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OLAVO CESAR LYRA PORTO

Determinação da espessura óssea entre o centro do forame apical e às superfícies externas das corticais na dentição humana em imagens de tomografia computadorizada de feixe cônico

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OLAVO CESAR LYRA PORTO

Determinação da espessura óssea entre o centro do forame apical e às superfícies externas das corticais na dentição humana em imagens de tomografia computadorizada de feixe cônico

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

Orientador: Prof. Dr. Carlos Estrela
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Ata da **Defesa de Tese de Doutorado** realizada por **Olavo Cesar Lyra Porto**. Aos **dezenove dias do mês de dezembro de 2018 às 09:00h**, reuniu-se no Auditório da Faculdade de Odontologia/UFG, a Comissão Julgadora infra nomeada para proceder ao julgamento da defesa de Tese intitulada: **"DETERMINAÇÃO DA ESPESSURA ÓSSEA ENTRE O CENTRO DO FORAME APICAL E ÀS SUPERFÍCIES EXTERNAS DAS CORTICAIS NA DENTIÇÃO HUMANA EM IMAGENS DE TOMOGRAFIA COMPUTADORIZADA DE FEIXE CÔNICO"**, como parte de requisitos necessários à obtenção do **título de Doutor**, área de concentração **DINÂMICA DO PROCESSO SAÚDE-DOENÇA.** O Presidente da Comissão julgadora, **Prof. Dr. Carlos Estrela**, iniciando os trabalhos concedeu a palavra ao candidato, para exposição em até **50** minutos do seu trabalho. A seguir, o senhor presidente concedeu a palavra, pela ordem sucessivamente, aos Examinadores, os quais passaram a arguir o candidato durante o prazo máximo de 30 minutos, assegurando-se o mesmo igual prazo para responder aos Senhores Examinadores. Ultimada a arguição que se desenvolveu nos termos regimentais, a Comissão, em sessão secreta, expressou seu Julgamento, considerando o candidato aprovado ou reprovado.

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Em face do resultado obtido, a Comissão Julgadora considerou a candidata **Olavo Cesar Lyra Porto** Habilitado ( ) Não habilitado ( ). Nada mais havendo a tratar, eu, **Prof. Dr. Carlos Estrela** lavrei a presente ata que, após lida e achada conforme, foi por todos assinada.

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A banca examinadora aprovou a seguinte alteração no título da Tese:

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Olavo Cesar Lyra Porto

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Data: 19/12/2018

Dedico este trabalho a minha família,
Gabriela e Helena.

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SUMÁRIO

TABELAS E FIGURAS

SÍMBOLOS, SIGLAS E ABREVIATURAS

CAD	Computer-aided design
CAM	Computer-aided manufacturing
CA	Califórnia
CBCT	Computed tomography cone beam
CCD	Dispositivo de carga acoplada (Charge Coupled Device)
D	Distal
FOV	Campo de visão (Field of View)
GO	Goiás
KVP	Kilovoltagem de potência
L	Lingual
Ma	Miliampère
M	Mesial
mm	Milímetro
P	Nível de significância
P	Palatal
PSP	Placa de fósforo foto-estimulada
RP	Radiografia periapical
TCFC	Tomografia computadorizada de feixe cônico
V	Vestibular
WA	Washington

RESUMO

O objetivo deste estudo foi determinar a espessura óssea entre o centro do forame apical e à superfície externa das corticais vestibular e lingual/palatal em dentes permanentes humanos usando imagens de tomografia computadorizada de feixe de cônico (TCFC). Uma amostra de 1.400 imagens de dentes de TCFC de 422 pacientes (394 mulheres, idade média de 44,46) foi selecionada, e a espessura óssea entre o centro do forame apical e a porção externa da cortical vestibular e lingual/palatal foi determinada nos cortes axial, coronal e sagital. A média e o desvio padrão das variáveis quantitativas foram obtidas, e a normalidade dos dados foi avaliada pelo teste de Kolmogorov-Smirnov. Para análise da comparação das amostras independentes foi utilizado o Teste-t para amostras independentes ou o Teste de Mann-Whitney. Foram considerados significativos valores de $p < 0,05$. Os resultados mostraram que no grupo dos dentes anteriores, a menor espessura óssea entre o centro do forame apical e a superfície externa da cortical vestibular foi observada no canino superior (1,49 mm ± 0,86) seguida pela do incisivo central superior (1,59 mm ± 0,67), e a maior espessura óssea entre o centro do forame apical e a cortical lingual/palatal foi observada no canino superior (8,63 mm ± 2,08) seguida do incisivo central superior (7,07 mm± 1,96). No grupo de pré-molares, a menor espessura foi verificada na cortical vestibular da raiz vestibular do primeiro (1,13 mm ± 0,68) e do segundo pré-molar (2,20 mm ± 1,21) superiores, e a maior espessura da cortical lingual/palatal foi encontrada na raiz palatal no primeiro (8,07 mm ± 1,63) seguida do segundo (7,62 mm ± 1,84) pré-molar superiores. No grupo dos molares, o primeiro molar superior apresentou a menor espessura da cortical vestibular da raiz mesiovestibular (1,98 mm ± 1,33) e o segundo molar inferior mostrou que a cortical vestibular (8,36 mm± 1,84) era mais espessa que a lingual (2,95 mm ± 1,16). O conhecimento da anatomia dos diferentes grupos dentários e das estruturas adjacentes como as espessuras ósseas das corticais alveolares influência na qualidade do planejamento terapêutico cirúrgico, bem como orienta a análise das vias de disseminação bacteriana nas infecções periapicais. A TCFC permite obter medidas lineares que favorecem análises comparativas.

Palavras chave: Anatomia humana, exames por imagens, tomografia computadorizada de feixe cônico, método de diagnóstico, planejamento cirúrgico

ABSTRACT

The aim of this study was to determine the thickness of the root apex in relation to cortical buccal and lingual / palatal human permanent teeth using computed tomography cone beam images (CBCT). A sample of 1,400 CBCT examination teeth from 422 patients (394 women, mean age of 44.46) was selected. The determination of the thickness of the apical foramen with the vestibular and lingual / palatal cortical was determined in CBCT images in the axial, coronal and sagittal sections, with reference to the center of the apical foramen and the external portion of the buccal and lingual / palatal cortical. The mean and standard deviation of the quantitative variables were obtained. The normality of the data was evaluated by the Kolmogorov-Smirnov test. Analysis of the comparison of independent samples was assessed by the t-Test for independent samples or by the Mann-Whitney Test. Values of $p < 0.05$ were considered significant. The results showed that in the upper and lower anterior teeth the smaller bone thicknesses are directed towards the vestibular cortical. The lowest cortical vestibular thickness was found in the superior canine (1.49mm ± 0.86) followed by the upper central incisor (1.59mm ± 0.67). The greater cortical lingual / palatal thickness was found in the superior canine (8.63 ± 2.08) followed by the upper central incisor (7.07 ± 1.96). The lowest thickness was found in the cortex of the buccal root of the first (1.13 ± 0.68) and second (2.20 ± 1.21) premolars. The greatest cortical thickness lingual / palatal was found in the palatal cortex of the first (8.07 ± 1.63) followed by the second (7.62 ± 1.84) upper premolars. In the first upper molar the smallest thickness was found in the buccal cortical of the mesiobuccal root (1.98 ± 1.33). In the second lower molar, it was verified that the buccal cortical (8.36 ± 1.84) was thicker than the lingual cortical (2.95 ± 1.16). Knowledge of the anatomy of different dental groups and adjacent structures such as bone thickness of alveolar cortices influences the quality of surgical therapeutic planning, as well as guides the analysis of bacterial dissemination pathways in periapical infections. The CBCT allows to obtain linear measures that favor comparative analysis.

Keywords: Human anatomy, cone beam computed tomography, diagnostic methods, imaging exams, surgical planning

1 INTRODUÇÃO

A infecção primária e secundária dos canais radiculares difunde-se naturalmente em direção aos tecidos periapicais. A etiopatogenia da lesão periapical inclui a necrose pulpar decorrente de falhas de procedimentos operatórios que podem ocorrer durante o processo de sanificação e selamento endodôntico e coronário (SUNDQVIST & FIGDOR, 2003; MARENDING *et al*., 2005; ESTRELA *et al*., 2011).

Os erros de procedimentos operatórios durante o tratamento do canal radicular (transporte do forame apical, perfuração radicular, fratura de instrumento endodôntico, sobre-instrumentação, sobre-irrigação e sobre-obturação), associados às injúrias dentárias traumáticas compõem os fatores de risco potenciais para a indução de inflamação e infecção na região periapical (ALENCAR *et al*., 2010; HARGREAVES *et al*., 2010; SILVA *et al*., 2012; ALVES *et al*., 2013; ESTRELA *et a*l., 2017).

Os sinais mais frequentes de insucesso são caracterizados pela presença de lesão periapical e sintomatologia dolorosa pós-tratamento. Estes aspectos clínicos e radiográficos representam importantes indicadores da necessidade de nova intervenção (ESTRELA *et al.*, 2014a,b).

Em diferentes condições clínicas tem sido indicada como opção terapêutica a cirurgia parendodôntica. A falha de um tratamento endodôntico com persistência de lesão periapical posterior ao retratamento por um período de 6 meses tem constituído uma indicação de cirurgia parendodôntica (BERNABÉ & HOLLAND, 2004). A cirurgia parendodôntica constitui a melhor opção em condições clínicas com risco iminente de perdas dentárias, como na ausência de acesso endodôntico, na presença de dilacerações excessivas, retentores intrarradiculares extensos, de fragmentos de instrumentos endodônticos, reabilitações extensas recém-cimentadas, calcificação parcial ou total de canais radiculares curvos associada à presença de lesão periapical, reabsorção radicular inflamatória externa que não pode ser tratada não cirurgicamente. Estas e outras condições clínicas com crítico prognóstico quanto ao risco, benefício e custo econômico, considerando a intervenção convencional e ao potencial de perda dentária, incluem indicações de cirurgias parendodônticas (DEL RIO, 1996; BERNABÉ & HOLLAND, 2004; ESTRELA *et al*., 2017).

As radiografias convencionais representam exames por imagens mais utilizados para a análise da relação anatômica entre os dentes e o rebordo alveolar, contudo, contém muitas limitações conhecidas. As limitações dos exames radiográficos bidimensionais das estruturas tridimensionais impedem a correta interpretação da relação dos ápices dentários com as lesões periapicais, bem como com suas estruturas adjacentes (BENDER, 1982; HUUMONEN & ØRSTAVIK, 2002).

A inclusão clínica da tomografia computadorizada de feixe cônico (TCFC) como recurso auxiliar no diagnóstico e planejamento tem contribuído de forma expressiva para o estabelecimento de protocolos terapêuticos mais eficazes (MOZZO *et al*., 1998; ARAI *et al*., 1999; COTTON *et al*., 2007; PATEL *et al*., 2007; ESTRELA *et al*., 2008). A importância da TCFC na análise das características morfológicas da dentição humana, estruturas adjacentes e sua relação com as estruturas ósseas tem sido demonstrada. O conhecimento anatômico das estruturas adjacentes aos dentes é de extrema importância não só para o diagnóstico preciso de alterações inflamatórias e infecciosas, mas também para o correto estabelecimentos de planejamentos terapêuticos, cirúrgicos e de reabilitação do complexo maxilomandibular (ESTRELA *et al*., 2016; NUNES *et al*., 2016). A possibilidade de navegação pela imagem da TCFC pode caracterizar a realidade de uma estrutura multidimensional, a qual auxilia com informação precisa sobre as estruturas anatômicas, presença, ausência ou regressão do processo inflamatório (BUENO *et al.*, 2011; NUNES *et al.*, 2016).

Em decorrência dos avanços conquistados pela TCFC, outras perspectivas foram conquistadas a partir deste exame por imagem, como o potencial de se trabalhar com guias em três dimensões nas diferentes áreas da odontologia, como cirurgia buco-maxilo-facial, implantodontia, ortodontia, prótese dentária, e mais recentemente, endodontia. Estes guias preparados a partir de exames por imagens em TCFC permitem um planejamento que monitora os acessos e as novas vias anatômicas para as cavidades (COHN, 2010; ABDUO *et al*., 2014; ALGHAZZAWI, 2016; VAN DER MEER *et al*., 2016, VERWEIJ *et al*., 2017a,b;, ANDERSON *et al.*, 2018). Neste sentido, a tecnologia do Computer-aided design-CAD e o Computer-aided manufacturing-CAM, auxiliada pelo conhecimento das áreas anatômicas decorrente dos exames por imagens em TCFC tem permitido a reprodução de protótipos que servem como guias para procedimentos endodônticos cirúrgicos e não cirúrgicos, além de aplicações no campo do ensino e da pesquisa (VAN DER MEER *et al.*, 2016, VERWEIJ *et al*., 2017a,b; ANDERSON *et al*., 2018).

A cirurgia parendodôntica envolve um cuidadoso planejamento, diagnóstico, osteotomia, ressecção radicular, que atualmente tem sido realizado com o auxílio de exames com TCFC (TSESIS *et al.* 2006; Kim & KRATCHMAN, 2006; ERSOY *et al.*, 2008; SCHNEIDER *et al.*, 2009; SETZER *et al.*, 2010; HARGREAVES *et al.*, 2010).

O conhecimento da estrutura da anatomia da dentição humana com fins endodônticos e cirúrgicos têm requerido especial atenção. Os ápices dos dentes estão posicionados em rebordos alveolares, próximos a cortical vestibular, lingual ou palatal. A relação da espessura óssea entre o ápice radicular e as corticais pode estabelecer uma associação que explica a tendência de expansão ou destruição, facilitada em determinadas áreas comparadas a outras, o que oportunizaria a difusão de infecções e presença de fístulas. Todas as raízes dentárias podem ser alvo de processos inflamatórios, fistulação ou rompimento, dependendo do tipo de osso (esponjoso ou compacto) presente, e da relação das raízes com as corticais. A espessura óssea entre o ápice dentário e a cortical óssea varia dependendo do gênero, idade, etnia e sua localização nos arcos dentários. Para o tratamento endodôntico é indispensável informações sobre a anatomia dental e estruturas adjacentes. Para o planejamento e procedimento cirúrgico, como a confecção de guias ou trajetos de processos infecciosos, o conhecimento da espessura óssea entre a cortical vestibular e lingual/palatal e ápice dental torna-se essencial. Considerando carência de estudos que determinam estes aspectos anatômicos de relevância, aplicação e justificativa no protocolo terapêutico clínico, buscou-se estudar determinar a espessura óssea entre o centro do forame apical de cada grupo dentário e a superfície externa das corticais vestibulares e lingual/palatal na dentição permanente humana.

2 OBJETIVOS

2.1 OBJETIVO GERAL

Determinar a espessura óssea entre o centro do forame apical e a superfície externa das corticais vestibular e lingual/palatal, na dentição permanente humana.

2.2 OBJETIVO ESPECÍFICO

Mensurar a espessura óssea entre o centro do forame apical e a superfície externa das corticais vestibulares e lingual/palatal de cada raiz em todos os grupos dentários usando imagens de tomografia computadorizada com feixe de cônico.

3 MÉTODO

3.1. Tipo de estudo

Este é um estudo transversal de avaliação de imagens de exames de TCFC realizado de janeiro de 2012 a abril 2017. Por tratar-se de um estudo retrospectivo para análise de exames de TCFC registrados em um banco de dados secundário, solicitou-se a dispensa do termo de consentimento livre e esclarecido (TCLE). Este trabalho foi aprovado pelo Comitê de Ética em Pesquisa da Universidade Federal de Goiás (COEP 37968214.8.0000.5083). Foram utilizadas imagens anonimizadas a fim de preservar a identidade do sujeito e firmado o termo de uso de banco de dados.

3.2. Seleção da amostra

3.2.1. Cálculo da amostra

O cálculo da amostra foi realizado com base em estudo piloto que permitiu visualizar 90% das posições dos forames apicais, variando 8% para mais ou para menos, dependendo da raiz dentária avaliada. Com o nível de significância de 5% seria necessário uma amostra de 54 raízes para cada grupo avaliado, totalizando 756 dentes. Nesse estudo optou-se por uma amostra de 1400 dentes, consequentemente menor margem de erro e maior confiabilidade dos resultados.

O estudo foi delineado usando bancos de dados de um centro de radiologia odontológica em Goiânia-GO (Unidade Radiodontológica de Goiânia Ltda., Goiânia, GO, Brasil). Os pacientes foram encaminhados para o serviço de radiologia odontológica por diversos fins de diagnóstico. Uma amostra de 1400 dentes, sendo 600 incisivos e caninos, 400 pré-molares e 400 molares, superiores e inferiores, selecionada a partir de exames tomográficos de 422 pacientes (394 mulheres, idade média de 44,46 anos).

3.2.2. Critérios de inclusão/exclusão

Os critérios de inclusão foram imagens de TCFC com dentes hígidos com ápice completamente formado; e ausência de canais radiculares calcificados; reabsorções radiculares externa ou interna; distúrbios de desenvolvimento e processos patológicos. Somente imagens de alta resolução foram incluídas para garantir uma análise mais precisa. Terceiros molares e dentes com aparelho ortodôntico foram excluídos do presente estudo.

3.3. Aquisição das imagens

As imagens foram adquiridas utilizando um tomógrafo PreXion 3D Inc. (San Mateo, CA, EUA) configurado para a realização de uma imagem com voxel isotrópico de 0,100 mm em um F.O.V. de 60 mm de altura e 56,00 mm de diâmetro durante uma exposição de 33,5 segundos (com 1.024 exposições por aquisição). A tensão de tubo foi de 90 kVp e a corrente de 4 mA. As imagens foram analisadas por meio do *software* PreXion 3D Viewer (Tera ReconInc, Foster City,CA,EUA), em uma estação de trabalho independente PC com o Windows 7 profissional SP - 2 (Microsoft Corp, Redmond , WA , EUA), com o processador Intel I7 1,86 Ghz -6300 (Intel Corp, Santa Clara,CA, EUA), placa de vídeo NVIDIA Ge Force 1070 turbo cache (NVIDIA Corporation, Santa Clara, CA, EUA) e com um monitor de alta resolução EIZO - Flexscan S2000, resolução de 1600x1200 pixels (EIZONANAO Corp, Hakusan).

3.4. Mensuração da espessura óssea

A estratégia de navegação em imagens de TFCF foi de acordo com estudo de BUENO *et al*. (2011). A distância entre o centro do forame apical e a superfície mais externa das corticais vestibular e lingual/palatal foi considerada como espessura óssea, sendo mensurada nas imagens de TCFC nos cortes axial, sagital e coronal. A menor medida era verificada na imagem sagital para os dentes anteriores e coronal para os dentes posteriores. A mensuração da espessura óssea foi realizada utilizando-se a ferramenta do próprio programa (Figura 1 e 2).

A referência padrão para a localização do forame apical foi correspondente ao canal radicular principal. A navegação axial foi empregada de forma individualizada para cada raiz. Nos molares superiores, a navegação axial iniciou na raiz mesiovestibular(MV), seguida pela análise da raiz distovestibular(DV), e palatal (P), e nos molares inferiores, iniciou na raiz mesial (M), seguida da análise da raiz distal (D). Quando havia raízes fusionadas, a navegação axial era concomitante nas duas raízes. A amostra consistiu de 2337 forames apicais.

Dois avaliadores, especialistas em radiologia odontológica com mais de 10 anos de experiência analisaram todas as imagens. Os examinadores foram calibrados avaliando 10% da amostra. Quando diferenças foram encontradas, o consenso foi alcançado depois que a imagem foi avaliada por um terceiro examinador, especialista em endodontia, com mais de 10 anos de experiência.

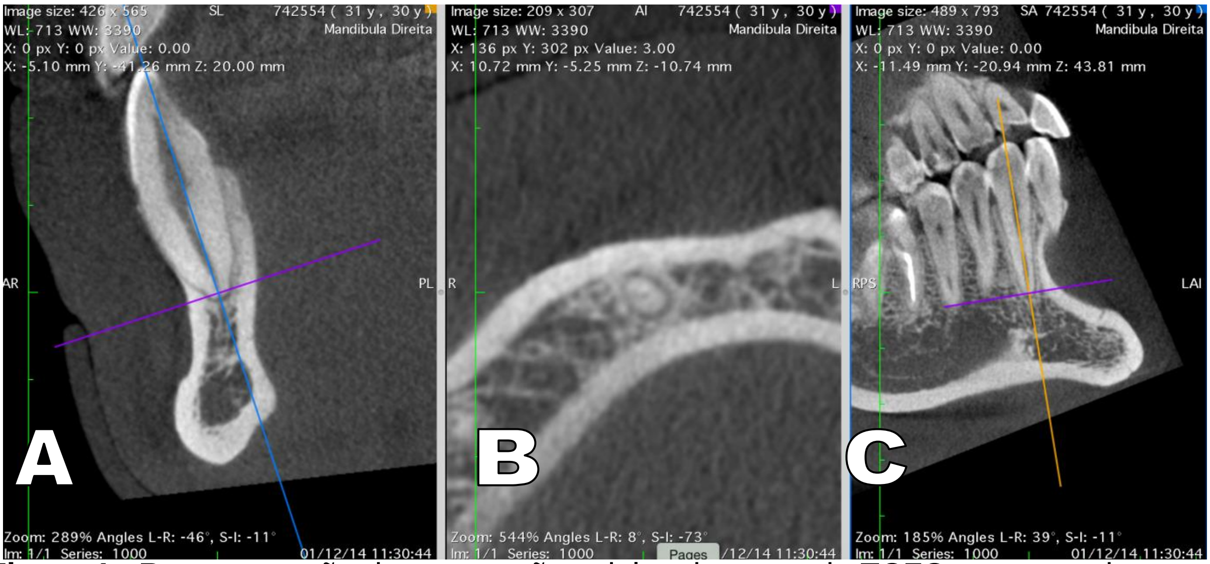

Figura 1. Representação da navegação axial na imagem de TCFC para o canino inferior (A. Corte sagital, B. Corte axial, C. Corte coronal).

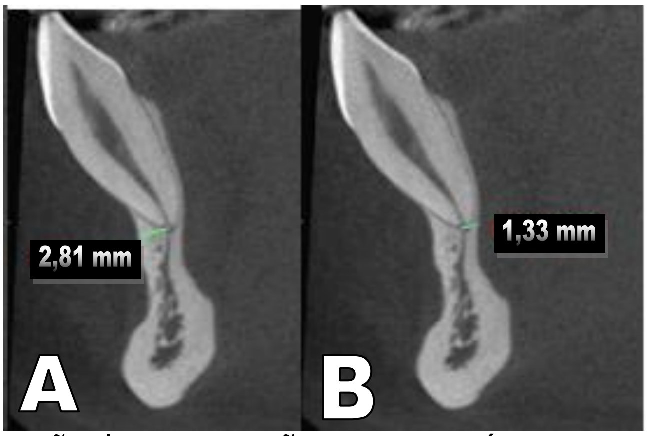

Figura 2. Representação da mensuração espessura óssea, no corte sagital, entre o centro do forame apical e as corticais vestibular e lingual em um canino inferior (A. Espessura óssea vestibular, B Espessura óssea lingual).

3.5. Análise estatística

A média e o desvio padrão das variáveis quantitativas foram obtidas. A normalidade dos dados foi avaliada pelo teste de Kolmogorov-Smirnov. A análise da comparação entre as espessuras ósseas das corticais vestibular e linguais/palatais de cada grupo dentário. Nas amostras independentes foi avaliada pelo Teste-t para amostras independentes ou pelo Teste de Mann-Whitney. Foram considerados significativos valores de $p < 0,05$. A análise estatística foi realizada utilizando o *software Statistical Package for the Social Sciences*, versão 20 (SPSS, Chicago, IL).

4 RESULTADOS

As médias e desvios padrões da espessura óssea entre o centro do forame apical e as superfície externa da cortical vestibular e lingual/palatal dos dentes anteriores, pré-molares e molares superiores e inferiores estão apresentados nas Tabelas de 1 a 3.

Os resultados mostraram que no grupo dos dentes anteriores, a menor espessura óssea entre o centro do forame apical e a superfície externa da cortical vestibular foi observada no canino superior (1,49 mm ± 0,86) seguida pela do incisivo central superior (1,59 mm ± 0,67), e a maior espessura óssea entre o centro do forame apical e a cortical lingual/palatal foi observada no canino superior (8,63 mm ± 2,08) seguida do incisivo central superior (7,07 mm± 1,96).

No grupo de pré-molares, a menor espessura foi verificada na cortical vestibular da raiz vestibular do primeiro (1,13 mm ± 0,68) e do segundo pré-molar (2,20 mm ± 1,21) superiores, e a maior espessura da cortical lingual/palatal foi encontrada na raiz palatal no primeiro (8,07 mm ± 1,63) seguida do segundo (7,62 mm ± 1,84) pré-molar superiores.

No grupo dos molares, o primeiro molar superior apresentou a menor espessura da cortical vestibular da raiz mesiovestibular (1,98 mm ± 1,33) e o segundo molar inferior mostrou que a cortical vestibular (8,36 mm± 1,84) era mais espessa que a lingual (2,95 mm ± 1,16).

Tabela 1. Média e desvio padrão das espessuras ósseas entre o forame apical (mm) dos dentes anteriores superiores e inferiores e as corticais vestibulares e linguais/palatais em imagens de TCFC, no plano sagital.

Dentes (n=600)	Espessura da cortical vestibular $\bar{X} \pm S$	N	Espessura da cortical lingual/palatal $\bar{X} \pm S$	N	*p*
ICS	1,59 ± 0,67	100	7,07 ± 1,96	100	0,000**
ILS	2,30 ± 1,20	100	5,28 ± 1,35	100	0,000**
CS	1,49 ± 0,86	100	8,63 ± 2,08	100	0,000**
ICI	2,72 ± 1,30	100	3,89 ± 1,15	100	0,000**
ILI	3,06 ± 1,29	100	4,01 ± 1,35	100	0,000**
CI	3,43 ± 1,31	100	4,78 ± 1,64	100	0,000**

($\bar{X}$: média. S: desvio padrão. * Teste-t para amostras independentes. ** Teste de Mann-Whitney).

Tabela 2. Média e desvio padrão das espessuras ósseas (mm) dos ápices dos ápices dos dentes pré-molares superiores e inferiores e as corticais vestibulares e linguais/palatais em imagens de TCFC, no plano coronal.

Dentes (n=400)	Espessura da cortical vestibular $\bar{X} \pm S$	N	Espessura da cortical lingual/palatal $\bar{X} \pm S$	N	*p*
1 PMS					
CV (MV)	1,13 ± 0,68	100	8,07 ± 1,63	100	0,000**
CP (P)	4,47 ± 1,85	86	4,52 ± 1,51	86	0,840*
2 PMS					
CV (MV)	2,20 ± 1,21	97	7,62 ± 1,84	97	0,000**
CP (P)	3,86 ± 1,74	36	5,82 ± 1,59	36	0,000*
1 PMI	3,27 ± 1,04	100	5,58 ± 1,66	100	0,000*
2 PMI	3,65 ± 1,35	100	5,46 ± 1,84	100	0,000*

($\bar{X}$: média. S: desvio padrão. * Teste-t para amostras independentes. ** Teste de Mann-Whitney).

Tabela 3. Média e desvio padrão das espessuras (mm) dos ápices dos ápices dos dentes molares superiores e inferiores e as corticais vestibulares e linguais/palatais em imagens de TCFC, no plano coronal.

Dentes (n=400)	Espessura da cortical vestibular $\bar{X} \pm S$	N	Espessura da cortical lingual/palatal $\bar{X} \pm S$	N	*p*
1 MS					
CMV	1,98 ± 1,33	100	11,91 ± 1,68	100	0,000**
CMP	3,10 ± 1,35	76	10,56 ± 1,81	76	0,000*
CDV	2,07 ± 1,45	100	12,35 ± 1,98	100	0,000**
CP	11,92 ± 2,38	100	2,84 ± 1,16	100	0,000**
2 MS					
CMV	4,48 ± 1,85	100	8,74 ± 2,47	100	0,000*
CMP	4,89 ± 1,48	34	8,46 ± 2,56	34	0,000*
CDV	3,51 ± 2,15	89	9,74 ± 2,41	89	0,000**
CP	10,39 ± 2,42	92	2,82 ± 1,86	92	0,000**
1 MI					
CMV	4,45 ± 1,46	100	6,49 ± 1,87	100	0,000**
CML	5,43 ± 1,41	100	5,63 ± 1,88	100	0,397*
CDV	5,91 ± 1,64	100	5,44 ± 1,82	100	0,056*
CDL	6,46 ± 1,86	24	4,68 ± 2,16	24	0,004*
2MI					
CMV	7,73 ± 1,83	100	3,46 ± 1,24	100	0,000*
CML	8,36 ± 1,84	80	2,95 ± 1,16	81	0,000*
CDV	8,01 ± 1,91	95	3,08 ± 1,13	94	0,000**
CDL	6,65 ± 4,47	4	2,19 ± 1,57	4	0,191**

($\bar{X}$: média. S: desvio padrão. * Teste-t para amostras independentes. ** Teste de Mann-Whitney).

5 DISCUSSÃO

No presente estudo verificou-se que nos dentes anteriores, a média de espessura óssea entre o centro do forame apical e a superfície externa da cortical vestibular variou 1,49 mm ± 0,86 a 3,43mm ± 1,31, sendo a menor média de espessura óssea observada no canino superior e incisivo central superior, 1,49 ± 0,86 e 1,59 mm ± 0,67, respectivamente.

Estudo de VERA *et al.* (2012) mostrou em dentes anteriores superiores, medianas de espessuras ósseas alveolares vestibulares em nível de 1 mm apical correspondente a 0,83 mm, e de ALTARAWNEH *et al*. (2017), de 0,6mm, 0,49mm e 0,4 mm para os incisivos centrais, incisivos laterais, e caninos, respectivamente. FUENTES et al. (2015) analisaram as dimensões anatômicas das paredes ósseas da região estética da maxila para colocação imediata do implante, com base em imagens de TCFC correspondente de uma amostra de pacientes adultos. As médias das espessuras ósseas das paredes vestibulares ao forame apical nos incisivos centrais, incisivos laterais e caninos foram 2.13 ± 0.67, 1.53 ± 0.94, e 1.81 ± 0.67, respectivamente. De acordo com os autores a idade e o sexo não mostraram diferenças significativas, e menos de 10% dos locais apresentaram mais de 2 mm de espessura de parede óssea, com exceção da região do incisivo central, onde 14,4% dos casos apresentaram espessura ≥ 2 mm.

No presente estudo no grupo de pré-molares, a menor espessura foi verificada na cortical vestibular da raiz vestibular do primeiro (1,13 mm ± 0,68) e do segundo pré-molar (2,20 mm ± 1,21) superiores, e a maior espessura da cortical lingual/palatal foi observada na raiz palatal no primeiro (8,07 mm ± 1,63) seguida do segundo (7,62 mm ± 1,84) pré-molar superiores.

ZAHEDI *et al*. (2018) após analisarem a anatomia dos dentes posteriores mandibulares usando feixe cônico tomografia computadorizada para endodontia cirúrgica em 170 exames de TCFC, considerando a espessura da cortical vestibular e o ápice de dentes inferiores, mostraram que os primeiros pré-molares, a maior e menor espessura óssea estava na cortical vestibular e lingual (4,70 a 0,42 mm e de 7,30 a 0,67 mm), respectivamente. Nos segundos pré-molares, estes valores foram de 5,41 a 0,42 mm e 7,40-0,95 mm, respectivamente. Resultado de estudo de VERA et al. (2012) mostrou medianas de espessuras ósseas alveolares em nível de 1 mm apical correspondente a 1,13 mm na área dos pré-molares.

No presente estudo no grupo dos molares, o primeiro molar superior apresentou a menor espessura da cortical vestibular da raiz mesiovestibular (1,98 mm ± 1,33) e o segundo molar inferior mostrou que a cortical vestibular (8,36 mm± 1,84) era mais espessa que a lingual (2,95 mm ± 1,16).) Estudo de ZAHEDI et al. (2018) mostrou as maiores espessuras ósseas verificadas nas corticais vestibulolingual foram de 9,08 mm e 7,66 para a raiz mesial e distal do primeiro molar, respectivamente; 8,09 mm e 7,71 para a raiz mesial e distal do segundo, respectivamente.

O conhecimento das distâncias entre os ápices radiculares e as corticais ósseas nos diferentes grupos dentários favorece o melhor entendimento para a análise das vias de disseminação das infecções endodônticas em direção às estruturas nobres da cabeça e pescoço (VASCONCELLOS et al., 2002; ROBERTSON & SMITH, 2009; BOSCOLO-RIZZO & DA MOSTO, 2009; SIQUEIRA-JR. & RÔÇAS, 2013). Igualmente, pode-se também estabelecer alguns parâmetros para o planejamento e a confecção de guias cirúrgicos (ERSOY et al., 2008; KALT *et al*., 2008; BEHNEKE *et al*., 2012; BUCHGREITZ *et al.,* 2016; VAN DER MEER et al., 2016; KRASTL *et al*., 2016; ZEHNDER et al., 2016; CONNERT *et al*., 2017;

VERWEIJ *et al*., 2017a,b).

A distribuição e a posição dos dentes no complexo bucomaxilofacial e as relações destes com as estruturas ósseas são essenciais para o planejamento preciso do tratamento endodôntico, cirúrgico ou mesmo ortodôntico (SIMONTON *et al.,* 2009; ESTRELA *et al*., 2010; KIM *et al*., 2010; GRIBEL *et al*., 2011; PORTO *et al*., 2014; WANG *et al*., 2017; ZAHEDI *et al*., 2018), bem como pode influenciar ou até favorecer a disseminação de infecção bacteriana aos tecidos moles adjacentes (TOPAZIAN & GOLDBERG, 1993; FLYNN, 2000; GILL & SCULLY, 2009; SIQUEIRA-JR & RÔÇAS, 2013).

As vias de disseminação bacteriana em direção aos espaços faciais ou outras áreas anatômicas nobres da cabeça podem ser imprevisíveis, porém, fatores de risco como a espessura óssea entre os ápices radiculares e as corticais externas podem facilitar o acesso, devido à destruição óssea, e chegar aos planos faciais. Dentre os espaços faciais que podem estar afetados incluem: o sublingual, submandibular, vestibular, pterigomandibular, temporal, massetérico, lateral, faríngeo e retrofaríngeo (TOPAZIAN & GOLDBERG, 1993; FLYNN, 2000; GILL & SCULLY, 2009; SIQUEIRA-JR & RÔÇAS, 2013). O favorecimento da propagação de infecções provenientes de canais radiculares em espaços da cabeça e do pescoço pode ser realçado pelo conhecimento da localização dos ápices radiculares e da espessura óssea em relação à cortical vestibular ou lingual/palatal; e, também, a relação do ápice radicular com a inserção de alguns músculos. Neste sentido, as infeções agudas como ocorre a de abscessos periapicais podem difundir o exsudato purulento em direção a espaços faciais sublingual ou submandibular. Condições mais críticas como a Angina de Ludwig podem ocorrer e trazer obstruções de vias aéreas, com severo quadro clínico. Em outras condições graves, as infecções dentárias também podem ser responsáveis pela trombose do seio cavernoso (TOPAZIAN & GOLDBERG, 1993; FLYNN, 2000; GILL & SCULLY, 2009).

As espessuras ósseas entre os forames apicais e as corticais podem também permitir um padrão de referência como guia para os implantes dentários ou as cirurgias parendodônticas. Alguns estudos buscaram informações de espessuras ósseas dos dentes as corticais externas (VERA et al., 2012; FUENTES et al., 2015; ALTARAWNEH et al., 2017; ZAHEDI et al., 2018), e reforçaram que o adequado conhecimento das dimensões anatômicas dos dentes e suas estruturas circundantes torna-se muito importante para a execução da cirurgia endodôntica.

Estudos têm demonstrado os avanços conquistados pelo odontologia com o advento da TCFC (MOZZO *et al.,* 1998; ARAI *et al*., 1999; SCARFE *et al*., 2007; BUENO *et al*., 2007; COTTON *et al.,* 2007; PATEL *et al*., 2007). A precisão dos exames por imagens permitiu o emprego de diversas metodologias em pesquisas (BUENO & ESTRELA, 2018), tanto utilizando *softwares* do próprio fabricante, quanto especializados, como por exemplo, o e-Vol DX (CDT, Bauru, SP, Brasil) (BUENO *et al*., 2018; ESTRELA *et al*., 2018).

A estratégia dinâmica de navegação aumentou as expectativas sobre a aplicação de imagens de TCFC em procedimentos operatórios complexos não só na endodontia como em toda odontologia (BUENO et al., 2007, 2011). Este método que permite uma visualização tridimensional minimiza limitações como as verificadas na radiografia periapical, exame bidimensional de uma estrutura tridimensional. Em adição, permite a navegação em imagens com uma visualização dinâmica das estruturas tridimensionais. Essa perspectiva de navegação forneceu informações valiosas para melhor determinação da espessura óssea no periápice dos dentes permanentes usando imagens em alta resolução (BUENO *et al*., 2011).

Um fator fundamental que envolve esta tecnologia está relacionada a ferramenta de mensuração da TCFC, a qual permite determinar as distâncias lineares e os volumes de estruturas anatômicas; realizar o planejamento pré-operatório de cirurgias parendodônticas; mensurar o comprimento da raiz e do nível ósseo, estabelecer a relação entre os dentes e as estruturas anatômicas, lesões periapicais e reabsorções radiculares, dentre várias outras alternativas (KOBAYASHI *et al.*, 2004; JIM *et al.,* 2005; PINSKY *et al*., 2006; LUDLOW *et al*., 2007; SIMONTON *et al*., 2009; ESTRELA *et al*., 2010; CAVALCANTI *et al*., 2010; KIM *et al*., 2010; AZIM *et al*., 2014; NUNES *et al*., 2015; BÜRKLEIN et al., 2015; ESTRELA *et al.,* 2016; CHONG *et al*., 2017; WANG *et al*., 2017; ZAHEDI *et al*., 2018).

Neste sentido, SILVA *et al*. (2017) avaliaram a acurácia de medidas lineares realizadas com dois *softwares* em imagens de tomografia computadorizada por multislice (TCMS) e feixe cônico (TCFC). As imagens de TCMS e TCFC mensuradas digitalmente com os *softwares* ST e IV apresentaram resultados confiáveis quando comparadas às medidas obtidas manualmente. Tanto o *software* quanto as modalidades de aquisição de imagens são úteis para planejar o procedimento cirúrgico na prática odontológica. SIMONTON *et al.* (2009) verificaram se as diferenças no sexo ou idade do paciente eram preditivas de diferenças na localização relativa do nervo alveolar inferior comparado com as raízes do primeiro molar mandibular. Independentemente da idade, as mulheres apresentaram distâncias verticais significativamente menores do nervo alveolar inferior para os ápices mesial e distal e, também, distâncias horizontais menores para a largura total da mandíbula. Além disso, a largura total da região mandibular óssea diminuiu em ambos os sexos nas terceiras e sextas décadas de vida. Coletivamente, esses dados indicaram que tanto o sexo quanto a idade são preditivos de relações anatômicas endodônticas cirúrgicas e deve ser considerado no planejamento pré-cirúrgico.

No presente estudo foram utilizados TCFC de 422 pacientes (394 mulheres) com idade média de 44,46. A estratégia de navegação em imagens de TFCF foi realizada de acordo com estudo de BUENO *et al*. (2011). As imagens de TCFC foram ajustadas nos planos sagital, axial e coronal para a obtenção da espessura óssea entre o centro do forame apical e a superfície mais externa das corticais. O registro das medidas foi executado no plano correspondente à imagem sagital para dentes anteriores e coronal para os dentes posteriores. A referência padrão para a localização do ápice radicular foi correspondente ao canal radicular principal, com cuidados destinados às especificidades dos diferentes grupos dentários.

O presente estudo registrou como a referência para a análise da espessura óssea o centro do forame apical e as corticais externas. Desta forma, em função da carência de estudos com estas características a comparação com outros estudos foi dificultada. No entanto, em recente estudo (ESTRELA et al., 2018) foi determinado a posição do forame apical em relação a superfícies da raiz de dentes permanentes humanos usando imagens de TCFC com um novo *software* e-Vol DX. Os resultados demonstraram que a posição de forame apical em dentes permanentes humanos foi central em 48,95% e 42,08% dos dentes maxilar e mandibular, respectivamente. Estes aspectos evidenciam possíveis diferenças entre os resultados do corrente estudo em que foi avaliado a distância do centro do forame apical com as corticais externas, com o trabalho de ZAHEDI et al. (2018), em que determinaram as mensurações entre a cortical vestibular e o ápice dos dentes posteriores inferiores. Enquanto que, VERA *et al*. (2012) e ALTARAWNEH *et al.* (2017) analisaram a espessura óssea vestibular e palatina nos dentes anteriores superiores nos terços apical, médio e coronal, bem como a distância da junção cemento-esmalte (CEJ) até a crista óssea usando imagens de TCFC. Outro aspecto que deve ser considerado no presente estudo está associado ao número de amostras analisadas (n=1400 dentes, 2337 forames apicais), comparado aos outros estudos e, também, o gênero e as idades dos pacientes.

Um fator de importância, o que deve ser realçado na metodologia, e que pode identificar fragilidades em alguns estudos que empregaram mensurações em imagens de TCFC, refere-se ao protocolo de aquisição das imagens. A resolução da imagem de TCFC pode ser um fator limitante na medição de objetos finos e delicados. Quanto maior o campo de visão, menor a resolução da imagem. As TCFCs utilizadas no presente estudo apresentaram um campo de visão pequeno, voxel isotrópico de 0,10 × 0,10 × 0,10 mm, com objetivo de diagnóstico para determinar o planejamento terapêutico preciso.

Os procedimentos endodônticos e cirúrgicos guiados cada vez mais têm sido alvo de estudos e aplicações clínicas devido os avanços conquistados pelas inovações tecnológicas da TCFC, como novos *softwares*, planejamentos assistidos e intervenções guiadas por imagens em 3D (CAD-CAM) e prototipagem. O planejamento digital e os guias de direções minimizam riscos e acidentes iatrogênicos, aumentam a efetividade dos planejamentos clínicos, e consequentemente, reduzem o tempo das intervenções (VAN DER MEER *et al*., 2016; LAVASANI *et al*., 2016; CONNERT *et al*., 2017; VERWEIJ *et al*., 2017a,b). Todavia, a compreensão da espessura das raízes dentárias, em especial de pré-molares e molares superiores, em nível apropriado para a ressecção da raiz, da espessura óssea sobre estas raízes e a proximidade de cada ápice radicular com o seio maxilar tem um impacto clínico importante no resultado terapêutico, além de auxiliar o profissional antes e durante o procedimento cirúrgico (LAVASANI *et al*., 2016).

O conhecimento da anatomia dos diferentes grupos dentários e das estruturas adjacentes como as espessuras ósseas das corticais alveolares influência na qualidade do planejamento terapêutico cirúrgico, bem como orienta a análise das vias de disseminação bacteriana nas infecções periapicais. A TCFC permite obter medidas lineares que favorecem análises comparativas.

6 CONCLUSÃO

O conhecimento da anatomia dos diferentes grupos dentários e das estruturas adjacentes como as espessuras ósseas das corticais alveolares influência na qualidade do planejamento terapêutico cirúrgico, bem como orienta a análise das vias de disseminação bacteriana nas infecções periapicais. A TCFC permite obter medidas lineares que favorecem análises comparativas.

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ANEXOS

ANEXO 1 – ARTIGO

Original Research Article:

Determination of bone thickness between the center of the apical foramen and the external surfaces of the cortical ones in the human permanent dentition in cone beam computed tomography

Running Title: Determination of bone thickness in CBCT

Keywords: Human anatomy, cone beam computed tomography, diagnostic methods, imaging exams, surgical planning

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Abstract

The aim of this study was to determine the thickness of the root apex in relation to cortical buccal and lingual / palatal human permanent teeth using computed tomography cone beam images (CBCT). A sample of 1,400 CBCT examination teeth from 422 patients (394 women, mean age of 44.46) was selected. The determination of the thickness of the apical foramen with the vestibular and lingual / palatal cortical was determined in CBCT images in the axial, coronal and sagittal sections, with reference to the center of the apical foramen and the external portion of the buccal and lingual / palatal cortical. The mean and standard deviation of the quantitative variables were obtained. The normality of the data was evaluated by the Kolmogorov-Smirnov test. Analysis of the comparison of independent samples was assessed by the t-Test for independent samples or by the Mann-Whitney Test. Values of $p < 0.05$ were considered significant. The results showed that in the upper and lower anterior teeth the smaller bone thicknesses are directed towards the vestibular cortical. The lowest cortical vestibular thickness was found in the superior canine (1.49mm ± 0.86) followed by the upper central incisor (1.59mm ± 0.67). The greater cortical lingual / palatal thickness was found in the superior canine (8.63 ± 2.08) followed by the upper central incisor (7.07 ± 1.96). The lowest thickness was found in the cortex of the buccal root of the first (1.13 ± 0.68) and second (2.20 ± 1.21) premolars. The greatest cortical thickness lingual / palatal was found in the palatal cortex of the first (8.07 ± 1.63) followed by the second (7.62 ± 1.84) upper premolars. In the first upper molar the smallest thickness was found in the buccal cortical of the mesiobuccal root (1.98 ± 1.33). In the second lower molar, it was verified that the buccal cortical (8.36 ± 1.84) was thicker than the lingual cortical (2.95 ± 1.16). Knowledge of the anatomy of different dental groups and adjacent structures such as bone thickness of alveolar cortices influences the quality of surgical therapeutic planning, as well as guides the analysis of bacterial dissemination pathways in periapical infections. The CBCT allows to obtain linear measures that favor comparative analysis.

Keywords: Human anatomy, cone beam computed tomography, diagnostic methods, imaging exams, surgical planning.

Introduction

Primary and secondary infection of the root canals diffuses naturally into the periapical tissues. The etiopathogenesis of the periapical lesion includes pulp necrosis due to failures of operative procedures that may occur during the sanitization and endodontic and coronary sealing process (Sundqvist & Figdor, 2003; Marending *et al*., 2005; Estrela *et al*., 2011).

Errors in operative procedures during root canal treatment (transport of the apical foramen, root perforation, endodontic instrument fracture, over-instrumentation, over-irrigation, and over-obturation) associated with traumatic dental injuries are the potential risk factors for the induction of inflammation and infection in the periapical region (Alencar *et al*., 2010; Hargreaves *et al*., 2010; Silva *et al*., 2012; Alves *et al*., 2013; Estrela *et a*l., 2017).

The most frequent signs of failure are characterized by the presence of periapical lesion and posttreatment pain symptomatology. These clinical and radiographic aspects represent important indicators of the need for new intervention (Estrela *et al.*, 2014a,b).

Parendodontic surgery has been indicated as a therapeutic option in different clinical conditions. The failure of an endodontic treatment with persistence of periapical lesion after retreatment for a period of 6 months has been an indication of parendodontic surgery (Bernabé & Holland, 2004). Parendodontic surgery is the best option under clinical conditions with imminent risk of dental loss, such as absence of endodontic access, excessive dilation, extensive intraradicular retainers, fragments of endodontic instruments, extensive newly cemented rehabilitations, partial or total calcification of curved root canals associated with the presence of periapical lesion, external inflammatory root resorption that can not be treated non-surgically. These and other clinical conditions with a critical prognosis regarding risk, benefit and economic cost, considering the conventional intervention and the potential of dental loss, include indications of parendodontic surgeries (Del Rio, 1996; Bernabé & Holland, 2004; Estrela *et al*., 2017).

Conventional radiographs represent the most used imaging tests for the analysis of the anatomical relationship between the teeth and the alveolar ridge, however, it contains many known limitations. The limitations of two-dimensional radiographic examinations of three-dimensional structures prevent correct interpretation of the relationship between dental apices and periapical lesions, as well as their adjacent structures (Bender, 1982; Huumonen & Ørstavik, 2002).

The clinical inclusion of concomitant computed tomography (CBCT) as an aid in diagnosis and planning has contributed significantly to the establishment of more effective therapeutic protocols (Estrela *et al*., 2016; Nunes *et al*., 2016). The importance of CBCT in the analysis of the morphological characteristics of human dentition, adjacent structures and their relationship with bone structures has been demonstrated. The anatomical knowledge of the structures adjacent to the teeth is of extreme importance not only for the precise diagnosis of inflammatory and infectious alterations, but also for the correct establishments of therapeutic, surgical and rehabilitation plans of the maxillomandibular complex(reference). The possibility of navigation through the CBCT image can characterize the reality of a multidimensional structure, which assists with precise information about the anatomical structures, presence, absence or regression of the inflammatory process (Bueno *et al.*, 2011; Nunes *et al.*, 2016).

As a result of the advances achieved by the TCFC, other perspectives were obtained from this imaging exam, such as the potential to work with guides in three dimensions in different areas of dentistry, such as buco-maxillofacial surgery, implantology, orthodontics, dental prosthesis , and more recently, endodontics. These guides, which are prepared from CTF imaging, allow planning that monitors the accesses and the new anatomical pathways to the cavities (Cohn, 2010; Abduo *et al*., 2014; Alghazzawi , 2016; Meer *et al*., 2016, Verweij *et al*., 2017a,b; van der , Anderson *et al.*, 2018). In this sense, Computer-aided design-CAD technology and Computer-aided manufacturing-CAM, aided by the knowledge of the anatomical areas resulting from the CBCT imaging examinations, has enabled the reproduction of prototypes that serve as guides for surgical endodontic procedures. as well as applications in the field of teaching and research cavidades (van der Meer *et al.*, 2016, Verweij *et al*., 2017a,b; Anderson *et al*., 2018).

The endodontic surgery involves careful planning, diagnosis, osteotomy, root resection, which has currently been carried out with the aid of tests with CBCT(Tsesis *et al.* 2006; Kim & Kratchman, 2006; Ersoy *et al.*, 2008; Schneider *et al.*, 2009; Setzer *et al.*, 2010; Hargreaves *et al.*, 2010).

The knowledge of the anatomical structure of the human dentition for endodontic and surgical purposes has required special attention. The apexes of the teeth are positioned on alveolar ridges, close to buccal, lingual or palatal cortical. The relationship of bone thickness between the root apex and cortical can establish an association that explains the tendency of expansion or destruction, facilitated in certain areas compared to others, which would allow the spread of infections and the presence of fistulas. All dental roots can be the target of inflammatory processes, fistulation or rupture, depending on the type of bone (spongy or compact) present, and the relationship of the roots with the cortical ones. The bone thickness between the tooth apex and the cortical bone varies depending on the gender, age, ethnicity and its location in the dental arches. Information about the dental anatomy and adjacent structures is indispensable for endodontic treatment. For the planning and surgical procedure, such as the preparation of guides or routes of infectious processes, the knowledge of the bone thickness between the buccal and lingual / palatal cortical and dental apex becomes essential. Considering the lack of studies that determine these anatomical aspects of relevance, application and justification in the clinical therapeutic protocol, we sought to determine the bone thickness between the center of the apical foramen of each dental group and the external surface of the buccal and lingual / palatal cortical human dentition(reference).

Materials and methods

Patients

The study was designed using databases of a dental radiology center in Goiânia-GO (Radiodontological Unit of Goiânia Ltda., Goiânia, GO, Brazil). Patients were referred to the dental radiology service for various diagnostic purposes. A sample of 1400 teeth with canines and incisors 600, 400 premolars and molars 400, upper and lower, selected from CT scans of 422 patients (394 women, mean age 44.46 years). Inclusion criteria were CBCT images with healthy teeth with a fully formed apex; and absence of calcified root canals; external or internal root resorption; developmental disorders and pathological processes. Only high resolution images were included to ensure a more accurate analysis. Third molars and teeth with orthodontic appliance were excluded from the present study.

Acquisition of images

Images were acquired using a PreXion 3D Inc. (San Mateo, CA, USA) tomograph configured to make a 0.100 mm isotropic voxel image in a F.O.V. of 60 mm in height and 56.00 mm in diameter during a 33.5 second exposure (with 1,024 exposures per acquisition). The tube voltage was 90 kVp and the current was 4 mA. The images were analyzed using PreXion 3D Viewer software (Tera ReconInc, Foster City, CA), in an independent PC workstation with Windows 7 professional SP - 2 (Microsoft Corp, Redmond, WA, USA), with the Intel I7 1.86 Ghz-6300 (Intel Corp, Santa Clara, CA, USA), NVIDIA GeForce 1070 turbocharged video card (NVIDIA Corporation, Santa Clara, CA, USA) and a high-resolution EIZO - Flexscan S2000, resolution of 1600x1200 pixels (EIZONANAO Corp, Hakusan).

Measurement of bone thickness

The strategy of navigation in TFCF images was according to a study by BUENO et al. (2011). The distance between the center of the apical foramen and the outermost surface of the buccal and lingual / palatal cortices was considered as bone thickness and was measured in the CBCT images in the axial, sagittal and coronal sections. The smallest measure was found in the sagittal image for the anterior teeth and coronal for the posterior teeth. The bone thickness was measured using the tool of the program itself (Figure 1 and 2).

The standard reference for the location of the apical foramen was corresponding to the main root canal. Axial navigation was used individually for each root. In the upper molars, the axial navigation began in the mesiobuccal root (MV), followed by the analysis of the distobuccal root (DV), and palatal (P), and in the lower molars, it started in the mesial root (M), followed by analysis of the distal root (D). When there were fused roots, the axial navigation was concomitant in the two roots. The sample consisted of 2337 apical foramina.

Two evaluators, specialists in dental radiology with more than 10 years of experience analyzed all the images. The examiners were calibrated by evaluating

10% of the sample. When differences were found, consensus was reached after the image was evaluated by a third-party endodontic examiner with more than 10 years of experience.

Statistical analysis

The mean and standard deviation of the quantitative variables were obtained. The normality of the data was evaluated by the Kolmogorov-Smirnov test. The analysis of the comparison between the bone thickness of the buccal and lingual / palatal cortices of each dental group. In the independent samples it was evaluated by the t-Test for independent samples or by the Mann-Whitney Test. Values of $p < 0.05$ were considered significant. Statistical analysis was performed using Statistical Package for Social Sciences, version 20 (SPSS, Chicago, IL).

Results

Means and standard deviations of the bone thickness between the center of the apical foramen and the outer surface of the cortical buccal and lingual / palatal of anterior teeth, premolar and upper and lower molars are shown in Tables 1 to 3.

The results showed that, in the anterior teeth group, the lower bone thickness between the apical foramen center and the external surface of the vestibular cortical was observed in the superior canine (1.49 mm ± 0.86) followed by the upper central incisor (1 , 59 mm ± 0.67), and the greater bone thickness between the center of the apical foramen and the lingual / palatal cortical was observed in the superior canine (8.63 ± 2.08 mm) followed by the maxillary central incisor (7.07 mm ± 1.96).

In the group of premolars, the lowest thickness was found in the buccal cortical of the buccal root of the first (1.13 mm ± 0.68) and the second premolar (2.20 mm ± 1.21), and the greater thickness of the lingual / palatal cortical was found in the palatal root in the first (8.07 ± 1.63) followed by the second (7.62 mm ± 1.84) superior premolar.

In the molars group, the first maxillary molar showed the lowest thickness of the buccal cortical of the mesiobuccal root (1.98 mm ± 1.33) and the lower molar showed that the buccal cortical (8.36 ± 1.84) was thicker than the lingual (2.95 mm ± 1.16).

Discussion

In the present study, the average bone thickness between the center of the apical foramen and the outer surface of the vestibular cortex varied from 1.49 mm ± 0.86 to 3.43 mm ± 1.31 in the anterior teeth, mean bone thickness observed in the upper canine and upper central incisor, 1.49 ± 0.86 and 1.59 mm ± 0.67, respectively.

A study by Vera *et al.* (2012) showed in anterior superior, median teeth of vestibular alveolar bone thickness at 1 mm apical level corresponding to 0.83 mm, and of ALTarawneh *et al.* (2017), 0.6mm, 0.49mm and 0.4mm for the central incisors, lateral incisors, and canines, respectively. Fuentes *et al.* (2015) analyzed the anatomical dimensions of the bone walls of the aesthetic region of the maxilla for immediate placement of the implant, based on corresponding CBCT images from a sample of adult patients. The averages of bone thickness of the vestibular walls to the apical foramen in the central incisors, lateral incisors and canines were 2.13 ± 0.67, 1.53 ± 0.94, and 1.81 ± 0.67, respectively. According to the authors, age and sex did not show significant differences, and less than 10% of sites presented more than 2 mm of bone wall thickness, except for the central incisor region, where 14.4% of the cases presented thickness ≥ 2 mm.

In the present study in the group of premolars, the lowest thickness was found in the vestibular cortical of the first vestibular root (1.13 mm ± 0.68) and the second premolar (2.20 mm ± 1.21) higher , and the greatest thickness of the lingual / palatal cortical was observed in the palatal root in the first (8.07 ± ± 1.63) followed by the second (7.62 mm ± 1.84) superior premolar.

Zahedi *et al.* (2018), after analyzing the anatomy of mandibular posterior teeth using a conical beam CT scan for surgical endodontics in 170 CFCT examinations, considering the thickness of the vestibular cortex and the apex of the lower teeth, showed that the first premolars, the largest and smallest premolars bone thickness was in the buccal and lingual cortex (4.70 to 0.42 mm and 7.30 to 0.67 mm), respectively. In the second premolars, these values were 5.41 to 0.42 mm and 7.40-0.95 mm, respectively. Results of a study by Vera *et al.* (2012) showed medians of alveolar bone thickness at the 1-mm apical level corresponding to 1.13 mm in the area of the premolars.

In the present study in the molar group, the maxillary first molar showed the lowest thickness of the buccal cortical of the mesiobuccal root (1.98 mm ± 1.33) and the lower second molar showed that the buccal cortical (8.36 mm ± 1, 84) was thicker than the lingual (2.95 mm ± 1.16).) Zahedi *et al.* (2018) showed the greatest bone thickness verified in the vestibulolingual cortices were 9.08 mm and 7.66 for the mesial and distal root of the first molar, respectively; 8.09 mm and 7.71 for the mesial and distal roots of the second, respectively.

The knowledge of the distances between the root apices and the cortical bone in the different dental groups favors the best understanding for the analysis of the routes of dissemination of the endodontic infections towards the noble structures of the head and neck (Vasconcellos *et al*., 2002; Robertson & Smith , 2009). In the present study, In addition, it is also possible to establish some parameters for the planning and preparation of surgical guides (Ersoy *et al*., 2008; Kalt *et al*., 2008, Beuchneke *et al*., 2012, Buchgreitz et al., 2016; van der Meer *et al*., 2016, Krastl *et al*., 2016, Zehnder *et al*., 2016, Connert *et al*., 2017, Verweij *et al*., 2017a, b).

The distribution and the position of teeth in the oral and maxillofacial complex and their relations with the bone structures are essential for precise planning of endodontic treatment, surgical or even orthodontic (Simonton et al, 2009;. Star *et al*, 2010;. Kim *et al* 2010). And may also influence or even promote the spread of bacterial infection to adjacent soft tissues (Gill *et al*., 2011). Gill & Scully, 2009).

The bacterial dissemination pathways to facial areas or other noble anatomical areas of the head can be unpredictable, but risk factors such as bone thickness between the root apex and the outer cortical can facilitate access due to bone destruction, and get to facial plans. Among the facial spaces that may be affected include: the sublingual, submandibular, vestibular, pterygomandibular, temporal, masseteric, lateral, pharyngeal and retropharyngeal (Topazian & Goldberg, 1993; Gill & Scully, 2009; Siqueira-Jr & Rôças , 2013). Favoring the propagation of root canal infections in head and neck spaces can be enhanced by knowledge of the root apex location and bone thickness in relation to the buccal or lingual / palatal cortex; and also the relation of the root apex to the insertion of some muscles. In this sense, acute infections such as periapical abscesses can diffuse the purulent exudate towards the sublingual or submandibular facial spaces. More critical conditions such as Ludwig's Angina may occur and lead to obstructions of the airways, with severe clinical picture. In other severe conditions, dental infections may also be responsible for cavernous sinus thrombosis (Topazian & Goldberg, 1993; Flynn, 2000; Gill & Scully, 2009).

Bone thicknesses between the apical and cortical foramina can also allow a reference pattern as a guide for dental implants or parendodontic surgeries. Some studies have sought information on the bone thickness of the external cortical teeth (Vera *et al.,* 2012; Fuentes *et al.,* 2015, ALTarawneh *et al.,* 2017; Zahedi *et al.,* 2018), and have reinforced that adequate knowledge of the dimensions anatomical characteristics of the teeth and their surrounding structures becomes very important for the execution of endodontic surgery.

Studies have demonstrated the advances achieved by dentistry with the advent of the CBCT (Mozzo *et al.,* 1998, Arai *et al.,* 1999, Scarfe *et al*., 2007, Bueno *et al.,* 2007, Cotton *et al.* et al., 2007). The accuracy of the imaging tests allowed the use of several research methodologies (Bueno & Estrela, 2018), both using the manufacturer's own software and specialized software, such as e-Vol DX (CDT, Bauru, SP, Brazil) (Bueno *et al.,* 2018, Estrela *et al.,* 2018).

The dynamic navigation strategy increased expectations about the application of CBCT images in complex operative procedures not only in endodontics but also in dentistry (Bueno et al., 2007, 2011). This method that allows a three-dimensional visualization minimizes limitations such as those verified in periapical radiography, two-dimensional examination of a three-dimensional structure. In addition, it allows navigation in images with a dynamic visualization of three-dimensional structures. This navigational perspective provided valuable information for better determination of bone thickness in the peri-penis of permanent teeth using high-resolution images (Bueno et al., 2011).

A fundamental factor that involves this technology is related to the tool of measurement of the TCFC, which allows to determine the linear distances and the volumes of anatomical structures; perform the preoperative planning of parendodontic surgeries; to measure the length of the root and bone level, to establish the relationship between the teeth and the anatomical structures, periapical lesions and root resorption, among several other alternatives(Kobayashi *et al.*, 2004; Jim *et al.,* 2005; Pinsky *et al*., 2006; Ludlow *et al*., 2007; Simonton *et al*., 2009; Estrela *et al*., 2010; Cavalcanti *et al*., 2010; Kim *et al*., 2010; Azim *et al*., 2014; Nunes *et al*., 2015; Bürklein et al., 2015; Estrela *et al.,* 2016; Chong *et al*., 2017; Wang *et al*., 2017; Zahedi *et al*., 2018).

In this sense, Silva *et al.* (2017) evaluated the accuracy of linear measurements performed with two softwares on multislice computed tomography (MSCT) and conical beam (CBCT) images. The MSCT and CBCT images digitally measured with the ST and IV software presented reliable results when compared to the measurements obtained manually. Both software and imaging modalities are useful for planning the surgical procedure in dental practice. Simonton *et al.* (2009) verified whether differences in sex or age of the patient were predictive of differences in the relative location of the inferior alveolar nerve compared to the roots of the first mandibular molar. Regardless of age, women presented significantly lower vertical distances of the inferior alveolar nerve to the mesial and distal apices and also smaller horizontal distances to the total width of the mandible. In addition, the total width of the mandibular bone region decreased in both sexes in the third and sixth decades of life. Collectively, these data indicated that both sex and age are predictive of surgical endodontic anatomical relationships and should be considered in preoperative planning.

In the present study, CBCT was used in 422 patients (394 women) with a mean age of 44.46. The strategy of navigation in TFCF images was performed according to a study by Bueno et al. (2011). The CBCT images were adjusted in the sagittal, axial and coronal planes to obtain the bone thickness between the center of the apical foramen and the outer surface of the cortical ones. The measurements were recorded in the plane corresponding to the sagittal image for anterior teeth and coronal for the posterior teeth. The standard reference for the location of the root apex corresponded to the main root canal, with care intended for the specificities of the different dental groups.

The present study registered as the reference for the analysis of the bone thickness the center of the apical foramen and the external cortical ones. Thus, due to the lack of studies with these characteristics the comparison with other studies was difficult. However, in a recent study (Estrela et al., 2018), the position of the apical foramen was determined in relation to root surfaces of human permanent teeth using TCFC images with a new e-Vol DX software. The results showed that the position of apical foramen in human permanent teeth was central in 48.95% and 42.08% of maxillary and mandibular teeth, respectively. These aspects evidenced possible differences between the results of the current study in which the distance from the center of the apical foramen to the external cortices was evaluated, with the work of Zahedi et al. (2018), in which they determined the measurements between the vestibular cortical and the apex of the lower posterior teeth. While, Vera et al. (2012) and ALTarawneh *et al.* (2017) analyzed the vestibular and palatine bone thickness in the upper anterior teeth in the apical, middle and coronal thirds, as well as the distance from the cementum-enamel junction (CEJ) to the bone crest using CBCT images. Another aspect that should be considered in the present study is associated with the number of samples analyzed (n = 1400 teeth, 2337 apical foramina), compared to the other studies, as well as the gender and ages of the patients.

A factor of importance, which should be highlighted in the methodology, and which can identify weaknesses in some studies that used measurements in CBCT images, refers to the protocol of image acquisition. Resolving the CBCT image may be a limiting factor in the measurement of fine and delicate objects. The larger the field of view, the lower the resolution of the image. The CBCTs used in the present study had a small field of view, isotropic voxel of 0.10 × 0.10 × 0.10 mm, with a diagnostic objective to determine the precise therapeutic planning.

Endodontic and surgical procedures guided increasingly have been the subject of studies and clinical applications due to the advances made by technological innovations of CBCT as new software, assisted planning and interventions guided by 3D images (CAD-CAM) and prototyping. Digital planning and the guides directions minimize risks and iatrogenic accidents, increase the effectiveness of clinical planning, and consequently reduce the time of interventions (van der Meer *et al,* 2016;. Lavasani *et al,* 2016;. Connert *et al.* , 2017, Verweij *et al.,* 2017a, b). However, understanding the thickness of the tooth roots, especially premolars and molars in appropriate level for the resection of the root, bone thickness on these roots and the proximity of each apex with the maxillary sinus has a clinical impact important in the therapeutic result, besides helping the professional before and during the surgical procedure (Lavasani *et al.,* 2016).

Knowledge of the anatomy of different dental groups and adjacent structures such as bone thickness of alveolar cortices influences the quality of surgical therapeutic planning, as well as guides the analysis of bacterial dissemination pathways in periapical infections. The CBCT allows to obtain linear measures that favor comparative analysis.

Acknowledgement

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Tables and figures:

Table 1. Mean and standard deviation of the bone thicknesses between the apical foramen (mm) of the upper and lower anterior teeth and the vestibular and lingual / palatal cortices in CBCT images in the sagittal section.

Teeth (n=600)	Cortical thickness Buccal $\bar{x} \pm s$	N	Cortical thickness Palatal $\bar{x} \pm s$	N	*p*
ICS	1,59 ± 0,67	100	7,07 ± 1,96	100	0,000**
ILS	2,30 ± 1,20	100	5,28 ± 1,35	100	0,000**
CS	1,49 ± 0,86	100	8,63 ± 2,08	100	0,000**
ICI	2,72 ± 1,30	100	3,89 ± 1,15	100	0,000**
ILI	3,06 ± 1,29	100	4,01 ± 1,35	100	0,000**
CI	3,43 ± 1,31	100	4,78 ± 1,64	100	0,000**

Table 2. Mean and standard deviation of the bone thicknesses (mm) of the apex apices of the upper and lower premolar teeth and the vestibular and lingual / palatal cortices in CBCT images in the coronal section.

Teeth (n=400)	Cortical thickness Buccal $\bar{X} \pm S$	N	Cortical thickness Palatal $\bar{X} \pm S$	N	*p*
1 PMS					
CV (MV)	1,13 ± 0,68	100	8,07 ± 1,63	100	0,000**
CP (P)	4,47 ± 1,85	86	4,52 ± 1,51	86	0,840*
2 PMS					
CV (MV)	2,20 ± 1,21	97	7,62 ± 1,84	97	0,000**
CP (P)	3,86 ± 1,74	36	5,82 ± 1,59	36	0,000*
1 PMI	3,27 ± 1,04	100	5,58 ± 1,66	100	0,000*
2 PMI	3,65 ± 1,35	100	5,46 ± 1,84	100	0,000*

Table 3. Mean and standard deviation of the thicknesses (mm) of the apices of the upper and lower molar teeth apexes and the vestibular and lingual / palatal cortices in CBCT images in the coronal section.

Teeth (n=400)	Cortical thickness Buccal $\bar{x} \pm s$	N	Cortical thickness Palatal $\bar{x} \pm s$	N	*p*
1 MS					
CMV	1,98 ± 1,33	100	11,91 ± 1,68	100	0,000**
CMP	3,10 ± 1,35	76	10,56 ± 1,81	76	0,000*
CDV	2,07 ± 1,45	100	12,35 ± 1,98	100	0,000**
CP	11,92 ± 2,38	100	2,84 ± 1,16	100	0,000**
2 MS					
CMV	4,48 ± 1,85	100	8,74 ± 2,47	100	0,000*
CMP	4,89 ± 1,48	34	8,46 ± 2,56	34	0,000*
CDV	3,51 ± 2,15	89	9,74 ± 2,41	89	0,000**
CP	10,39 ± 2,42	92	2,82 ± 1,86	92	0,000**
1 MI					
CMV	4,45 ± 1,46	100	6,49 ± 1,87	100	0,000**
CML	5,43 ± 1,41	100	5,63 ± 1,88	100	0,397*
CDV	5,91 ± 1,64	100	5,44 ± 1,82	100	0,056*
CDL	6,46 ± 1,86	24	4,68 ± 2,16	24	0,004*
2MI					
CMV	7,73 ± 1,83	100	3,46 ± 1,24	100	0,000*
CML	8,36 ± 1,84	80	2,95 ± 1,16	81	0,000*
CDV	8,01 ± 1,91	95	3,08 ± 1,13	94	0,000**
CDL	6,65 ± 4,47	4	2,19 ± 1,57	4	0,191**

Figure 1. Representation of the axial navigation in the CBCT image for the lower canine (A. Sagittal section, B. Axial section, C. Coronal section).

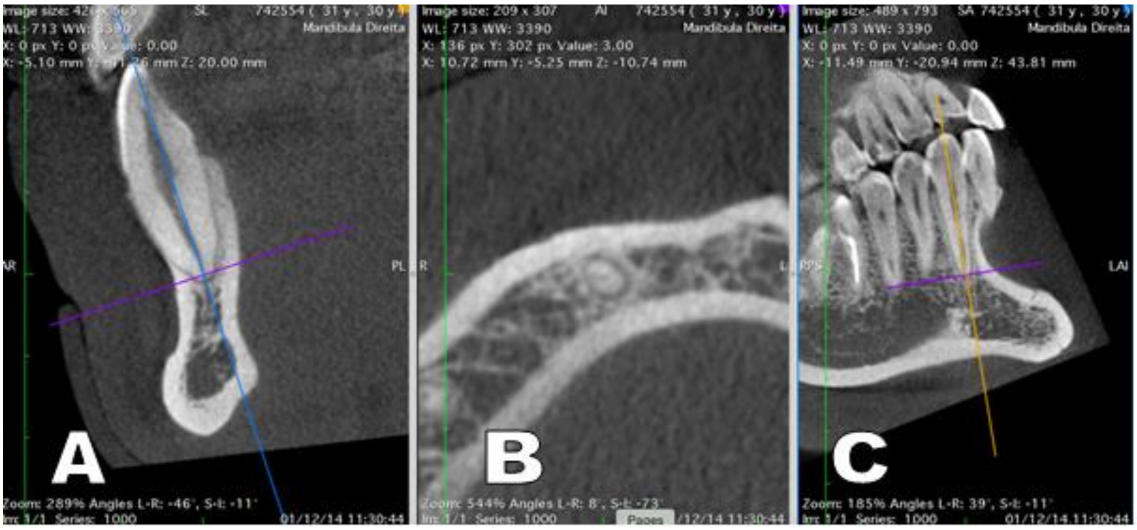
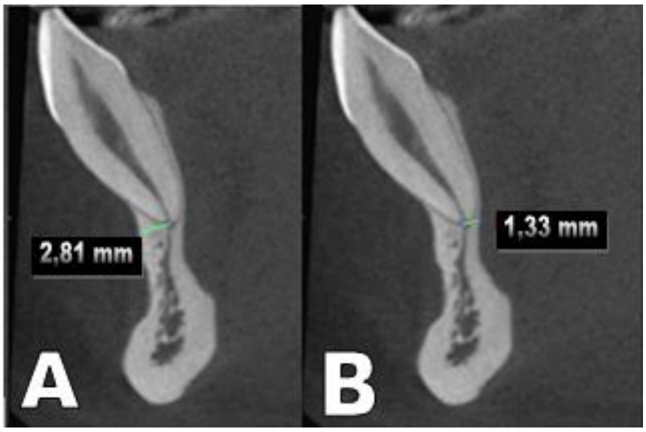


Figure 2. Representation of measuring bone thickness in the sagittal section between the center of the apical foramen and the buccal and lingual cortical on a lower canine (A. bone thickness buccal, lingual bone thickness B).



ANEXO 2 – PARECER DO COMITE DE ÉTICA

utilizando o banco de imagens provenientes de exames de tomografia computadorizada de feixe cônico de uma clinica radiológica odontológica privada em Goiânia-Go. Tais exames foram solicitados por diferentes cirurgiões-dentistas e com finalidades variadas dentro das diversas especialidades odontológicas. Benefícios: Os trabalhos publicados na literatura apresentam alta incidência de istmo na raiz mesio-vestibular dos molares superiores e na raiz mesial dos molares inferiores. No entanto a incidência dessa estrutura nos demais grupos dentários da dentição permanente, ainda necessita de estudos e publicações. É sabido que a anatomia interna dos canais radiculares está intimamente relacionada às taxas de sucesso do tratamento endodôntico. Espera-se que as informações levantadas nesse trabalho possam colaborar com novos conhecimentos a respeito da anatomia dos canais radiculares de elementos dentários que necessitam de tratamento endodôntico, contribuindo diretamente na correta escolha do plano de tratamento e técnica operatória.

Comentários e Considerações sobre a Pesquisa:

Solicitou dispensa do TCLE, por se tratar de pesquisa em banco de dados secundários, porém apresentou o TCUD - Termo de consentimento de Uso de Banco de Dados, assinado pela instituição detentora dos exames. Relataram que a pesquisa será realizada garantindo-se o anonimato do participante, sem conter qualquer indicador da sua identidade, a não ser ao acesso as informações referente ao seu gênero e idade, condições necessárias para a realização da pesquisa. Também não implicará em nenhum custo financeiro ou biológico adicional ao participante, pois não necessitará de exames complementares.

Considerações sobre os Termos de apresentação obrigatória:

Apresentou os seguintes documentos: Termo de compromisso dos pesquisadores; Certidão de ata do CD da FO/UFG, aprovando o projeto; Solicitação de dispensa do TCLE; Folha de rosto, devidamente assinada; Projeto de pesquisa; Informações básicas do projeto;TCUD - Termo de consentimento de Uso de Banco de Dados.

Recomendações:

Conclusões ou Pendências e Lista de Inadequações:

Após leitura e análise dos documentos anexados, sugerimos a aprovação do p.p., SMJ.

Situação do Parecer:

Aprovado

Necessita Apreciação da CONEP:

Não

ANEXO 3 – NORMAS DE PUBLICAÇÃO DOS RESPECTIVOS PERIÓDICOS

American Association of Endodontists
Specialists in Saving Teeth

Home > Publications and Research > Journal of Endodontics > Authors and Reviewers > Guidelines for Publishing Papers in the JOE

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

Organization of Original Research Manuscripts

Manuscripts Category Classifications and Requirements

Available Resources

1. **General Points on Composition**
    1. 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 or syntax. The following list represents common errors in manuscripts submitted to the *JOE*:
    2. The paragraph is the ideal unit of organization. Paragraphs typically start with an introductory sentence that is followed by sentences that describe additional detail or examples. The last sentence of the paragraph provides conclusions and forms a transition to the next paragraph. Common problems include one-sentence paragraphs, sentences that do not develop the theme of the paragraph (see also section "c" below), or sentences with little to no transition within a paragraph.
    3. 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.
    4. 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.
    5. 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.)
    6. 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.
    7. 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."

8. 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.
9. Authors should be aware that the *JOE* uses iThenticate, plagiarism detection software, to assure originality and integrity of material published in the *Journal*. The use of copied sentences, even when present within quotation marks, is highly discouraged. Instead, the information of the original research should be expressed by new manuscript author's own words, and a proper citation given at the end of the sentence. Plagiarism will not be tolerated and manuscripts will be rejected, or papers withdrawn after publication based on unethical actions by the authors. In addition, authors may be sanctioned for future publication.

2. **Organization of Original Research Manuscripts**

Please Note: *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.*

1. **Title Page:** The title should describe the major emphasis 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***). The manuscript title, name and address (including email) of one author designated as the corresponding author. This author will be responsible for editing proofs and ordering reprints when applicable. The contribution of each author should also be highlighted in the cover letter.
2. **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.
3. **Introduction:** The introduction should briefly review the pertinent literature in order to identify the gap in knowledge that the study is intended to address and the limitations of previous studies in the area. The purpose of the study, the tested hypothesis and its scope should be clearly 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 succinctly summarize the gap in knowledge that the study addresses. It is important to note that many successful manuscripts require no more than a few paragraphs to accomplish these goals. Therefore, authors should refrain from performing extensive review or the literature, and discussing the results of the study in this section.
4. **Materials and Methods:** The objective of the materials and methods section is to permit other investigators to repeat your experiments. The four components to this section are the detailed description of the materials used and their components, 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 essential aspects used in the present study. Thus, the reader should still be able to understand the method used in the experimental approach and concentration of the main reagents (*e.g.*, antibodies, drugs, etc.) even when citing a previously published method. 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 must state that they either followed manufacturer's protocol *or* specify any changes made to the protocol. If the study used an ***in vitro* model** to simulate a clinical outcome, the authors must describe experiments made to validate the model, or previous literature that proved the clinical relevance of the model. Studies on **humans** must conform to the Helsinki Declaration of 1975 and state that the institutional IRB/equivalent committee(s) approved the protocol and that informed consent was obtained after the risks and benefits of participation were described to the subjects or patients recruited. Studies involving **animals** must 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 as a basis for sample size computation, drop-outs from clinical trials, the effects of important confounding variables, and bivariate versus multivariate analysis.
5. **Results:** Only experimental results are appropriate in this section (*i.e.*, neither methods, discussion, nor conclusions should be in this section). Include only those data that are critical for the study, as defined by the aim(s). Do not include all available data without justification; any repetitive findings will be rejected from publication. All Figures, Charts and Tables should be described in their order of numbering with a brief description of the major findings. Author may consider the use of supplemental figures, tables or video clips that will be published online. Supplemental material is often used to provide additional information or control experiments that support the results section (*e.g.*, microarray data).
6. **Figures:** There are two general types of figures. The first type of figures 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 to emphasize the most important feature of each photomicrograph, but it greatly increases the total number of illustrations that you can present in your paper. 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 Jeger et al (J Endod 2012;38:884–888); Olivieri et al., (J Endod 2012;38:1007 1011); Tsai et al (J Endod 2012;38:965–970). Please note that color figures may be published at no cost to the authors and authors are encouraged to use color to enhance the value of the illustration. Please note that a multipanel, composite figure only counts as one figure when considering the total number of figures in a manuscript (see section 3, below, for maximum number of allowable figures).

The second type of figures are graphs (*i.e.*, line drawings including bar graphs) 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.

7. **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 be 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).

8. **Discussion:** This section should be used to interpret and explain the results. Both the strengths and weaknesses of the observations should be discussed. 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. What are the major conclusions of the study? How does the data support these conclusions

9. **Acknowledgments:** All authors must affirm that they have no financial affiliation (*e.g.*, employment, direct payment, stock holdings, retainers, consultantships, patent licensing arrangements or honoraria), or involvement with any commercial organization with direct financial interest in the subject or materials discussed in this manuscript, nor have any such arrangements existed in the past three years. Any other potential conflict of interest should be disclosed. Any author for whom this statement is not true must append a paragraph to the manuscript that fully discloses any financial or other interest that poses a conflict. Likewise the sources and correct attributions of all other grants, contracts or donations that funded the study must be disclosed

10. **References:** The reference style follows Index Medicus and can be easily learned from reading past issues of the *JOE*. The *JOE* uses the Vancouver reference style, which can be found in most citation management software products. 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.

3. **Manuscripts Category Classifications and Requirements**

Manuscripts submitted to the *JOE* must fall into one of the following categories. The abstracts for all these categories would have a maximum word count of 250 words:

1. CONSORT Randomized Clinical Trial-Manuscripts in this category must strictly adhere to the Consolidated Standards of

Reporting Trials-CONSORT- minimum guidelines for the publication of randomized clinical trials. These guidelines can be found at ***www.consort-statement.org/***. These manuscripts have a limit of 3,500 words, [including abstract, introduction, materials and methods, results, discussion and acknowledgments; excluding figure legends and references]. In addition, there is a limit of a total of 4 figures and 4 tables*.

2. Review Article-Manuscripts in this category are either narrative articles, or systematic reviews/meta-analyses. Case report/Clinical Technique articles even when followed by extensive review of the literature will should be categorized as "Case Report/Clinical Technique". These manuscripts have a limit of 3,500 words, [including abstract, introduction, discussion and acknowledgments; excluding figure legends and references]. In addition, there is a limit of a total of 4 figures and 4 tables*.
3. Clinical Research (*e.g.*, prospective or retrospective studies on patients or patient records, or research on biopsies, excluding the use of human teeth for technique studies). These manuscripts have a limit of 3,500 words [including abstract, introduction, materials and methods, results, discussion and acknowledgments; excluding figure legends and references]. In addition, there is a limit of a total of 4 figures and 4 tables*.
4. Basic Research Biology (animal or culture studies on biological research on physiology, development, stem cell differentiation, inflammation or pathology). Manuscripts that have a primary focus on biology should be submitted in this category while manuscripts that have a primary focus on materials should be submitted in the Basic Research Technology category. For example, a study on cytotoxicity of a material should be submitted in the Basic Research Technology category, even if it was performed in animals with histological analyses. These manuscripts have a limit of 2,500 words [including abstract, introduction, materials and methods, results, discussion and acknowledgments; excluding figure legends and references]. In addition, there is a limit of a total of 4 figures or 4 tables*.
5. Basic Research Technology (Manuscripts submitted in this category focus primarily on research related to techniques and materials used, or with potential clinical use, in endodontics). These manuscripts have a limit of 2,500 words [including abstract, introduction, materials and methods, results, discussion and acknowledgments; excluding figure legends and references]. In addition, there is a limit of a total of 3 figures and tables *.
6. Case Report/Clinical Technique (*e.g.*, report of an unusual clinical case or the use of cutting-edge technology in a clinical case). These manuscripts have a limit of 2,500 words [including abstract, introduction, materials and methods, results, discussion and acknowledgments; excluding figure legends and references]. In addition, there is a limit of a total of 4 figures or tables*.

* Figures, if submitted as multipanel figures must not exceed 1 page length. Manuscripts submitted with more than the allowed number of figures or tables will require approval of the *JOE* Editor or associate editors. If you are not sure whether your manuscript falls within one of the categories above, or would like to request preapproval for submission of additional figures please contact the Editor by email at ***jendodontics@uthscsa.edu***.

Importantly, 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 while maintaining its focus and significance. Authors are encouraged to focus on only the essential aspects of the study and to avoid inclusion of extraneous text and figures. The Editor may reject manuscripts that exceed these limitations.

Available Resources:

Strunk W, White EB. The Elements of Style. Allyn & Bacon, 4th ed, 2000, ISBN 020530902X.
Day R. How to Write and Publish a Scientific Paper. Oryx Press, 5th ed. 1998. ISBN 1-57356-164-9.
Woods G. English Grammar for Dummies. Hungry Minds:NY, 2001 (an entertaining review of grammar).
Alley M. The Craft of Scientific Writing. Springer, 3rd edition 1996 SBN 0-387-94766-3.
Alley M. The Craft of Editing. Springer, 2000 SBN 0-387-98964-1.

APÊNDICE 1

UFG

FACULDADE DE ODONTOLOGIA UFG

APÊNDICE 1

Apêndice 1 - Termo de Consetimento de uso de banco de dados

O Centro Integrado de Radiologia Odontológica (CIRO) está de acordo, franqueará acesso ao seu banco de dados radiológico e se compromete a apoiar o desenvolvimento da pesquisa e execução do projeto da pesquisadora Luiz Eduardo Gregoris Rabelo, sob a orientação do Prof. Dr. Carlos Estrela da Universidade Federal de Goiás, com o título "Detecção de istmo na dentição permanente humana por meio de imagens de tomografia computadorizada de feixe cônico".

Declaramos conhecer e cumprir as Resoluções Éticas Brasileiras, em especial a Resolução 466/2012 do CNS. O CIRO está ciente de suas co-responsabilidades como co-participante do presente projeto de pesquisa, e de seu compromisso no resguardo da segurança e bem-estar dos sujeitos de pesquisa nela recrutados, dispondo de banco de dados necessários com a garantia da confidencialidade desses sujeitos.

INFORMAÇÕES SOBRE A PESQUISA:

- Essa pesquisa pretende determinar a prevalência dos istmos radiculares nos diferentes grupos dentários por meio de tomografia computadorizada de feixe cônico utilizando como amostra uma subpopulação brasileira.
- O período de participação nessa pesquisa refere-se ao tempo em que for necessário à obtenção dos arquivos de seu banco de dados.
- A pesquisa será realizada sem expor seu centro de radiologia, garantindo plenamente o sigilo quanto a sua privacidade. Não haverá qualquer tipo de constrangimento ou coação para o preenchimento deste documento, sendo dada total liberdade de recusar a participar do grupo a qualquer tempo, sem que seja penalizado.

Atenciosamente,

Goiânia, 10 de Setembro de 2014.

Centro Integrado de Radiologia Odontológica

(CNPJ 37.307.618/0001-09)

UNIDADADE RADIODONTOLOGICA
DE GOIÂNIA LTDA
CNPJ:37.307.618/0001-09
Av. T9 nº 249 Setor Marista
CEP:74.150-300

Pesquisador responsável

Luiz Eduardo Gregoris Rabelo.

APÊNDICE 2

APÊNDICE 2

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO (TCLE)

DISPENSA

Eu, Luiz Eduardo Gregoris Rabelo, solicito a dispensa da aplicação do Termo de consentimento livre e esclarecido do projeto de pesquisa intitulado Detecção de istmo na dentição permanente humana por meio de imagens de tomografia computadorizada de feixe cônico, com a seguinte justificativa:

1. Trata-se de pesquisa retrospectiva com uso de banco de dados radiológicos do Centro Integrado de Radiologia Odontológica.

Atenciosamente,

Goiânia, 10 de Setembro de 2014.

Pesquisador responsável

Luiz Eduardo Gregoris Rabelo.