript ID IEJ-16-00570**
De	International Endodontic Journal <onbehalfof+iejeditor+cardiff.ac.uk@manuscriptcentral.com>
Remetente	<onbehalfof+iejeditor+cardiff.ac.uk@manuscriptcentral.com>
Para	<karina.devito@ufjf.edu.br>
Responder para	<iejeditor@cardiff.ac.uk>
Data	27/08/2016 22:41

27-Aug-2016

Dear Prof. Devito

Your manuscript entitled "Diagnosis of mesiodistal vertical root fractures in teeth with metal posts: influence of applying filters in CBCT images at different resolutions" has been successfully submitted online to the International Endodontic Journal.

Your manuscript ID is IEJ-16-00570.

Please mention the above manuscript ID in all future correspondence or when calling the Editorial Office for questions. If there are any changes in your postal or e-mail address, please log in to ScholarOne Manuscripts at https://mc.manuscriptcentral.com/iej and edit your user information as appropriate.

You can also view the status of your manuscript at any time by checking your Author Centre after logging in to https://mc.manuscriptcentral.com/iej.

Thank you for submitting your manuscript to the International Endodontic Journal.

Kind regards

Paul Dummer
Editor, International Endodontic Journal
iejeditor@cardiff.ac.uk