**UNIVERSIDADE FEDERAL DE GOIÁS**
**PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS DA SAÚDE**

**Julio Almeida Silva**

# Detecção de erros de procedimentos em tratamentos endodônticos e implantes dentários por meio de tomografia computadorizada de feixe cônico

**GOIÂNIA**
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# Detecção de erros de procedimentos em tratamentos endodônticos e implantes dentários por meio de tomografia computadorizada de feixe cônico

Trabalho apresentado para defesa de tese de doutorado ao Programa de Pós-Graduação em Ciências da Saúde da Universidade Federal de Goiás.

**Orientador: Prof. Dr. Carlos Estrela**
**Co-orientadora: Profa. Dra. Ana Helena G. Alencar**

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**DA UNIVERSIDADE FEDERAL DE GOIÁS**

## BANCA EXAMINADORA DA TESE DE DOUTORADO

**Aluno: Julio Almeida Silva**

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|---|
| **Membros:** |
| **1. Prof. Dr. Carlos Estrela** |
| **2. Profa. Dra. Ana Helena Gonçalves de Alencar** |
| **3. Prof. Dr. Hélio Pereira Lopes** |
| **4. Prof. Dr. Sicknan Soares da Rocha** |
| **5. Pro. Dra. Heloísa Helena Pinho Veloso** |
| **Suplentes:** |
| **1. Prof. Dr. Lawrence Gonzaga Lopes** |
| **2. Prof. Dr. José Marcos Alves Fernandes** |

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# Dedicatória

***Este trabalho é dedicado a minha esposa Mariana. Um anjo que me ampara e traz serenidade. A mulher que compartilha dos meus sonhos e dá sentido a minha vida.***

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# LISTA DE ABREVIATURAS, SIGLAS E SÍMBOLOS

| | |
|---|---|
| % | Porcentagem |
| TCFC | Tomografia computadorizadade feixe cônico |
| CBCT | Cone beam computed tomography |
| p | Nível de significância / significance level |
| EPO | Erro de procedimento operatório |
| OPE | Operatory procedural errors |
| DTE | Dente tratado endodonticamente |
| ETT | Endodontically treated teeth |
| ID | Implante dentário |
| DI | Dental implant |
| OCR | Obturação do canal radicular |
| RCO | Root canal obturation |
| PR | Perfuração radicular |
| RP | Radicular perforation |
| mm | Milímetros |
| n | Número |
| USA | United States of America |
| PA | Pensylvania |
| WA | Washington |
| MI | Michigan |

| | |
|---|---|
| kVp | Peak kilovoltage |
| mA | Miliampére |
| Ghz | Giga hertz |

# RESUMO

**Introdução:** Um protocolo terapêutico aceitável em odontologia depende dos resultados observados com a proservação. Erros de procedimentos operatórios (EPOs) podem ocorrer e representam fatores de risco capazes de comprometer um dente ou um implante dentário. O objetivo do artigo foi detectar EPOs em dentes tratados endodonticamente (DTE) e implantes dentários (IDs) por meio de tomografia computadorizada de feixe cônico (TCFC). **Metodologia:** Foram analisadas TCFC de 816 pacientes realizadas entre janeiro de 2009 e outubro de 2010, e somente as que apresentavam DTE e/ou IDs foram selecionadas. A amostra final envolveu exames tomográficos de 195 pacientes (n = 200 DTE e n = 200 IDs), 72 do sexo masculino, 123 do sexo feminino, com idade média de 51 anos. Nos DTE, os aspectos incluídos como EPOs foram: inadequada obturação do canal radicular (OCR), sobreobturação e perfuração radicular (PR); enquanto que para implantes dentários foram incluídos: roscas expostas, contato com as estruturas anatômicas, e contato com o dente adjacente. O teste Kolmogorov-Smirnov foi utilizado para análise estatística. O nível de significância foi estabelecido em $\alpha = 5\%$. **Resultados:** Inadequada OCR, sobreobturação, e PR foram detectadas em 59%, 8% e 4,5%, respectivamente. Implantes dentários com roscas expostas, contato com estruturas importantes e contato com dentes adjacentes mostraram valores de 37,5%, 13% e 6,5%, respectivamente. Em 37,5% dos casos de DTE e 11% dos IDs foram detectadas hipodensidade nas imagens TCFC. **Conclusões**: Erros de procedimentos operatórios foram detectados em DTE e IDs. Os erros mais frequentes foram a inadequada OCR em DTE, e roscas expostas em IDs.

## INTRODUÇÃO

A saúde dos tecidos periapicais e a manutenção do dente na cavidade bucal constituem os principais objetivos da terapia endodôntica (1). Uma alternativa para substituir o dente comprometido é a reabilitação sobre implantes dentários (IDs) (2). No entanto, ambas as especialidades são desafiadoras, e mostram várias circunstâncias de prognóstico duvidoso. Considerando as dificuldades encontradas durante o tratamento endodôntico, podem ser mencionadas o entendimento da morfologia interna, o controle do biofilme endodôntico e a complexidade resposta imunológica do paciente. Condições importantes também devem ser consideradas no planejamento de IDs, tais como a localização do dente, qualidade do osso, condição dos tecidos periodontais, restaurabilidade e fatores sistêmicos. Esses aspectos podem ser ainda associados com a habilidade profissional e o conhecimento científico em ambas as áreas.

A terapia endodôntica ou a colocação de um ID requerem um planejamento suportado por um conceito de saúde baseado em evidência. Erros de procedimentos operatórios (EPOs) caracterizam a não-observância do protocolo terapêutico, o desconhecimento dos princípios que envolvem a endodontia e a implantodontia, e a deficiência técnica. O tratamento inadequado pode conduzir a um prognóstico desfavorável, resultando em sequelas, as quais têm sido responsáveis por sérias questões judiciais.

Exames clínicos e radiográficos têm sido utilizados para determinar o sucesso de tratamentos em ambas especialidades. Em DTE, os critérios estabelecidos de sucesso incluem: ausência de dor e inchaço, ausência de fístula, dente em função e com fisiologia normal, e desaparecimento de rarefação óssea periapical prévia (3). De acordo com Misch *et al.*, 2006 (4), o sucesso de tratamento reabilitador com ID pode ser determinado por escalas de qualidade. O sucesso (saúde ótima) é considerado quando o paciente relata ausência de dor ou sensibilidade no implante em função, quando há ausência de mobilidade e exsudato, e perda óssea radiográfica inicial inferior a 2 mm. Em um implante com sobrevida satisfatória o paciente relata ausência de dor no implante função, há ausência de mobilidade e exsudato, perda óssea radiográfica inicial entre 2-4 mm. Em situações de sobrevivência comprometida o paciente pode relatar dor no implante em função e pode haver presença de exsudato, há ausência de mobilidade, a profundidade de sondagem é maior que 7 mm, e a perda óssea radiográfica inicial é superior a 4 mm (desde que seja menor do que a metade do corpo do implante). O insucesso clínico ou absoluto é caracterizado pela dor no implante em função, mobilidade, exsudato descontrolado, perda óssea radiográfica inicial superior a metade do comprimento do implante, ou implantes removidos.

Recursos de imagem têm sido rotineiramente usados antes, durante e após o tratamento odontológico. Imagens radiográficas convencionais fornecem uma versão bidimensional de uma estrutura tridimensional, o que pode resultar em erros de interpretação. Lesões periapicais de origem endodôntica podem estar presentes, mas não visíveis em radiografias convencionais em 2 dimensões (2D) (5,6). A avaliação do tratamento odontológico por meio da tomografia computadorizada representa um avanço expressivo de informação em estudos de saúde (7) e contribui para o planejamento, diagnóstico, processo terapêutico e prognóstico de diversas patologias. O contínuo desenvolvimento da tecnologia possibilitou o surgimento da tomografia computadorizada de feixe cônico (TCFC) (8,9), que revelou inúmeras perspectivas de aplicações em diferentes áreas de pesquisa e clínica odontológica (6,8-10).

A acurácia do diagnóstico é fundamental para o sucesso do tratamento. A correta manipulação da imagem TCFC pode revelar anormalidades que são incapazes de serem detectadas em radiografias periapicais, o que torna o planejamento e o tratamento mais previsíveis. A possibilidade da leitura por mapeamento em imagens TCFC reduz os problemas relacionados às condições de difícil avaliação que requerem cuidados especiais durante o diagnóstico, tais como perfurações radiculares (11).

Os exames tomográficos fornecem imagens detalhadas de alta resolução das estruturas bucais e permitem a detecção precoce de alterações nas estruturas maxilo-faciais. Esta tecnologia permite a determinação de distâncias lineares e do volume de estruturas anatômicas, do comprimento da raiz e do nível ósseo marginal durante o tratamento ortodôntico, e ainda permite o planejamento pré-cirúrgico de lesões maxilo-faciais (11-13).

EPOs são causados por fatores inerentes ao próprio paciente e/ou profissional, cujas consequências podem determinar o prognóstico. Alencar *et al.*, 2011 (14), detectaram erros de procedimentos (instrumentos fraturados, perfurações e transporte apical) criados por instrumentos rotatórios de níquel-titânio no preparo do canal, e observaram que os exames TCFC ofereceram maiores recursos de diagnóstico quando comparados aos de radiografias convencionais.

O dilema da substituição de uma estrutura biológica por um material biocompatível requer minuciosa avaliação dos critérios e taxas de sucesso de DTE e de

IDs. A escassez de estudos comparando os resultados de tratamentos endodônticos com tratamentos com IDs e as limitações nas interpretações dos resultados de estudos longitudinais (15) exigem a realização de mais pesquisas com ferramentas de avaliação acuradas. O grande potencial da TCFC como método de diagnóstico justifica a sua utilização na detecção de EPOs em DTE e IDs.

O objetivo desse estudo foi detectar Erros de procedimentos operatórios em DTE e IDs por meio de TCFC. A hipótese nula foi que tanto Erros de procedimentos operatórios em DTE quanto em IDs seriam acuradamente detectados por meio de TCFC.

# OBJETIVO

O objetivo desse estudo foi detectar erros de procedimentos operatórios em dentes tratados endodonticamente e em implantes dentários por meio de Tomografia computadorizada de feixe cônico.

## METODOLOGIA

Este estudo transversal avaliou os EPOs em DTE e IDs detectados por meio TCFC, usando a base de dados de uma clínica privada de radiologia (Centro Integrado de Radiologia - C.I.R.O., Goiânia, GO, Brasil). Os pacientes foram encaminhados ao serviço de radiologia odontológica com diferentes fins de diagnóstico. Foram analisadas TCFC de 816 pacientes realizadas entre janeiro de 2009 e outubro de 2010, e somente as que apresentavam DTE e/ou IDs foram selecionadas. A amostra final envolveu exames tomográficos de 195 pacientes (n = 200 DTE e n = 200 IDs), 72 do sexo masculino, 123 do sexo feminino, com idade média de 51 anos. O delineamento do estudo foi aprovado pelo Comitê de Ética em Pesquisa Local (Universidade Federal de Goiás, Processo 169/2008).

Os critérios de inclusão foram: tomografias de pacientes com DTE e/ou IDs, imagens de boa qualidade, alta resolução e ausência de artefato de técnica que pudesse tornar a análise imprecisa.

*Análise das imagens*

Imagens TCFC foram adquiridas com i-CAT Cone Beam de primeira geração com sistema de imagens em três dimensões (Imaging Sciences International, Hatfield, PA, USA). Os volumes foram reconstruídos com *voxels* isotrópicos isométricos de 0,20 mm X 0,20 mm X 0,20 mm. A voltagem usada foi de 120 kVp, a corrente de 36,12 mA e o tempo de exposição de 40 segundos. Para a análise das imagens utilizou-se o software específico do aparelho (Xoran version 3.1.62; Xoran Technologies, Ann Arbor, MI, USA) em um computador com Microsoft Windows XP professional SP-2 (Microsoft

Corp, Redmond, WA, USA), com processador Intel® Core$^{TM}$ 2 Duo-6300 1.86 Ghz (Intel Corporation, USA), placa de vídeo Nvidia GeForce 6200 turbo cache (Nvidia Corporation, USA), e monitor Eizo - Flexscan S2000, resolução 1600X1200 pixels (Eizo Nanao Corporation Hakusan, Japan).

Dois examinadores (um especialista em endodontia e outro em radiologia odontológica, ambos com mais de 5 anos de formação) foram calibrados para a análise das imagens, usando 10% da amostra. Quando houve diferenças entre os dois examinadores, um consenso foi obtido discutindo a imagem com um terceiro (especialista em endodontia).

Os examinadores avaliaram as imagens para determinar os seguintes EPOs em DTE: presença de sobreobturação (material obturador além do ápice), inadequada OCR (subobturação > 2mm aquém do ápice; presença de espaços vazios na obturação; espaço entre a obturação e o retentor intracanal > 3mm; remanescente da obturação < 3mm), e perfuração radicular. Considerou-se como EPOs em IDs: roscas expostas em mais de 1/3 do corpo do implante (fora do osso alveolar), IDs em contato com estruturas anatômicas importantes (canal mandibular, forame mentoniano ou forame incisivo, e IDs com mais de 1/3 do corpo invadindo seio maxilar ou cavidade nasal), e IDs em contato com dentes adjacentes. A presença de hipodensidade associada tanto a DTE quanto a IDs foi detectada e computada.

*Análise Estatística*

O teste Kolmogorov-Smirnov foi utilizado para avaliar o grau de ajustamento entre a distribuição do conjunto de valores da amostra, com nível de significância estabelecido em $\alpha = 5\%$.

## RESULTADOS

A distribuição dos 200 DTE, analisados nas TCFC, apresentou-se da seguinte forma: região anterior superior n = 75; região posterior superior n = 85; região anterior inferior n = 3; região posterior inferior n = 37. Inadequada OCR, sobreobturação, e PR foram detectadas em 59%, 8% e 4,5%, respectivamente (Tabela 1).

Tabela 1. Distribuição dos erros de procedimentos operatórios (EPOs) em dentes tratados endodonticamente (DTE).

| Erros de procedimentos operatórios | OCR Inadequada | Sobreobturação | PR | Nível de significância |
|---|---|---|---|---|
| Anterior Superior (n=75) | 26 (34,66%) | 9 (12%) | 3 (4%) | *p<0,05* |
| Posterior Superior (n=85) | 71 (83,52%) | 3 (3,52 %) | 5 (5,88%) | *p<0,05* |
| Anterior Inferior (n=3) | 3 (100%) | 0 (0%) | 0 (0%) | *p>0,05* |
| Posterior Inferior (n=37) | 18 (48,64%) | 4 (18,81%) | 1 (2,7%) | *p<0,05* |
| Total (n=200) | 118 (59%) | 16 (8%) | 9 (4,5%) | *p<0,05* |

Dos 200 IDs analisados, 67 estavam localizados na região anterior superior; 65 na região posterior superior; 8 na região anterior inferior; e 60 na região posterior inferior. IDs com roscas expostas, contato com estruturas anatômicas importantes e contato com dentes adjacentes apresentaram valores de 37,5%, 13% e 6,5%, respectivamente (Tabela 2).

Tabela 2. Distribuição dos erros de procedimentos operatórios (EPOs) em tratamentos com implantes dentários (IDs).

| **Erros de procedimentos operatórios** | **Roscas expostas** | **Contato com estruturas anatômicas** | **Contato com dente adjacente** | **Nível de significância** |
|---|---|---|---|---|
| Anterior Superior (n=67) | 40 (59,7%) | 6 (8,95%) | 8 (11,67%) | $p<0,05$ |
| Posterior Superior (n=65) | 18 (27,69%) | 4 (6,15%) | 12 (18,46%) | $p>0,05$ |
| Anterior Inferior (n=8) | 1 (12,5%) | 0 (0%) | 2 (25%) | $p>0,05$ |
| Posterior Inferior (n=60) | 16 (26,66%) | 3 (5%) | 4 (6,66%) | $p<0,05$ |
| Total (n=200) | 75 (37,5%) | 13 (6,5%) | 26 (13%) | $p<0,05$ |

Do número total de dentes analisados 75 DTE apresentavam hipodensidade periapical (37,5%) enquanto que hipodensidade ao redor do corpo de IDs foi detectada em 22 casos (Tabela 3).

Tabela 3. Hipodensidade associada com dentes tratados endodonticamente (DTE) e com implantes dentários (IDs).

| **Erros de procedimentos operatórios** | **Tratamentos endodônticos** | **Implantes dentários** | **Nível de significância** |
|---|---|---|---|
| Anterior Superior | 22/75 (29,33%) | 15/67 (22,38%) | $p>0,05$ |
| Posterior Superior | 35/85 (41,17%) | 1/65 (1,53%) | $p<0,05$ |
| Anterior Inferior | 2/3 (66,66%) | 4/8 (50%) | $p>0,05$ |
| Posterior Inferior | 16/37 (43,24%) | 2/60 (3,33%) | $p<0,05$ |
| Total | 75/200 (37,5%) | 22/200 (11%) | $p<0,05$ |

EPOs em DTE e IDs detectados nos cortes tomográficos coronais, sagitais e axiais estão exemplificados nas Figuras 1 e 2. Na Figura 3 podem ser observados cortes sagitais e axiais de ID em estrutura óssea normal e ID com hipodensidade ao redor do corpo. A hipótese nula foi confirmada uma vez que foram observados EPOs tanto em DTE quanto em IDs.

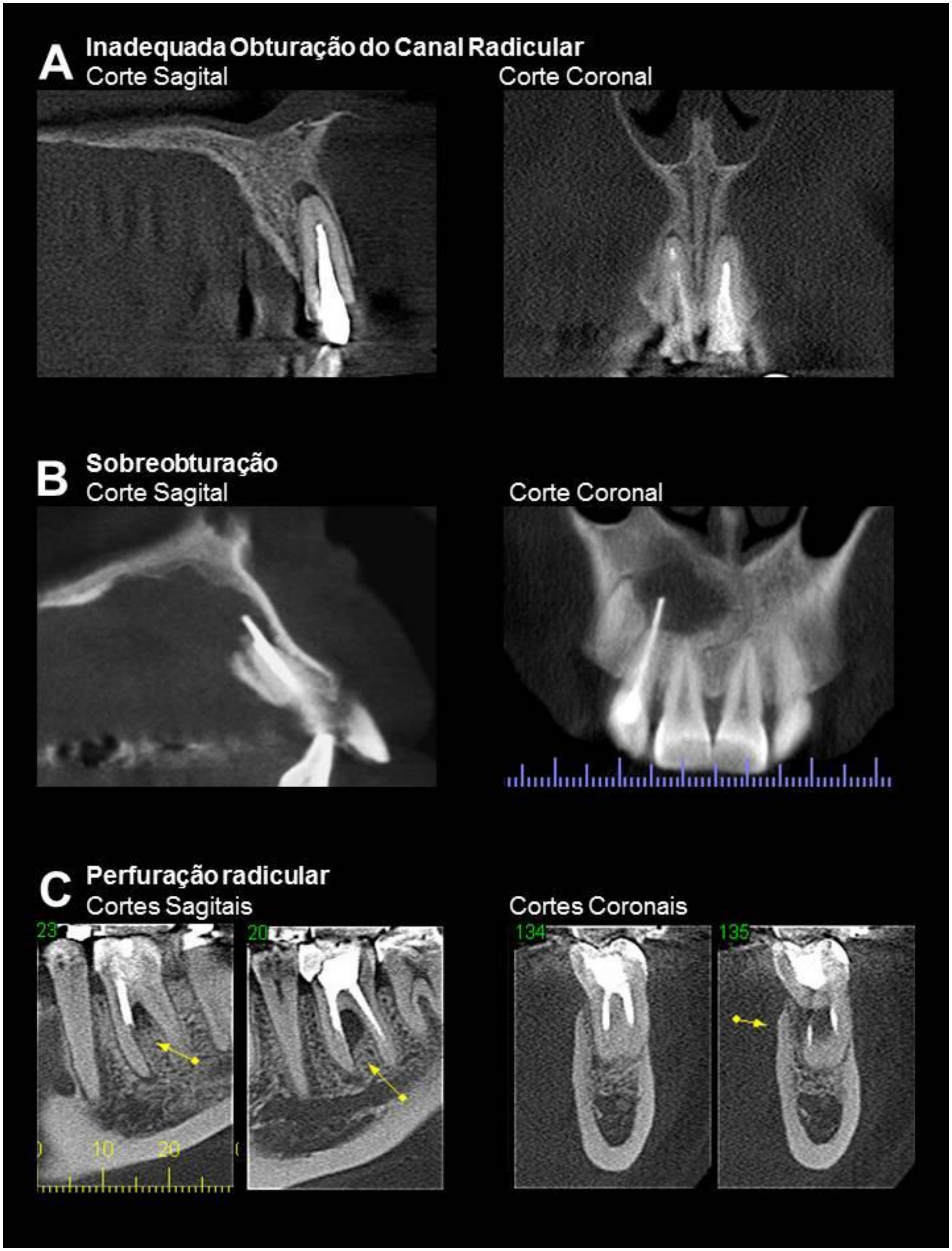


Figura 1 – Erros de procedimentos operatórios em dentes tratados endodonticamente: A) Corte sagital e coronal de Incisivo Central Superior com subobturação apresentando hipodensidade periapical, B) Corte sagital e coronal de Incisivo Lateral Superior com sobrebturação do canal radicular associada com extensa hipodensidade periapical, C) Cortes sagitais e coronais de Primeiro Molar Inferior com perfuração na região de furca exibindo hipodensidade.

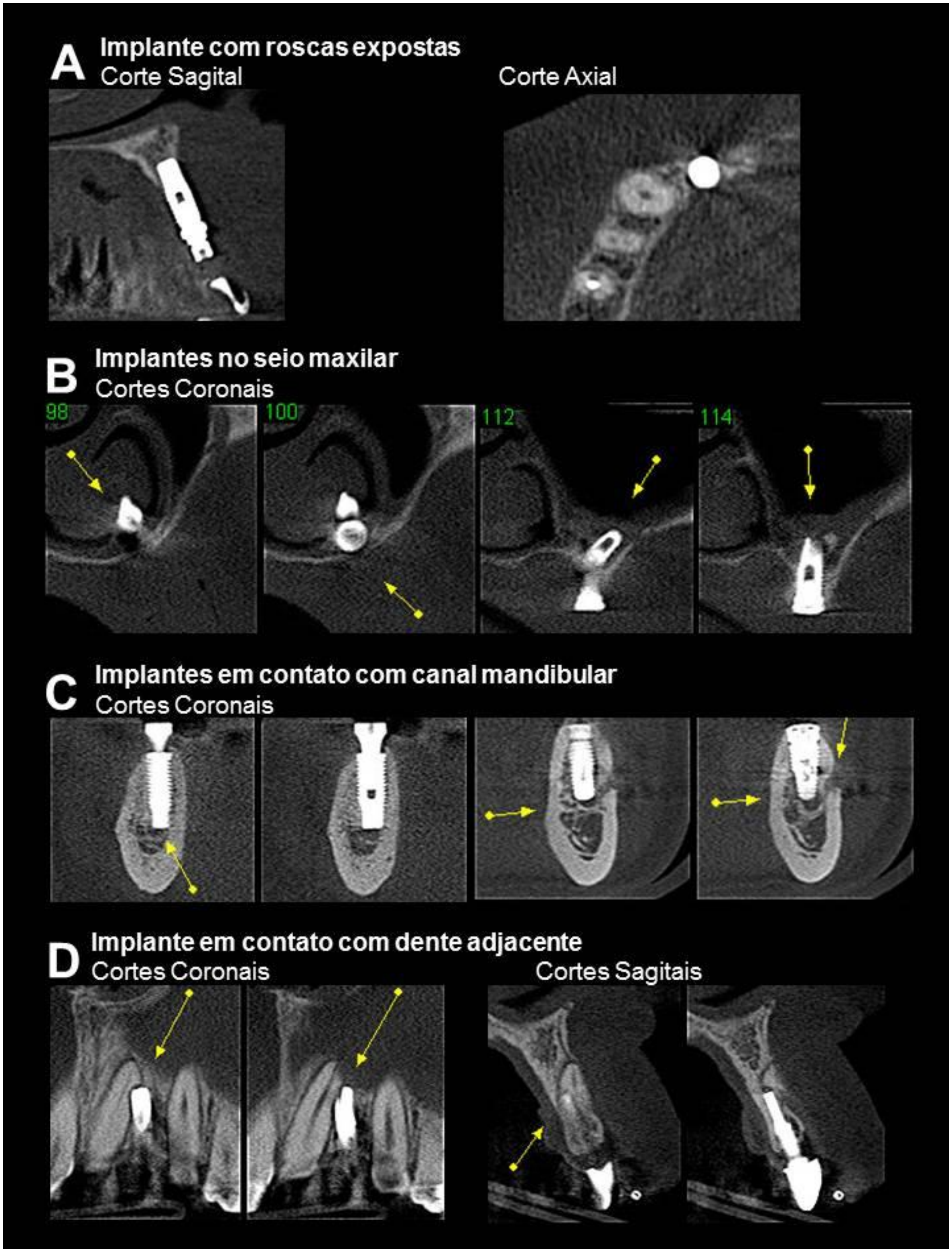


Figura 2 – Erros de procedimentos operatórios em implantes dentários: A) Corte sagital e axial de ID na região anterior superior com roscas expostas na face vestibular e palatina, B) Cortes coronais de IDs na região posterior superior com mais de 1/3 do corpo dentro do seio maxilar, C) Cortes coronais de IDs na região posterior inferior em contato com canal mandibular, D) Cortes Coronais de IDs na região anterior superior em contato com dente adjacente.

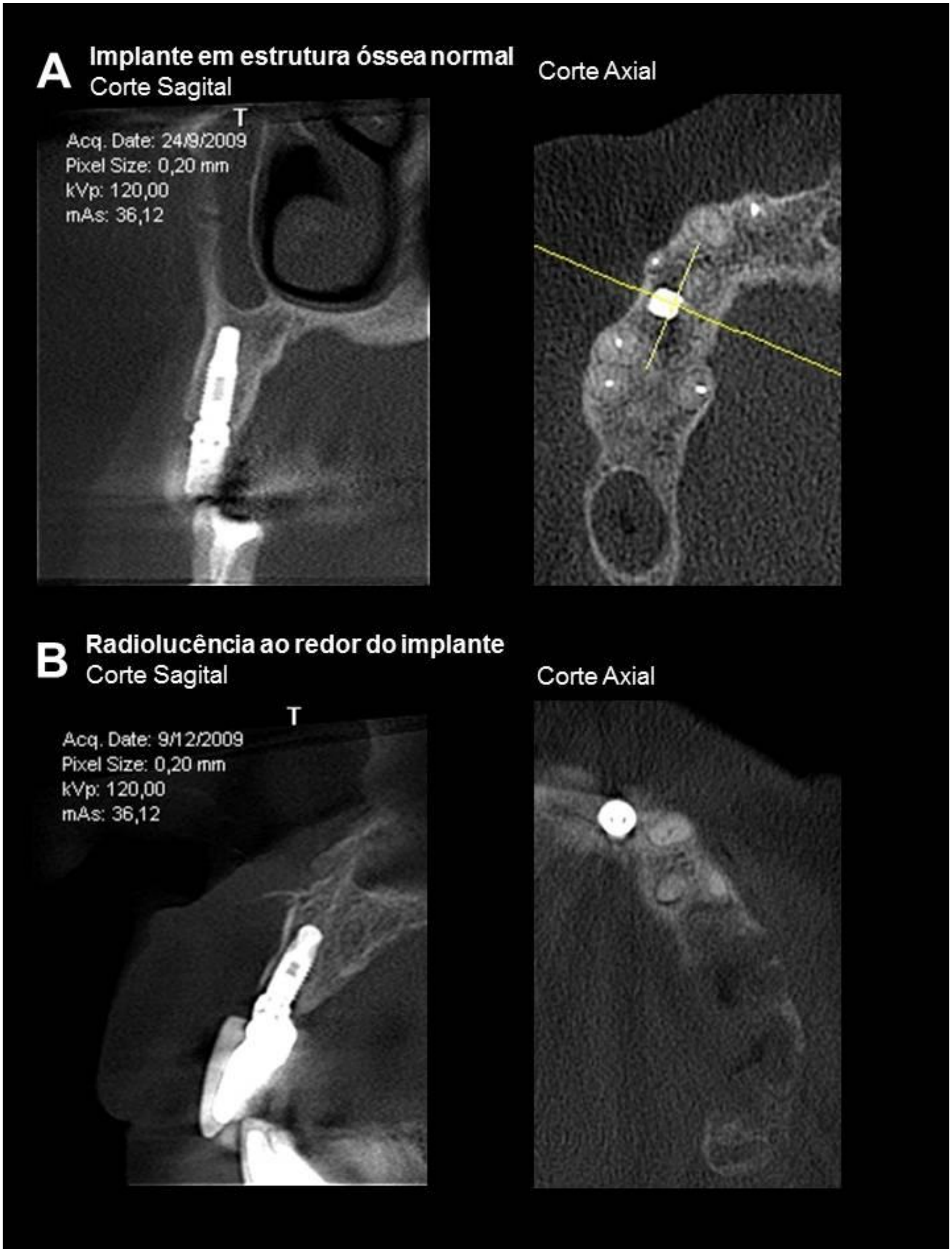

Figura 3 – Cortes sagitais e axiais: A) Implante dentário em estrutura óssea normal, B) Implante dentário com hipodensidade ao redor do corpo.

## DISCUSSÃO

A terapia do canal radicular e implantes dentários envolvem uma importante discussão na odontologia. A extensão do tratamento de um dente condenado à extração pode ser um implante dentário. A detecção de EPOs em DTE e IDs é clinicamente controversa e complexa, devido às limitações das radiografias periapicais e panorâmicas. O valor da radiografia periapical para identificar a qualidade do DTE e a posição do ID é reconhecido. No entanto, apesar dos benefícios, este método de imagem convencional apresenta limitações, principalmente a sobreposição de imagens e a necessidade de extensa perda óssea para que a imagem da rarefação seja visualizada (5,6).

A possibilidade de avaliar o DTE e o ID usando a TCFC aumenta o potencial de avaliação do protocolo terapêutico (6,10,12,13). Imagens TCFC fornecem a possibilidade de uma leitura por mapeamento, com aquisição de informações valiosas por meio de uma visualização dinâmica em diferentes planos (11). Tem sido demonstrada maior acurácia no diagnóstico de periodontites apicais quando da utilização de TCFC comparado com exames radiográficos convencionais (6,10,12,16).

A formação de artefatos principalmente próximos de corpos de alta densidade, como os metálicos (núcleos intra-radiculares, coroas e restaurações metálicas) requer cuidados durante das imagens de TCFC evitando erros de diagnóstico. Este efeito é chamado endurecimento do raio *(beam hardening)* (17). No presente estudo, as imagens da TCFC foram analisadas por um especialista em endodontia e um especialista em radiologia, com experiência em rastreamento tridimensional e preparados para identificar artefatos de técnica.

Os resultados deste estudo para a detecção de EPOs em DTE, por meio de TCFC, mostraram 59% de inadequada OCRs, 8% de sobreobturações, e 4,5% PRs. Resultados estes semelhantes aos de Moura *et al*., 2009 (18), que encontraram 10% de sobreobturações em dentes anteriores, e aos de Alencar *et al.,* 2011 (14), no qual perfurações radiculares foram detectadas em 5% (6/120) de canais radiculares tratados endodonticamente, ambos utilizando TCFC. Em contraste, quando a radiografia convencional foi utilizada como método de diagnóstico, Santos *et al*., 2010 (19), observaram 0,37% de raízes com perfurações e 2,67% de raízes com sobreobturação. Este fato justifica-se pela dificuldade de se comparar estudos utilizando diferentes critérios e ferramentas de análise de imagens.

Os maiores índices valores de inadequada OCR foram encontrados em dentes posteriores superiores, alcançando 83,52% (Tabela 1). Resultados estes concordantes com os de Moussa-Badran *et al*., 2008 (20), que observaram 76,3% de obturações inadequadas em dentes posteriores. Esse fato se justifica em função da grande proporção de dentes posteriores avaliados nestes estudos, da complexidade anatômica e da localização dos dentes no arco, as quais podem ter dificultado o tratamento endodôntico.

Estudos epidemiológicos realizados em diferentes grupos populacionais tem relatado diferenças entre as a porcentagens de OCR adequada (21,22). Essa variação pode ser atribuída ao nível de formação do operador, estudantes, clínicos gerais, pós-graduandos ou especialistas, adicionado ao tempo de experiência.

Os resultados do presente estudo evidenciaram hipodensidade em 37,5% (75/200) dos DTE. Estudos anteriores mostraram taxas mais elevadas de periodontite apical associadas com DTE utilizando diferentes metodologias (6,12,23,24). A inadequada OCR e a restauração coronária deficiente foram associadas com um aumento da incidência de periodontite apical (23). Embora a qualidade técnica da OCR seja importante para o sucesso do tratamento, ela não necessariamente reflete a qualidade do tratamento em geral. Procedimentos de assepsia e antissepsia durante o tratamento, técnica de preparo do canal radicular e materiais usados são fatores determinantes do prognóstico e comumente desconhecidos em estudos epidemiológicos (25).

A ocorrência de IDs com roscas expostas, em contato com as estruturas anatômicas importantes e em contato com dentes adjacentes apresentaram, nesta investigação, valores de 37,5%, 13% e 6,5%, respectivamente. Os dentes anteriores superiores apresentaram maior freqüência de IDs com roscas expostas. Dos 200 IDs avaliados hipodensidade foi identificada em 11%.

A literatura é carente de estudos que utilizaram a TCFC para avaliar EPOs em implantes dentários. Todavia existem pesquisas que a partir de sinais radiográficos estabelecem o prognóstico dos IDs (26). O exame radiográfico permanece como uma importante ferramentas para a identificação de falha nos IDs na prática clínica. Os fatores essenciais para a avaliação apropriada da condição do implante são a qualidade da radiografia juntamente com experiência do examinador (27). Uma sequência longitudinal de radiografias padronizadas é requerida para mensurar alterações no nível ósseo interproximal e detectar radiolucência periimplantar. A imagem radiográfica de radiolucência periimplantar sugere ausência de contato direto ósseo/implante e a possibilidade de perda de estabilidade, no entanto pode-se ter perda óssea marginal e o implante permanecer estável (28).

EPOs representam fatores de risco capazes de comprometer um dente ou um implante dentário. Um protocolo clínico de tratamento bem estruturado favorece as condições de sobrevivência de um DTE ou de um ID. O sucesso ou insucesso constituem parâmetros importantes para indicar e manter um protocolo terapêutico apropriado. Todavia, critérios clínicos e radiográficos distintos têm sido utilizados para avaliar índices de sucesso em diferentes estudos, o que impossibilita a comparação de resultados.

Torabinejad & Bahjri, 2005 (29), discutiram o tratamento odontológico baseado em evidências. Poucos estudos de alto nível foram publicados nas últimas quatro décadas, relacionados com o sucesso e o fracasso do tratamento endodôntico. Têm sido ressaltadas como limitações de estudos clínicos longitudinais a análise radiográfica, que está sujeita a interpretação pessoal, a mudança de angulagem, que pode dar uma aparência completamente diferente à lesão fazendo-a aparecer menor ou maior, os sintomas clínicos como presença de dor, fístula ou edema que podem ocorrer sem a evidência radiográfica de destruição óssea (30). Estrela *et al.*, 2008 (6), revelaram a alta acurácia da TCFC comparada a radiografia periapical e panorâmica na detecção da periodontite apical. Wu *et al.*, 2009 (16), mostraram que uma alta porcentagem de DTE que apresentavam aspectos de normalidade por radiografias foram revelados com periodontite apical pela TCFC e exame histológico. Portanto, os resultados dos estudos epidemiológicos de taxas de sucesso em tratamentos endodônticos deveriam ser reavaliados com critérios mais rigorosos, a longo prazo, e utilizando ferramentas mais acuradas como a TCFC (6,16,30).

A implantodontia está desenvolvendo novos resultados de pesquisa que proporcionam melhor conhecimento dos princípios biológicos do ID (31). Os critérios utilizados para análise de sucesso em DTE têm sido mais rigorosos do que aqueles aplicados para tratamentos com IDs (30). Os parâmetros usados para avaliar o fracasso do ID têm sido sinais clínicos de infecção, mobilidade aumentada e sinais radiográficos de perda óssea, estabelecendo-se a partir destes a distinção entre implante “fracassado” e implante “fracassando” (31). Existe na literatura uma grande heterogeneidade de estudos considerando tempo de proservação, critérios de sucesso, tipo de ID e tempo de carga do implante (32).

A relação entre as taxas de insucesso de tratamentos endodônticos e tratamentos com IDs tem sido enfatizada em alguns estudos contemporâneos (33,34). Schmidlin *et al.*, 2010 (33), demonstraram uma maior sobrevivência a longo prazo e taxas de sucesso mais elevadas para coroas unitárias em dentes com polpas vitais em comparação com coroas unitárias em DTE ou sobre IDs. Coroas metalocerâmicas em DTE com pinos fundidos revelaram baixas taxas de sobrevivência em 10 anos. Apesar dos IDs apresentarem altas taxas de sobrevivência exigiram tratamentos subsequentes. Resultados semelhantes foram encontrados por Hannahan & Eleazar, 2008 (34), quanto a necessidade de tratamentos pós-operatórios para manter o ID na cavidade bucal em condições adequadas, todavia as taxas de sucesso dos implantes dentários *versus* tratamento endodôntico mostraram-se essencialmente idênticas.

Quando a taxa de sobrevivência (dentes em função com ou sem lesão radiográfica) para dentes tratados endodonticamente é usada, em detrimento dos critérios tradicionais, a taxa de sucesso do DTE por endodontista é igual ou maior do que o sucesso do ID a longo prazo (35).

Iqbal & Kim, 2008 (32), discutiram os fatores que influenciam a decisão de tratamento com ID *versus* preservação de DTE. Concluíram que IDs são alternativas úteis para reposição de dentes que não podem ser tratados com bom prognósticos. Entretanto, ID provocam dor e inflamação, são aproximadamente duas vezes mais onerosos que o tratamento endodôntico, estão associados com extensas intervenções pós tratamento e não apresentam taxas melhores de sobrevivência do que DTE e restaurados.

Uma discussão na odontologia contemporânea é a seleção do tratamento para dentes severamente comprometidos. O papel do tratamento com ID em pacientes com dentes comprometidos tem permanecido incerto, controverso e tema de consideráveis debates. Não somente a escolha do tratamento, mas também os critérios que definem o dente como comprometido são controversos e sujeitos a diferenças na interpretação. Portanto uma criteriosa consideração das indicações e contra indicações, riscos e benefícios de ambos ID e DTE, é fator crítico de importância, e uma acurada avaliação da opção de tratamento deve ser apresentada ao paciente para seu consentimento informado (32).

Os EPOs constituem fatores de risco que podem contribuir para o insucesso tanto da terapia endodôntica quanto do tratamento com implantes dentários. O conhecimento desses erros sugere a necessidade de maior cuidado durante o planejamento e execução dos procedimentos operatórios.

## CONCLUSÃO

Erros de procedimentos operatórios foram detectados em dentes tratados endodonticamente e em implantes dentários. Nos dentes tratados endodonticamente, foram verificados mais frequentemente a inadequada obturação do canal radicular, enquanto que roscas expostas representaram a maioria dos erros de procedimento em IDs.

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## PUBLICAÇÃO

Operatory Procedural Errors Detection in Endodontically Treated Teeth and Dental Implants by Using Cone Beam Computed Tomography

JULIO ALMEIDA SILVA, DDS, MSc, PhD
Professor of Endodontics, Federal University of Goiás, Goiânia, GO, Brazil;

ANA HELENA GONÇALVES DE ALENCAR, DDS, MSc, PhD;
Professor of Endodontics, Federal University of Goiás, Goiânia, GO, Brazil;

SICKNAN SOARES DA ROCHA, DDS, MSc, PhD;
Professor of Oral Rehabilitation, Federal University of Goiás, Goiânia, GO, Brazil;

LAWRENCE GONZAGA LOPES, DDS, MSc, PhD;
Professor of Oral Rehabilitation, Federal University of Goiás, Goiânia, GO, Brazil;

CARLOS ESTRELA, DDS, MSc, PhD;
Chairman and Professor of Endodontics, Federal University of Goiás, Goiânia, GO, Brazil;

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Correspondence and offprint requests:
Professor Carlos ESTRELA
Department of Stomatologic Sciences, Federal University of Goiás, PraçaUniversitária s/n, SetorUniversitário, CEP 74605-220, Goiânia, GO, Brazil.
E-mail address: estrela3@terra.com.br.

Operatory Procedural Errors Detection in Endodontically Treated Teeth and Dental Implants by Using Cone Beam Computed Tomography


**Abstract**

**Introduction:** Acceptable therapeutic protocol in dentistry depends of outcomes obtained with follow up. Operatory procedural errors (OPEs) may occur and it represents risk factors able to compromise a tooth or a dental implant. The aim of this article is to detect the OPEs in endodontically treated teeth (ETT) and dental implant (DI) by using cone beam computed tomography (CBCT). **Methods:** Eight hundred and sixteen (816) CBCT exams were performed between January 2009 and October 2010, and only those which presented ETT and/or DI were selected. The sample involved was like this: 195 patients (n =200 teeth and 200 dental implants), 72 male, 123 female, with mean age – 51 years. In endodontically treated teeth the OPEs included were inadequate root canal obturation (RCO), overfilling, and radicular perforation (RP); while those for dental implant were: thread exposures, contact with anatomical structures, and contact with adjacent tooth. Kolmogorov-Smirnov test was used for statistical analyses. The significance level was set at $\alpha$ = 5%.**Results:**Inadequate RCO, overfilling, and RP were detected in 59%, 8% and 4.5%, respectively. Dental implant with thread exposures, contact with important anatomical structures and contact with adjacent tooth showed values of 37.5%, 13% and 6.5%, respectively. Radiolucency was identified in 37.5% of cases of endodontically treated teeth and in 11% of dental implants. **Conclusions**: OPEs were detected in endodontically treated teeth and dental implant.In endodontically

treated teeth were verified more frequently inadequate RCO, while, for dental implant, thread exposures.

## Introduction

The periapical tissue health and the maintaining of tooth in the oral cavity constitute the main objective of endodontic therapy (1). Another alternative to replace the compromised tooth is dental implant-based restoration (2). However, both specialties are fantastically challenging, and which also present circumstances of doubtful prognosis. Considering the difficulties that may be encountered during endodontic treatment it can be mentioned the understanding of internal morphology, control of endodontic biofilm, and the immunological response. Important conditions must also be considered into the DI planning, such as the location of tooth, quality of bone, periodontal status and tissue type, restorability and systemic factors. These aspects may be still associated with the professional ability and scientific knowledge in both areas.

Endodontic therapy or placement of a dental implant requires planning, knowledge and an accurate operatory ability. Operatory procedural errors (OPE) characterize disability, non-observance of therapeutic protocol and low level of knowledge involving the endodontics and implant dentistry principles. Deficient attendance may be responsible by serious consequences and sequels which reduce the prognosis level, and may be responsible for severe judicial questions.

Clinical radiographic criteria of therapeutic success have been considered important to establish a clinical decision in both specialties. In endodontically treated teeth (ETT) the success includes: absence of pain and swelling; absence of drainage and fistula; tooth in function, with normal physiology; disappearance of periapical bone rarefaction (3). The clinical condition after rehabilitation treatment with DI might be determined with an implant quality scales. Success (optimum health) is considered when the patient does not report pain or tenderness upon function, absence of mobility, radiographic bone loss initial surgery less than 2 mm, and no exudate history. Satisfactory survival presents no pain upon function, absence of mobility, radiographic bone loss between 2-4 mm, and no exudate history. In situations of compromised survival there may be sensitivity on function, absence of mobility, radiographic bone loss greater than 4 mm (less than half of implant body), probing depth greater than 7 mm and no exudate history, and there may be exudates history. Clinical or absolute failure is characterized by the pain on function, mobility, radiographic bone loss greater than half the length of implant, uncontrolled exudate, and no longer in mouth (4).

The assessment of dental treatment by computed tomography (CT) represents an expressive advance of information in health studies (5) and contributes in planning, diagnosis, therapeutic process and prognosis of several diseases. The continuous development of technology enabled cone beam computed tomography (CBCT) (6,7), which had shown numerous perspectives for applications in different research areas and clinical dentistry (7-9). Imaging resources routinely had been used before, during and after dental management. Conventional radiographic images provide a two-dimensional rendition of a three-dimensional structure, which may result in interpretation errors. Periapical lesions of endodontic origin may be present but not visible on conventional 2D radiographs (9-10). Diagnostic accuracy is critical for treatment success. The correct management of CBCT images might reveal abnormality that is unable to be detected in periapical radiography and may favor more predictable planning and treatment. A possibility of map-reading approach with CBCT images reduces problems related to difficult evaluation conditions which require special care during diagnosis (11).

CBCT scans provide detailed high-resolution images of oral structures and permit early detection of alterations in maxillofacial structures. This technology allows the determination of linear distances and volume of anatomic structures, pre-surgical planning of maxillofacial lesions, root length and marginal bone level during orthodontic treatment, reconstruction techniques, bone level changes following regenerative periodontal therapy, periodontal defect, periapical lesions, and root resorptions (12,13).

Operatory procedural errors are caused by several factors inherent to patient and/or professional, whose consequences may influence on prognosis. Alencar *et al.*, 2011 (14), detecting procedural errors (fractured instruments, perforations and apical transportation) created by rotary NiTi instruments during root canal preparation by using CBCT, observed that this imaging method offered more resources for diagnosis.

The dilemma of replacing a biological structure by biocompatible material requires care, information about criteria and rates of success in endodontically treated teeth and dental implant. Thus, viewing the lack of studies comparing the outcome between endodontic therapy with IDs and the limitations in its longitudinal interpretations (15) showed the necessity of researches using tool more accuracy. The potential of CBCT such as diagnosis imaging method justify this study. The aim of this article is to detect the OPE in endodontically treated teeth and dental implant by using CBCT.

**Material and Methods**

This cross-sectional study evaluates procedural errors in endodontically treated teeth and dental implant detected by using CBCT. It was structured using databases of private radiology clinics (Centro Integrado de Radiologia – C.I.R.O., Goiânia, GO, Brazil). The patients were referred to the dental radiology service for different diagnostic purposes. Eight hundred and sixteen (816) CBCT exams were performed between January 2009 and October 2010, and only those which presented ETT and/or DI were selected. The sample involved was like this: 195 patients (n =200 teeth and 200 dental implants), 72 male, 123 female, with mean age – 51 years. The study design was approved by the Local Ethics Research Committee (UFG, Proc. #169/2008).

Criteria inclusion for both groups included all patients with one or more teeth with a history of ETT and with or without apical periodontitis (AP), and one or more DI. It was considered just images with high resolution quality and absence of metallic artifact that could difficult an accurate analysis.

*Imaging Analysis*

CBCT images were acquired with the first generation i-CAT Cone Beam 3D imaging system (Imaging Sciences International, Hatfield, PA, USA). The volumes were reconstructed with isotropic- isometric voxels measuring 0.20 mm X 0.20 mm X 0.20 mm. The tube voltage was 120 kVp and the tube current 36.12 mA. Exposure time was 40 seconds. Images were examined with the scanner's proprietary software (Xoran version 3.1.62; Xoran Technologies, Ann Arbor, MI, USA) in a PC workstation running Microsoft Windows XP professional SP-2 (Microsoft Corp, Redmond, WA, USA), with processor Intel(R) Core(TM) 2 Duo-6300 1.86 Ghz (Intel Corporation, USA), Nvidia GeForce 6200 turbo cache videocard (NVIDIA Corporation, USA) and Monitor Eizo - Flexscan S2000, resolution 1600x1200 pixels (Eizo Nanao Corporation Hakusan, Japan).

All imaging exams were analyzed by 2 investigators (specialist in endodontics and dental radiology, both with 5 or more years of training), which were calibrated by using 10% of the sample; when differences were noted, a consensus was reached, discussing the image with a third investigator.

The examiners evaluated the images to determine the following OPE in ETT: presence of overfilling (the filling material beyond apex), inadequate RCO (underfilling > 2mm from the apex; inhomogeneous root filling with visible voids; space between root canal filling and intracanal post > 3mm; remaining root canal filling < 3mm),radicular perforation. The analysis of OPE in DI regarded: thread exposures more than 1/3 of the implant body (outside of the alveolar bone), IDs in contact with important anatomical structures (mandibular canal,mental foramen or incisive foramen, and DIs with more than 1/3 of the body invading maxillary sinus or nasal cavity), contact with the adjacent tooth. In both groups, radiolucency was evaluated associated with endodontically treated teeth or dental implant.

*Statistical Analysis*

Kolmogorov-Smirnov test was used for statistical analyses. The significance level was set at $\alpha$ = 0,05%.

**Results**

The distribution of 200 ETT, analyzed in CBCT, was presented as follows: upper anterior region n = 75; upper posterior region n = 85; lower anterior region n = 3, lower posterior region n = 37. Inappropriate RCO, overfilling, and RP were detected in 59%, 8% and 4.5% respectively (Table 1).

Of the 200 DIs tested, 67 were located in the upper anterior region, 65 in the upper posterior one; 8 in the lower anterior one, and 60 in the lower back region. DIs with exposed threads, contact with important anatomical structures and contact with adjacent teeth showed values of 37.5%, 13% and 6.5% respectively (Table 2).

Of the total number of teeth examined, 75 ETT had periapical radiolucency (37.5%) while the radiolucency around the body of DIs was detected in 22 cases (Table 3).

OPEs in ETT and DIs, detected in tomographic coronal slices, sagittal and axial ones are illustrated in Figures 1 and 2. In Figure 3 it can be observed sagittal and axial slices of DI in normal bone structure and DI with radiolucency around its body.

**Discussion**

Root canal and dental implants therapy involve an important discussion in dentistry. The extension of treatment for a tooth condemned to extraction can be a dental implant. The detection of OPEs in ETT and DIs is medically controversial and complex, due to limitations of periapical and panoramic radiographies. The value of periapical radiography to identify the quality of ETT and the position of the DI is recognized. However, despite the benefits, this conventional imaging method has limitations, mainly the image overlapping and the need for extensive bone loss to display the rarefaction image (9-10).

The possibility of evaluating ETT and DI using the CBCT increases the potential for evaluating the therapeutic protocol (8,9, 12,13,) CBCT images provide the possibility of a reading by mapping, with the acquisition of valuable information through a dynamic display in different planes (11). It has been shown a greater accuracy in the diagnosis of apical periodontitis when using CBCT compared with conventional radiographs (8,9,12,16).

The formation of artifacts especially near bodies of high density such as metal (intra-radicular cores, crowns and metal restorations) requires care during CBCT images, avoiding misdiagnosis. This effect is called beamhardening. In this study, the CBCT images were analyzed by a specialist in endodontics and a specialist in radiology, with expertise in three-dimensional tracking and prepared to identify technical artifacts (17).

The results of this study to detect OPEs at ETT, through CBCT imaging , showed 59% of inadequate RCOs, 8% of overfillings and , 4.5% RPs. These results are similar to those from Moura *et al*., 2009 (18), which had found 10% of overfillings in anterior teeth, and to those from Alencar *et al*., 2011 (14), in which radicular perforations were detected in 5% (6/120) of the endodontically treated radicular canals, both using CBCT images. In contrast, when conventional radiography was used as a diagnostic method, Santos *et al*., 2010 (19) observed 0.37% of roots with perforations and 2.67% of roots with overfilling. This fact is justified by the difficulty in comparing studies using different criteria and tools for image analysis.

The highest values of inadequate RCO were found in upper posterior teeth, reaching 83.52% (Table 1). These results were similar to those from Moussa-Badran *et al*., 2008 (20), which observed 76.3% of inadequate fillings in posterior teeth. This fact is justified by the large proportion of posterior teeth evaluated in these studies, by anatomic complexity and by teeth location into dental arch, which may have hindered the endodontic treatment.

Epidemiological studies conducted in different population groups have reported differences between the percentages of inadequate RCO (21,22). This variation can be attributed to the level of training of operator, students, general practitioners, graduate students and specialists, plus the length of experience.

The results of this study showed radiolucency in 37.5% (75/200) of the ETT. Previous studies have shown higher rates of apical periodontitis associated with ETT using different methodologies (9,12,23,24). The inadequate RCO and poor coronal restoration were associated with an increased incidence of apical periodontitis (23). Although the technical quality of the RCO is important for successful treatment, it does not necessarily reflect the quality of care in general. Procedures of asepsis and antisepsis during treatment, technique for root canal preparation, and materials used are determinants of prognosis and commonly unknown in epidemiological studies (25).

The occurrence of DIs with exposed threads, in touch with important anatomical structures and in contact with adjacent teeth showed, in this investigation, values of 37.5%, 13% and 6.5% respectively. The upper front teeth had a greater frequency of DIs with exposed threads. Of 200 IDs evaluated, radiolucency was identified in 11%.

The literature is scarce on studies using CBCT to assess OPEs in dental implants. However there is research that from radiographic signs establish the prognosis of DIs (26). The radiographic examination remains an important tool to identify failure in IDs in clinical practice. The essential factors for proper evaluation of the condition of the implant is the quality of radiography with experience of the examiner (27). A sequence of longitudinal standardized radiographs are required to measure changes in interproximal bone level and detect peri-implant radiolucencies. The radiographic image of periimplant radiolucency suggests no direct contact with bone / implant and the possibility of loss of stability, however there may be marginal bone loss and implant remains stable (28).

OPEs represent risk factors that can affect one tooth or a dental implant. A well-structured clinical protocol of treatment favors the survival conditions for an ETT or a DI. The success or failure are important parameters to indicate and maintain an appropriate therapeutic protocol. However, distinct clinical and radiographic criteria have been used to evaluate success rates in different studies, making it impossible to compare results.

Torabinejad & Babjri, 2005 (29), discussed about dental treatment based on evidences. Few high-level studies have been published in the last four decades, related to success and failure of endodontic treatment. There have been highlighted as limitations on longitudinal clinical studies the radiographic analysis, which is subject to personal interpretation, to change in angulation, which can give a completely different look to injury, making it appear smaller or larger, to the clinical symptoms such as presence of pain, fistula or swelling that can occur without radiographic evidence of bone destruction (30). Estrela *et al.*, 2008 (9), revealed the high accuracy of CBCT compared with periapical and panoramic radiography in the detection of apical periodontitis. Wu *et al.*, 2009 (16), showed that a high percentage of ETT presenting aspects of normality in radiographs were revealed with apical periodontitis by CBCT and histological examination. Therefore, the results of epidemiological studies of success rates in endodontic treatments should be reassessed with more stringent criteria, in long term, and using more accurate tools such as CBCT (9,16,30).

The implantodontology is developing new research results that provide better knowledge of biological principles of DI (31). The criteria used for analysis of success in ETT have been more stringent than those applied to treatments with DIs (30). The parameters used to evaluate the failure of DI have been clinical signs of infection, increased mobility and radiographic signs of bone loss, taking from them the distinction between "failed" implant and "failing" implant (31). There has been a great heterogeneity of studies considering the time of follow up, success criteria, type of DI and loading time of implant (32).

The relation between failure rates of endodontic treatments and treatments with DIs has been emphasized in some contemporary studies (33,34). Schmidlin *et al.*, 2010 (33), demonstrated a greater long-term survival and higher success rates for single crowns in teeth with vital pulp in comparison with single crowns in ETT or on DIs. Metal ceramic crown at ETT with fused pin lead to lower survival rates in 10 years. Despite the DIs have high rates of survival, they required subsequent treatment. Similar results had been found by Hannahan e Eleazar, 2008 (34), regarding the need for postoperative treatments to keep the DI in the oral cavity under appropriate conditions, however the success rates of dental implants versus root canal treatment proved to be essentially identical.

When the survival rate (teeth in function with or without radiographic lesion) for endodontically treated teeth is used, instead of the traditional criteria, the success rate of the teeth, endodontically treated by endodontist, is equal to or greater than the success of DI in long-term (35).

Iqbal e Kim, 2008 (32), discussed the factors that influence the decision to treat with DI versus preservation of ETT. They concluded that DIs are useful alternatives for teeth replacement that can not be treated with good prognosis. However, DIs cause pain and inflammation, are about twice more expensive than endodontic treatment, are associated with extensive interventions post treatment and they do not have better survival rates than ETT and restored.

A discussion on contemporary dentistry is the selection of treatment for severely compromised teeth. The role of treatment with DI in patients with involved teeth has remained uncertain, controversial and subject of considerable debates. Not only the choice of treatment, but also the criteria that define the tooth as compromised are controversial and subject to differences in interpretation. Therefore, a careful consideration of the indications and contraindications, risks and benefits of both DI and ETT, is a critical factor of importance, and an accurate evaluation of treatment options should be presented to the patient for his informed consent (32).

OPEs are risk factors that may contribute to both the failure of endodontic therapy and treatment with dental implants. Knowledge of these errors suggests the need for greater care during the planning and execution of operatory procedures.

**Acknowledgments**

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Table 1.Distribution of operatory procedural errors (OPEs) in endodontically treated teeth (ETT).

| **Procedural Erros** | **Inadequate RCO** | **Overfilling** | **RP** | **Significance level** |
|---|---|---|---|---|
| Anterior Maxillary (n=75) | 26 (34.66%) | 9 (12%) | 3 (4%) | $P<0.05$ |
| Posterior Maxillary (n=85) | 71 (83.52%) | 3 (3.52 %) | 5 (5.88%) | $P<0.05$ |
| Anterior Mandibular (n=3) | 3 (100%) | 0 (0%) | 0 (0%) | $P>0.05$ |
| Posterior Mandibular (n=37) | 18 (48.64%) | 4 (18.81%) | 1 (2.7%) | $P<0.05$ |
| Total (n=200) | 118 (59%) | 16 (8%) | 9 (4.5%) | $P<0.05$ |

Table 2.Distribution of operatory procedural errors (OPEs) in dental implant (DI).

| **Procedural Erros** | **Thread exposures** | **Contact with anatomical structures** | **Contact with adjacent tooth** | **Significancelevel** |
|---|---|---|---|---|
| Anterior Maxillary (n=67) | 40 (59.7%) | 6(8.95%) | 8 (11.67%) | *P<0.05* |
| Posterior Maxillary (n=65) | 18(27.69%) | 4(6.15%) | 12(18.46%) | *P>0.05* |
| Anterior Mandibular (n=8) | 1 (12.5%) | 0 (0%) | 2 (25%) | *P>0.05* |
| Posterior Mandibular (n=60) | 16(26.66%) | 3(5%) | 4(6.66%) | *P<0.05* |
| Total (n=200) | 75 (37.5%) | 13 (6.5%) | 26 (13%) | *P<0.05* |

Table 3. Radiolucency associate with endodontically treated teeth (ETT) and dental implant (DI).

| **Procedural Erros** | **Endodontictreatment** | **Dental implants** | **Significancelevel** |
|---|---|---|---|
| Anterior Maxillary | 22/75 (29.33%) | 15/67 (22.38%) | *P>0.05* |
| Posterior Maxillary | 35/85 (41.17%) | 1/65 (1.53%) | *P<0.05* |
| Anterior Mandibular | 2/3 (66.66%) | 4/8 (50%) | *P>0.05* |
| Posterior Mandibular | 16/37 (43.24%) | 2/60 (3.33%) | *P<0.05* |
| Total | 75/200 (37.5%) | 22/200 (11%) | *P<0.05* |

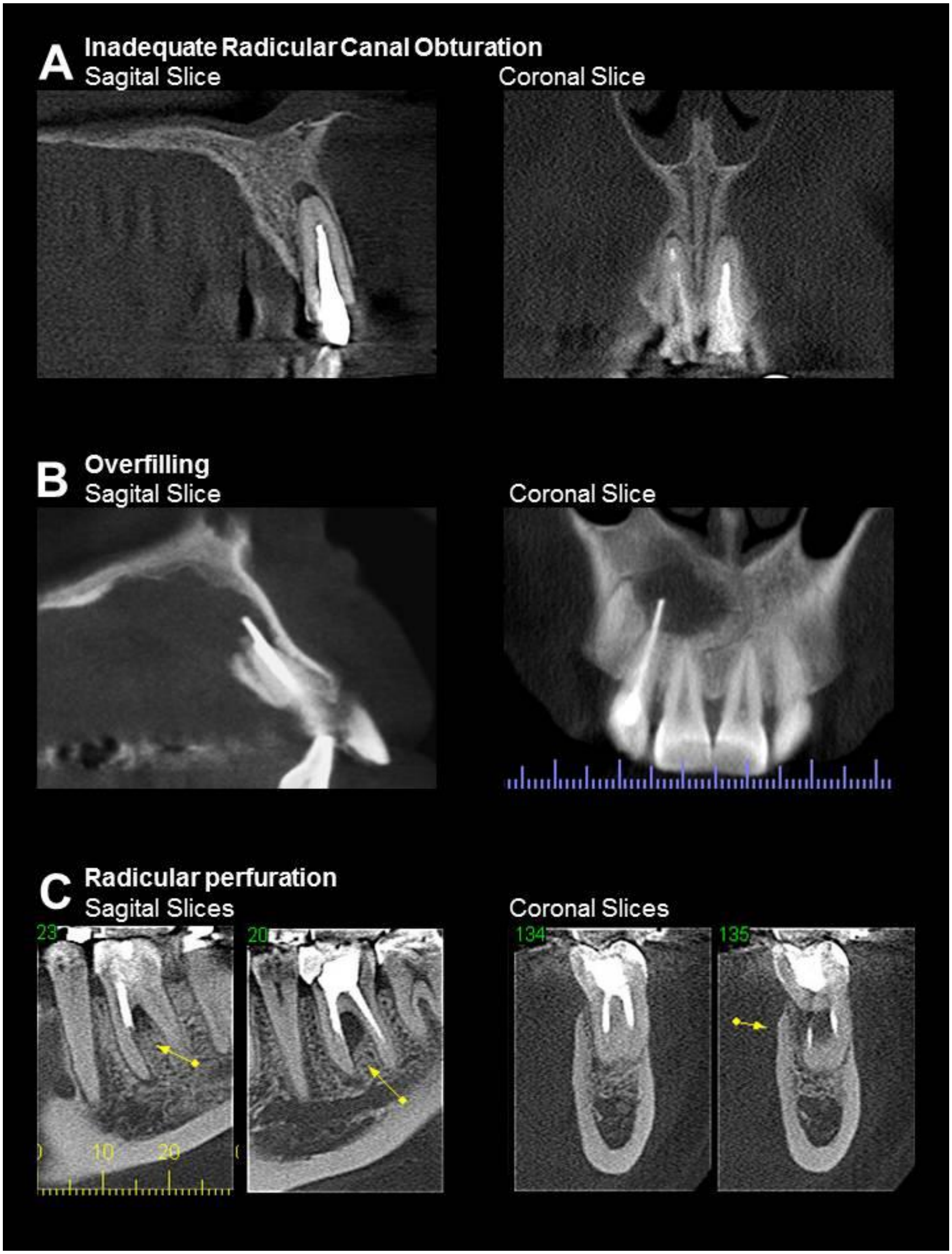


Figure 1 – Operatory procedural errors (OPEs) in endodontically treated teeth (ETT): A) Sagital and coronal slices of maxillary central incisor with underfilling showing periapical radiolucency, B) Sagital and coronal slices of maxillary lateral incisor with overfilling associated with extensive periapical radiolucency, C) Sagital and coronal slices of mandibular molar with radicular perforation.

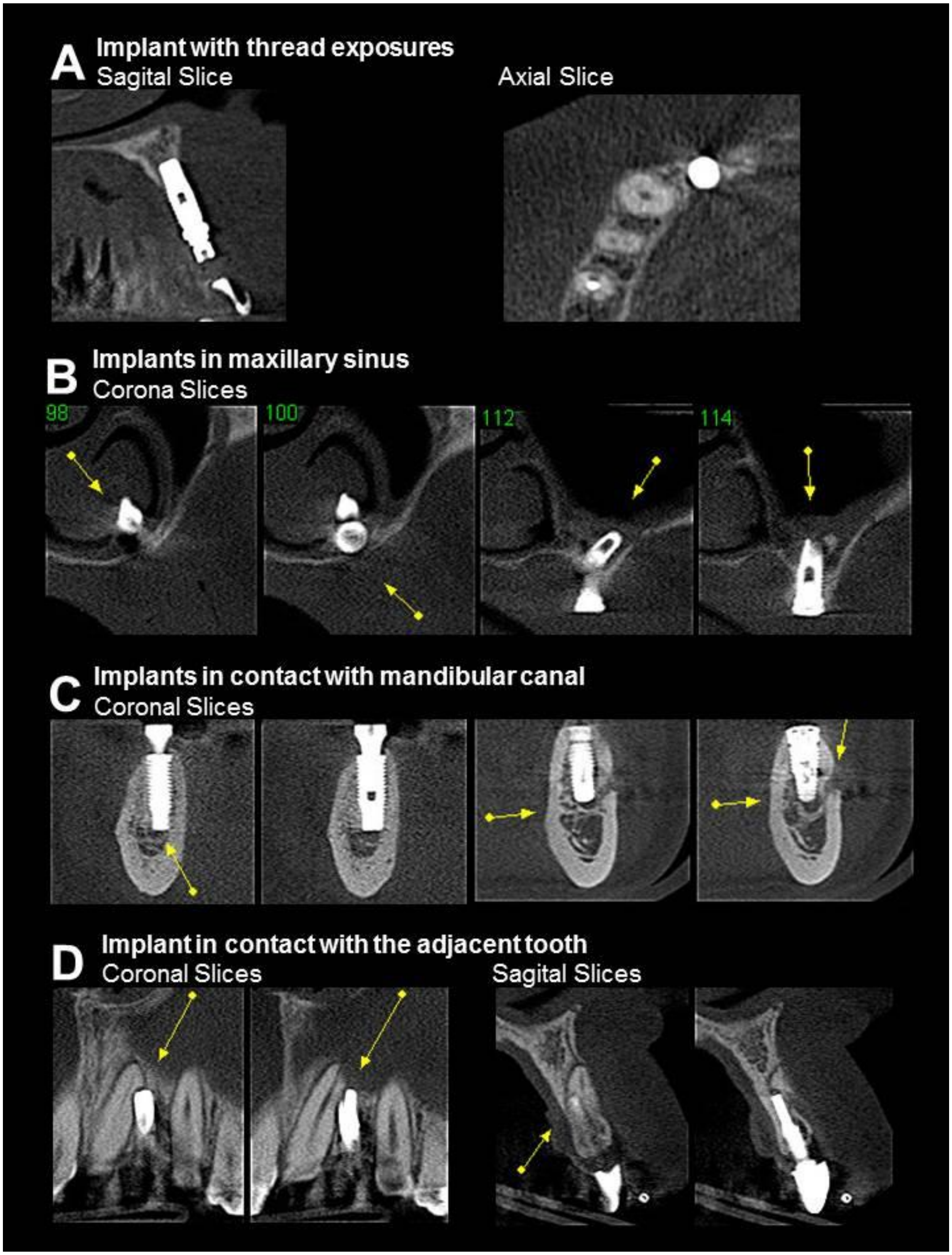


Figure 2 – Operatory procedural errors (OPEs) in dental implants (DIs): A) Sagital and axial slices of DI in maxillary anterior region with thread exposures in buccal and palatal faces, B) Coronal slices of DIs in posterior maxillary region with more than 1/3 body in maxillary sinus, C) Coronal slices of DIs in posterior mandibular region in contact with mandibular canal, D) Coronal and sagittal slices of DIs in anterior maxillary region in contact with the adjacent tooth.

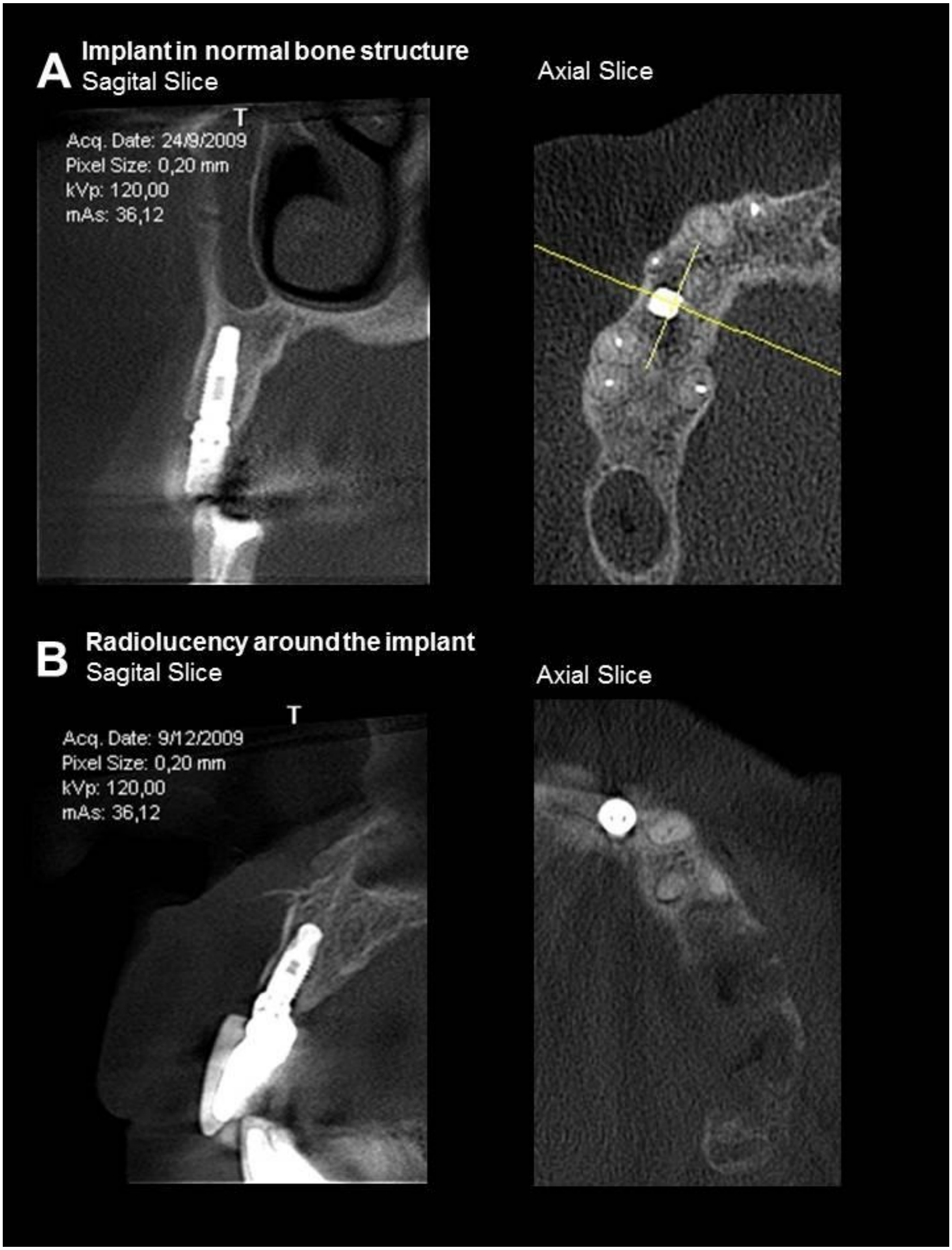

Figure 3 – Sagital and axial slices: A) Dental Implant (DI) in normal bone structure, B) Dental Implant (DI) with radiolucency around the implant body.

# ANEXOS

## 1 - NORMAS DE PUBLICAÇÃO JOURNAL OF ENDODONTICS

## Guidelines for Publishing Papers in the JOE

Writing an effective article is a challenging assignment. The following guidelines are provided to assist authors in submitting manuscripts.

The *JOE* publishes original and review articles related to the scientific and applied aspects of endodontics. Moreover, the *JOE* has a diverse readership that includes full-time clinicians, full-time academicians, residents, students and scientists. Effective communication with this diverse readership requires careful attention to writing style.

### General Points on Composition

Authors are strongly encouraged to analyze their final draft with both software (e.g., spelling and grammar programs) and colleagues who have expertise in English grammar. References listed at the end of this section provide a more extensive review of rules of English grammar and guidelines for writing a scientific article. Always remember that clarity is the most important feature of scientific writing. Scientific articles must be clear and precise in their content and concise in their delivery since their purpose is to inform the reader. The Editor reserves the right to edit all manuscripts or to reject those manuscripts that lack clarity or precision, or have unacceptable grammar. The following list represents common errors in manuscripts submitted to the *JOE*:

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

b. Keep to the point. The subject of the sentence should support the subject of the paragraph. For example, the introduction of authors' names in a sentence changes the subject and lengthens the text. In a paragraph on sodium hypochlorite, the sentence, "In 1983, Langeland et al., reported that sodium hypochlorite acts as a lubricating factor during instrumentation and helps to flush debris from the root canals" can be edited to: "Sodium hypochlorite acts as a lubricant during instrumentation and as a vehicle for flushing the generated debris (Langeland et al., 1983)". In this example, the paragraph's subject is sodium hypochlorite and sentences should focus on this subject.

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

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

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

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

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

## General Points on the Organization of Original Research Manuscripts

a. **Please Note**: *Starting in 2009, all abstracts should be organized into sections that start with a one-word title (in bold), i.e., Introduction, Methods, Results, Conclusions, etc., and should not exceed more than 250 words in length.*
b. **Title Page**: The title should describe the major conclusion of the paper. It should be as short as possible without loss of clarity. Remember that the title is your advertising billboard-it represents your major opportunity to solicit readers to spend the time to read your paper. It is best not to use abbreviations in the title since this may lead to imprecise coding by electronic citation programs such as PubMed (e.g., use "sodium hypochlorite" rather than NaOCl). The author list must conform to published standards on authorship (see authorship criteria in the Uniform Requirements for Manuscripts Submitted to Biomedical Journals at *www.icmje.org*).
c. **Abstract**: The abstract should concisely describe the purpose of the study, the hypothesis, methods, major findings and conclusions. The abstract should describe the new contributions made by this study. The word limitations (250 words) and the wide distribution of the abstract (e.g., PubMed) make this section challenging to write clearly. This section often is written last by many authors since they can draw on the rest of the manuscript. Write the abstract in past tense since the study has been completed. Three to ten keywords should be listed below the abstract.
d. **Introduction**: The introduction should briefly review the pertinent literature in order to identify the gap in knowledge that the study is intended to address. The purpose of the study, the tested hypothesis and its scope should be described. Authors should realize that this section of the paper is their primary opportunity to establish communication with the diverse readership of the *JOE*. Readers who are not expert in the topic of the manuscript are likely to skip the paper if the introduction fails to provide sufficient detail. However, many successful manuscripts require no more than a few paragraphs to accomplish these goals.
e. **Material and Methods**: The objective of the methods section is to permit other investigators to repeat your experiments. The three components to this section are the experimental design, the procedures employed, and the statistical tests used to analyze the results. The vast majority of manuscripts should cite prior studies using similar methods and succinctly describe the particular aspects used in the present study. The inclusion of a "methods figure" will be rejected unless the procedure is novel and requires an illustration for comprehension. If the method is novel, then the authors should carefully describe the method and include validation experiments. If the study utilized a commercial product, the manuscript should state that they either followed manufacturer's protocol or specify any changes made to the protocol. Studies on humans should conform to the Helsinki Declaration of 1975 and state that the institutional IRB approved the protocol and that informed consent was obtained. Studies involving animals should state that the institutional animal care and use committee approved the protocol. The statistical analysis section should describe which tests were used to analyze which dependent measures; p-values should be specified. Additional details may include randomization scheme, stratification (if any), power analysis, drop-outs from clinical trials, etc.
f. **Results**: Only experimental results are appropriate in this section (i.e., neither methods nor conclusions should be in this section). Include only those data that are critical for the study. Do not include all available data without justification, any repetitive findings will be rejected from publication. All Figs./Charts/Tables should be described in their order of numbering with a brief description of the major findings.

**Figures**: There are two general types of figures. The first type of figure includes photographs, radiographs or micrographs. Include only essential figures, and even if essential, the use of composite figures containing several panels of photographs is encouraged. For example, most photo-, radio- or micrographs take up one column-width, or about 185 mm wide X 185 mm tall. If instead, you construct a two columns-width figure (i.e., about 175 mm wide X 125 mm high when published in the *JOE*), you would be able to place about 12 panels of photomicrographs (or radiographs, etc.) as an array of four columns across and three rows down (with each panel about 40 X 40 mm). This will require some editing on your part given the small size of each panel, you will only be able to illustrate the most important feature of each photomicrograph. Remember that each panel must be clearly identified with a letter (e.g., "A", "B", etc.), in order for the reader to understand each individual panel. Several nice examples of composite figures are seen in recent articles by Chang, et al, (*JOE* 28:90, 2002), Hayashi, et al, (*JOE* 28:120, 2002) and by Davis, et al (JOE 28:464, 2002). At the Editor's discretion, color figures may be published at no cost to the authors. However, the Editor is limited by a yearly allowance and this offer does not include printing of reprints.

The second type of figure are graphs (i.e., line drawings) that plot a dependent measure (on the Y axis) as a function of an independent measure (usually plotted on the X axis). Examples include a graph depicting pain scores over time, etc. Graphs should be used when the overall trend of the results are more important than the exact numerical values of the results. For example, a graph is a convenient way of reporting that an ibuprofen treated group reported less pain than a placebo group over the first 24 hours, but was the same as the placebo group for the next 96 hours. In this case, the trend of the results is the primary finding; the actual pain scores are not as critical as the relative differences between the NSAID and placebo groups.

**Tables**: Tables are appropriate when it is critical to present exact numerical values. However, not all results need be placed in either a table or figure. For example, the following table may not necessary:

| % NaOCl | N/Group | % Inhibition of Growth |
|---|---|---|
| 0.001 | 5 | 0 |
| 0.003 | 5 | 0 |
| 0.01 | 5 | 0 |
| 0.03 | 5 | 0 |
| 0.1 | 5 | 100 |
| 0.3 | 5 | 100 |
| 1 | 5 | 100 |
| 3 | 5 | 100 |

Instead, the results could simply state that there was no inhibition of growth from 0.001-0.03% NaOCl, and a 100% inhibition of growth from 0.03-3% NaOCl (N=5/group). Similarly, if the results are not significant, then it is probably not necessary to include the results in either a table or as a figure. These and many other suggestions on figure and table construction are described in additional detail in Day (1998).

f. **Discussion**: The conclusion section should describe the major findings of the study. Both the strength and weaknesses of the observations should be discussed. What are the major conclusions of the study? How does the data support these conclusions? How do these findings compare to the published literature? What are the clinical implications? Although this last section might be tentative given the nature of a particular study, the authors should realize that even preliminary clinical implications might have value for the clinical readership. Ideally, a review of the potential clinical significance is the last section of the discussion.
g. **References**: The reference style follows Index Medicus and can be efficiently learned from reading past issues of the *JOE*. Citations are placed in parentheses at the end of a sentence or at the end of a clause that requires a literature citation. Do not use superscript for references. Original reports are limited to 35 references. There are no limits in the number of references for review articles.

## 4. Page Limitations for Manuscripts in the Category of Basic Science/Endodontic Techniques

a. **What is the limitation?** Original research reports in the category of basic science/endodontic techniques are limited to no more than 2,000 words (total for the abstract, introduction, methods, results and conclusions), and a total of three Figs./Charts/Tables. If a composite figure is used (as described above), then this will count as two of the three permitted Figs./Charts/Tables.
b. **Does this apply to me?** Manuscripts submitted to the *JOE* can be broadly divided into several categories including review articles, clinical trials (e.g., prospective or retrospective studies on patients or patient records, or research on biopsies excluding the use of human teeth for technique studies), basic

science/biology (animal or culture studies on biological research related to endodontics, or relevant pathology or physiology), and basic science/techniques (e.g., stress/strain/compression/strength/failure/composition studies on endodontic instruments or materials). Manuscripts submitted in this last category are the only category subject to these limitations. If you are not sure whether your manuscript falls within this category please contact the Editor by e-mail at *jendodontics@uthscsa.edu*.

c. **Why page limitations?** Most surveyed stakeholders of the *JOE* desire timely publication of submitted manuscripts and an extension of papers to include review articles and other features. To accomplish these goals, we must reduce the average length of manuscripts since increasing the *JOE*'s number of published pages is prohibitively expensive. Although a difficult decision, restricting this one category of manuscripts accomplishes nearly all of these goals since ~40-50% of published papers are in this category.

d. **How do I make my manuscript fit these limitations?** Adhering to the general writing methods described in these guidelines (and in the resources listed below) will help to reduce the size of the manuscript. Authors are encouraged to focus on only the essential aspects of the study and to avoid inclusion of extraneous text and figures. The Editor will reject manuscripts that exceed these limitations.

## 5. Available Resources:

. Strunk W, White EB. The Elements of Style. Allyn & Bacon, 4th ed, 2000, ISBN 020530902X

a. Day R.. How to Write and Publish a Scientific Paper. Oryx Press, 5th ed. 1998. ISBN 1-57356-164-9

b. Woods G. English Grammar for Dummies. Hungry Minds:NY, 2001 (an entertaining review of grammar)

c. Alley M. The Craft of Scientific Writing. Springer, 3rd edition 1996 SBN 0-387-94766-3.

d. Alley M. The Craft of Editing. Springer, 2000 SBN 0-387-98964-1.

**2 - ARTIGOS PUBLICADOS 2009 / 2010**

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