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Ana Paula Tulio Manfron

Avaliação da região posterior de mandíbula por meio de tomografia computadorizada de feixe cônico

Curitiba
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Tese apresentada ao Programa de Pós-Graduação em Odontologia da Pontifícia Universidade Católica do Paraná, como parte dos requisitos para obtenção do título de Doutor em Odontologia, Área de Concentração em Radiologia Odontológica.

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ANA PAULA TULIO MANFRON

AVALIAÇÃO DA REGIÃO POSTERIOR DE MANDÍBULA POR MEIO DE TOMOGRAFIA COMPUTADORIZADA DE FEIXE CÔNICO

Tese apresentada ao Programa de Pós-Graduação em Odontologia da Pontifícia Universidade Católica do Paraná, como parte dos requisitos parciais para a obtenção do Título de **Doutor em Odontologia**, Área de Concentração em **Radiologia**.

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Curitiba, 16 de fevereiro de 2017.

Dedico este trabalho aos meus pais pela presença,
carinho e apoio em todos os momentos de minha vida,
ao meu esposo e ao meu filho pela compreensão
em todos os momentos, principalmente naqueles em
que os privei de minha companhia.

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“Não há uma pegada do meu caminho que não passe pelo caminho do outro”

(Simone de Beauvoir)

SUMÁRIO

RESUMO

Introdução: O canal da mandíbula (CM) está localizado no interior do corpo da mandíbula, entre os forames da mandíbula e mentual. Nas proximidades do forame mentual, o CM bifurca-se, originando assim os feixes vásculo-nervosos mentual e incisivo. O CM pode apresentar algumas variações anatômicas, como trajetos alternados, canais acessórios e/ou ramificações, entre elas, o canal retromolar (CRM). **Objetivos:** Os objetivos desse estudo foram: descrever frequência, localização e variações do CM e do CRM por meio das imagens de tomografia computadorizada de feixe cônico (TCFC), além de avaliar a acurácia da radiografia panorâmica na observação do CRM. **Materiais e métodos:** Foram interpretadas imagens de TCFC pertencentes ao acervo do Instituto Latino Americano de Pesquisa e Ensino Odontológico - Ilapeo /Curitiba/PR. Os critérios de exclusão foram imagens de pacientes com história de trauma ou intervenções cirúrgicas na mandíbula, presença de processos patológicos na região posterior de mandíbula e imagens que apresentassem artefatos interferindo no padrão de qualidade. Nas imagens selecionadas, foram avaliadas: presença, localização e classificação das variações do CM e do CRM. Para análise da acurácia das panorâmicas, foram selecionadas imagens de TCFC e as correspondentes panorâmicas de 26 pacientes que apresentavam CRM. A interpretação das imagens foi realizada por um único avaliador calibrado. **Resultados**: Foram interpretadas imagens de TCFC de 751 pacientes, 486 (64,7%) mulheres e 265 (35,3%) homens, com média de idade de 54,57 (±13,23;14-93) anos. No total de 1502 imagens de hemi-mandíbulas analisadas, variações do CM e presença de CRM foram observadas em 130 (8,6%) e 58 (7,7%) pacientes, respectivamente. A variação do CM mais frequente foi a do tipo I (n=68;52,2%) e, em relação ao CRM, o tipo mais frequente foi o B1 (n=33;47,1%). O CM apresentou distâncias médias entre cortical superior do CM e base da mandíbula, cortical vestibular do CM e cortical óssea vestibular da mandíbula e cortical superior do CM e rebordo alveolar da mandíbula de 12,16mm (±2,68), 4,17mm (±1,30) e 12,97mm (±4,01), respectivamente. O diâmetro médio dos CRMs foi 0,97mm (±0,44), e a distância média entre forame retromolar e cortical vestibular da mandíbula foi 4,12mm (±1,35). Não houve diferenças significativas entre distâncias e sexo, e distâncias e lados (p>0,05), para a presença de CRM. A sensibilidade da radiografia panorâmica em detectar CRM foi de 56,25% e a especificidade, de 70%. Os valores falso-positivo e falso-negativo das panorâmicas foram 30% e 43,75%, respectivamente. **Conclusão:** A prevalência de variações do CM e a presença do CRM na amostra estudada foi de 8,6% e 7,7%, respectivamente. O tipo mais frequente do CM foi o tipo I. O CRM apresentou-se predominantemente unilateral com maior frequência do tipo B1. As radiografias panorâmicas apresentaram baixa acurácia na identificação do CRM.

Palavras-chave: canal da mandíbula, variação anatômica, tomografia computadorizada de feixe cônico

ABSTRACT

Introduction: The mandibular canal (MC) is located inside the mandible body, between the mandible and mental foramen. Proximity of the mental foramen, the MC bifurcates, originating the mental and incisive nervous-vascular bundles. The MC may present some anatomical variations, such as, accessory canals or branches, the most important of them is the retromolar canal (RMC). **Objectives:** The objectives of this study were: to describe the frequency, location and variations of MC and RMC with cone beam computed tomography (CBCT) images, and to evaluate the accuracy of panoramic radiography in the observation of RMC. **Materials and methods:** Were analyzed CBCT images of patients from Latin America Institute for Dental Research and Education-Curitiba,Pr,Brazil. Exclusion criteria were images of patients with a history of trauma or surgical interventions in the mandible, presence of pathological processes in the posterior region of the mandible, and presence of artifacts that would interfer with the quality standard. In the selected images, we evaluated the presence, location and classification of MC and RMC anatomical variations. For the analysis of the accuracy of the panoramic radiography, images of CBCT and the corresponding panoramic images of 26 patients with RMC were selected. The interpretation of the images was performed by a calibrated evaluator. **Results:** CBCT images of 751 patients, 486 (64.7%) women and 265 (35.3%) men were interpreted, with a mean age of 54.57 (± 13.23, 14-93) years. In the total of 1502 hemi-mandibles images were analyzed, MC anatomical variation was observed in 130 (8.6%) and presence of RMC in 58 (7.7%). The most frequent MC variation was type I (n=68;52.2%) and, in relation to RMC, the most frequent type was B1 (n=33;47.1%). The MC presented mean distances between upper cortical of MC and base of mandible, cortical vestibular of MC and buccal cortical bone of mandible and upper cortical of MC and alveolar ridge of mandible of 12.16mm (± 2.68), 4.17mm (± 1.30) and 12.97mm (± 4.01), respectively. The mean diameter of the CRMs was 0.97 mm (± 0.44), and the mean distance between the retromolar foramen and the buccal cortical of the mandible was 4.12 mm (± 1.35). There were no significant differences between distances and sex, and distances and sides ($p > 0.05$), for the presence of RMC. The sensitivity of panoramic radiography in detecting RMC was 56.25% and the specificity was 70%. The false-positive and false-negative values of the panoramic radiography were 30% and 43.75%, respectively.**Conclusion:** The prevalence of MC variations and the presence of RMC in this studied sample was 8.6% and 7.7%, respectively. The most frequent type of MC was type I. The CRM was predominantly unilateral with a higher frequency of type B1. Panoramic radiographs presented low accuracy in the identification of RMC.

Key-words: mandibular canal, anatomical variation, cone beam computed tomography

INTRODUÇÃO

O canal da mandíbula está localizado no interior do corpo da mandíbula, entre os forames da mandíbula e mentual, funcionando como um ducto para o feixe vásculo-nervoso alveolar inferior. Apresenta aproximadamente, em média, 3mm de diâmetro e é dividido em três segmentos: segmento posterior, que compreende a região da língula da mandíbula até o segundo molar; segmento médio que se estende do segundo molar até o segundo pré-molar; e o segmento anterior, que começa na região do segundo pré-molar com direção para anterior, onde então se bifurca, originando assim os feixes vásculo-nervosos mentual e incisivo[1,2]. O canal da mandíbula pode apresentar algumas variações anatômicas, como trajetos alternados, canais acessórios e/ou ramificações[1,3], entre elas, uma importante variação anatômica do canal da mandíbula é o canal retromolar.

O canal retromolar surge a partir de uma ramificação do canal da mandíbula, e projeta-se posteriormente para a região do terceiro molar, exteriorizando-se pelo forame retromolar [4,5]. O forame retromolar encontra-se na região da fossa retromolar, área localizada no terço médio do ramo da mandíbula, entre o plano oclusal e o processo coronóide[6]. Seu feixe vásculo-nervoso pode estender-se às áreas do tendão do músculo temporal, de inserção do músculo bucinador, à região posterior do processo alveolar do terceiro molar, além da própria fossa retromolar [4,7]. Seu trajeto não é constante e pode apresentar-se de diversas formas, modificando, assim, a região a ser suprida[8].

Devido à presença de maior condensação óssea na região posterior da mandíbula, a qual ocorre pela sobreposição da borda anterior do ramo da mandíbula, a continuidade com a linha oblíqua e a linha milohióidea, a observação da localização, trajeto e variações anatômicas do canal da mandíbula em região posterior por meio de técnicas radiográficas convencionais (periapicais ou panorâmicas) torna-se limitada. Sendo assim, a tomografia computadorizada de feixe cônico (TCFC) apresenta-se como um importante instrumento de diagnóstico, visto que as relações anatômicas podem ser observadas em múltiplos planos (axial, coronal e sagital), bem como reprodução 3D, permitindo adequada observação de sua localização, detalhes anatômicos e suas variações[3,5,9,10]. A presença de variações anatômicas do canal da mandíbula ocorre em 10% a 66% dos casos relatados em estudos com TCFC[1,9,11,12].

O conhecimento das variações anatômicas do canal da mandíbula é de considerável importância, pois lesões no feixe vásculo-nervoso que passa por este canal podem levar a eventuais complicações, tais como; hemorragia, falhas na anestesia, agressão a ramos nervosos durante procedimentos cirúrgicos, como a remoção de blocos ósseos ou durante cirurgias ortognáticas[2,9,13-16].

Com base nestes dados, fica evidente a relevância clínica da análise destas variações anatômicas durante o planejamento para a realização de procedimentos cirúrgicos, evitando-se, assim, possíveis ocorrências de acidentes cirúrgicos e complicações pós-operatórias.

ARTIGO 1 – VERSÃO EM PORTUGUÊS

Estudo descritivo do canal da mandíbula em região posterior por meio da tomografia computadorizada de feixe cônico

Resumo

Introdução: O conhecimento do trajeto e possíveis variações anatômicas do canal da mandíbula (CM) em região posterior é importante para o planejamento de procedimentos cirúrgicos que envolvam a região. **Objetivos:** Descrever frequência, localização e variações do CM, por meio da tomografia computadorizada de feixe cônico (TCFC). **Materiais e métodos:** Foram interpretadas imagens de TCFC pertencentes ao acervo do Instituto Latino Americano de Pesquisa e Ensino Odontológico – Ilapeo/Curitiba/PR, obtidas entre o período de junho/2008 a fevereiro/2013. A interpretação das imagens foi realizada por um único avaliador calibrado, de acordo com presença, localização e classificação da variação do CM. Mensurações de distância horizontais e verticais das variações do CM em relação às corticais ósseas da mandíbula foram obtidas em dois pontos (cortes de 0mm e 20mm). **Resultados:** Foram interpretadas imagens de TCFC de 751 pacientes, 486 (64,7%) mulheres e 265 (35,3%) homens, com média de idade de 54,57 (±13,23;14-93) anos. No total de 1502 imagens de hemi-mandíbulas analisadas, variação do CM foi observada em 130 (8,6%). Foram identificadas 64 (49,2%) variações do CM do lado direito e 66 (50,8%) do lado esquerdo. As distâncias médias entre cortical superior do CM e base da mandíbula, cortical vestibular do CM e cortical óssea vestibular da mandíbula, e cortical superior do CM e rebordo alveolar da mandíbula foram 12,16mm (±2,68), 4,17mm (±1,30) e 12,97mm (±4,01), respectivamente. O CM do tipo I (n=68;52,2%) foi o mais frequente na amostra, seguido pelo tipo III (n=34;26,1%). **Conclusão:** A prevalência de variações do CM foi de 8,6% na amostra estudada, com predominância do tipo I e seu trajeto apresentou uma maior proximidade da face lingual, em região de segundo molar.

Palavras-chave: canal da mandíbula, variação anatômica, tomografia computadorizada de feixe cônico

Introdução

Na Implantodontia, pequenos enxertos ósseos são muitas vezes necessários previamente a instalação de implantes. Quando há opção pela utilização de enxerto autógeno, a área doadora intrabucal mais comumente utilizada é a região posterior de mandíbula (área de fossa retromolar e borda anterior do ramo)[1,2]. Agressões ao canal da mandíbula (CM) podem provocar complicações durante ou após os procedimentos cirúrgicos, tais como, hemorragia[3-7] e distúrbios neurosensoriais temporários ou permanentes relacionados ao feixe vásculo-nervoso alveolar inferior[8-10].

O CM está localizado no interior do corpo da mandíbula, entre os forames da mandíbula e mentual. Nas proximidades do forame mentual, o CM bifurca-se, originando os feixes vásculo-nervosos mentual e incisivo[4,7]. O CM pode apresentar algumas variações anatômicas, como trajetos alternados, canais acessórios e/ou ramificações[3,6,]. A prevalência de variações anatômicas do CM é variável. Estudos com tomografia computadorizada de feixe cônico (TCFC) revelam presença de variações do CM em 10-66% das amostras estudadas[4,11-15]. Seu reconhecimento por meio das imagens tomográficas permite um melhor detalhamento em relação a localização e trajeto destas variações, apresentando-se como um importante instrumento de diagnóstico na avaliação do planejamento cirúrgico[11,16,17].

A fim de se evitar agressões ao CM, principalmente frente a situações de instalação de implantes dentários e remoção de blocos ósseos, é essencial o conhecimento das variações anatômicas e da exata localização do CM no corpo da mandíbula. Nesse sentido, os objetivos deste estudo foram descrever frequência, localização e variações do CM, por meio da TCFC.

Materiais e métodos

Este estudo retrospectivo, observacional do tipo transversal, foi aprovado pelo Comitê de Ética em Pesquisa da Pontifícia Universidade Católica do Paraná – PUCPR (parecer 887.888/2014).

Amostra

Utilizando o método de amostragem de proporções para um nível de confiança de 95% e erro máximo de amostragem de 2% para mais ou para menos, admitindo p=(1-p)=0,5, uma vez que foram analisadas variáveis com escala nominal dicotômica e politômica, o tamanho mínimo da amostra foi calculado em 1334 imagens tomográficas de um total de aproximadamente 3000 imagens tomográficas. Foram avaliadas as imagens de TCFC de 1544 hemi-mandíbulas (772 pacientes), pertencentes ao acervo do Departamento de Imaginologia do ILAPEO (Instituto Latino Americano de Pesquisa e Ensino Odontológico – Curitiba/PR) obtidas entre o período de junho/2008 à fevereiro/2013. Foram incluídas na amostra todas as imagens tomográficas da região de ramo da mandíbula de ambos os lados. Os critérios de exclusão foram imagens de pacientes com história de trauma ou intervenções cirúrgicas (ortognáticas ou lateralização do nervo alveolar inferior), presença de processos patológicos na região posterior de mandíbula e presença de qualquer tipo de artefato que pudesse afetar a qualidade da imagem.

Aquisição das imagens e análises

As imagens foram obtidas por meio de um tomógrafo computadorizado de feixe cônico Galileos@ (*Sirona, Bensheim*, Alemanha). Os fatores de aquisição para as tomografias foram constantes: 14 segundos de aquisição, FOV de 15x15 cm^3, 42 mAs, alto contraste, 85 kV e espessura de corte de 0,3 mm. A técnica foi realizada de forma padronizada: posição da cabeça do paciente com o plano oclusal paralelo ao solo e o plano mediano perpendicular ao solo. Todas as imagens foram avaliadas por meio do *software Galaxis* versão 1.7 (*Sirona, Bensheim,* Alemanha). A interpretação das imagens foi realizada em ambiente escurecido, utilizando monitor *LCD Dell* (Dell, Texas, EUA), 18”5 polegadas, resolução 1366 x 768, por um único examinador devidamente calibrado (Dahlberg <3%) e em caso de dúvidas um segundo radiologista foi consultado.

Os seguintes dados foram coletados:

a) Identificação dos pacientes (sexo e idade);

b) Presença de dentes posteriores: A presença de dentes posteriores foi observada nas imagens tomográficas e dicotomizada em “presente” e “ausente”, considerando-se como “presente”, a presença de, no mínimo, um dos molares inferiores.

c) Variações do CM, de acordo com classificação preconizada por Naitoh et al.[12] e Muinelo-Lorenzo et al.[18]: Tipo I: Canal retromolar - bifurcação do CM na região do ramo atingindo a região retromolar; Tipo II: Canal dental - bifurcação do CM no sentido anterior com seu término no ápice das raízes do segundo e terceiro molar; Tipo III: Canal para anterior - bifurcação do CM no sentido anterior com ou sem união. Tipo IV: Canal vestíbulo-lingual – bifurcação do CM no sentido vestibular ou no sentido lingual. Tipo V: Canal superior - bifurcação do CM no sentido superior que não atende a nenhum dos critérios de classificação citados (Figura 1).

d) Localização do CM: Foram realizadas mensurações em dois pontos de referência: uma linha vertical inicial foi traçada tangenciando o ponto mais posterior da região mais côncava do ramo da mandíbula próximo a base do processo coronóide (início da linha oblíqua) (corte 0mm) e outra linha traçada a uma distância de 20mm para anterior desta linha inicial (corte 20mm), seguindo parcialmente a metodologia utilizada por Leite et al.[19] (Figura 2).

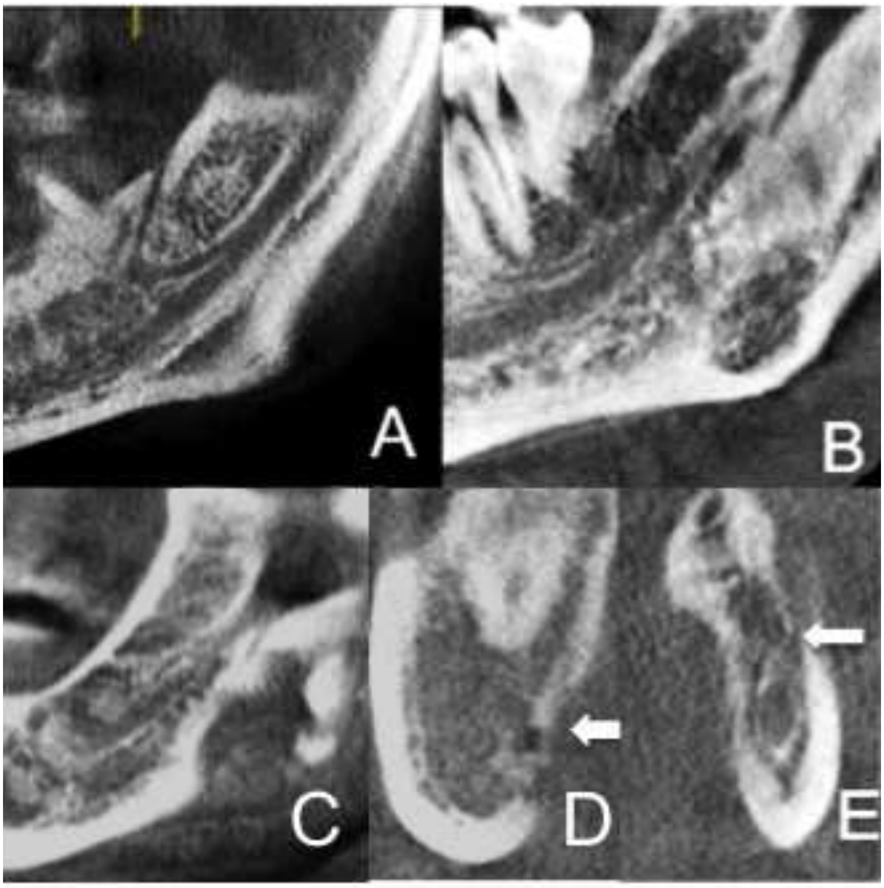

Fig. 1. Imagens de TCFC demonstrando a presença de variações do canal da mandíbula, de acordo com classificação preconizada: Imagens de reconstrução sagital: A. Tipo I (Canal retromolar). B. Tipo II (Canal dental). C. Tipo III (Canal para anterior). Imagens de reconstrução parassagital: D. Tipo IV (bifurcação no sentido vestibular ou no sentido lingual). E. Tipo V (bifurcação no sentido superior).

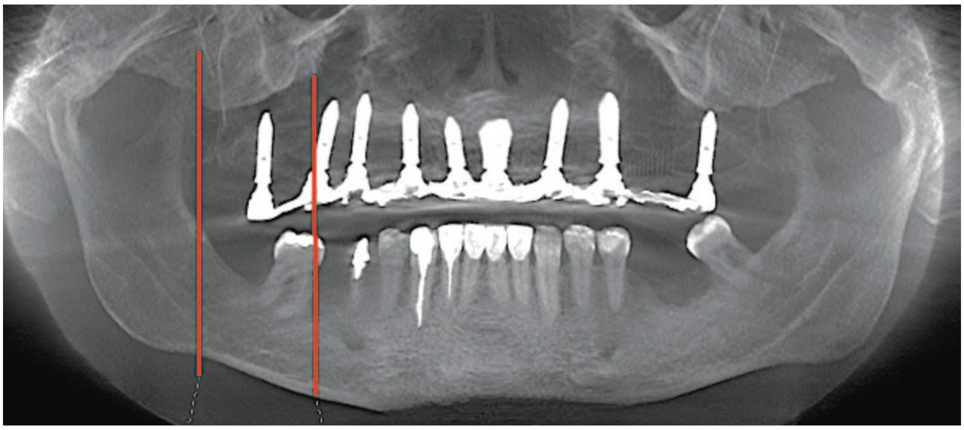

Fig. 2. Reconstrução coronal panorâmica ilustrando a localização dos pontos de referência (0mm e 20mm) para mensuração da localização do canal da mandíbula.

A partir destes pontos de referência foram gerados os relatórios no *report viewer*. Os procedimentos para criar um *report* (cortes transversais padronizados) foram realizados por meio da ferramenta “inserir achados”, aplicando-se distância entre os cortes de 2mm e a espessura de corte de 2mm. Nos cortes 0mm e 20mm, as seguintes mensurações foram realizadas nos cortes parassagitais (Figura 3): a) mensuração da distância da cortical superior do CM até a base da mandíbula (altura 1); b) mensuração da distância da cortical superior do CM até a região de crista alveolar (altura 2); c) mensuração da distância da cortical vestibular do CM até a superfície da cortical óssea vestibular (espessura).

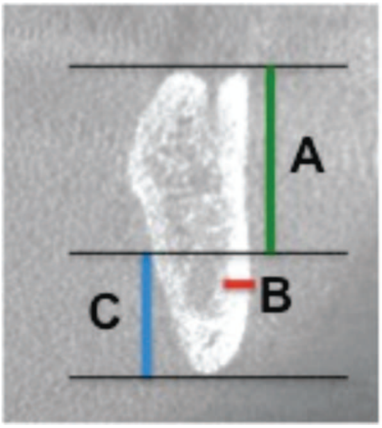

Fig. 3. Reconstrução parassagital demonstrando as mensurações realizadas, nos cortes 0 e 20mm: a) mensuração da distância da cortical superior do CM até a região de crista alveolar (altura 2); b) mensuração da distância da cortical vestibular do CM até a superfície da cortical óssea vestibular (espessura); c) distância da cortical superior do CM até a base da mandíbula (altura 1).

Com o objetivo de avaliar a concordância intra-examinador, um mês após a primeira coleta, 30 imagens de TCFC foram aleatoriamente selecionadas, e nestas mesmas imagens, foram realizadas novas mensurações do CM (altura 1, altura 2 e espessura)[18]. Os valores calculados a partir do teste de reproducibilidade de Dahlberg não ultrapassaram 3% para as três mensurações, nos dois cortes avaliados (0mm e 20mm), o que indicou que o avaliador reproduziu as mensurações de forma aceitável.

Análise Estatistica

A análise estatística foi realizada utilizando o *software* SPSS® versão 21.0 para *Windows (*IBM Corporation, Armonk, NY, EUA). Foram realizadas análises descritivas. O nível de reproducibilidade das mensurações intra-examinador para as medidas anatômicas foi avaliado pelo teste de reproducibilidade de Dahlberg (<3%). A prevalência para cada variável foi obtida por meio da distribuição de frequência categórica dicotômica ou politômica. Foi utilizado o teste T para amostras independentes com objetivo de avaliar se a idade média da população estudada apresentava diferença significativa em relação à variável sexo. Para as demais variáveis que apresentaram escala nominal dicotômica ou politômica, a verificação da associação segundo sexo ou presença de variação anatômica foi feita utilizando o teste qui-quadrado.

Foi adotado nível de significância de 5% ($p<0,05$) para todos os testes.

Resultados

Foram analisadas 1544 imagens de TCFC de hemi-mandíbulas, pertencentes a 772 indivíduos. De acordo com os critérios de exclusão, foram excluídas da população do estudo 42 imagens de TCFC: 31 apresentaram qualidade de imagem inadequada; imagens de oito pacientes apresentaram artefatos metálicos na região (presença de implantes e mini-implantes para ancoragem ortodôntica em cinco pacientes e placas de contenção de fratura em três pacientes) e imagens de três pacientes apresentaram lesões radiopacas compatíveis com áreas de esclerose óssea.

A amostra final consistiu de 751 pacientes, 486 (64,7%) mulheres e 265 (35,3%) homens, com média de idade de 54,57±13,23 anos, e idade variando entre 14-93 anos.

No total de 1502 imagens de hemi-mandíbulas analisadas, a variação do CM foi identificada em 130 (8,6%) imagens, de 105 (14%) pacientes. Foram observadas 64 (49,2%) variações do CM do lado direito e 66 (50,8%) do lado esquerdo. A presença de variação do CM foi significativamente maior em homens (n=62;23,4%) comparado as mulheres (n=68;14%) ($p=0,001$). Foi observada presença de molares em 427 (56,85%) pacientes (855 hemi-mandíbulas) e ausência de molares em 324 (43,14%) pacientes (647 hemi-mandíbulas).

O tipo de CM mais frequente na amostra foi o do tipo I (n=68; 52,3%), seguido pelo tipo III (n=34; 26,1%). Em dois (1,4%) casos foi observada, presença de dois tipos diferentes de variações anatômicas do mesmo lado. Em um caso, havia canais do tipo I e III e, no outro caso, os tipos III e IV.

A tabela 1 mostra a distribuição da classificação do CM em relação ao sexo. A presença de variação do CM do tipo III foi significativamente maior no sexo masculino comparado ao sexo feminino (p=0,004).

Tabela 1: Distribuição da classificação do canal da mandíbula em relação ao sexo.

Canal da mandíbula	Sexo		Total
	masculino	feminino	
	n(%)	n(%)	n(%)
Tipo I	25 (19,2)	43(33,1)	68(52,3)
Tipo II	11(8,5)	10 (7,7)	21(16,2)
Tipo III	22(17,0)	12(9,2)	34(26,2)
Tipo IV	2 (1,5)	2(1,6)	4 (3,2)
Tipo V	1(0,7)	0 (0,0)	1 (0,7)
Tipo I e III	0(0,0)	1 (0,7)	1 (0,7)
Tipo III e IV	1(0,7)	0 (0,0)	1(0,7)
Total	62(47,7)	68(52,3)	130(100)

A tabela 2 mostra os valores médios e desvio-padrão das distâncias entre cortical superior do CM e base da mandíbula (altura 1), cortical vestibular do CM e cortical óssea vestibular da mandíbula (espessura) e cortical superior do CM e região de crista alveolar da mandíbula (altura 2), nos cortes de 0mm e 20mm. Houve correlação significante da altura 1 entre os cortes 0mm e 20mm (p=0,005; r=0,072), e altura 2 entre os cortes 0mm e 20mm (p=0,001; r=0,177), demonstrando fraca correlação.

Tabela 2. Distribuição das mensurações das distâncias nos cortes em 0mm e 20mm.

Distâncias	Corte 0mm X±DP (min-max)	Corte 20mm X±DP (min-max)
Base da mandíbula à cortical superior do canal (altura 1)	12,16±2,68 (4,45-24,29)	10,66±1,76 (4,65-20,64)
Cortical do canal à cortical vestibular da mandíbula (espessura)	4,17±1,29 (0,95-11,75)	4,66±1,43 (0,48-13,81)
Cortical superior do canal ao rebordo alveolar (altura 2)	12,97±4,01 (1,27-26,19)	12,10±4,08 (0,50-25,88)

Os valores médios das distâncias mensuradas foram comparados entre indivíduos do sexo masculino e feminino (Tabela 3).

Tabela 3. Distribuição das mensurações das distâncias nos cortes em 0mm e 20mm em relação ao sexo.

Distâncias Sexo	Base da mandíbula a cortical superior do canal (altura1)		Cortical do canal à cortical vestibular da mandíbula (espessura)		Cortical superior do canal ao rebordo alveolar (altura 2)	
	0mm X±DP	20mm X±DP	0mm X±DP	20mm X±DP	0mm X±DP	20mm X±DP
Homens	12,27±2,46[a]	10,74±1,79	4,16±1,27	4,78±1,45[a]	13,30±4,02[a]	12,31±4,16
Mulheres	12,10±2,79[b]	10,64±1,74	4,17±1,31	4,59±1,42[b]	12,79±3,79[b]	11,99±4,03

* letras diferentes em coluna indicam diferença estatística significativa ($p<0,05$)

A tabela 4 mostra os valores médios e desvio-padrão das distâncias: altura 1, espessura e altura 2, nos cortes de 0mm e 20mm, em relação a presença e ausência de dentes posteriores. Houve diferença estatística significativa entre pacientes desdentados (ausência dos molares inferiores) e dentados (presença de, pelo menos, um molar inferior) quanto a altura 2, nos cortes 0mm (p=0,01) e 20mm (p=0,01

Tabela 4. Distribuição das mensurações das distâncias em relação a presença de, pelo menos, um molar inferior e ausência de dentes posteriores, nos cortes de 0mm e 20mm.

Distâncias Presença de dentes	Base da mandíbula a cortical superior do canal (altura1)		Cortical do canal à cortical vestibular da mandíbula (espessura)		Cortical superior do canal ao rebordo alveolar (altura 2)	
	0mm X±DP	20mm X±DP	0mm X±DP	20mm X±DP	0mm X±DP	20mm X±DP
Com dentes	12,27±2,59	10,59±1,76	4,15±1,29	4,72±1,43	13,24±3,86[a]	12,50±3,99[a]
Sem dentes	12,02±2,79	10,75±1,75	4,19±1,30	4,57±1,44	12,62±4,18[b]	11,58±4,13[b]

* letras diferentes em coluna indicam diferença estatística significativa ($p<0,05$)

Os valores médios e desvio-padrão das distâncias: altura 1, altura 2 e espessura de ambos os sexos, foram comparados em relação a presença e ausência de dentes posteriores (Tabela 5). Houve diferença estatística significante entre os indivíduos do sexo masculino dentados e desdentados em relação a distância entre a base da mandíbula e a cortical superior do canal (altura 1) no corte 20mm (p=0,03) e entre os indivíduos do sexo feminino dentados e desdentados em relação a distância entre a cortical superior do canal ao rebordo alveolar (altura 2), nos cortes 0mm (p=0,00) e 20mm(p=0,00).

Tabela 5. Distribuição das mensurações das distâncias entre sexo e presença de, pelo menos, um molar inferior e ausência de dentes posteriores, nos cortes de 0mm e 20mm.

Distâncias	Base da mandíbula a cortical superior do canal (altura1)		Cortical do canal à cortical vestibular da mandíbula (espessura)		Cortical superior do canal ao rebordo alveolar (altura 2)	
Sexo/Presença de dentes	0mm X±DP	20mm X±DP	0mm X±DP	20mm X±DP	0mm X±DP	20mm X±DP
Homens dentados	12,48 ±2,44	12,57 ±1,76[a]	4,13 ±1,27	4,83±1,41	13,18 ±3,94	12,66 ±4,17
Homens desdentados	11,92 ±2,45	11,01 ±1,81[b]	4,21 ±1,25	4,69±1,50	13,50 ±4,14	11,73 ±4,09
Mulheres dentadas	12,14 ±2,68	10,60 ±1,75	4.17 ±1,30	4,65±1,43	13,28 ±3,81[a]	12,39 ±3,87[a]
Mulheres desdentadas	12,06 ±2,93	12,64 ±1,72	4,18 ±1,32	4,52±1,41	12,23 ±4,14[b]	11,52 ±4,16[b]

* letras diferentes em coluna indicam diferença estatística significativa ($p<0,05$)

Discussão

Uma vez que cirurgias em região posterior de mandíbula são muito frequentes na prática odontológica, principalmente, na implantodontia, e complicações trans e pós-operatórias podem decorrer da presença de variações anatômicas do CM nessa região, torna-se importante o conhecimento da frequência, trajeto e variações do CM. Neste estudo, a presença de variação do CM foi observada em 130 (8,6%) hemi-mandíbulas, sendo o tipo I (n=68;52,2%) o mais frequente. Houve maior prevalência de variações anatômicas do CM em homens comparado a mulheres.

No presente estudo, foram observadas bifurcações do CM em 130 (8,6%) hemi-mandíbulas. Este resultado foi consideravelmente inferior a relatos anteriores: 22,8%(103/450)[18];15,6%(47/301)[4]; 43,0%(105/244)[12];18,5%(64/346)[20]; 16,2%(122/755)[21]; 46,5%(225/484)[15]. Pórem apresentou-se semelhante ao estudo de Kang et al. (2014)[11], que relatou prevalência de 10,2% (198/1933 pacientes) de variações anatômicas em CM. Essas diferenças entre os estudos não são apenas atribuíveis aos diferentes tamanhos das amostras, mas também podem estar relacionadas a diferenças étnicas (japoneses[4,21], turcos[15] e espanhóis[18]) entre as populações investigadas.

De acordo com a classificação preconizada, o tipo de CM mais frequente encontrado na presente amostra foi o tipo I (n=68;52,3%), seguido pelo tipo III (n=34;26,1%), diferindo de outros estudos, que relataram maior prevalência do tipo II[4,11,20]. Estas diferenças podem ser explicadas por variações no número de indivíduos desdentados entre os estudos[4,21] , já que a ausência de dentes causa remodelação óssea, o que pode interferir na interpretação da localização e classificação das variações anatômicas nas imagens (por exemplo, em casos de avançada perda óssea em desdentados, variações do CM do tipo I podem ser interpretadas e classificadas como tipo II).

Dois casos de variação anatômica que não pertencem diretamente à classificação utilizada foram observados em nosso estudo. Nesses casos, foi identificada presença de dois tipos de variação do CM do mesmo lado. Em um caso, foram detectadas variações do tipo I e III e, em outro caso, variações do tipo III e IV. Achados semelhantes foram relatados no estudo de Muinello et al.[18].

Em nosso estudo, não houve associação significativa entre presença de variações anatômicas do CM e idade, mas houve diferença significativa em relação ao sexo. A prevalência de variações do CM foi significativamente maior em homens quando comparado as mulheres, o que corrobora com estudos anteriores[18,20]. Como era esperado, indivíduos com, pelo menos, um molar inferior apresentaram valores médios da altura 1 (distância entre base da mandíbula e cortical superior do CM) e da altura 2 (distância entre cortical superior do CM e rebordo alveolar) significativamente maiores quando comparados a indivíduos desdentados, o que é justificado pela maior remodelação óssea presente nos últimos.

Alguns estudos incluíram análise morfométrica das bifurcações do CM, considerando diâmetro, comprimento, altura e ângulos[4,11,15,18]. No presente estudo, de acordo com a metodologia empregada, a distância média entre cortical superior do CM e rebordo alveolar (12,97mm) foi inferior ao relatado por Hsu et al.[23] (16,15mm). Os valores médios da distância entre cortical vestibular do CM e cortical vestibular da mandíbula (espessura) foi de 4,17mm, demonstrando que o CM mantêm proximidade da face lingual, na região de segundo molar, de acordo com resultados anteriores: 5,77mm[24], 3,79mm[19]; 4,72mm[23]. Esses dados são de grande importância, considerando-se que a face vestibular da região posterior de mandíbula é utilizada como área doadora em procedimentos de enxertia óssea. O enxerto ósseo removido desta região deve compreender dimensões de aproximadamente 3-5mm de espessura, 30-35mm de comprimento e até 10mm de altura[25,26]. Devido a isso, o conhecimento da posição e possíveis variações do CM em relação a cortical óssea vestibular da mandíbula e rebordo alveolar deve ser enfatizado.

Várias classificações do CM, de acordo com localização e configuração anatômica, foram descritas e utilizadas em estudos anteriores[12,15,27-29]. No presente estudo foi utilizada a classificação desenvolvida por Naitoh et al. (2009)[12] e adaptada por Muinelo-Lorenzo et al. (2014)[18], que classificam o CM em cinco tipos.

Devido a limitações das imagens bidimensionais para localização exata de variações anatômicas do CM, muitos estudos têm utilizado a TCFC para esta avaliação[4,12,17,30,31]. Vários estudos concordam que a TCFC proporciona melhor observação destas estruturas anatômicas relacionadas a diâmetro, localização exata, trajeto e a relação com estruturas adjacentes[3,6,11,17].

A comparação direta dos resultados encontrados em nosso estudo com estudos anteriores é limitada, pois há diferenças relacionadas com as características étnicas da população envolvida e os diferentes padrões de metodologia empregados. Devido ao fato de ser um estudo retrospectivo com análise de imagens, pode-se destacar como principal limitação do presente estudo a dificuldade para acessar informações clínicas quanto a possíveis injúrias ao CM decorrentes das características do seu trajeto, durante e após procedimentos cirúrgicos na região estudada.

Conclusão

A prevalência de variações do CM foi de 8,6% na amostra estudada, com predominância do tipo I e seu trajeto apresentou maior proximidade a face lingual, em região de segundo molar.

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ARTIGO 1-VERSÃO EM INGLÊS

The prevalence and configuration of the mandibular canal in the posterior region of the mandible using cone beam CT.

Running title: CBCT study of the mandibular canal in posterior region

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Abstract

Objectives: To describe the prevalence and configuration of mandibular canal in the posterior region of the mandible using cone beam computed tomography (CBCT). **Methods:** CBCT images of patients from Latin America Institute for Dental Research and Education (Curitiba, Brazil), performed between June/2008 and February/2013, were evaluated by one examiner. The interpretation of the images was conducted according to the presence, classification, and location of the mandibular canal. The measurement of horizontal and vertical distances from mandibular canal in the ramus region and in the molar region was registered. **Results:** CBCT images of 751 patients, 486 (64.7%) women and 265 (35.3%) men, were interpreted, with a mean age of 54.57 (±13.23,14-93) years. Out of the 1502 hemi-mandibles images, mandibular canal anatomical variations were observed in 130 (8.6%). A total of 64(49.2%) mandibular canal variations were identified on the right side and 66(50.8%), on the left side. The mean distances between the superior cortical of the mandibular canal and the base of the mandible; the buccal cortical of mandibular canal and the buccal cortical bone of the mandible; and the superior cortical of the mandibular canal and the alveolar ridge of the mandible were 12.16mm (±2.68), 4.17mm (±1.30) and 12.97mm (±4.01), respectively. Type I mandibular canal variation (68;52.2%) was the most frequent, followed by type III (34;26.1%). **Conclusion:** The prevalence of mandibular canal anatomical variations was 8.6% in the present sample, the type I was the most common one, and its direction showed proximity to the lingual surface, in the second molar region.

Key words: Mandibular canal; anatomic variation; cone beam computed tomography.

Introduction

Bone augmentation is often required prior to implant placement. When there is an indication for use of autogenous bone, the most common intraoral donor area is the posterior region of the mandible (retromolar fossa and anterior border of the mandibular ramus).[1,2]

Injuries to the mandibular canal in the posterior region of the mandible may cause complications during or after surgical procedures, such as bleeding[3-7] and temporary or permanent neurosensory disturbances.[8-10] The mandibular canal is located inside the body of the mandible, between the mandibular foramina and mental foramen, where it bifurcates, originating the mental and incisive neurovascular bundles.[4,7] However, the mandibular canal may present some anatomical variations, such as alternating runs, accessory canals and/or ramifications.[3,6] The prevalence of anatomical variations of the mandibular canal is variable; it ranges from 10 to 66% in studies using cone beam computed tomography (CBCT).[4,11-15] Its recognition through tomographic images allows an exact location and a definition of the course of these variations, presenting as an important diagnostic tool in the evaluation for surgical planning.[11,16,17]

In order to avoid injuries to mandibular canal, especially during dental implants placement and bone augmentation procedures, it is essential to know the anatomical variations and the exact location of the mandibular canal in the body of the mandible. Thus, the aim of this study was to describe the frequency, location and variations of the mandibular canal on CBCT images.

Materials and methods

This transversal and retrospective observational study was approved by the Local Ethics and Research Committee (887.888/2014).

The overall sample consisted of CBCT images of patients attending the Radiology Department of Latin America Institute for Dental Research and Education (ILAPEO - Curitiba, Brazil) from June/2008 to February/2013. Using a statistic proportion sample calculation for a confidence interval of 95% and the maximum error of 2%, the size of the sample was based on the total number of CBCT images (approximately 3,000 images). Thus, the sample size was estimated in 1334 images. The pre-operative CBCT imaging was requested for various clinical indications, mainly for implants planning, impacted-tooth extractions, and orthodontics treatments. The 3D images were obtained using a CBCT unit Galileos (Sirona, Bensheim, Germany). All images were performed using the following protocol for patient position and exposure acquisition parameters: occlusal plane parallel to the floor, 14 s, FOV 15x15 cm^3, 42 mAs, high contrast, 85 kV and 0.3 mm slice thickness. Exclusion criteria were images with the presence of pathological processes in the posterior region of the mandible and the presence of any artifacts that might affect the image quality. All CBCT scans analysis were performed using the Galaxis software version 1.7 (Sirona, Bensheim, Germany).

Radiographic Assessment and Measurements

All CBCT image interpretation was performed on a liquid crystal display monitor with a resolution of 1366 x 768 (Dell, TX) in a low-light room, by one calibrated examiner. In cases of doubts, another specialist was consulted. In order to evaluate the intra-examiner agreement,[18] the CBCT images of 30 patients were randomly selected and evaluated, and after 30 days these images were re-evaluated by the same examiner (Dahlberg's error < 3%).

The following data were collected: (a) presence or absence of posterior teeth, considering as "presence" the presence of at least one lower molar tooth; (b) presence of mandibular canal anatomical variations, according to the following classification:[12,18] type I: retromolar canal – a mandibular canal bifurcation which coursed upwards reaching the retromolar region; type II: dental canal – mandibular canal bifurcation with anterior direction from the roots of the second and third molars; type III: forward canal – mandibular canal bifurcation for anterior direction with or without joining; type IV: bucco-lingual canal – mandibular canal bifurcation from buccal or lingual direction; type V: superior canal – mandibular canal bifurcation that does not meet any of the anterior classification criteria (Figure 1); (c) mandibular canal location: measurements were performed in the ramus region (a line tangent to the anterior border of the mandibular ramus - 0mm), and in the molar region (20mm forward from the ramus region - 20mm), partially following the methodology described by Leite et al.[19] (Figure 2).

The report viewer was generated from the images in the ramus region and in the molar region. To create a report (standard cross sections) the tool "insert findings" was selected, applying a 2mm distance between the cross sections, and thickness. In the ramus region (0mm) and in the molar region (20mm), the following measurements were performed in the parasagittal sections: (a) distance from the superior cortical of the mandibular canal to the base of the mandible (height 1); (b) distance from the superior cortical of mandibular canal to the alveolar ridge (height 2); (c) distance of the buccal cortical of the mandibular canal to the buccal cortical bone of the mandible (thickness).

Statistical analysis

Statistical analysis was performed using SPSS® version 21.0 for Windows (IBM Corporation, Armonk, NY). Descriptive statistics were performed. The t-test for independent samples was used to test the mean age and the gender. For all others variables, the x^2 test was used to test differences in frequency of mandibular canal variations between genders. The level of significance for all tests was set at $p<0.05$.

Results

A total of 772 CBCT images (1544 hemi-mandibles images) was interpreted. According to the exclusion criteria, 42 CBCT images were excluded from the study population: 31 showed inadequate image quality; 8 presented with metallic artifacts in the posterior region of the mandible (presence of implants or mini-implants), and 3 images showed radiopaque lesions compatible with bone sclerosis in the above mentioned region. The final sample comprised of 751 CBCT images, 486 (64.7%) were from female patients, and 265 (35.3%), from male ones, with mean age of 54.57 (±13.23), ranging from 14 to 93 years.

A total of 1502 hemi-mandibles were analyzed. Mandibular canal variation was detected in 130 (8.6%) hemi-mandibles from 105 (14%) patients. A total of 64 (49.2%) mandibular canal variation was observed on the right side and 66 (50.8%), on the left side. The presence of mandibular canal anatomical variation was significantly higher in males (62; 23.4%) compared to females (68; 14%) (p = 0.001). The presence of molars was observed in 427 (56.85%) patients (855 hemi-mandibles). The type I was the most frequent in the sample (68; 52.3%), followed by type III (34; 26.1%). In two (1.4%) cases the presence of two bifid canals on the same side was observed. In one case, there was the presence of both type I and type III canals, and in the other case, types III and IV.

Table 1 shows the distribution of the mandibular canal classification in relation to gender. The type III was significantly higher in males when compared to females (p = 0.004).

The mean values and standard deviation of height 1, height 2 and thickness, in the ramus region (0mm) and in the molar region (20mm) are shown in table 2. There was a significant correlation between height 1 in the ramus region (0mm) and in the molar region (20mm) ($p = 0.005$; $r = 0.072$), and height 2 in the ramus region (0mm) and in the molar region (20mm) ($p = 0.001$; $r = 0.177$), showing low correlation.

The mean values of the distances were compared between male and female subjects (Table 3).

The mean values and standard deviation of height 1, height 2 and thickness of patients from both genders were compared in relation to the presence and absence of posterior teeth (Table 4). There was a significant difference between dentulous and edentulous males in relation to the height 1, in the molar region (20mm) ($p = 0.03$), and between the dentulous and edentulous females in relation to the height 2, in the ramus region (0mm) ($p = 0.00$) and in the molar region (20mm) ($p = 0.00$).

Discussion

Surgeries in the posterior mandible are very frequent in dental practice, especially in Implantology. Trans and postoperative complications may result from the presence of mandibular canal anatomical variations in this region. Thus, it becomes important to know the frequency, location and variations of the mandibular canal. In this study, the presence of mandibular canal anatomical variation was observed in 130 (8.6%) hemi-mandibles, and type I (68; 52.2%) was the most frequent. There was a higher prevalence of anatomical variations in men compared to women.

In the present study, bifid mandibular canal was observed in 130 (8.6%) hemi-mandibles. This result was considerably lower than previous reports: 15.6% (47/301),[4] 43.0% (105/244),[12] 46.5% (225/484),[15] 22.8% (103/450),[18] 18.5% (64/346),[20] 16.2% (122/755).[21] Conversely, it was quite similar to the results described by Kang et al. (2014),[11] who reported a prevalence of 10.2% (198/1933 patients). These differences between the studies are not only attributable to the different sample sizes, but may also be related with ethnic differences (Turkish[15], Spanish[18] and Japanese[4,21]).

Our results show that the most frequent type of mandibular canal variations was type I (68; 52.3%), followed by type III (34; 26.1%), which disagree with others studies[4,11,20] that reported a higher prevalence of type II mandibular canal variation. These differences can be explained by differences in the number of edentulous individuals in the studied samples,[4,21] and/or by divergence of images interpretation (i.e. in cases of advanced bone loss in edentulous patients, type I variations could be classified as type II). Two cases of mandibular canal anatomical variation that do not belong to the classification followed in this study were observed. In these cases, two types of mandibular canal anatomical variation on the same side were identified. In one case, type I and type III anatomical variations were simultaneously observed in one side, and, in another case, type III and IV anatomical variations. Similar findings were reported by Muinello et al.[18]

In our study, there was no significant association between the presence of anatomical variations and age, but there was a significant difference in relation to gender. The prevalence of mandibular canal anatomical variations was significantly higher in men when compared to women, in agreement with previous studies.[18,20] As expected, individuals with at least one lower molar had significantly higher values of height 1 (distance from the superior cortical of the mandibular canal to the base of the mandible) and height 2 (distance from the superior cortical of mandibular canal to the alveolar ridge) when compared with edentulous, which is justified by bone remodeling.

Some studies included morphometric analysis of bifid mandibular canals, considering the following measurements: diameter, length, height and angles.[4,11,15,18] In the present study, according to the methodology, the mean distance between the superior cortical of the mandibular canal and the alveolar ridge (12.97mm) was lower than reported by Hsu et al.[23] (16,15mm). The mean values of the distance between the buccal cortical of the mandibular canal and the buccal cortical of the mandible (thickness) (4.17mm) showed the proximity of the mandibular canal to the lingual surface in the second molar region, in agreement with previous results: 5.77mm,[24] 3.79mm,[19] and 4.72mm.[23] These data are of great importance considering that the buccal side of the posterior mandible is used as a donor area in bone augmentation. The bone graft removed from this region should have dimensions of approximately 3-5mm thickness, 30-35mm length, and 10mm high.[25,26] Because of this, the knowledge of the position and possible variations of mandibular canal relative to the buccal cortical of the mandible and alveolar ridge should be emphasized.

Several mandibular canal classifications, according to anatomical location and configuration, have been described and used in previous studies.[12,15,27-29] The classification described by Naitoh et al. (2009)[12] and adapted by Muinelo-Lorenzo et al. (2014),[18] that classifies mandibular canal variations into five types, was followed in the present study.

Due to limitations of two-dimensional images for exact location of mandibular canal anatomical variations, many studies have used CBCT.[4,12,17,30,31] Several studies accept that CBCT provides better observation of these anatomical structures, such as: diameter, exact location, and relation with adjacent structures.[3,6,11,17] The direct comparison of the results found in our study with previous studies is limited because there are differences related to the ethnic characteristics of the population involved and differences in the methodology. Due to the fact that it is a retrospective study with image analysis, the main limitation of the present study is the difficulty in accessing clinical information regarding possible injuries to the mandibular canal due the characteristics of its course, during and after surgical procedures in the studied region.

Conclusion

The prevalence of mandibular canal anatomical variations was 8.6% in the present sample, the type I was the most common one, and its direction showed proximity to the lingual surface, in the second molar region.

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Figures and Tables

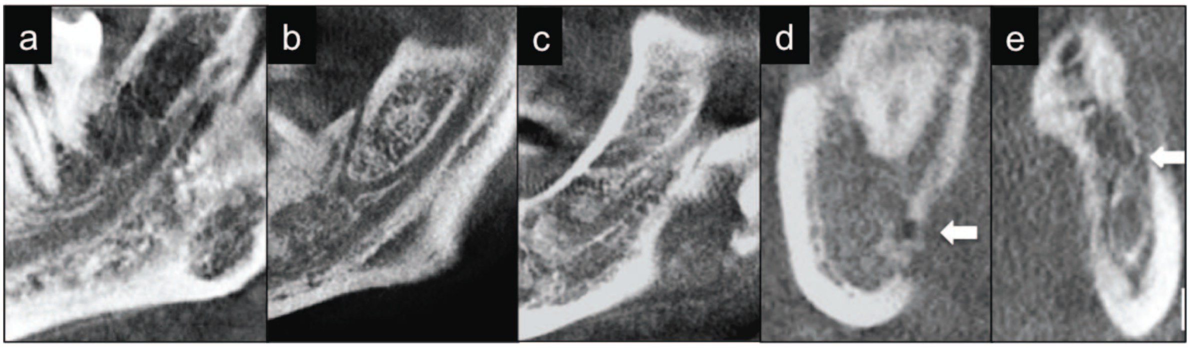

Figure 1. Bifid mandibular canals on CBCT: On sagital reconstruction: (a) Type I: retromolar canal; (b) Type II: Dental canal; (c) Type III: Forward canal. On cross-sectional images: (d) Type IV: Buccal-lingual canal ; (e) Type V: Superior canal.

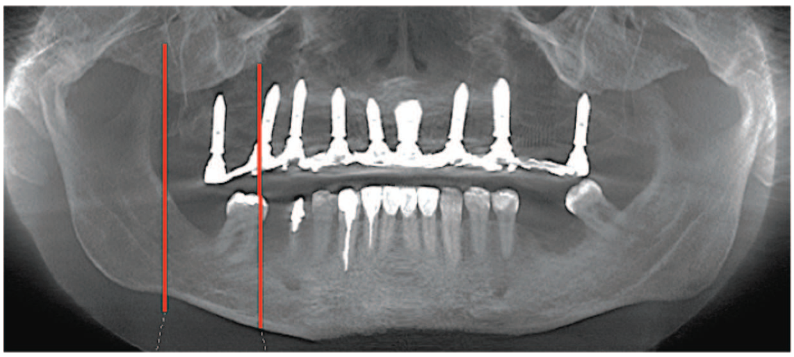

Figure 2. Panoramic reconstruction shows the ramus region (a line tangent to the anterior border of the mandibular ramus - 0mm), and the molar region (20mm forward from the ramus region - 20mm), where the measurements were performed.

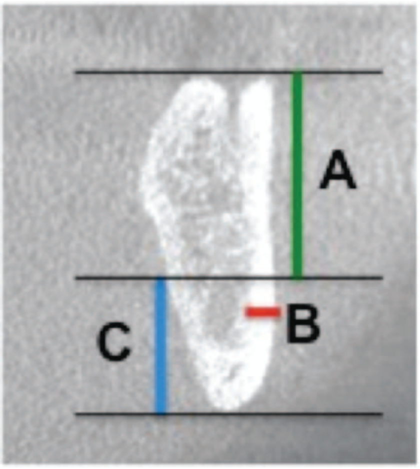

Figure 3. Parasagittal image demonstrating the measurements (0 and 20mm): (a) distance from the superior cortical of mandibular canal to the alveolar ridge (height 2); (b) distance of the buccal cortical of the mandibular canal to the buccal cortical bone of the mandible (thickness); (c) distance from the superior cortical of the mandibular canal to the base of the mandible (height 1).

Table 1: Distribution of mandibular canal classification in relation to gender.

Mandibular canal	Gender		Total
	male	female	
	n(%)	n(%)	n(%)
Type I	25 (19.2)	43(33.1)	68(52.3)
Type II	11(8.5)	10 (7.7)	21(16.2)
Type III	22(17.0)	12(9.2)	34(26.2)
Type IV	2 (1.5)	2(1.6)	4 (3.2)
Type V	1(0.7)	0 (0.0)	1 (0.7)
Type I e III	0(0.0)	1 (0.7)	1 (0.7)
Type III e IV	1(0.7)	0 (0.0)	1(0.7)
Total	62(47.7)	68(52.3)	130(100)

Table 2. Distribution of the measurements of the distances in the CBCT cross sections (Ramus region - 0mm and Molar region - 20mm).

Distances	0mm X±SD (min-max)	20mm X±SD (min-max)
Superior cortical of the mandibular canal and base of the mandible (height 1)	12.16±2.68 (4.45-24.29)	10,66±1.76 (4.65-20.64)
Buccal cortical of the mandibular canal and buccal cortical bone of the mandible (thickness)	4.17±1.29 (0.95-11.75)	4.66±1.43 (0.48-13.81)
Superior cortical of the mandibular canal and alveolar ridge (height 2)	12.97±4.01 (1.27-26.19)	12.10±4.08 (0.50-25.88)

Table 3. Distribution of the measurements in the CBCT cross sections (Ramus region - 0mm and Molar region - 20mm) in relation to the gender.

Distances	Superior cortical of the mandibular canal and base of the mandible (height 1)		Buccal cortical of the mandibular canal and buccal cortical bone of the mandible (thickness)		Superior cortical of the mandibular canal and alveolar ridge (height 2)	
Gender	0mm X±SD	20mm X±SD	0mm X±SD	20mm X±SD	0mm X±SD	20mm X±SD
Males	12.27±2.46[a]	10.74±1.79	4.16±1.27	4.78±1.45[a]	13.30±4.02[a]	12.31±4.16
Females	12.10±2.79[b]	10.64±1.74	4.17±1.31	4.59±1.42[b]	12.79±3.79[b]	11.99±4.03

* Different letters in column indicate significant statistical difference (p<0,05)

Table 4. Distribution of the measurements of the distances between gender and in relation to the presence and absence of posterior teeth (Ramus region - 0mm and Molar region - 20mm).

Distances	Superior cortical of the mandibular canal and base of the mandible (height 1)		Buccal cortical of the mandibular canal and buccal cortical bone of the mandible (thickness)		Superior cortical of the mandibular canal and alveolar ridge (height 2)	
Gender/Presence of teeth	0mm X±SD	20mm X±SD	0mm X±SD	20mm X±SD	0mm X±SD	20mm X±SD
Dentate male	12.48 ±2.44	12.57 ±1.76[a]	4.13 ±1.27	4.83±1.41	13.18 ±3.94	12.66 ±4.17
Edentolous male	11.92 ±2.45	11.01 ±1.81[b]	4.21 ±1.25	4.69±1.50	13.50 ±4.14	11.73 ±4.09
Dentate female	12.14 ±2.68	10.60 ±1.75	4.17 ±1.30	4.65±1.43	13.28 ±3.81[a]	12.39 ±3.87[a]
Edentolous female	12.06 ±2.93	12.64 ±1.72	4.18 ±1.32	4.52±1.41	12.23 ±4.14[b]	11.52 ±4.16[b]

* Different letters in column indicate significant statistical difference (p<0,05)

ARTIGO 2 - VERSÃO EM PORTUGUÊS

Estudo do canal retromolar por meio da tomografia computadorizada de feixe cônico: prevalência, classificação e localização.

Resumo

Introdução: O canal retromolar (CRM) é uma importante variação anatômica do canal da mandíbula. Em geral, o CRM surge a partir de projeções do canal da mandíbula estendendo-se para a região de terceiro molar e posteriormente exteriorizando-se no forame retromolar. **Objetivos:** Avaliar prevalência, localização e classificação do CRM por meio da tomografia computadorizada de feixe cônico (TCFC). **Materiais e métodos**: Foram interpretadas imagens de TCFC pertencentes ao acervo do Instituto Latino Americano de Pesquisa e Ensino Odontológico - Ilapeo /Curitiba/PR, obtidas entre o período de junho/2008 a fevereiro de 2013. A interpretação das imagens foi realizada por um único avaliador calibrado, de acordo com presença, localização e classificação da variação do CRM. Mensurações de distâncias horizontais do CRM em relação às corticais ósseas da mandíbula e do diâmetro do CRM foram obtidas. **Resultados:** Foram interpretadas imagens de TCFC de 751 pacientes, 486 (64,7%) mulheres e 265 (35,3%) homens, com média de idade de 54,57 (±13,23;14-93) anos. No total de 1502 imagens de hemi-mandíbulas analisadas, presença de CRM foi observada em 58 (7,7%) pacientes, 23 homens e 35 mulheres. O CRM foi identificado em 69 (4,6%) hemi-mandíbulas, 44 (63,8%) do sexo feminino e 25 (36,2%) do sexo masculino. Trinta (42,8%) CRMs foram observados no lado direito e 40 (57,2%) no lado esquerdo. O diâmetro médio dos CRMs foi 0,97mm (±0,44), e a distância média entre forame retromolar e cortical vestibular da mandíbula foi 4,12mm (±1,35). O CRM do tipo B1 (n=33;47,1%) foi o mais frequente, seguido pelo tipo A1 (n=18,25,7%). Não houve diferenças significativas entre distâncias e sexo, e distâncias e lados (p>0,05). **Conclusão:** A prevalência de CRM na amostra estudada foi de 7,7%, predominantemente unilateral e do tipo B1.

Palavras-chave: Canal retromolar, variação anatômica, tomografia computadorizada de feixe cônico.

Introdução

O canal da mandíbula pode apresentar algumas variações anatômicas, entre elas destaca-se o canal retromolar (CRM)[1-3]. Quando presente, o CRM localiza-se no terço posterior do canal da mandibula e projeta-se em direção à fossa retromolar, exteriorizando-se por meio do forame retromolar[1,2,4]. Seu trajeto nem sempre é constante, podendo apresentar modificações, sendo assim, seu feixe vásculo-nervoso pode suprir diferentes regiões[5]. Esse feixe leva suprimento ao terceiro molar, à região mais posterior do processo alveolar e gengiva vestibular dos dentes pré-molares e molares, podendo estender-se às áreas de inserção dos músculos temporal e bucinador[1,6].

Em procedimentos cirúrgicos, tais como, extração de terceiros molares, instalação de implantes e procedimentos de enxertos ósseos, é de fundamental importância a identificação de CRMs[4,7,8-13], uma vez que, agressões a estes canais estão relacionadas com parestesia, neuromas traumáticos, sangramento abundante, edema pós-operatório e distúrbios sensoriais temporários ou permanentes[7,8,11,13-16]. Danos a esta inervação também podem causar impacto nas fibras dos músculos temporal e bucinador[14,17]. Alguns autores têm sugerido que a presença do CRM poderia facilitar a propagação de infecções da orofaringe por via sanguínea[18].

Nas técnicas radiográficas convencionais, devido à sobreposição das estruturas anatômicas, a identificação do CRM torna-se limitada. Sendo assim, o uso da tomografia computadorizada de feixe cônico (TCFC) contribui significativamente para o diagnóstico e plano de tratamento cirúrgico[7,19]. A prevalência de CRM varia entre 14 e 65%[2,4,9,20] em estudos com TCFC. Até o presente momento, poucas investigações[21,23] descreveram a morfologia e posição do CRM, fatores fundamentais nos procedimentos cirúrgicos envolvendo esta região. Sendo assim, o objetivo desse estudo foi avaliar prevalência, localização e classificação do CRM em imagens de TCFC.

Materiais e métodos

Este estudo retrospectivo, observacional do tipo transversal, foi aprovado pelo Comitê de Ética em Pesquisa da Pontifícia Universidade Católica do Paraná – PUCPR (parecer 887.888/2014).

Utilizando o método de amostragem de proporções para um nível de confiança de 95% e erro máximo de amostragem de 2% para mais ou para menos, admitindo p=(1-p)=0,5, uma vez que foram analisadas variáveis com escala nominal dicotômica e politômica, o tamanho mínimo da amostra foi calculado em 1334 imagens tomográficas de um total de aproximadamente 3000 imagens tomográficas. Foram avaliadas as imagens de TCFC de 1544 hemi-mandíbulas (772 pacientes), pertencentes ao acervo do Departamento de Imaginologia do Instituto Latino Americano de Pesquisa e Ensino Odontológico - Ilapeo /Curitiba/PR, realizadas para várias indicações clínicas, como planejamento de implantes, extrações de dentes impactados, tratamentos ortodônticos, obtidas entre o período de junho/2008 a fevereiro de 2013. Foram incluídas na amostra todas as imagens tomográficas da região de ramo da mandíbula de ambos os lados. Os critérios de exclusão foram: imagens de pacientes com história de trauma ou intervenções cirúrgicas (ortognáticas ou lateralização do nervo alveolar inferior); presença de processos patológicos na região posterior de mandíbula e presença de qualquer tipo de artefato que pudesse afetar a qualidade da imagem.

As imagens foram obtidas por meio de um tomógrafo computadorizado de feixe cônico Galileos@ (*Sirona, Bensheim*, Alemanha). Os fatores de aquisição para as tomografias foram constantes: 14 segundos de aquisição, FOV de 15x15 cm^3, 42 mAs, alto contraste, 85 kV e espessura de corte de 0,3 mm. A técnica foi realizada de forma padronizada: posição da cabeça do paciente com o plano oclusal paralelo ao solo e o plano mediano perpendicular ao solo.

Interpretação Tomográfica

A interpretação das imagens foi realizada em ambiente escurecido, utilizando monitor *LCD Dell* (Dell, Texas, EUA), 18"5 polegadas, resolução 1366 x 768, por um único examinador devidamente calibrado e em caso de dúvidas um segundo radiologista foi consultado.

Os seguintes dados foram coletados:

1) Identificação do paciente: sexo e idade

2) Variações do CRM, de acordo com a classificação preconizada por Ossenberg (1987)[1] e Von Arx et al. (2011)[2] (Fig.1): tipo A1 – canal vertical reto anterior; tipo A2 – canal vertical anterior com ramo horizontal adicional; tipo B1 – canal com curvatura para posterior; tipo B2 - canal com curvatura para posterior e ramo horizontal adicional; e tipo C – canal horizontal reto posterior.

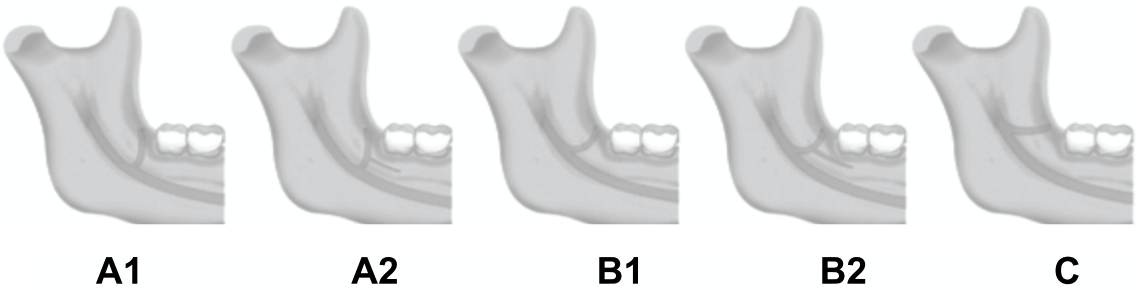

Figura 1. Desenho esquemático representando o canal retromolar de acordo com a classificação de von Arx et al. (2011)[2].

3) Localização do CRM (Fig.2): Nas reconstruções sagitais, as imagens foram analisadas no sentido vestíbulo-lingual de posterior para anterior procurando a melhor imagem do trajeto do CRM. As linhas de referência foram observadas no sentido vestíbulo-lingual de posterior para anterior procurando a melhor imagem do trajeto do CRM. Nas imagens parassagitais, foi realizada a mensuração da

distância do ponto mais anterior da curvatura do CRM à cortical óssea vestibular da mandíbula (horizontalmente). Nas imagens parassagitais, foi medida a distância do forame retromolar à cortical óssea vestibular da mandíbula, 3mm abaixo da crista alveolar.

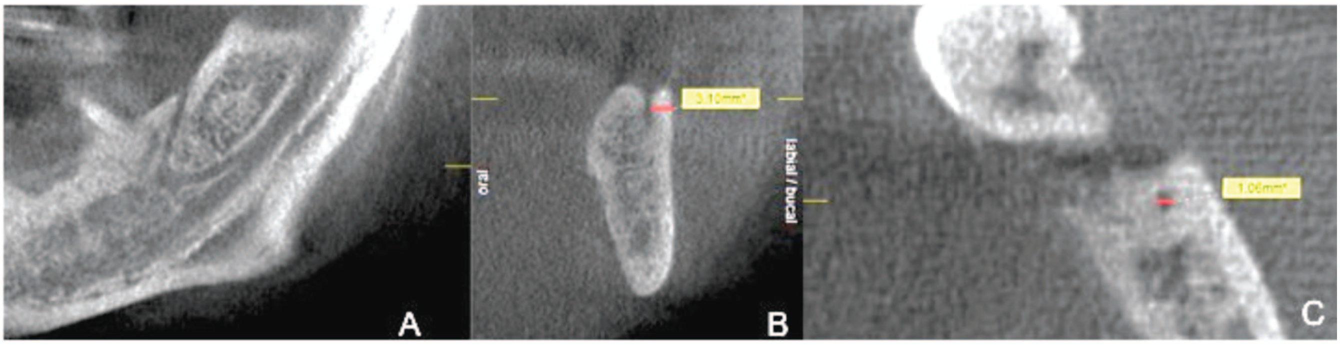

Figura 2. A. Reconstrução sagital demonstrando a melhor imagem do trajeto do canal retromolar. B. Imagem parassagital para a mensuração do ponto mais anterior da curvatura do canal retromolar à cortical óssea vestibular da mandíbula. C. Imagem axial para mensuração do diâmetro do canal retromolar.

3) O diâmetro do forame retromolar foi mensurado 3 mm abaixo da crista alveolar nos cortes axiais[2,21].

Com o objetivo de avaliar a concordância intra-examinador, um mês após a primeira coleta, 30 imagens de TCFC foram aleatoriamente selecionadas, e nestas mesmas imagens, foram realizadas outras mensurações do CRM (localização e diâmetro do CRM)[13]. Os valores calculados a partir do teste de reprodutibilidade de Dahlberg não ultrapassaram 3% para as mensurações nos cortes avaliados, o que indicou que o avaliador reproduziu as mensurações de forma aceitável.

Análise estatística

A análise estatística foi realizada utilizando o *software SPSS*® versão 21.0 para *Windows (*IBM Corporation, Armonk, NY,EUA). Foram realizadas análises descritivas. O nível de concordância intra-observador foi avaliado pelas medidas anatômicas usando o teste de variância do erro de Dahlberg (<3%). A prevalência para cada variável foi obtida por meio da distribuição de frequência categórica dicotômica ou politômica. Foi utilizado o teste T para amostras independentes, com o objetivo de avaliar se a idade média da população estudada apresentava diferença estatisticamente significativa em relação à variável sexo.

Para as demais variáveis que apresentaram escala nominal dicotômica ou politômica, a verificação da associação segundo sexo ou presença de variação anatômica foi feita utilizando o teste qui-quadrado. Para todos os testes estatísticos, foi adotado nível de significância de 5% ($p<0,05$).

Resultados

Foram analisadas 1544 imagens de TCFC de hemi-mandíbulas, pertencentes a 772 indivíduos. De acordo com os critérios de exclusão, foram excluídas da população do estudo 42 imagens de TCFC: 31 apresentaram qualidade de imagem inadequada; imagens de oito pacientes apresentaram artefatos metálicos na região (presença de implantes e mini-implantes para ancoragem ortodôntica em cinco pacientes e placas de contenção de fratura em três pacientes) e imagens de três pacientes apresentaram lesões radiopacas compatíveis com áreas de esclerose óssea.

A amostra final consistiu de 751 pacientes, 486 (64,7%) mulheres e 265 (35,3%) homens, com média de idade de 54,57±13,23 anos, e idade variando entre 14-93 anos. A presença do CRM foi observada em 58 (7,7%) pacientes, 23 homens e 35 mulheres. No total de 1502 imagens de hemi-mandíbulas analisadas, o CRM foi identificado em

69(4,6%), 44 (63,8%) de mulheres e 25 (36,2%) de homens. Foram observados 30 (42,8%) CRMs do lado direito e 40 (57,2%) do lado esquerdo.

O CRM do tipo B1 (n=33; 47,1%) foi o mais frequente, seguido pelo tipo A1 (n=18; 25,7%). Um total de 3 (10,3%) mulheres e 2 (6,9%) homens apresentaram CRMs bilaterais. A distribuição da frequência dos tipos de CRM observados em relação ao sexo está descrita na tabela 1.

Tabela 1. Distribuição da frequência dos tipos de canal retromolar e o sexo.

CANAL RETROMOLAR	Sexo		Total
	Masculino	Feminino	
	n(%)	n(%)	n(%)
Tipo A1	6(8,6)	12(17,1)	18(25,7)
Tipo A2	2(2,9)	2 (2,9)	4(5,8)
Tipo B1	11(15,7)	22(31,4)	33(47,1)
Tipo B2	5 (7,1)[a]	0(0,0)[b]	5 (7,1)
Tipo C	0(0,0)[a]	8 (11,4)[b]	8 (11,4)
Tipo A1 e B1	2(2,9)	0(0,0)	2 (2,9)
Total	26(37,2)	44(62,8)	70(100)

* letras diferentes em linha indicam diferença estatística significativa (p<0,05)

Na amostra avaliada, foi observado um caso com dois CRMs do mesmo lado (Figura 3), sendo classificados como tipo A1 e B1, uma vez que não preencheram os critérios para serem classificados em qualquer outro grupo.

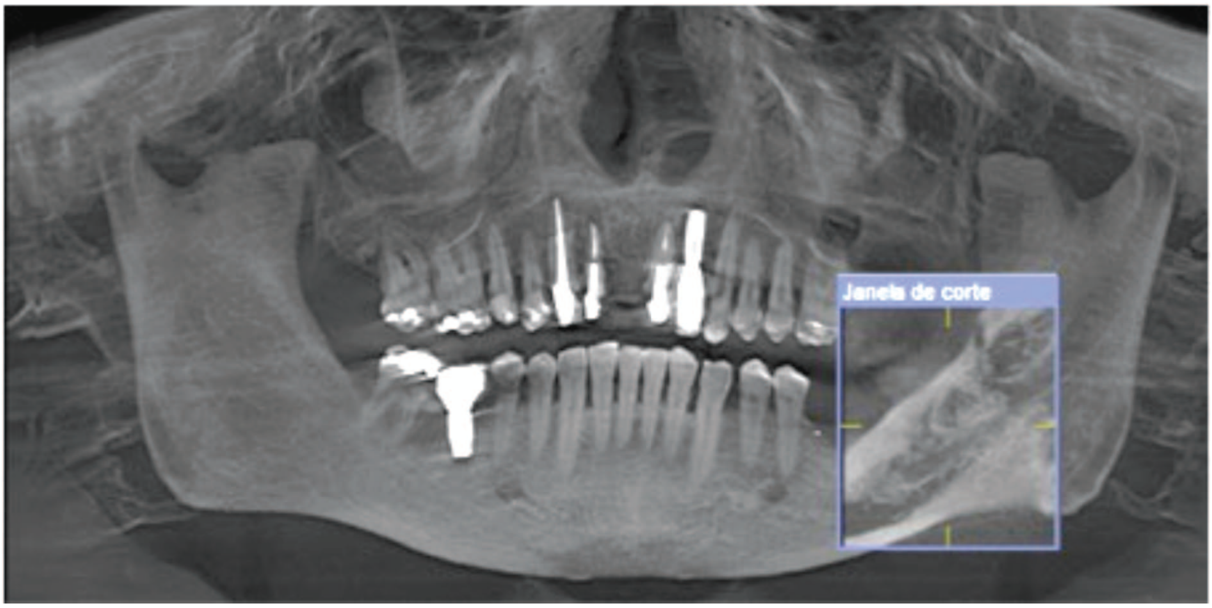

Figura 3. Reconstrução panorâmica demonstrando a presença de dois canais retromolares do mesmo lado.

O diâmetro dos CRMs apresentou valor médio de 0,97mm (±0,44; 0,86-1,07mm). O valor médio da distância entre forame retromolar e cortical vestibular da mandíbula foi 4,12mm (±1,35; 3,79-4,44mm), e o valor médio da distância do ponto mais anterior da curvatura do CRM à cortical óssea vestibular da mandíbula foi 3,72mm (±1,27; 3,41-4,02mm).

Não houve diferença significante entre as distâncias mensuradas e o sexo, assim como entre as distâncias e os lados ($p>0,05$).

Discussão

Complicações cirúrgicas durante ou após procedimentos na região posterior da mandíbula, podem estar associadas à presença de CRM[16,21], assim, propusemos-nos a descrever prevalência, localização e classificação do CRM em imagens de TCFC. No presente estudo, observou-se baixa prevalência de CRM. O CRM do tipo B1 foi o mais frequente na amostra e um caso incomum de CRM duplo do mesmo lado foi observado.

O CRM foi observado em 7,7% da amostra avaliada no presente estudo. A prevalência do CRM varia de 1 a 72% em mandíbulas secas[1,4,19,23], e de 12,4 a 46,8% em estudos *in vivo*[2,13,20]. Em nosso estudo, a prevâlencia de CRM foi inferior quando comparada a outros estudos que utilizaram a mesma metodologia: 8,8%(40/450)[13], 12,16%(216/1340)[21],14,6%(34/233)[20] .

Nossos resultados mostraram predominância de casos de CRM unilaterais, em concordância com a maioria dos estudos, que também mencionaram não haver diferença em relação à presença de CRM e lado de ocorrência[2,12,13,21,22].

Em relação à classificação do CRM, o tipo B1 (n=33, 47,1%) foi o mais frequente no presente estudo, seguido pelo tipo A1 (n=18, 25,7 %), o que está de acordo com os resultados de Patil et al. (2013)[12]. Por outro lado, outros estudos, que utilizaram a mesma classificação, encontraram maior frequência do CRM do tipo A1[2,21].

Neste estudo, foi observada a presença de dois CRMs em uma única imagem tomográfica de hemi-mandíbula, que, por sua, vez, não preenche nenhum dos critérios de classificação utilizados. Há diferentes classificações quanto ao trajeto do CRM[1,2,10,12]. Nesse estudo, foi utilizada a classificação descrita por Von Arx et al. (2011)[2], baseada na classificação de Ossenberg (1987)[1], que classifica o trajeto do CRM em cinco tipos.

No presente estudo, o diâmetro do CRM foi mensurado 3mm abaixo do forame retromolar, já que, nem sempre é possível observar a sua exteriorização. Foi observada variação entre 0,20 a 2,66mm no diâmetro do forame, o que está de acordo com estudos prévios que realizaram a mesma mensuração[2,21]. Outros estudos, que utilizaram metodologias diferentes para a mensuração, relataram variação entre 0,8 a 3,6 mm[12,13] no diâmetro do forame retromolar.

O valor médio da distância entre forame retromolar e cortical vestibular da mandíbula foi 4,12mm, no presente estudo. O ramo da mandíbula é utilizado como área doadora de blocos ósseos para enxertia prévia à colocação de implantes. A identificação da distância entre cortical óssea vestibular e eventuais detalhes anatômicos (sentido vestíbulo-lingual) é importante para o planejamento da espessura do enxerto a ser removido. Seguindo trabalhos clássicos da implantodontia[24,25], o enxerto ósseo deve ter dimensões máximas de aproximadamente 3-5 mm de espessura, de 30-35 mm de comprimento e não exceder 10 mm de altura. De acordo com nossos resultados, enfatizamos que o enxerto não deve ter espessura superior a 4mm na região posterior de mandíbula, para que haja sucesso na remoção do mesmo, com risco mínimo de lesão em feixe vásculo-nervoso.

As imagens bidimensionais, tais como radiografias panorâmicas, podem limitar a observação da região posterior da mandíbula[13,26-28]. Imagens pré-operatórias utilizando apenas radiografias panorâmicas podem levar a falhas na observação da presença do CRM, e consequentemente, a complicações cirúrgicas, que poderiam ser evitadas[15]. Devido a essas limitações, muitos estudos têm utilizado TCFC para observar estas variações anatômicas, podendo assim avaliar a sua localização além da relação com estruturas adjacentes [2,4,7,12,22,26,29-31] .

Por ser um estudo retrospectivo com análise de imagens, destaca-se como principal limitação da presente investigação, a dificuldade para acessar informações clínicas quanto a possíveis injúrias ao CRM na região estudada. Porém, deve ser ressaltado que os procedimentos cirúrgicos em região posterior da mandíbula precisam considerar as implicações clínicas decorrentes da eventual presença do CRM, uma vez que a região retromolar representa, com frequência, um local de acesso para cirurgias de extração de terceiros molares e também uma das áreas doadoras de blocos ósseos. A não identificação do canal e do forame retromolar pode acarretar em complicações durante procedimentos cirúrgicos na mandíbula, como, por exemplo, sangramento abundante, significativo edema pós-operatório e distúrbios sensoriais[4,7,11,13,15-18]. Dessa maneira, a observação do diâmetro e da exata posição do CRM em relação à cortical óssea vestibular da mandíbula representam fatores de identificação relevantes nos procedimentos realizados nessa região.

Conclusão

A presença do CRM na amostra estudada foi de 7,7%, predominantemente unilateral e do tipo B1.

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ARTIGO 2 - VERSÃO EM INGLÊS

CBCT study of the mandibular retromolar canal: Prevalence, types and location.

Running Title: CBCT study of the mandibular retromolar canal.

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Abstract

Objective: To describe the prevalence, location and clinical implications related to the presence of the retromolar canal (RMC) on cone beam computed tomography (CBCT) images. **Materials and methods:** CBCT images of patients from Latin America Institute for Dental Research and Education (Curitiba, Brazil) performed between June/2008 and February/2013 were evaluated by one examiner. The interpretation of the images was conducted according to the presence, location and classification of the RMC variation. The measurements of horizontal distances of the RMC in relation to the buccal bone cortical and the diameter of these canals were registered. **Results:** CBCT images of 751 patients, 486 (64.7%) women and 265 (35.3%) men with a mean age of 54.57 (±13.23;14-93) years, were interpreted. The presence of RMC was observed in 58 (7.7%) patients, 23 men and 35 women. Out of the 1,502 hemi-mandibles images, the presence of RMC was identified in 69(4.6%), 44(63.8%) from females and 25(36.2%) from males. A total of 30 (42.8%) RMC was observed on the right side and 40 (57.2%), on the left one. The type B1 (n=33; 47.1%) was the most common, followed by the type A1 (n=18; 25.7%). The mean diameter of RMC was 0.97mm±0.44, and the mean distance between retromolar foramen and the buccal cortical of the mandible was 4.12mm±1.35. There were no significant differences between distances and genders, and distances and sides ($p > 0.05$). **Conclusion:** The prevalence of RMC was 7.7% in the studied sample; they were predominantly unilateral and showed to be type B1.

Introduction

Among the anatomical variations of the mandibular canal, the retromolar canal (RMC) should be highlighted (Ossenberg 1987; Von Arx et al. 2011; Sekerci et al. 2013). It is projected from the posterior third of the mandibular canal and externalizes at retromolar foramen in the retromolar fossa (Ossenberg 1987; Bilecenoglu & Tuncer 2006; Von Arx et al. 2011). The trajectory is not constant and can present in different ways, thus changing the region to be supplied (Blanton & Jeske 2003).

RMC is coursed by branches that contribute to the innervation and supply of the third molar, the most posterior zone of the alveolar process, and the buccal gingival of mandibular pre-molars and molars. It may extend itself to areas of the temporal and buccinator muscle insertions (Schejtman et al.,1967; Ossenberg 1987). The identification of RMC becomes important for surgical procedures, such as, extraction of third molars, implant placement and bone graft procedures (Reyneke et al.2002; Bilecenoglu & Tuncer 2006; Suazo et al. 2007; Naitoh et al. 2009; Potu et al.2013; Sisman et al. 2015; Patil et al. 2013; Muinelo-Lorenzo et al. 2014). Injuries to this canal during surgical procedures are related to traumatic neuromas, profuse bleeding, significant postoperative swelling and temporary or permanent sensory disturbances (Singh 1981; Reyneke et al. 2002; Lew & Townsen 2006; Suazo et al. 2007; Potu et al. 2013; Muinelo-Lorenzo et al. 2014; Boronat Lopez & Penarrocha Diago 2016). Some studies suggest the relationship between the damage to this canal and its impact on the temporal and buccinator muscle fibers (Carter & Keen 1971; Singh 1981). Conversely, some authors suggested the hypothesis that the presence of RMC makes oropharynx infection spreads to the blood circulation easy because of its neurovascular bundle (Pinsolle et al. 1997).

The observation of this canal by conventional radiographic techniques is limited due to overlapping anatomical structures. The use of cone beam computed tomography (CBCT) provides a significant contribution to diagnosis and treatment planning (Kawai et al. 2012; Potu et al.2013). CBCT studies demonstrated the prevalence of RMCs ranging from 14 to 65 % (Von Arx et al. 2011; Bilecenoglu & Tuncer 2006; Naitoh et al. 2009; Lizio et al. 2013).

To our acknowledgement, there are few investigations aiming to describe the morphology and importance of RMC position. Due to this fact, the aim of this study was to describe the prevalence, classification and location of the RMC on CBCT images.

Materials and methods

This cross-sectional and retrospective observational study was approved by the Institutional Review Board (887.888/2014).

The overall sample consisted of CBCT images of patients attending the Radiology Department of Latin America Institute for Dental Research and Education (ILAPEO - Curitiba, Brazil) from June/2008 to February/2013. Using a statistic proportion sample calculation for a confidence interval of 95% and the maximum error of 2%, the size of the sample was based on the total number of CBCT images (approximately 3,000 images). Thus, the sample size was estimated in 1,334 images. The pre-operative CBCT imaging was requested for various clinical indications, mainly for implants planning, impacted-tooth extractions, and orthodontics treatments. The 3D images were obtained using a CBCT unit Galileos (Sirona, Bensheim, Germany). All images were performed using the following protocol for patient position and exposure acquisition parameters: occlusal plane parallel to the floor, 14 s, FOV 15x15 cm^3, 42 mAs, high contrast, 85 kV and 0.3 mm slice thickness. Exclusion criteria were images with the presence of pathological processes in the posterior region of the mandible and the presence of any artifacts that might affect the image quality. All CBCT scans analysis were performed using the Galaxis software version 1.7 (Sirona, Bensheim, Germany).

Radiographic Assessment and Measurements

All CBCT images interpretation were performed on a liquid crystal display monitor with a resolution of 1366 x 768 LCD Dell (Dell, TX) in a low-light room, by one trained examiner and, in case of doubt, another specialist was consulted. In order to assess intra-examiner variability, the CBCT images of 30 patients were randomly selected, and the same examiner performed a re-measurement after one month (Muinelo-Lorenzo et al. 2014). The following measurements were performed:

1) Variations of RMC were classified into five categories according to the its course and morphology (Ossenberg 1987; Von Arx et al. 2011) (Fig.1): type A1: vertical course of RMC; type A2: vertical course of RMC with additional horizontal branch; type B1: curved course of RMC; type B2: curved course of RMC with additional horizontal branch; type C: horizontal course of RMC.
2) Location of RMC (Fig.2): Sagittal reconstructions were rotated horizontally according to the course of RMC. Reference lines have been moved buccal/lingual to posterior/anterior aiming to achieve the best image of the course of the RMC for individual observation in axial and parasagittal images. The following measurements were performed: a) measurement from the most anterior point of the curvature of the RMC to the buccal cortical bone (horizontally); b) measurement from the buccal cortical bone to the retromolar foramen, 3mm below the crest.
3) The diameter of the retromolar foramen was measured 3 mm below the crest in axial images, according to Von Arx et al. 2011 and Filo et al. 2015.

Statistical analysis

Statistical analysis was performed using SPSS® version 21.0 for Windows (IBM Corporation, Armonk, NY). Descriptive statistics were performed. The level of intra-examiner agreement was assessed by Dahlberg's error (< 3%). The x^2 test and the t-test were used to test differences in frequency and the morphologic characteristics of RMC between genders. The level of significance for all tests was set at $p<0.05$.

Results

A total of 772 CBCT images (1,544 hemi-mandibles images) was interpreted. According to the exclusion criteria, 42 CBCT images were excluded from the study population: 31 showed inadequate image quality; 8 presented with metallic artifacts in the posterior region of the mandible (presence of implants or mini-implants), and 3 images showed radiopaque lesions compatible with bone sclerosis in the above mentioned region. The final sample comprised of 751 CBCT images, 486 (64.7%) were from female patients, and 265 (35.3%), from male ones, with mean age of 54.57 years (±13.23), ranging from 14 to 93 years.

The presence of RMC was observed in 58 (7.7%) patients, 23 men and 35 women. A total of 1502 hemi-mandibles were analyzed. The RMC was detected in 69(4.6%) hemi-mandibles, 44(63.8%) from females and 25(36.2%) from males. In one hemi-mandible, the presence of two RMC was observed, totaling 70 RMC observed in the sample. There were observed 30 (42.8%) RMC on the right side and 40 (57.2%) on the left side. The type B1 (n =33; 47.1%) was the most common, followed by the type A1 (n=18, 25.7%). A total of 3 (10.3%) women and 2 (6.9%) men showed double RMC.

The distribution of frequency of anatomical variations and gender is described in Table 1. The prevalence of type B2 was significantly higher in men compared with women. Women showed a higher frequency of type C compared to men ($p<0.05$). In the total sample, one patient showed two RMC on the same side, being classified as both type A1 and B1. The mean diameter of RMC was 0.97mm(±0.44) ranging from 0.86 to 1.07mm. The mean distance between retromolar foramen and the buccal cortical of the mandible was 4.12mm (±1.35; 3.79-4.44) and the mean distance between cortical curvature of RMC and the buccal cortical of the mandible was 3.72mm (±1.27; 3.41-4.02). There were no significant differences between the distances and gender, and distances and sides ($p > 0.05$)

Discussion

Because some complications may occur during or after surgical procedures in the posterior region of the mandible and their occurrence is associated with the presence of RMC (Boronat Lopez & Penarrocha Diago 2006; Filo et al.2015), we set out to describe the prevalence, location and clinical implications related to the presence of the RMC on CBCT images. In the present tomographic evaluation of 751 subjects, we found a low percentage (7.7%) of RMC. The type B1 was the most frequent, and an unusual presentation of double unilateral RMC was observed.

The prevalence of RMC ranges from 1% to 72% in dry mandibles (Ossenberg 1987; Bilecenoglu & Tuncer 2006; Kawai et al. 2012; Garnieldien & Schoor 2016), and from 12.4 to 46.8% in *in vivo* studies (Von Arx et al. 2011; Lizio et al.2013; Muinelo-Lorenzo et al. 2014). The prevalence of RMC observed in this study (7.7%) is lower compared to other studies that used the same methodology: 14.6% (34/233) (Lizio et al. 2013); 8.8% (40/450) (Muinelo-Lorenzo et al. 2014) and 12.16% (216/1340) (Filo et al. 2015). Our results showed predominantly unilateral presence of RMCs, in accordance with the majority of the studies that mentioned that there was no difference in the occurrence of RMCs regarding the sides of the mandible (Von Arx et al. 2011; Patil et al. 2013; Muinelo-Lorenzo et al. 2014; Kang et al. 2014; Filo et al.2015).

According to the classification, the type B1 (n=33, 47.1%) was the most frequent in the present study, followed by type A1 (n=18, 25.7 %). This is in accordance with Patil et al. (2013) who observed prevalence of 75.2% (97/129) of type B1 RMC, followed by type A1 (n=19/14.7%). Conversely, others studies that used the same classification showed a higher frequency for type A1: 41.9%(n=13)(Von Arx et al. 2011); 39.8 %(n=86) (Filo et al. 2016), in contrast to type B1: 29% (n=9))(Von Arx et al. 2011); 24% (n=52) (Filo et al. 2016).

In this study we added a previously undescribed canal presentation: the presence of two RMCs on the same side, which did not meet the criteria for classification into any other group. There are different classifications of the course of the RMC (Ossenberg 1987; Von Arx et al. 2011; Patil et al.2013; Sisman et al.2015). We used the classification described by Von Arx et al. (2011) based on the classification of Ossenberg (1987), which distinguishes the course of the RMC in five different types.

In the present study, the diameter of RMCs was determined 3mm below the retromolar foramen, because it is not always possible to observe its externalizing. Due to this fact a variation between 0.20 to 2.66mm in the diameter of RMC was observed, corroborating with previous studies in which measurements had been carried out following the same methodology (Von Arx et al. 2011; Filo et al. 2016). Others studies that used unspecific measuring point showed variations from 0.8 to 3.6mm (Patil et al. 2013; Muinelo-Lorenzo et al. 2014). In the present study, the mean distance between retromolar foramen and the buccal cortical of the mandible was 4.12mm. Considering the use of the mandibular ramus as a donor site for onlay grafting prior to implant placement, the bone graft should have dimensions of approximately 3-5 mm in thickness, 30-35 mm in length and do not exceed 10mm in height (Mish 2000; Di Bari et al.2004). Due this fact, the knowledge of the position of RMC in relation to the buccal cortical bone of the mandible should be emphasized. Two-dimensional images, such as panoramic radiographs, may limit the observation of the posterior region of the mandible (Levine et al. 2007; Naitoh et al.2010; Ozturk et al.2012; Muinelo-Lorenzo et al.2014). Pre-operative images using only panoramics may lead to underestimation of the presence of RMC and to surgical complications, which could have been avoided[15]. Because of these limitations, many studies have used CBCT to observe these anatomical variations, assessing the exact location and relationship to adjacent structures (Bilecenoglu & Tuncer 2006; Levine et al.2007; Kuribayashi et al. 2010; Von Arx et al. 2011; Mizbah et al.2012; Fukami et al.2012; Potu et al.2013; Patil et al.2013; Filo et al.2016).

Surgical procedures involving the posterior region of the mandible need to consider the clinical implications of RMC. Because of the retrospective character of this study, it can be highlighted as the main limitation the difficulty to access clinical information regarding eventual injuries to the RMCs in the posterior region. However, it should be emphasized that the retromolar region represents a frequently access site during third extraction and a donor site of harvesting bone blocks; the absence of identification of RMC and retromolar foramen might put a patient at risk for surgical canal damage during surgical procedures in the mandible, that are related to profuse bleeding, significant postoperative swelling and sensory disturbances on the retromolar region (Carter & Keen 1971; Pinsolle et al.1997; Bilecenoglu & Tuncer 2006; Lew & Townsen 2006; Boronat Lopez & Penarrocha Diago 2006; Suazo et al.2007; Potu et al.2013; Muinelo-Lorenzo et al.2014). Thus, we should be warned that the diameter and the exact position of the RMC in relation to the buccal cortical bone of the mandible represents relevant factors for visualization.

Conclusion

The prevalence of RMC was 7.7% in the studied sample, predominantly unilateral, and classified as type B1.

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Figures and Table

A1 A2 B1 B2 C

Figure 1. Schematic drawing representing the anatomical variations of the retromolar canal according to Von Arx et al,2011[2]

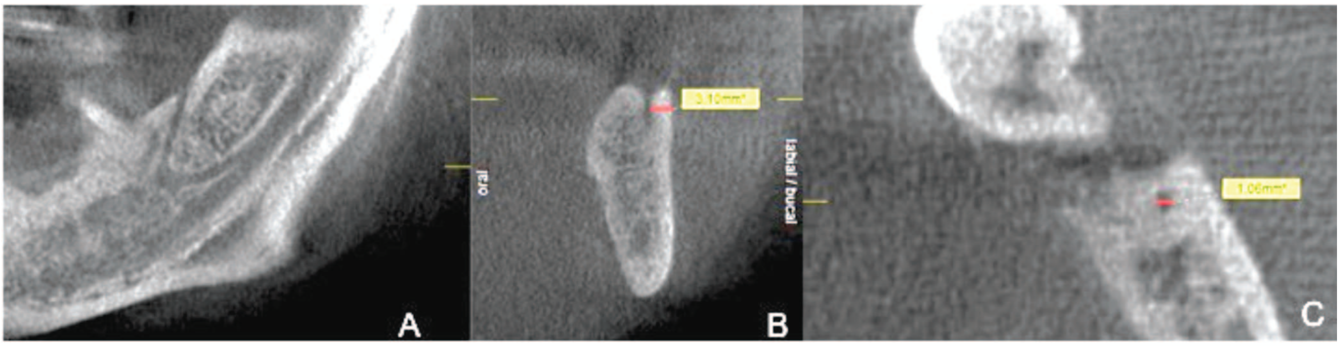

Figure 2.A. Sagittal cross sections showing the best image of the course of the RMC. B. Parasagittal cross sections for measurement of the distance between buccal cortical bone and the retromolar foramen. C. Axial cross sections showing the diameter of retromolar foramen.

Table 1. Distribution of retromolar canal variations and gender.

RETROMOLAR CANAL	Sex		Total
	Male	Female	
	n(%)	n(%)	n(%)
Type A1	6(8.6)	12(17.1)	18(25.7)
Type A2	2(2.9)	2 (2.9)	4(5.8)
Type B1	11(15.7)	22(31.4)	33(47.1)
Type B2	5 (7.1)	0(0.0)	5 (7.1)
Type C	0(0.0)	8 (11.4)	8 (11.4)
Type A1 e B1	2(2.9)	0(0.0)	2 (2.9)
Total	26(37.2)	44(62.8)	70(100)

ARTIGO 3 - VERSÃO EM PORTUGUÊS

Acurácia da radiografia panorâmica na detecção do canal retromolar

Resumo

Introdução: O canal retromolar (CRM) é uma importante variação anatômica do canal da mandíbula. Sua observação por meio de radiografias panorâmicas é um pouco limitada devido a sobreposição de estruturas anatômicas, o que pode gerar dúvidas quanto a sua presença e localização. **Objetivos:** Avaliar a acurácia da radiografia panorâmica na identificação do CRM. **Materiais e Métodos:** A amostra foi composta por imagens de tomografia computadorizada de feixe cônico (TCFC) e de radiografias panorâmicas de 26 pacientes, pertencentes ao acervo do Instituto Latino Americano de Pesquisa e Ensino Odontológico - Ilapeo /Curitiba/PR, que apresentavam CRM. A interpretação foi realizada por um examinador calibrado. Os resultados da acurácia da radiografia panorâmica foram estimados pela sensibilidade, especificidade, valor de falso positivo e valor de falso negativo para identificação do CRM. **Resultados:** Trinta e um CRM foram observados nas 26 imagens de TCFC analisadas, sendo que apenas 18 foram identificados por meio de radiografias panorâmicas. A sensibilidade da radiografia panorâmica foi de 0,56 (56,25%). A probabilidade de identificação de CRM na radiografia panorâmica foi de 30% e a probabilidade de identificação da sua ausência na radiografia panorâmica foi de 43,75%. **Conclusão:** As radiografias panorâmicas apresentaram baixa acurácia na identificação dos CRMs. Para melhor determinação, a TCFC deve ser considerada como método de escolha.

Palavras-chave: Canal retromolar, radiografia panorâmica, variação anatômica, tomografia computadorizada de feixe cônico.

Introdução

A radiografia panorâmica é uma das técnicas radiográficas mais solicitadas e difundidas para avaliação da região maxilofacial na prática odontológica, proporcionando visão geral das estruturas dento-maxilo-mandibulares, além de apresentar baixas doses de radiação[1,2]. No entanto, algumas limitações podem gerar dificuldades na interpretação das imagens[3].

Algumas variações do canal da mandíbula (CM) são observadas por meio de radiografias panorâmicas e tomografia computadorizada de feixe cônico (TCFC). Ao comparar estudos de investigações anatômicas e radiográficas do CM, são descritos relatos de que as radiografias panorâmicas podem subestimar a morfologia do CM, porque são limitadas para detecção de canais bífidos[4-6]. A prevalência de CM bífidos em radiografias panorâmicas varia entre 0,35% a 0,95%[7-9], enquanto em imagens de TCFC, há variação entre 10% a 66% [10-13].

Uma das mais importantes variações anatômicas do CM é o canal retromolar (CRM) que surge a partir de uma bifurcação do CM, e projeta-se posteriormente para a região do terceiro molar, exteriorizando-se pelo forame retromolar[6,12,14]. O conhecimento do trajeto do CM e suas variações anatômicas é de grande importância, pois seu conteúdo neurovascular, se lesado, pode levar a complicações, tais como: hemorragia, e agressão aos ramos nervosos durante procedimentos cirúrgicos, como a remoção de blocos ósseos, extrações de terceiros molares ou durante cirúrgias ortognáticas[15-20].

Frente a esse fato, o objetivo do presente estudo foi avaliar a acurácia da radiografia panorâmica na observação do CRM.

Materiais e Métodos

Este estudo foi aprovado pelo Comitê de Ética em Pesquisa da Pontifícia Universidade Católica do Paraná (PUCPR) (887.888/2014).

Amostra e avaliação na TCFC

A população do estudo consistiu de imagens de TCFC e de radiografias panorâmicas de pacientes atendidos no Departamento de Radiologia do Instituto Latino Americano de Pesquisa e Ensino Odontológico - Ilapeo /Curitiba/PR, obtidas entre o period de junho/2008 a fevereiro/2013. As imagens de TCFC e as radiografias panorâmicas foram indicadas por vários motivos clínicos, dentre eles, o planejamento de instalação de implantes, extrações de dentes impactados e tratamentos de ortodontia. Foram interpretadas todas as imagens tomográficas da região de ramo da mandíbula de ambos os lados. Os critérios de exclusão foram: imagens de pacientes com história de trauma ou intervenções cirúrgicas (ortognáticas ou lateralização do nervo alveolar inferior); presença de processos patológicos na região posterior de mandíbula e presença de qualquer tipo de artefato que pudesse afetar a qualidade da imagem. Foram incluídas na amostra imagens de TCFC, onde a presença do CRM foi detectada. Em seguida, as radiografias panorâmicas dos pacientes cujas imagens de TCFC exibiam presença de CRM também foram incluídas na amostra.

Imagens de TCFC

As imagens foram obtidas por meio de um tomógrafo computadorizado de feixe cônico Galileos@ (*Sirona, Bensheim*, Alemanha). Os fatores de aquisição para as tomografias foram constantes: 14 segundos de aquisição, FOV de 15x15 cm^3, 42 mAs, alto contraste, 85 kV e espessura de corte de 0,3 mm. A técnica foi realizada de forma padronizada: posição da cabeça do paciente com o plano oclusal paralelo ao solo e o plano mediano perpendicular ao solo. Todas as imagens foram avaliadas por meio do *software Galaxis* versão 1.7 (*Sirona, Bensheim,* Alemanha). A interpretação das imagens foi realizada em ambiente escurecido, utilizando monitor *LCD Dell* (Dell, Texas, EUA), 18”5 polegadas, resolução 1366 x 768, por um único examinador devidamente calibrado e em caso de dúvidas um segundo radiologista foi consultado.

Imagens de radiografia panorâmica

A partir das imagens tomográficas selecionadas com a presença de CRM, as radiografias panorâmicas correspondentes foram incluídas na amostra. As radiografias panorâmicas foram obtidas por meio de um aparelho panorâmico digital Orthophos XG (*Sirona, Bensheim*, Alemanha). Os fatores de aquisição foram constantes: 14s, 73kV e 15 mA. A técnica foi realizada de forma padronizada, posição da cabeça do paciente com o plano de Frankfurt paralelo ao solo e o plano mediano perpendicular ao solo.

A interpretação das radiografias panorâmicas foi realizada pelo mesmo examinador, em uma sala escura utilizando um monitor de tela de cristal líquido com resolução de 1366 x 768 *LCD Dell* (Dell, Texas, EUA). Com o objetivo de avaliar a concordância intra-examinador, 15 radiografias panorâmicas foram aleatoriamente selecionadas e, após 30 dias, estas mesmas imagens foram novamente avaliadas[19]. A concordância intraexaminador foi verificada pelo teste estatístico de Cohen Kappa (k = 0,71).

Análise estatística

A análise estatística foi realizada utilizando o programa SPSS® versão 20.0 para *Macintosh (IBM Corporation, Armonk, NY)*. Os resultados da acurácia da radiografia panorâmica como método de diagnóstico do CRM em relação as imagens de TCFC foram estimados pela sensibilidade, especificidade, valor de falso positivo e valor de falso negativo.

Resultados

Um total de 751 imagens de TCFC (1502 imagens de hemi-mandíbulas) foram interpretadas no período de desenvolvimento do trabalho. A presença do CRM foi observada em 69 hemi-mandíbulas (4,6%), pertencentes a 58 pacientes. Dos 58 pacientes, apenas 26 apresentavam radiografias panorâmicas. Desta forma, para permitir o cálculo de especificidade e sensibilidade do método, foram incluídas no estudo as radiografias panorâmicas correspondentes às 26 imagens tomográficas dos pacientes que apresentaram CRM. Nas imagens de TCFC dos 26 pacientes, foram observados 31 CRM. Destes, apenas 18 foram identificados nas radiografias panorâmicas correspondentes (Fig 1A e 1B). Isto representa uma taxa de observação do CRM nas radiografias panorâmicas de 58%. A sensibilidade da radiografia panorâmica foi de 0,56, ou seja, o avaliador detectou corretamente 56,25% de presença do CRM nas radiografias panorâmicas, os quais também estavam presentes nas imagens de TCFC. A especificidade foi de 0,70, demonstrando que 70% das imagens que não apresentaram CRM nas TCFC foram corretamente diagnosticados com ausência de CRM na radiografia panorâmica.

A probabilidade de identificar a presença do CRM na radiografia panorâmica, quando ausente nas imagens de TCFC, foi de 30% (valor falso-positivo). A probabilidade de identificar a ausência do CRM na radiografia panorâmica, quando presente nas imagens de TCFC, foi de 43,75% (valor falso-negativo). Na tabela 1, estão descritos os valores de sensibilidade, especificidade, falsos-positivos e falsos-negativos.

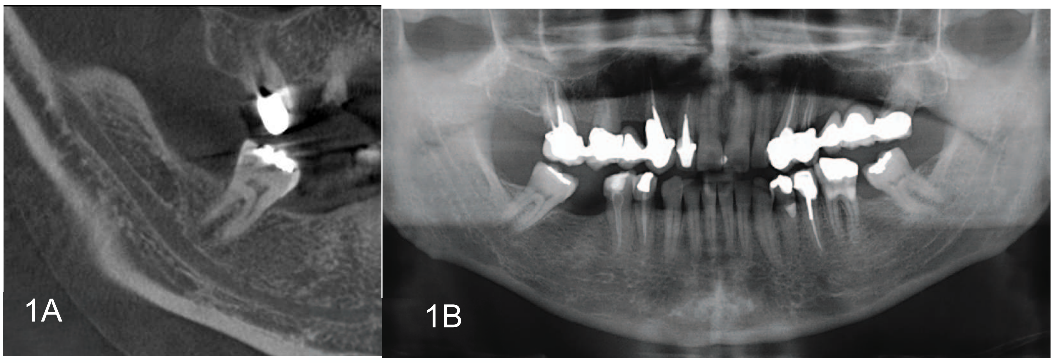

Fig. 1A. Reconstrução sagital demonstrando a presença de canal retromolar (lado direito); 1B. Radiografia panorâmica demonstrando a dificuldade na observação do canal retromolar.

Tabela 1. Valores de sensibilidade, especificidade, falso-negativo e falso-positivo das imagens de radiografia panorâmica em relação as imagens de tomografia computadorizada de feixe cônico (TCFC) na observação do canal retromolar (CRM).

CRM (Radiografia Panorâmica)	**CRM (TCFC)**	
	Ausência	**Presença**
Ausência	70% Especificidade	43,75% Valor falso-negativo
Presença	30% Valor falso-positivo	56,25% Sensibilidade

Discussão

Limitações na localização exata das variações do CM nas imagens bidimensionais são relatadas[13,21]. Dentre as variações do CM, destaca-se o CRM, que é um subtipo do CM, observado em estudos anatômicos e radiológicos[6,17]. Considerando que a região retromolar representa um local frequente de remoção de blocos ósseos para enxertos e cirurgia do terceiro molar, a localização do CRM deve ser cuidadosamente avaliada durante o planejamento de procedimentos cirúrgicos nessa região de modo a evitar lesões ao feixe neurovascular[6,15-20]. Uma vez que na clínica odontológica, as radiografias panorâmicas são muito utilizadas, propusemo-nos a avaliar a acurácia das panorâmicas na detecção do CRM, tendo como referência as imagens de TCFC. No presente estudo, a sensibilidade da radiografia panorâmica em detectar CRM foi de 56,25% e a especificidade, de 70%. Os valores falso-positivo e falso-negativo da radiografia panorâmica foram 30% e 43,75%, respectivamente.

No presente estudo, dos 31 CRM detectados nas imagens de TCFC dos 26 pacientes, 18 (58%) CRM foram identificados nas radiografias panorâmicas, o que refletiu em sensibilidade do método de 56,25%. Esse valor é superior a valores relatados em estudos anteriores: 46,8%[22], 32,5%[19], e 23%[6]. Esta diferença pode estar relacionada com diferenças na interpretação radiográfica ou a fatores anatômicos, como em casos de CRM muito estreitos, o que pode levar a uma dificultadade em sua observação.

O valor falso-negativo da radiografia panorâmica em nosso estudo foi 43,75%, mostrando que pacientes que apresentaram CRM nas imagens de TCFC foram diagnosticados como não os apresentando nas imagens panorâmicas. Esse dado reforça que a capacidade da radiografia panorâmica em detectar o CRM é limitada[6,19]. Algumas limitações podem contribuir para interpretação inadequada das estruturas anatômicas nas panorâmicas, tais como: presença de sobreposições de estruturas anatômicas inerentes à técnica rotacional e/ou posicionamento inadequado do paciente causando distorção na imagem[23].

A baixa acurácia da radiografia panorâmica observada nesse estudo reflete a variabilidade de prevalência do CRM relatada na literatura. Em panorâmicas a prevalência de CRM varia entre 0,08 a 0,95%[7-9,24]. Por outro lado, nas imagens de TCFC a prevalência varia entre 14% a 75% em diferentes populações[6,17,25,26]. A TCFC oferece melhor visualização das estruturas anatômicas, tais como: diâmetro, localização exata e direção dos canais acessórios e sua relação com estruturas anatômicas adjacentes[10,12,13,17,25] Assim, quando houver suspeita da presença do CRM ou outros canais acessórios do CM na radiografia panorâmica, a TCFC deve ser solicitada para confirmação. De acordo com recomendações internacionais[27,28], as quais aplicam que, as imagens tomográficas devem ser indicadas nos casos específicos em que são necessárias maiores informações para o plano de tratamento. Essa decisão dependerá de exame clínico detalhado e aplicação de técnicas radiográficas intra e/ou extrabucais. Desta forma, a técnica radiográfica escolhida deve fornecer informações necessárias, com menor exposição do paciente à radiação.

Conclusão

As radiografias panorâmicas apresentaram acurácia moderada a baixa na identificação de CRM. Para melhor determinação, quando necessário, a TCFC deve ser considerada como método de escolha.

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ARTIGO 3 - VERSÃO EM INGLÊS

Title: Diagnostic accuracy of panoramic radiograph in detecting the retromolar canal

Short title: Accuracy of panoramic radiograph on retromolar canal observation

Type of manuscript: Short Communication

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Abstract

Objectives: To assess the diagnostic accuracy of panoramic radiography for detection of the retromolar canal (RMC). **Methods:** The sample consisted of 26 images of cone beam computed tomography (CBCT) and panoramic radiographs from Latin America Institute for Dental Research and Education - Curitiba, Brazil. The interpretation was performed by a calibrated examiner. The accuracy of panoramic radiograph was estimated by sensitivity, specificity, false positive and false negative values. **Results:** Out of the 31 RMC observed on 26 panoramic radiographs, 18 were identified using panoramic radiographs. The sensitivity of the panoramic radiograph was 0.5625 (56.25%). The probability of the RMC to be identified in the panoramic radiograph was 30% and the probability of identifying its absence in the panoramic radiograph was 43.75%. **Conclusion:** Panoramic radiographs showed low accuracy in the identification of RMC.

Keywords: Mandible; anatomic variation; panoramic radiography; cone-beam computed tomography.

Introduction

The panoramic radiograph is one of the most requested radiographic techniques to evaluate the maxillofacial region in dental practice, providing an overview of the maxillofacial structures with lower doses of radiation.[1,2] However, some limitations may cause difficulties in interpreting the imagens.[1] Some variations of the mandibular canal (MC) have been reported using panoramic radiographs and cone beam computed tomography (CBCT). Comparing anatomical and radiographic investigations, some authors believe that panoramic radiograph images under-estimate the morphology of this structure, because they are insufficient to detect all bifid canals.[3-7] The prevalence of bifid mandibular canal on panoramic radiographs varies 0.35% to 0.95%;[5-7,11] on CBCT images, it ranges from 10% to 66%.[8,9,12]

One of the most important anatomical variations of the MC is the retromolar canal (RMC). Frequently, the RMC comes attached to the MC; it is projected to the third molar region and externalizes in the retromolar foramen.[5,10,13] The knowledge of the course of the MC and its anatomical variations is of great importance because the neurovascular content through this canal can lead to eventual complications, such as hemorrhage, and aggression to nerve branches during surgical procedures (i.e. removal of bone blocks, third molar extraction, orthognathic surgery).[5,9,13] Thus, the aim of the present study was to assess the diagnostic accuracy of panoramic radiographs in the detection of the RMC.

Materials and methods

This study was approved by the Local Ethics and Research Committee (887.888/2014).

Patients and CBCT Assessment

The overall sample consisted of CBCT images and panoramic radiographs of patients attending the Radiology Department of Latin America Institute for Dental Research and Education (ILAPEO - Curitiba, Brazil) from June/2008 to February/2013. The pre-operative CBCT imaging was requested for various clinical indications, mainly for implants planning, impacted-tooth extractions, and orthodontics treatments. The 3D images were obtained using a CBCT unit Galileos (Sirona, Bensheim, Germany). All images were performed using the following protocol for patient position and exposure acquisition parameters: occlusal plane parallel to the floor, 14 s, FOV 15x15 cm^3, 42 mAs, high contrast, 85 kV and 0.3 mm slice thickness. Exclusion criteria were images with the presence of pathological processes in the posterior region of the mandible and the presence of any artifacts that might affect the image quality. All CBCT scans analysis were performed using the Galaxis software version 1.7 (Sirona, Bensheim, Germany). CBCT images with the presence of RMC were included in the sample; then all the corresponding panoramic radiographs of patients whose CBCT showed RMC presence were also included in the sample.

Panoramic Radiograph Assessment

Panoramic radiographs were obtained by a digital panoramic machine Orthophos XG (Sirona, Bensheim, Germany). The acquisition factors were constant: 14s, 73kV and 15mA. Panoramic radiographs interpretation were performed by one trained examiner, on a liquid crystal display monitor with a resolution of 1366 x 768 LCD Dell (Dell, TX), in a low-light room. In order to evaluate the intra-examiner agreement, the following condition was adopted: 15 panoramic radiographs were randomly selected and evaluated, and after 30 days, these same images were re-evaluated.[12] Intraexaminer assessment agreement was verified by Cohen Kappa test (k = 0.71).

Statistical Analysis

Statistical analysis was performed using SPSS® version 20.0 for Macintosh (IBM Corporation, Armonk, NY). The results of the accuracy of panoramic radiographs as a diagnostic method for RMC detection compared to CBCT images were estimated by sensitivity, specificity, false positive value and false negative value.

Results

A total of 751 CBCT images (1502 hemi-mandibles images) was interpreted. The RMC was observed in 69 (4.6%) CBCT images from 58 patients. Of the 58 patients, only 26 had panoramic radiographs. Thus, to allow the specificity and sensitivity of the method, the panoramic radiographs from the 26 patients whose CBCT images showed the RMC presence were included in the study. In the 26 CBCT images 31 RMC were observed. Of these, only 18 (58%) were identified in the corresponding panoramic radiographs (Figure 1a and 1b). The sensitivity of the panoramic radiograph was 0.56, showing that the examiner correctly detected 56% of RMC in panoramic radiographs, which were also present in CBCT images. The specificity of panoramic radiographs was 0.70, showing that 70% of the images of RMC that were not present in the CBCT images were correctly diagnosed as RMC absence in the panoramic radiograph.

The probability of identifying the RMC presence in the panoramic radiograph, when it was absent in CBCT images, was 30% (false positive value). The probability of identifying the absence of RMC in the panoramic radiograph, when it was present in CBCT images, was 43.75% (false negative).

Discussion

Limitations on the exact location of the MC variations in two-dimensional images are reported.[9,11] Among the variations of the MC, there is the RMC, which is a subtype of the MC observed in anatomic and radiologic studies.[5,13] The retromolar region is a frequent site of bone grafts and third molar surgery. The location of the RMC should be carefully considered during the planning of surgical procedures in this region in order to avoid injury to the neurovascular bundle.[5,9,13] Because panoramic radiographs are widely used in dental practice, we set out to evaluate the accuracy of the detection of the RMC on panoramic images, having the CBCT images as reference. In this study, the sensitivity of panoramic radiography in detecting RMC was 56.25%, and the specificity was 70%. False-positive and false-negative values of the panoramic images were 30% and 43.75%, respectively.

In this study, out of the 31 RMC detected in 26 CBCT images, 18 (58%) were identified on panoramic radiographs, which resulted in 56.25% of sensitivity of the method. This value is higher than others reported in previous studies: 23%,[5] 32.5%,[12] and 46.8%.[14] These differences may be related to differences in radiographic interpretation or anatomical factors, such as in cases of very narrow RMC, which may difficult the observation.

The false-negative value of panoramic radiographs in our study was 43.75%, showing that patients who had RMC in CBCT images were diagnosed as not having in the panoramic images. This data reinforces that the ability of panoramic radiography in detecting the RMC is limited.[5,12] Some limitations may contribute to inadequate interpretation of anatomical structures in the panoramic radiograph, such as the presence of overlapping structures related to the technique and/or inadequate patient positioning.[1,11]

Low accuracy of panoramic radiograph observed in this study reflects the variability in prevalence of RMC reported in the literature. In panoramic images, RMC prevalence ranges from 0.08 to 0.95%.[5-7,11] Conversely, CBCT images prevalence varies from 14% to 75% in different populations.[5,8,9,12,13] The CBCT provides better visualization of these structures, such as diameter, exact location and direction of the accessory canals, and its relationship to adjacent anatomical structures.[4,8,9,12] When there is a suspicion of the presence of accessory mandibular canals in panoramic radiograph, CBCT should be requested for confirmation. This is in accordance with international recommendations:[2,15] tomographic images should be indicated in the cases where more information to the treatment plan are needed. This decision will depend on detailed clinical examination and application of intra or extraoral radiographic techniques. Thus, the selected radiographic technique must provide necessary information with less radiation exposure to patient.

Conclusion

Panoramic radiographs showed a low accuracy in identification of RMCs. For better determination of its presence, a CBCT device should be considered.

Acknowledgements

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Figures

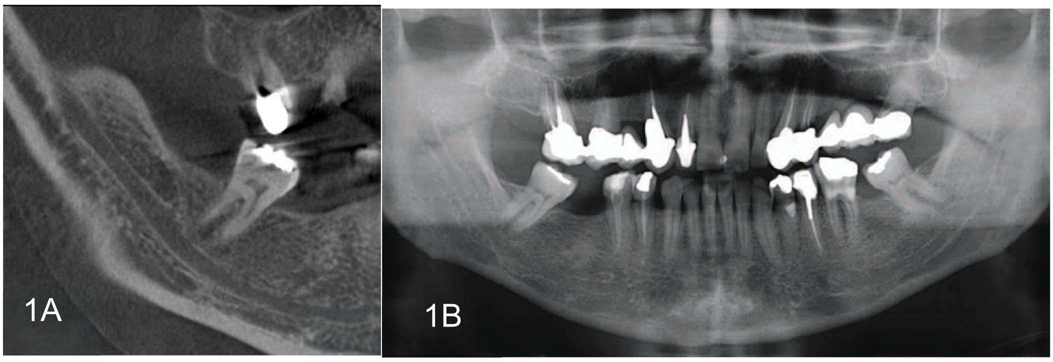

Fig. 1A. Sagittal reconstruction showing a RMC (right side); 1B. RMC could not be identified on panoramic radiography

CONCLUSÕES

Com base nos resultados encontrados, conclui-se que:

- A prevalência de variações do canal da mandíbula e do canal retromolar foi baixa na amostra estudada;
- O tipo mais frequente de canal da mandíbula foi o tipo I, enquanto o canal retromolar apresentou-se predominantemente unilateral e do tipo B1;
- As radiografias panorâmicas apresentaram baixa acurácia na identificação do canal retromolar.

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ANEXOS

Anexo 1

Parecer do Comitê de Ética em Pesquisa

Comitê de Ética em Pesquisa da PUCPR

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PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Avaliação da região posterior de mandíbula por meio de tomografia computadorizada de feixe cônico

Pesquisador: Luciana Reis Azevedo Alanis

Área Temática:

Versão: 1

CAAE: 38849914.0.0000.0020

Instituição Proponente: Pontifícia Universidade Católica do Parana - PUCPR

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 887.888

Data da Relatoria: 25/11/2014

Apresentação do Projeto:

Estudo retrospectivo que consistirá em avaliar a localização do canal da mandíbula; as implicações clínicas relacionadas com as alterações de localização do canal da mandíbula; a prevalência e a localização do canal retromolar e as implicações clínicas e/ou cirúrgicas relacionadas com a presença do canal retromolar. Serão avaliadas 3000 tomografias computadorizadas de feixe cônico, de acordo com alguns critérios de inclusão e exclusão.

Objetivo da Pesquisa:

Objetivo Primário:

Avaliar as variações anatômicas do canal da mandíbula em região posterior, por meio da tomografia computadorizada de feixe cônico, avaliando suas implicações clínicas.

Objetivo Secundário:

• Avaliar a localização do canal da mandíbula; • Avaliar as implicações clínicas relacionadas com as alterações de localização do canal da mandíbula;• Avaliar a prevalência e a localização do canal retromolar;• Avaliar as implicações clínicas e/ou cirúrgicas relacionadas com a presença do canal retromolar

Avaliação dos Riscos e Benefícios:

Riscos:

Em um contexto geral, considera-se que não há riscos uma vez que este estudo está baseado em uma análise de exames (tomografias computadorizadas de feixe cônico) que são parte de um arquivo de tomografias do Instituto Latino Americano de Pesquisa e Ensino Odontológico (ILAPEO), Curitiba, Paraná. Este instituto de pesquisa atende um grande número de pacientes, os quais necessitam de reabilitações bucais. Para que estas reabilitações sejam realizadas, exames tomográficos são solicitados. Assim, as tomografias que compõem esta amostra não foram solicitadas para a realização deste estudo. O estudo prevê o anonimato dos participantes.

Benefícios:

A realização deste estudo será de grande importância para a comunidade científica uma vez que o conhecimento das variações anatômicas do canal da mandíbula é de considerável importância, pois o conteúdo vásculo-nervoso que passa por este canal pode levar a eventuais complicações, tais como; hemorragia, falhas na anestesia, agressão a ramos nervosos durante procedimentos cirúrgicos, como a remoção de blocos ósseos ou durante cirurgias de maiores dimensões, como avanços ou recuos mandibulares em cirurgias ortognáticas (KODERA & HASHIMOTO, 1995; REYNEKE, TSAKIRIS & BECKER, 2002; BILENENOGLU E TUNCER, 2006; SUAZO et al.,2007 e POTU et al.,2013;MUINELO-LORENZO et al,2014). Para os participantes deste estudo, não haverá benefício direto individual. Ao fazer parte desta investigação, ele contribuirá para que mais informações sejam obtidas a respeito da presença de variações anatômicas na região posterior da mandíbula.

Comentários e Considerações sobre a Pesquisa:

Projeto de pesquisa relevante, metodologicamente adequado.

Considerações sobre os Termos de apresentação obrigatória:

TCUD adequado.

Recomendações:

Não há.

Conclusões ou Pendências e Lista de Inadequações:

Projeto de pesquisa aprovado.

Situação do Parecer:

Aprovado

Necessita Apreciação da CONEP:

Não

Considerações Finais a critério do CEP:

Anexo 2. Normas para publicação do artigo 1 e 3.

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- Peer-review process
- Permissions
- Post acceptance
- For NIH-funded authors
- Promote your article

The abstract should be an accurate and succinct summary of the paper, not exceeding **250 words**. For papers containing research: the abstract should be constructed under the following subheadings:

- Objectives;
- Methods;
- Results;
- Conclusions.

These subheadings should appear in the text of the abstract and the abstract should not contain references. The abstract should: indicate the specific objective or purpose of the article; describe the methods used to achieve the objective, stating what was done and how it was done; present the findings of the methods described – key statistics should be included; present the conclusion of the study based solely on the data provided, and highlight the novelty of the work.

Beneath the abstract please select up to 5 keywords from the current Medical Subject Headings (MeSH).

Main text

Please organise your paper in a logical structure with clear subheadings to indicate relevant sections. It is up to the authors to decide the specific nature of any subheadings as they see fit. Research papers typically follow the structure:

- Introductory section;
- Methods and materials/patients;
- Results;
- Discussion;
- Conclusion;
- Acknowledgments (if relevant).

Present results in a clear logical sequence. The conclusions drawn should be supported by the results obtained and the discussion section should comment critically on the findings and conclusions as well as any limitations of the work.

Acknowledgments should be brief and should indicate any potential conflicts of interest and sources of financial support.

An appendix may be used for mathematical formulae or method details of interest to readers with specialist knowledge of the area.

In addition:

- Avoid repetition between sections.
- Avoid repetition of text featured in tables and the main body of the article.
- Abbreviations and acronyms may be used where appropriate, but must always be defined where first used.
- The names and locations (town, country) of manufacturers of all equipment and non-generic drugs must be given.
- Avoid the use of footnotes.
- Use SI units throughout the text (Grays, Sieverts not RADs and REMs).

References

- Authors are responsible for the accuracy of the references. Only papers closely related to the work should be cited; exhaustive lists should be avoided. All references must appear both in the text and the reference list.
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- At the end of the paper they should be listed (double-spaced) in numerical order corresponding to the order of citation in the text.
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- References to private communications should be given only in the text (i.e. no number allocated). The author and year should be provided.
- If there are 6 or fewer authors, list them all. If there are 7 or more, list the first 6 followed by et al.
- Abbreviations for titles of medical periodicals should conform to those used in the latest edition of Index Medicus.
- The first and last page numbers for each reference should be provided.
- Abstracts and letters must be identified as such.

Examples of references:

Journal article:
Gardner DG, Kessler HP, Morency R, Schaffner DL. The glandular odontogenic cyst: an apparent entity. J Oral Pathol 1988; 17:359–366.

Journal article, in press:
Dufoo S, Maupome G, Diez-de-Bonilla J. Caries experience in a selected patient population in Mexico City. Community Dent Oral Epidemiol (in press).

Complete book:
Kramer IRH, Pindborg JJ, Shear M. Histological typing of odontogenic tumours (2nd edn). Berlin: Springer Verlag, 1992.

Chapter in book:
DelBalso AM, Ellis GE, Hartman KS, Langlais RP. Diagnostic imaging of the salivary glands and periglandular regions. In: DelBaso AM (ed). Maxillofacial imaging. Philadelphia, PA: WB Saunders, 1990, pp 409–510.

Abstract:
Mileman PA, Espelid I. Radiographic treatment decisions - a comparison between Dutch and Norwegian practitioners. J Dent Res 1986; 65: 609 (Abstr 32).

Letter to the Editor:

Tables

Tables should be referred to specifically in the text of the paper but provided as separate files.

- Number tables consecutively with Arabic numerals (1, 2, 3, etc.), in the order in which they appear in the text.
- Give each table a short descriptive title.
- Make tables self-explanatory and do not duplicate data given in the text or figures.
- Aim for maximum clarity when arranging data in tables. Where practicable, confine entries in tables to one line (row) in the table, e.g. "value (±sd) (range)" on a single line is preferred to stacking each entry on three separate lines.
- Ensure that all columns and rows are properly aligned.
- Include horizontal rules at the top and bottom of a table and one below the column headings. If a column heading encompasses two or more subheadings, then the main headings and subheadings should be separated by a single short rule. No other rules should be included, neither horizontal nor vertical.
- Appropriate space should be used to separate columns. Rows should be double-spaced.
- A table may have footnotes if necessary. These should be referred to within the table by superscript letters, which will then also be given at the beginning of the relevant footnote. Begin each footnote on a new line. A general footnote referring to the whole table does not require a superscript letter.
- Define abbreviations in tables in the footnotes even if defined in the text or a previous table.
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- EPS is preferred for drawn artwork (line drawings and graphs).
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- Unless essential to the content of the article, all illustrations should be supplied in black and white with no colour (RGB, CMYK or Pantone references) contained within them.
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Appendices

Appendices should be used to include detailed background material that is essential for the understanding of the manuscript e.g. statistical analyses, very detailed preliminary studies, but which is too comprehensive to include as part of the main text.

Where possible, authors are encouraged to include all relevant material in the main body of the text, however, if an appendix is necessary it should be supplied as a separate file. If more than one appendix is included, these should be identified using different letters.

- An appendix may contain references, but these should be listed separately and numbered A1, A2, etc.
- Appendices must be referred to in the main text in the relevant section.

Supplementary material

Supplemental material is intended for material that would add value to your manuscript but is not essential to the understanding of the work. Supplementary material is typically used for including material that can not be accommodated in print form, for example multimedia files such as dynamic images, video/audio files etc.

There are no restrictions on supplementary file formats, though it is recommended that authors choose file types that the majority of readers will be able to open e.g.

- Text/Data: PDF, Word, Excel, Powerpoint, .txt
- Graphics: TIF, PNG, JPEG, GIF
- Video: AVI, MOV, MP4, MPEG, WMV
- Audio: mp3, m4a

Units, symbols and statistics

Authors should use the International System of Units (SI) [1]. Units of radiation should be given in SI, e.g. 1 Sv, 1 Gy, 1 MBq. Exceptions are mmHg for blood pressure and g dl–1 for haemoglobin. For guidance, authors can refer to the publication Units, Symbols and Abbreviations. A guide for medical and scientific authors [2].

- All radiation factors (dose/time/fractionation) must be listed.
- Equations should be numbered (1), (2) etc. to the right of the equation. Do not use punctuation after equations.
- Do not include dots to signify multiplication – parameters should simply be typed closed up, or with a multiplication sign if necessary to avoid ambiguity.

Statistical Guidelines

The aim of the study should be clearly described and a suitable design, incorporating an appropriate number of subjects, should be used to accomplish the aim. It is frequently beneficial to consult a professional statistician before undertaking a study to confirm it has adequate power, and presentation of a power calculation within the paper demonstrates the ability of the study to detect clinically or biologically meaningful effects.

Details should be provided on selection criteria, whether data were collected prospectively or retrospectively, and any exclusions or losses to follow-up that might affect the study population. Information on subject characteristics in groups being compared should be given for any factors that could potentially bias the comparison of the groups; such information is often best presented in a tabular format in which the groups are in adjacent columns. If the study was randomized, details of the randomization procedure should be included.

Measures of variation should be included for all important results. When means are presented, the standard deviation or the standard error of the mean should also be given, and it should be clear which of these two measures is being quoted. When medians are given, measures of variation such as the interquartile range or overall range should also be included. Estimates of differences, e.g. between two means being compared, should be provided with 95% confidence limits to aid the reader and author to interpret the results correctly. Note that estimation of the size of effects, e.g. treatment or prognostic factor effects, is as important as hypothesis testing.

Statistical procedures should be described and referenced for all p-values given, and the values from which they were derived should be included. The validity of statistical procedures should also be confirmed, e.g. the t-test requires normal distribution(s) in the basic data and the chi-squared test is not valid when the expected numbers in cells are less than 5. Data may sometimes be transformed, e.g. using a log or square root transformation, to achieve normality. Non-parametric tests should be used when the conditions for normality are not met. It should be noted, however, that the Wilcoxon signed rank test (the non-parametric equivalent of the paired t-test) is semi-quantitative. If more than two groups are being compared then an analysis of variance should be performed before undertaking comparisons of pairs of groups. You are advised to seek the help of a professional statistician if you are uncertain of the appropriateness or interpretation of statistical methods.

Analysis of repeated measurements on the same subject can give rise to spurious results if comparisons are made at a large number of different time points. It is frequently preferable to represent each subject's outcome by a single summary measure chosen for its appropriateness. Examples of such measures are the area under the curve, the overall mean, the maximum or minimum, and the time to reach a given value. Simple statistics can then be applied to these summary measures.

The results of the evaluation of a test procedure should state clearly the criteria used to define positivity, and the sensitivity, specificity, positive predictive value and negative predictive value should all be quoted together with their 95% confidence limits.

1. Goldman DT, Bell RJ, eds. The International System of Units (SI). 5th edn. London, UK: HMSO; 1987.

2. Baron DN, ed. Units, symbols and abbreviations. A guide for medical and scientific authors. 5th edn. London, UK: Royal Society of Medicine Press; 1994.

Anexo 3. Normas para publicação do artigo 2.

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Author Guidelines

Content of Author Guidelines: 1. General, 2. Ethical Guidelines, 3. Submission of Manuscripts, 4. Manuscript Types Accepted, 5. Manuscript Format and Structure, 6. After Acceptance.

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1. GENERAL

Clinical Oral Implants Research conveys scientific progress in the field of implant dentistry and its related areas to clinicians, teachers and researchers concerned with the application of this information for the benefit of patients in need of oral implants. The journal addresses itself to clinicians, general practitioners, periodontists, oral and maxillofacial surgeons and prosthodontists, as well as to teachers, academicians and scholars involved in the education of professionals and in the scientific promotion of the field of implant dentistry.

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

2. ETHICAL GUIDELINES

Clinical Oral Implants Research adheres to the below ethical guidelines for publication and research.

2.1. Authorship and Acknowledgements

Authors submitting a paper do so on the understanding that the manuscript have been read and approved by all authors and that all authors agree to the submission of the manuscript to the Journal. ALL named authors must have made an active contribution to the conception and design and/or analysis and interpretation of the data and/or the drafting of the paper and ALL must have critically reviewed its content and have approved the final version submitted for publication. Participation solely in the acquisition of funding or the collection of data does not justify authorship.

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Up to 6 authors are accepted without need for justification. In the case of a specific and detailed justification of the role of every author, up to 8 authors may be mentioned. It is a requirement that all authors have been accredited as appropriate upon submission of the manuscript. Contributors who do not qualify as authors should be mentioned under Acknowledgements.

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2.2. Ethical Approvals

Experimentation involving human subjects will only be published if such research has been conducted in full accordance with ethical principles, including the World Medical Association Declaration of Helsinki (version, 2013) and the additional requirements, if any, of the country where the research has been carried out. Manuscripts must be accompanied by a statement that the experiments were undertaken with the understanding and written consent of each subject and according to the above mentioned principles. A statement regarding the fact that the study has been independently reviewed and approved by an ethical board should also be included. Editor reserve the right to reject papers if there are doubts as to whether appropriate procedures have been used.

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

Clinical Oral Implants Research requires authors of pre-clinical animal studies submit with their manuscript the Animal Research: Reporting In Vivo Experiments (ARRIVE) guidelines checklist.

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Information on PRISMA - TRANSPARENT REPORTING of SYSTEMATIC REVIEWS and META-ANALYSES can be found on http://www.prisma-statement.org/PRISMAStatement/Default.aspx

Additional guidance on compliance with various research guidelines can be found on the Guideline Information - Enhancing the Quality and Transparency of Health Research: www.equator-network.org.

The ARRIVE guidelines can be found here:
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3.4. Single Blind Review
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Treatment rational by experts with evidence-based treatment approach.

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Acknowledgements: Acknowledge only persons who have made substantive contributions to the study. Authors are responsible for obtaining written permission from everyone acknowledged by name because readers may infer their endorsement of the data and conclusions. Sources of financial support should be acknowledged.

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medical editors and authors (1988), p. 52, London: The Royal Society of Medicine.

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name(s) of author(s), year, title of paper, title of journal, volume number, first and last page numbers.
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name(s) of author(s), year, title of book, edition, volume, chapter and/ or page number, town of publication, publisher.

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c) The title of the paper should be included, without quotation marks.

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Poole, B., Ohkuma, S. & Warburton, M. (1978) Some aspects of the intracellular breakdown of erogenous and endogenous proteins. In: Segal, H.S. & Doyle, D.J., eds. Protein turnover and lysosome function, 1st edition, p. 43. New York: Academic Press.
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