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Faculdade de Odontologia

AVALIAÇÃO TRIDIMENSIONAL DO PALATO ÓSSEO

Taiane dos Santos Lopes

CD

Dissertação submetida ao corpo docente da Faculdade de Odontologia da Universidade Federal do Rio de Janeiro - UFRJ, como parte dos requisitos, para a obtenção do Título de Mestre em Odontologia (Ortodontia).

Rio de Janeiro

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Avaliação tridimensional do palato ósseo

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Prof[a]. Dr[a]. Mônica Tirre de Souza Araújo

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"Não devemos nos orgulhar de sermos melhores que os outros, mas sim melhores do que já fomos"

(Bernardinho)

RESUMO

LOPES, TS. **Avaliação Quantitativa e Qualitativa do Palato Ósseo por meio de Tomografia Computadorizada**. Orientadoras: Prof[a]. Dr[a]. Maria Augusta Visconti e Prof[a]. Dra. Mônica Tirre de Souza Araújo. Rio de Janeiro: UFRJ/Faculdade de Odontologia, 2020. Dissertação (Mestrado em Odontologia – Ortodontia) 70f.

O objetivo deste estudo foi avaliar nas formas qualitativa e quantitativa as regiões ósseas do palato, mensurar o conhecimento de ortodontistas acerca da interpretação das imagens tomográficas, de acordo com sua experiência, além de avaliar a intensidade dos valores dos v*oxels* das regiões ósseas do palato utilizando programa ImageJ/Fiji®. A amostra foi composta por cinquenta exames de Tomografia computadorizada de feixe cônico pertencentes ao banco de dados da Disciplina de Ortodontia e Radiologia Oral, da Faculdade de Odontologia da Universidade Federal do Rio de Janeiro, e vinte e quatro examinadores, pós-graduados em Ortodontia. Esses realizaram o preenchimento do questionário para análise qualitativa em três tempos, com intervalo de quinze dias entre eles. Para análise quantitativa, dois examinadores, pesquisadores do estudo, realizaram as mensurações ósseas a fim de estabelecer o padrão-ouro. Para análise dos dados, o nível de significância adotado foi de 0,05 e o programa utilizado foi o SPSS v.25. De acordo com a análise quantitativa, encontrou-se uma espessura óssea palatal 28% maior nos homens comparada às mulheres. A espessura óssea palatal diminui gradualmente da região anterior para a posterior, sendo a maior encontrada 9 mm lateralmente à sutura palatal mediana. Um aumento significativo da espessura no grupo dos adolescentes foi notado. A análise qualitativa mostrou que não houve significância no desempenho de acordo com a experiência dos examinadores ($p>0,05$), demonstrando maior dificuldade na questão relativa à sutura palatal mediana e maior facilidade na questão sobre a área de maior qualidade óssea. Quando considerada a análise quantitativa dos valores de intensidade de *voxels* da região palatal, revelou confiabilidade com os resultados da questão relativa à classificação óssea em D1, D2 e D3. Conclui-se que o método proposto para quantificar os valores de *voxels* é eficaz e pode ser utilizado clinicamente para avaliar a qualidade óssea em relação aos valores de *voxels* da região de interesse.

SUMMARY

LOPES, TS. **Avaliação Quantitativa e Qualitativa do Palato Ósseo por meio de Tomografia Computadorizada.** Orientadoras: Prof[a]. Dr[a]. Maria Augusta Visconti e Prof[a]. Dra. Mônica Tirre de Souza Araújo. Rio de Janeiro: UFRJ/Faculdade de Odontologia, 2020. Dissertação (Mestrado em Odontologia – Ortodontia) 70f.

The objective of the present study was to evaluate qualitative and quantitative forms such as bone regions of the palate, to measure or the knowledge of orthodontists on the interpretation of tomographic images, according to their experience, in addition to evaluating the intensity of the values of voxels in bone regions of the palate using the ImageJ / Fiji® program, version 1.50d (NIH, Bethesda, USA). The sample consisted of fifty CBCT exams belonging to the database of the Clinics of Orthodontics and Oral Radiology, Faculty of Dentistry, Federal University of Rio de Janeiro - FO / UFRJ, and twenty-four examiners, post-graduated in Orthodontics. They carried out the full fill the questionnaire for qualitative analysis in three stages, with an interval of fifteen days between them, under the same conditions. For quantitative analysis, two examiners, researchers in the study, perform bone measurements at the end of the gold standard. The level of significance adopted was 0.05 and the program used was SPSS v.25.

According to the quantitative analysis, 28% greater palatal bone thickness was found in men compared to women. The palatal bone thickness gradually decreased from the anterior to the posterior region and the greater thickness was found 9 mm laterally in the median palatal suture. A significant increase in thickness was noticed in the group of adolescents. The data from the qualitative analysis, which showed that there was no significance in performance, showed the levels of experience of the examiners ($p > 0.05$), however, a greater difficulty in the question regarding median palatal mediation was detected and easier in the question about an area of higher bone quality. When taking into account a quantitative analysis of the values of voxel variables of the palatal region, revealed tests with the results of the question regarding the bone classification in D1, D2 and D3. Conclude whether the proposed method for quantifying voxel values is effective and can be used clinically to assess bone quality in relation to voxel values in the region of interest.

LISTA DE SIGLAS

DICOM	*Digital imaging and communications in medicine format*
ERM	Expansão rápida da maxila
FOV	Campo de visão - *Field of view*
ICC	*Intraclass Correlation Coefficient*
MAV	Maria Augusta Visconti
Model GEE	Modelo de Equações de Estimações Generalizadas
MDF	Matheus Diniz Ferreira
ROI	Região de interesse - *Region of interest*
SARPE	*Surgically Assisted Rapid Palatal Expansion*
SPSS	*Statistical Package for the Social Sciences*
TCLE	Termo de Consentimento Livre e Esclarecido
TCFC	Tomografia Computadorizada de Feixe Cônico
TCMD	Tomografia Computadorizada de Multidetectores
TSL	Taiane dos Santos Lopes

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1 INTRODUÇÃO

A região óssea do palato é uma estrutura cada vez mais explorada por diversos estudos (SUTEERAPONGPUN; WATTANACHAI; JANHOM; TRIPUWABHRUT *et al.*, 2018; WEHRBEIN, 2008; 2009; WEHRBEIN; YILDIZHAN, 2001), com o intuito de compreender melhor suas dimensões, espessura e qualidade do osso palatal. No entanto, grande parte das pesquisas atuais enfatiza que tais informações são necessárias apenas para instalação de mini-implantes ortodônticos (BONANGI; KAMATH; SRIVATHSA; BABSHET, 2018; HUANG; SHOTWELL; WANG, 2005; MARQUEZAN; NOJIMA; FREITAS; BARATIERI *et al.*, 2012; PARK; LEE; JEONG; KWON, 2008; WANG; SUN; YU; DING, 2017).

Entretanto, não se deve associar a análise do osso palatal apenas à finalidade de inserção de mini-implantes, pois essa complementa outras opções de tratamento tais como: disjunção palatal, movimentação dentária ortodôntica e cirurgia ortognática (ANGELIERI; CEVIDANES; FRANCHI; GONÇALVES *et al.*, 2013; ROY; RTSHILADZE; STEVENS; PHILLIPS, 2019). Angelieri et al., 2013, propuseram uma classificação da sutura palatal mediana em cinco estágios que ainda é amplamente utilizada pelos ortodontistas. O conhecimento desta classificação auxilia os profissionais a determinarem parâmetros suficientes para decisão clínica entre uma expansão rápida da maxila (ERM) ou uma expansão cirúrgica (SARPE) (ANGELIERI; FRANCHI; CEVIDANES; GONÇALVES *et al.*, 2017).

Do mesmo modo, deve-se considerar que a arquitetura esquelética característica de algumas maloclusões pode interferir diretamente na espessura deste osso. Portanto, um paciente com mordida aberta esquelética tende a possuir as dimensões palatais diminuídas em relação a outras arquiteturas faciais (SUTEERAPONGPUN; WATTANACHAI; JANHOM; TRIPUWABHRUT *et al.*, 2018). Dessa forma, percebe-se que o osso palatal fornece um amplo espectro de informações por meio de sua configuração anatômica, sutura palatal mediana e suas dimensões ósseas.

A análise óssea da região palatal pode ser realizada de forma complementar por exames de imagem, como exames radiográficos e tomográficos (BONANGI; KAMATH; SRIVATHSA; BABSHET, 2018; HUANG; SHOTWELL; WANG, 2005). As radiografias por sua vez, apesar de possuírem baixo custo e emitirem menor dose de radiação efetiva aos pacientes - quando comparadas a exames mais complexos - possuem uma grande limitação que é a bidimensionalidade (WALDTHALER; REUTERWALL-HANSSON; ARNELO; KADESJÖ, 2020). Exames bidimensionais não permitem observar o volume das estruturas anatômicas, e isso pode, em alguns casos, prejudicar o diagnóstico e plano de tratamento, principalmente quando a espessura deve ser considerada na análise. Além disso, a bidimensionalidade dos exames provoca a sobreposição de estruturas anatômicas contíguas, interferindo na qualidade do exame e consequentemente no valor diagnóstico oferecido por ele (ABBASSY; SABBAN;

HASSAN; ZAWAWI, 2015; HOUNSFIELD, 1995; MANJULA; MURALI; KUMAR; TAJIR *et al.*, 2015).

No início da década de 70, a tomografia computadorizada de multidetectores (TCMD) foi criada pelo físico Allan Cormack e o Britânico Godfrey Newbold Hounsfield, proporcionando-lhes o prêmio Nobel de Medicina em 1979 (BROOKS, 1993; HOUNSFIELD, 1995). No entanto, com o passar dos anos, a utilização da tomografia na Odontologia necessitou de uma adaptação para melhorar a visualização das corticais ósseas da região maxilofacial, reduzir a dose de radiação efetiva e o custo financeiro do exame. Atingindo esses anseios, a tomografia computadorizada de feixe cônico (TCFC) surgiu no final da década de 90 (MOZZO; PROCACCI; TACCONI; MARTINI *et al.*, 1998; PARKS, 2000).

A TCFC é uma modalidade de imagem amplamente utilizada na Odontologia, pois permite a obtenção de imagens tridimensionais (3D) com alta precisão, intensidade de sinal e baixo ruído. Além disso, quando comparada à TCMD, emite uma menor dose de radiação efetiva aos pacientes e permite imagens mais precisas para região de cabeça e pescoço (BROOKS, 1993; NAKAJIMA; SAMESHIMA; ARAI; HOMME *et al.*, 2005; PARKS, 2000).

Ainda na década de 90, a TCFC adquiriu notoriedade na Ortodontia, com a finalidade de diagnóstico, tratamento e avaliação das relações dento-esqueléticas pré e pós-tratamento (HAJEER; MILLETT; AYOUB; SIEBERT, 2004; KAU; RICHMOND; PALOMO; HANS, 2005). Foi sugerido que a TCFC pudesse ser usada rotineiramente em Ortodontia para o diagnóstico e planejamento, reduzindo as exposições à radiação através das imagens 2D (PALOMO; KAU; PALOMO; HANS, 2006). Atualmente, na literatura, é evidente que o uso da TCFC deve ser restrito aos casos essenciais e com indicações conscientes. De acordo com

SEDENTEXCT (2012), a TCFC é indicada quando são necessárias informações sobre o volume ósseo em momentos pré-cirúrgicos ou em análises de dentes retidos em proximidades com estruturas anatômicas nobres.

Atualmente sabe-se que as dimensões ósseas maxilares podem ser observadas tridimensionalmente por meio de imagens provenientes de TCFC, o que permite mensurações antes não realizadas com os exames bidimensionais (2D). As imagens tomográficas permitem a visualização das estruturas anatômicas, sem sobreposição e distorção, possibilitando melhor avaliação da área a ser estudada (ABBASSY; SABBAN; HASSAN; ZAWAWI, 2015).

Diversas análises demonstraram desigualdades na espessura óssea do palato, quando avaliada em imagens de TCFC, especialmente em função das diferentes regiões selecionadas. Tanto a espessura do palato quanto a qualidade óssea, expressa pela intensidade dos valores de *voxels* na região avaliada, ou seja, valores de cinza são fatores que influenciam diretamente no sucesso dos tratamentos ortodônticos (BONANGI; KAMATH; SRIVATHSA; BABSHET, 2018; WANG; SUN; YU; DING, 2017).

Alguns estudos relataram a avaliação quantitativa da densidade óssea através de Unidades *Hounsfield* (HU, do inglês *Hounsfield Units*) em TCFC, porém, essa só deve ser realizada em exames de TCMD (HAN; BAYOME; LEE; LEE *et al.*, 2012; NORTON; GAMBLE, 2001; PARK; LEE; JEONG; KWON, 2008; YANG; LI; CAO; CHEN *et al.*, 2015). Logo, há a necessidade de outras formas de avaliação da densidade óssea do palato para diferentes finalidades ortodônticas como: ancoragem com mini-implantes, disjunção palatal, movimentações dentárias no rebordo alveolar maxilar, e para melhor entendimento e avaliação de outros mecanismos ortodônticos de tratamento.

Além disso, o grau de conhecimento do ortodontista em relação à interpretação de imagens tomográficas é outro fator que pode interferir no correto planejamento ortodôntico, tendo em vista que os exames tridimensionais requerem experiência e acuidade visual. Entretanto, destaca-se que há controvérsia nos estudos encontrados na literatura quanto à interferência da experiência em Ortodontia relacionada a um melhor desempenho em avaliar as imagens de TCFC (ENGEL; RENKEMA; KATSAROS; PAZERA *et al.*, 2015; RONGO; VALLETA; BUCCI; BONETTI *et al.*, 2015).

É de fundamental importância para a rotina clínica do ortodontista, a análise das estruturas ósseas do palato, e o correto treinamento do mesmo para visualizar imagens tomográficas. Portanto, de acordo com o exposto, o objetivo do estudo foi avaliar, nas formas qualitativa e quantitativa, o palato ósseo, bem como mensurar o conhecimento de ortodontistas acerca da interpretação das imagens tomográficas.

2 PROPOSIÇÃO

O presente estudo teve como objetivo:

2.1 avaliar quantitativamente, por meio de exames de TCFC, as espessuras ósseas da região do palato, através de um padrão consensual, levando em conta a idade e o sexo;

2.2 avaliar qualitativamente o conhecimento dos ortodontistas com diferentes níveis de experiência, em relação à interpretação de imagens de TCFC da região do palato ósseo, e;

2.3 sugerir uma nova metodologia de avaliação clínica qualitativa da densidade do palato ósseo em exames de TCFC através da análise da intensidade dos valores de *voxels*.

3 DELINEAMENTO DA PESQUISA

3.1 DESENHO E LOCAL PARA REALIZAÇÃO DO ESTUDO

Trata-se de um estudo transversal e toda pesquisa foi realizada nas dependências dos Departamentos de Odontopediatria e Ortodontia (Clínica de Ortodontia) e de Patologia e Diagnóstico Oral (Clínica de Radiologia Odontológica) do Programa de Pós-Graduação em Odontologia da Faculdade de Odontologia da Universidade Federal do Rio de Janeiro (FO/UFRJ).

3.2 ASPECTOS ÉTICOS ENVOLVIDOS

Esta pesquisa foi previamente aprovada pelo Comitê de Ética em Pesquisa do Hospital Universitário Clementino Fraga Filho da Universidade Federal do Rio de Janeiro (CEP/HUCFF/UFRJ), sob parecer nº 3.296.739 (Anexo 7.2, página 69).

Todos os exames de TCFC utilizados para este estudo pertencem ao acervo da Clínica de Ortodontia do Programa de Pós-Graduação em Odontologia – Ortodontia da FO/UFRJ e constituem parte da documentação ortodôntica solicitada. O acesso e uso do banco de dados obedeceram aos princípios éticos legais regulamentados pela resolução do Conselho Nacional de Saúde 466/2012 e a Declaração de Responsabilidade foi devidamente assinada para os respectivos assuntos (Anexo 7.1, página 68). Todos os participantes do estudo, após os devidos esclarecimentos referentes à execução da pesquisa, consentiram sua participação e assinaram o Termo de Consentimento Livre e Esclarecido (TCLE).

3.3 CARACTERIZAÇÃO DA AMOSTRA

Para o cálculo do tamanho da amostra, foi utilizado o programa WinPepi WINPEPI (PEPI-for-Windows) para epidemiologistas (Epidemiologic Perspectives & Innovations, 2004, 1: 6), versão 11.65 (ABRAMSON, 2004), utilizando 24 examinadores. Sendo estes subdivididos em três grupos de acordo com o nível de experiência: 1 - oito ortodontistas sem experiência (sem experiência); 2 - oito ortodontistas com menos de cinco anos de experiência (experiência < 5 anos); e 3 - oito ortodontistas com cinco ou mais anos de experiência (experiência ≥ 5 anos). O tamanho da amostra total calculado foi de 1200 respostas, ou seja, 400 respostas por grupo, e dessa forma 50 exames de TCFC seriam necessários. Essa amostra teve a capacidade de detectar uma diferença de 0,6 desvios entre as médias, considerando o desvio padrão unitário. Para este cálculo, foi considerado poder de 80% e nível de significância de 5%.

Todos os exames de TCFC foram adquiridos utilizando o tomógrafo de feixe cônico Kodak 9500® (*Carestream Health*, Rochester, NY, USA), seguindo sempre os mesmos parâmetros de aquisição: 90 kVp, 10 mA, FOV (*field of view*) de 18,4 x 20,6 cm, *voxel* isotrópico de 0,3 mm e tempo de escaneamento de 24 segundos. O protocolo de aquisição padronizado garante que a realização do exame respeitou as linhas de orientação, sendo estas utilizadas para manter os planos de referência (plano horizontal de Frankfurt paralelo ao plano horizontal e o plano sagital mediano perpendicular ao plano horizontal, com os dentes em máxima intercuspidação).

A seleção inicial da amostra foi realizada por dois pesquisadores do estudo (TSL e MAV), devidamente treinados e com experiência em análise de imagens tomográficas. Todo o banco de dados foi investigado e 1807 registros foram selecionados. Após criteriosa análise, foram excluídas duplicadas, imagens bidimensionais (2D) e pacientes sem código de identificação, restando 569 exames de TCFC para aplicação dos critérios de elegibilidade.

Foram incluídos exames de indivíduos com idade superior a 10 anos, de ambos os sexos e sem histórico de tratamento ortodôntico prévio à aquisição da imagem tomográfica. Foram excluídos exames de pacientes com malformações craniofaciais visíveis na imagem tomográfica, que apresentassem processos patológicos, ausências ou retenções dentárias na maxila.

Os exames incluídos no estudo foram categorizados em grupos de acordo com a faixa etária dos pacientes: Grupo 1 (<13 anos); Grupo 2 (13 a 17 anos) e Grupo 3 (≥18 anos). Os mesmos foram armazenados em mídia óptica no formato *DICOM (digital imaging and communications in medicine format)* para serem posteriormente avaliados. Os arquivos em formato DICOM foram importados para o programa Dolphin Imaging®, versão 11.7 *Premium* (*Dolphin Imaging, Chatsworth*, Califórnia, USA).

Em seguida, as imagens foram analisadas em um monitor LCD com tela *widescreen* de 21,5 polegadas, sob as mesmas condições. Inicialmente foi realizada a padronização da imagem por dois examinadores (TSL e MDF), pesquisadores do estudo, devidamente treinados. O treinamento inicial ocorreu utilizando cinco exames, que posteriormente foram descartados da amostra principal, sob a supervisão de um terceiro pesquisador radiologista, com experiência em imagens tomográficas (MAV). A padronização das imagens consistiu em orientar corretamente o esqueleto craniofacial por meio do estabelecimento de pontos anatômicos e planos de referência, utilizando a reconstrução 3D (BARATIERI; ALVES; BOLOGNESE; NOJIMA *et al.*, 2014).

Os pontos Orbital (Or) e Pório (Po) foram selecionados para o lado direito (OrD e PoD) e para o lado esquerdo (OrE e PoE), sendo definidos como: o ponto mais inferior do contorno inferior da órbita e o ponto mais superior do meato acústico externo, respectivamente, para ambos os lados. O ponto Násio (N) foi definido na intersecção da sutura frontonasal com a sutura internasal. A partir da união de pontos anatômicos, foram determinados os planos de referência, sendo esses: plano axial, definido pelos pontos OrD, OrE, e PoD; plano coronal, estabelecido pelos pontos PoD e PoE, sendo perpendicular ao plano axial selecionado; e plano sagital, interceptando o ponto N e perpendicular aos planos axial e coronal já estabelecidos (Figura 1, página 11).

Após a padronização do posicionamento do esqueleto craniofacial nos três planos de referência, um único examinador (TSL), pesquisador do estudo, confeccionou *templates* contendo imagens representativas do palato ósseo nas reconstruções multiplanares sagital, axial e coronal, que posteriormente foram avaliadas pelos 24 examinadores participantes do estudo.

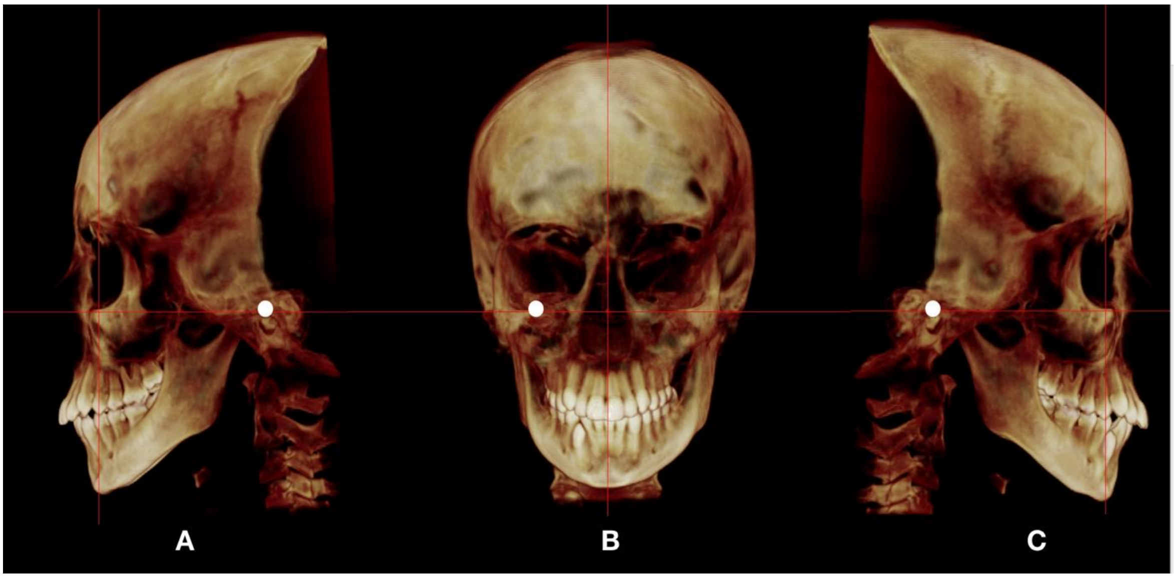

Figura 1 Reconstruções tridimensionais do esqueleto craniofacial do indivíduo após orientação de acordo com os três planos de referência. A e C. Vistas laterais evidenciando o pório como referencial para o plano horizontal. B. Vista frontal evidenciando o forame infraorbitário como referencial para o plano horizontal. Fonte: Clínica de Ortodontia do PPGO da FO/UFRJ - Imagem gerada no programa Dolphin Imaging®, versão 11.7 Premium.

3.4 EXAMINADORES PARTICIPANTES DO ESTUDO

Foram incluídos participantes com diferentes níveis de experiência profissional em Ortodontia. Dessa forma, três grupos foram estabelecidos: 1 - oito ortodontistas sem experiência (recém-formados); 2 - oito ortodontistas com menos de cinco anos de experiência (experiência < 5 anos); e 3 - oito ortodontistas com cinco ou mais anos de experiência (experiência ≥ 5 anos).

3.5 CRONOLOGIA DO ESTUDO

3.5.1 ANÁLISE QUANTITATIVA

A avaliação quantitativa foi realizada pelos examinadores pesquisadores do estudo (n=2) e consistiu na mensuração da espessura óssea palatal, através de medidas lineares, seguindo os métodos de Wang *et al*. (2017) e Bonangi *et al*.

(2018), porém, adaptados para este estudo. Dessa forma, na reconstrução sagital, foi estabelecido o posicionamento de referência onde a borda posterior do forame incisivo estivesse no mesmo plano horizontal da espinha nasal posterior (BONANGI; KAMATH; SRIVATHSA; BABSHET, 2018; WANG; SUN; YU; DING, 2017). Os valores referentes às espessuras ósseas no sentido anteroposterior foram categorizados em 4, 8, 12 e 14 mm a partir do ponto mais súpero-posterior do forame incisivo.

Da mesma forma, na reconstrução coronal, foram realizadas medidas da espessura óssea palatal em 0, 3, 6 e 9 mm lateralmente à sutura palatal mediana, tanto para o lado direito como para o esquerdo (Figuras 2 e 3, página 13). O mapeamento do palato ósseo resultou em 35 pontos obtidos através da interseção das reconstruções sagital e coronal (Figura 2A).

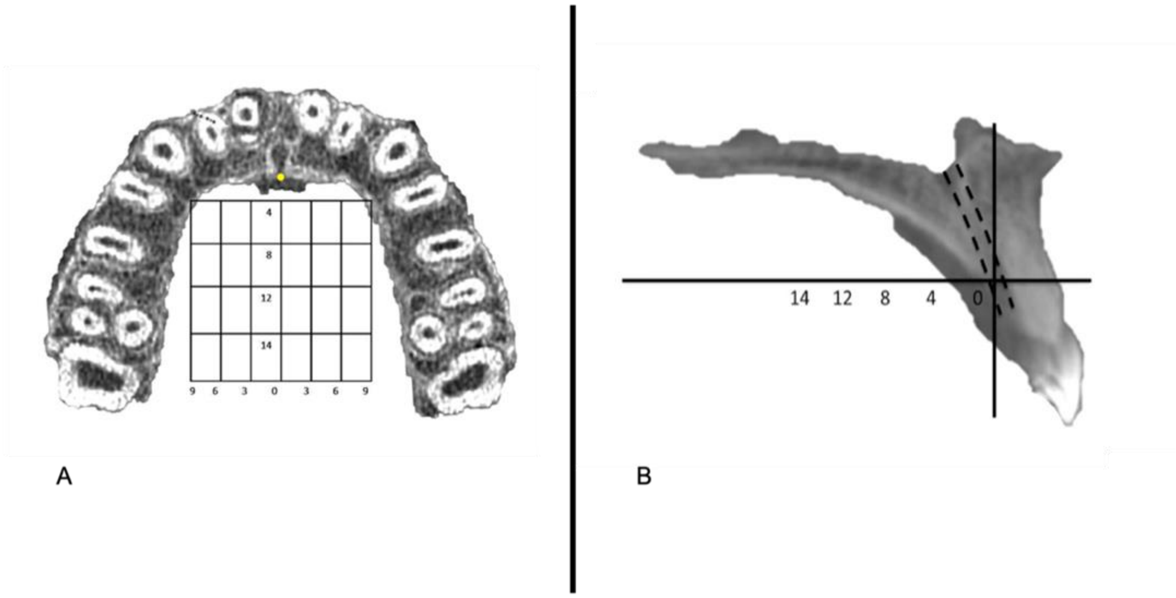

Figura 2 Desenhos esquemáticos ilustrando as linhas de referência para mensurar a espessura óssea palatal nos pontos pré-determinados nas reconstruções axial (A) e sagital (B).

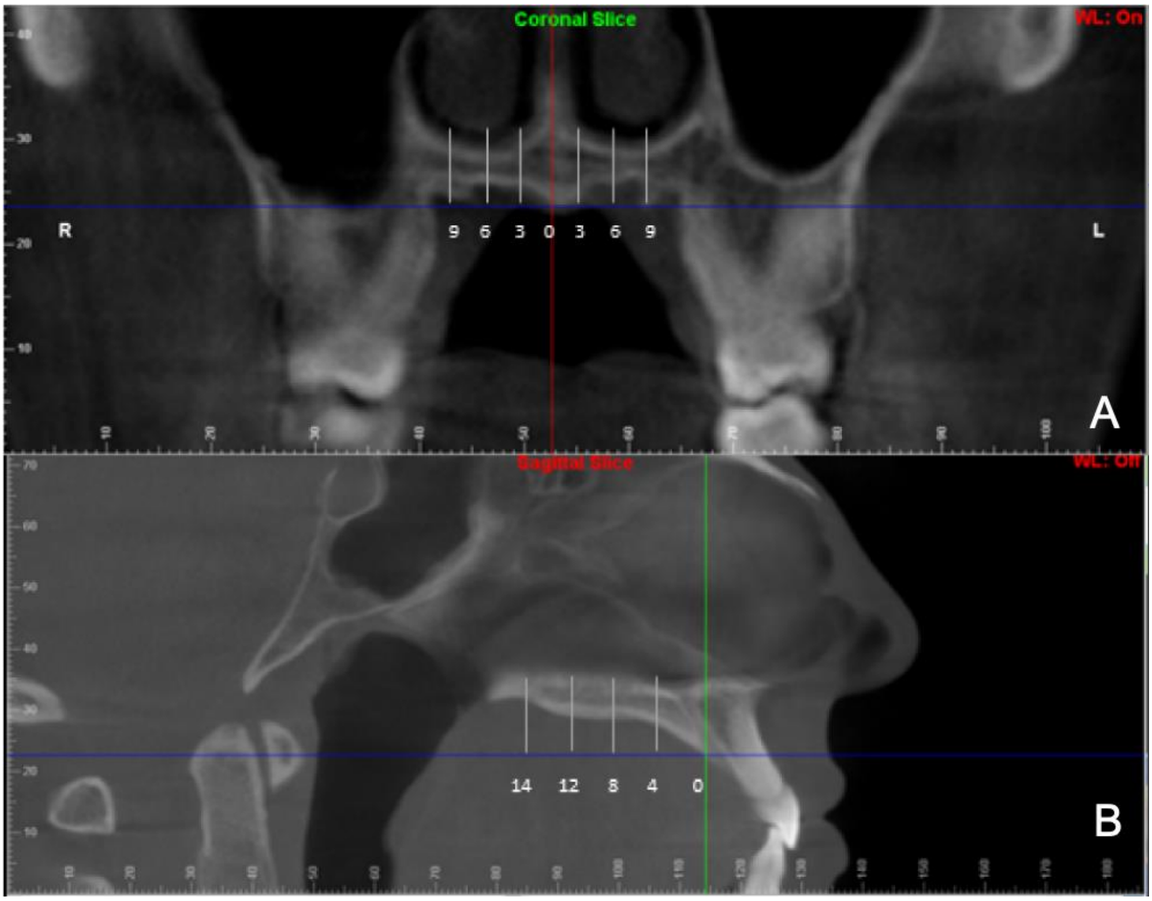

Figura 3 Reconstruções coronal (A) e sagital (B) demonstrando as mensurações realizadas nos pontos pré-determinados, lateralmente à sutura palatal mediana (A) e a partir do ponto mais póstero-superior do forame incisivo (B). Fonte: Clínica de Ortodontia do PPGO da FO/UFRJ **-** Imagem gerada no programa Dolphin Imaging®, versão 11.7 Premium.

Para estabelecer o padrão de respostas corretas da análise quantitativa, dois examinadores, pesquisadores do estudo (TSL e MDF), devidamente treinados, mensuraram a espessura óssea palatal, sob a supervisão do pesquisador radiologista com experiência em análise de imagens tomográficas (MAV). No treinamento, as mensurações foram realizadas em cinco exames tomográficos que posteriormente foram excluídos da amostra principal. Somente após estabelecerem alta concordância (ICC=0,955), as avaliações foram realizadas utilizando o método do padrão consensual como referência para as respostas corretas. Esses examinadores não fizeram parte da casuística da análise qualitativa.

3.5.2 ANÁLISE QUALITATIVA

A avaliação qualitativa também foi realizada pelos participantes do estudo (n=24), subdividos em três grupos de acordo com o nível de experiência em Ortodontia (sem experiência; experiência < 5 anos; e experiência ≥ 5 anos). Cada participante teve acesso a um vídeo explicativo, com duração de aproximadamente quatro minutos, em que os propósitos da pesquisa foram esclarecidos. Além disso, foi fornecido um guia impresso para auxiliar no preenchimento do questionário II (Apêndice 1, página 70).

No primeiro momento da avaliação (T1), foi realizada a análise do conhecimento geral dos participantes sobre Radiologia Oral. O questionário I (Apêndice 2, página 71) continha perguntas relacionadas aos princípios de interpretação tomográfica, de modo geral, relacionadas a um *template* com imagens de TCFC.

Após 15 dias (T2), um segundo questionário (Apêndice 3, página 72), foi entregue aos participantes. Nesse, as perguntas eram relacionadas à classificação anatômica do osso palatal (SASSOUNI, 1977); estágio de fusão da sutura palatal mediana (ANGELIERI; CEVIDANES; FRANCHI; GONÇALVES *et al.*, 2013); e qualidade óssea, definida de acordo com a tonalidade de cinza e o aspecto visual do osso (MISCH, 2008). O guia fornecido aos participantes continha orientações para responder às perguntas, com desenhos esquemáticos, tanto para as classificações utilizadas (ANGELIERI; CEVIDANES; FRANCHI; GONÇALVES *et al.*, 2013; SASSOUNI, 1977), como para a análise subjetiva da densidade óssea, através de uma escala de tonalidades de cinza somada a um desenho esquemático modificado daquele proposto por (MISCH, 2008). Dessa forma, o osso era classificado em: D1 (osso cortical denso; excelente qualidade); D2 (osso cortical poroso e trabecular denso; boa qualidade); D3 (osso cortical poroso e trabecular fino; baixa qualidade). (MISCH, 2008) (Figura 4).

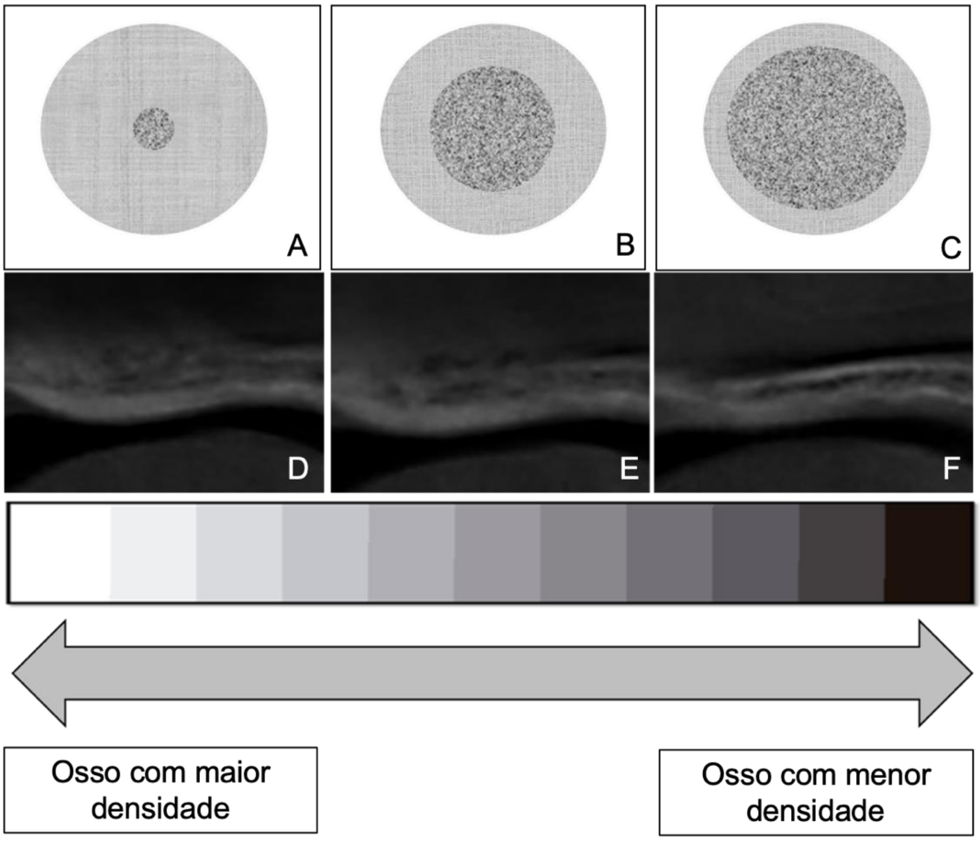

Figura 4 Desenho esquemático modificado e reconstruções tomográficas do palato ósseo exemplificando a qualidade óssea de acordo com a escala de cinza. D1 - osso cortical denso; excelente qualidade (A e D); D2 - osso cortical poroso e trabecular denso; boa qualidade (B e E); D3 - osso cortical poroso e trabecular fino; baixa qualidade (C e F).

Para evitar fadiga visual, a avaliação de T2 foi realizada em dois momentos distintos, sendo fornecidos aos participantes apenas 25 exames por vez (CHO, 2011; ROSADO; BARBOSA; DE AQUINO; JUNQUEIRA *et al.*, 2019). Após 30 dias (T3) os participantes reavaliaram 20% da amostra para obtenção do cálculo intraexaminador (ROSADO; BARBOSA; DE AQUINO; JUNQUEIRA *et al.*, 2019).

Portanto, a avaliação qualitativa foi realizada em três momentos (T1, T2 e T3), sob as mesmas condições, com intervalo de tempo entre elas, conforme discriminado resumidamente na Tabela I.

Tabela I Discriminação resumida da cronologia do estudo

	T1	**T2**	**T3**
Material	Questionário I	Questionário II	Questionário II
Momento da avaliação (n de exames)	Dia 1 (n=1)	Dia 15 (n=25) Dia 30 (n=25)	Dia 60 (n=10)
Descrição do objetivo	Testar o conhecimento sobre princípios de interpretação tomográfica	Avaliação qualitativa da amostra para anatomia do osso palatal; sutura palatal mediana; e qualidade do osso palatal	Reavaliação de 20% da amostra de T2 para o cálculo intra-examinador

Para verificar quantitativamente os resultados da questão 5 do questionário II da análise qualitativa referente à qualidade óssea e estabelecer o padrão-ouro, os valores de intensidade de cinza foram determinados. Através dos valores numéricos dos *voxels* da imagem, utilizando o programa ImageJ/Fiji®, versão 1.50d (NIH, Bethesda, USA) foi possível estabelecer a intensidade de cinza de cada região e, dessa forma, supor qual delas é mais ou menos densa, sem fazer correspondência com as unidades *Hounsfield* (HU).

Essa análise foi realizada por um único examinador (TSL), pesquisador do estudo, devidamente treinado, na qual foram calculados valores numéricos dos *voxels e* a partir destes foi estabelecida a média da intensidade de cinza. Através das coordenadas X e Y do programa, o mesmo corte e a mesma região demarcada na avaliação qualitativa foi selecionada, garantindo que exatamente a mesma região fosse analisada. Para cada região estudada, foi estabelecida uma ROI (*region of interest*) padronizada de 46 x 46 mm e os valores de cinza foram calculados utilizando a ferramenta do programa que determina a média de intensidade a partir de um histograma (Figura 5).

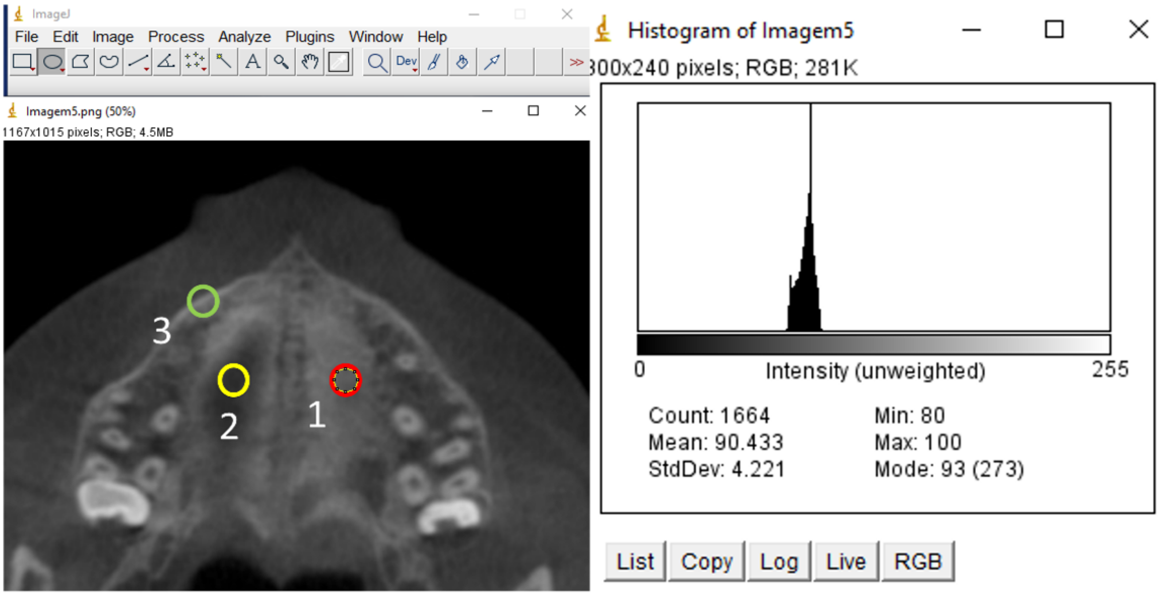

Figura 5 Interface do programa ImageJ/Fiji®, versão 1.50d (NIH, Bethesda, USA), onde foram calculados valores numéricos dos *voxels* dentro das mesmas regiões definidas na questão 5 do questionário.

3.6 ANÁLISE ESTATÍSTICA

Foi realizada a comparação das médias pela análise de variância (ANOVA 2-*way*) das espessuras ósseas, entre os fatores distância, sexo e a interação dupla (distância*sexo) em cada uma das reconstruções tomográficas utilizadas. Quando significativo, foi usado o teste *post-hoc* de Bonferroni para identificar as categorias distintas.

Na análise quantitativa, as variáveis foram representadas pela média e desvio-padrão. Foram calculados os limites de concordância, com intervalo de 95% e realizada a análise gráfica de *Bland-Altman* para representar as concordâncias entre avaliadores. Foi realizado o teste t pareado para verificar se as medidas foram concordantes e o índice de correlação intraclasse (ICC). As análises foram realizadas tanto na amostra geral como também para cada reconstrução tomográfica (S, C0, C3, C6, C9, bilateralmente).

Para análise qualitativa, as variáveis categóricas foram representadas pela frequência absoluta e relativa. O modelo de Equações de Estimações Generalizadas (Model GEE) foi usado para comparar as proporções de acertos (ZEGER; LIANG, 1986).

Para este modelo, foi utilizada uma distribuição binomial com função de ligação probito. Dois modelos foram realizados: 1 - teste do efeito principal de questões entre os níveis de experiência; 2 - teste do efeito principal do nível de experiência entre as categorias de questões. O modelo foi composto por uma matriz de correlação de trabalho independente e uma matriz de covariância. Quando significativo, o teste de Bonferroni foi utilizado como *post-hoc* para identificar as categorias distintas.

O índice kappa foi utilizado para verificar a reprodutibilidade intra e interobservador. Quando significativo, a concordância foi classificada conforme as faixas: concordância pobre (0-0,19), concordância baixa (0,20-0,39), concordância moderada (0,40-0,59), concordância substancial (0,60-0,79) e concordância quase perfeita (0,80–1,00) (LANDIS; KOCH, 1977). O nível de significância adotado foi de 0,05 e o programa utilizado foi o SPSS (Versão 25).

4 DESENVOLVIMENTO DA PESQUISA

4.1 ARTIGO 1

LOPES TS, ARAÚJO MTS, FERREIRA MD, VISCONTI MA. Investigation of bone palate thickness in children, adolescents and adults: observational study in cone beam computed tomography. A ser submetido para publicação no periódico International Journal of Oral and Maxillofacial Surgery.

Short title: Bone palate thickness in cone beam tomography

4.2 ARTIGO 2

LOPES TS, ARAÚJO MTS, FERREIRA MD, VISCONTI MA. New method for assessing bone density and reliability of orthodontists in qualitative analysis of bone palate. A ser submetido para publicação no periódico American Journal of Orthodontics and Dentofacial Orthopedics.

4.1 ARTIGO 1

Investigation of bone palate thickness in children, adolescents and adults: observational study in cone beam computed tomography.

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ABSTRACT

INTRODUCTION: The objectives of the present study were to quantitatively determine the thickness of the bone palate from cone beam computed tomography images based on a consensus analysis pattern and to determine the influence of age and sex. **METHODS:** The sample consisted of 50 exams from the database of an Orthodontics Service, comprised of 11 children (mean age 12 ± 0.79 years), 28 adolescents (mean age 14.5 ± 1.3 years) and 11 adults (mean age 24.6 ± 6.3 years). Two examiners performed measurements of palatal bone thickness using Dolphin Imaging® software. Distances 4, 8, 12 and 14 mm lateral to the median palatal suture were defined for sagittal reconstruction and 0, 3, 6 and 9 mm for coronal reconstruction. **RESULTS:** The thickness of the palate was greater in males than in females ($p < 0.001$), and gradually decreased from the anterior to posterior regions in both groups. A significant increase in thickness was observed in adolescents compared to children and adults. **CONCLUSION:** The anterior region showed a greater bone thickness, which varied according to age and sex, and the distance of 4 mm being the place with the largest bone volume. The palate thickness was highest in males and in adolescents.

KEY WORDS: Palate; Orthodontics; Cone beam computed tomography

INTRODUCTION

The bone region of the palate has been the subject of an increasing number of studies[1-5] that aim to better understand the dimensions, thickness and bone quality of this structure. Current research is focused on the installation of orthodontic mini-implants[4, 6-10]; however, knowledge of the palatal bone anatomy and its particularities concerning its limits is extremely important when planning orthognathic surgeries, extractions, removal of pathological processes and maxillary expansion, among other applications[11-14].

Orthodontic anchorage continues to be a concern for orthodontists[15-18]. The correct anchorage planning criteria is a determining factor for the success of orthodontic treatment [19-21]. Mechanics like as molar distalization require the insertion of mini-screws, often in the median region of the palate[7, 22, 23] . The palatal bone structure is a preferred region for the insertion of these devices as it is easily accessible, has a low risk of damaging important anatomical structures (except the palatine nerve) and has a better prognosis when the mini-implant is installed in the attached gingiva (keratinized mucosa) and low risk of root damage[8, 24, 25].

In addition to the insertion of mini-implants, research has also focused on evaluating the medial palatal suture for the purpose of clinical decision-making for rapid maxillary expansion (ERM) or surgical expansion (SARPE)[11, 26] , and also in relation to its anatomical configuration. In a study by Suteerapongpun et al.[5], the palatal region was mapped to assess its bone thickness in patients with malocclusion, concluding that patients with vertical class I malocclusion had reduced bone thickness.

Currently, the maxillary bone dimensions can be observed three-dimensionally by means of cone beam computed tomography (CBCT) images, which allows measurements that were not previously performed with two-dimensional (2D) examinations. The CBCT allows examination of the anatomical structures without overlap and distortion, with high definition, low noise and lower effective dose to be applied to the patient, when compared to other tomographic exams[27]. Several studies have analyzed different methods for the bone region of the palate and have demonstrated inequalities in thickness when evaluated in CBCT images, especially due to the different regions selected, in addition to the differences between the patient's sex and age [4, 6, 28, 29].

The present study quantitatively analyzed palatal bone observations on CBCT images according to a consensus pattern, taking into account the age and sex of patients.

MATERIALS AND METHODS

This research was carried out following approval by the Research Ethics Committee [redacted] (3.217.506/2019).

WinPepi[30] (PEPI-for-Windows; version 11.65) for epidemiologists was used for sample calculation. Based on the experimental groups and the number of measured regions, an estimated 50 CBCT exams were required to detect a difference of 0.6 deviations, considering the unitary standard deviation. For this calculation, a power level of 80% and significance level of 5% were considered.

Our sample consisted of 50 CBCT exams obtained from the database of an Orthodontics Service. All images were displayed on the same Kodak 9500 digital tomograph (Carestream Health, Rochester, NY, USA) and obtained with the same acquisition parameters: 90 kVp, 10 mA, field of view (FOV) of 18.4 × 20.6 cm, 0.3 mm isotropic voxel size, and scanning time of 24 s.

The sample included patients over 10 years of age of both sexes (25 females and 25 males) with no history of orthodontic treatment prior to the acquisition of the CBCT image. Patients were excluded in case of their examinations showed craniofacial malformations that were visible on the tomographic image, if they presented pathological processes in the maxilla, or had absences or dental retentions in the upper arch. The images were subdivided into three groups according to patient age: group 1; n=11 children (<13 years), group 2; n=28 adolescents (13 to 17 years), and group 3; n=11adults (≥18 years).

All volumes were stored on optical media in digital image and communications in medical (DICOM) format and imported into Dolphin Imaging software (version 11.7 Premium; Dolphin Imaging, Chatsworth, CA, USA) for analysis. Two examiners (TSL and MDF), researchers of the study, were trained using five tomographic examinations that were later excluded from the main sample. After establishing high agreement (ICC = 0.955), they started evaluations, establishing the consensual standard as a reference.

Standardization of all images was performed to ensure the correct orientation of the patient's head. The anatomical points and reference planes used to standardize the orientation of the head in the 3D reconstruction were defined according to Baratieri et al.[31] From these anatomical points, three reference planes were defined: axial plane, defined by the points OrD, OrE and PoD; coronal plane, formed by the PoD and PoE points, which were perpendicular to the selected axial plane; and the sagittal plane, which intersected the N point and lay perpendicular to the already established axial and coronal planes.

Measurements of palatal bone thickness were performed on sagittal and coronal multiplanar reconstructions using the modified method described by Wang et al.[4] and Bonangi et al.[6]. In the sagittal reconstruction, a reference was established on the posterior edge of the incisor foramen in the same horizontal plane as the posterior nasal spine[4]. Subsequently, perpendicular to the horizontal plane with no change in the anteroposterior direction, measurements of palatal bone thickness were performed 4, 8, 12 and 14 mm from the most posterior point of the incisor foramen.

In the coronal plane the thickness measurements of the palatal bone were performed 0, 3, 6 and 9 mm lateral to the median palatal suture, using the sagittal sections (4, 8, 12 and 14 mm) like reference. The measurements were made at the points of intersection of the reference lines (C0, C3, C6 and C9). Bone palate mapping was performed, resulting in a total of 35 points, followed by the intersection of the sagittal and coronal reconstructions (Figures 1 and 2).

STATISTICAL ANALYSIS

A comparison of means was performed by analyzing the variances (ANOVA 2-way) of bone thickness between the factors distance, sex and the double interaction (distance * sex) in each of the tomographic reconstructions. When significant, a Bonferroni post hoc test was used to identify differences between the groups.

In the quantitative analysis, variables were presented as the mean and standard deviation. The limits of agreement were calculated with a 95%

confidence interval (CI), and Bland-Altman graphical analysis was performed to examine the agreement between examiners.

The paired t test was performed to verify the agreement of the measures and the intraclass correlation coefficient (ICC). The analyses were performed both for the general sample and for the different tomographic reconstructions (sagittal and C0, C3, C6, C9; bilaterally).

RESULTS

The ICC showed high reliability among the two examiners for all measurements performed (ICC $>$ 0.90). Tables 1 and 2 compares the average bone thickness between males and females for each region and for the coronal and sagittal multiplanar reconstructions, in addition to the interaction between region and sex.

The sex variable was significant for all interactions, with a significantly higher average found in males regardless of the region ($p < 0.001$). In the sagittal and coronal reconstructions (C0), sex was the only significant variable ($p < 0.001$).

Note that the coronal reconstruction in the C9 region at 4 mm was statistically significant when compared to the other regions ($p < 0.001$). For the C3, C6 and C9 regions, there was a bilateral decrease in bone thickness from anterior to posterior regions (Tables 1 and 2).

The mean age of patients was 12 years (± 0.79) in group 1 (<13 years), 14.5 years (± 1.3) in group 2 (13–17 years), and 24.6 years (± 6.3) in group 3 (≥18 years).

As shown in Table 3, the mean of the age brackets differed in the sagittal and coronal reconstructions (C6, left side only; C9, bilateral). In the sagittal and coronal reconstructions (C6, left side), the bone thickness of group 1 differed from group 2. In the coronal reconstruction (C9, right side), there was a difference between patients in group 2 and group 3 (older than 18 years). In the same region (C9), however, on the contralateral side, the thickness of the palate in group 2 was different to groups 1 and 3 (Figure 3).

Regarding regions C3, C6 and C9 (both sides), a significant difference between sex was observed. Age was significant for all regions, except C9, direct side, and C3, bilaterally. Despite the few differences found, the average measurement for the region at 4 mm was greater when compared to all other regions.

DISCUSSION

The anatomy of the bone palate has been studied by many different authors over the years[2, 4, 5]. Several clinical situations have triggered this interest, including palatal disjunction, insertion of mini-implants, dental movements in the upper alveolar crest, retained teeth traction, removal of pathological processes and cleft palate, in addition to a better understanding and evaluation of orthodontic treatment mechanisms[11, 12, 14, 32]. However, the measurement of bone thickness and quality for the insertion of orthodontic mini-implants is currently the most commonly reported indication[4-6, 8, 10, 29, 33].

The bone palate is an easily accessible region that contains no vital structures (except the palatine nerve) and adequate keratinized tissue, and also presents a low risk for the development of root lesions during surgical procedures [10, 16, 28]. Thus, the bone palate and its dimensions in patients of different ages and genders must be considered, not only in relation to the installation of mini-implants. However, correct planning is only possible when the three-dimensional (3D) bone structure is known.

Previous studies used CBCT to visualize and perform measurements on the palatal bone. This technique is considered superior to radiographs as it allows a 3D evaluation without exposing structures[4, 6, 10, 29, 33-36]. Three-dimensional images obtained by CBCT were used in the present study, making it possible to quantitatively evaluate different bone regions taking into account the volumetric dimensions across the anatomical structure.

This study measured the bone thickness of the palatal bone in patients of different ages, similar to a study by Holm et al.[33] which used a sample of 431 patients split into three age groups: 9 to 13 years, 14 to 18 years, and 19 to 30 years. In his work was found a smaller bone thickness in children aged 9 to 13 compared to the other two groups, and there was no difference between the groups aged 14 to 18 years and 19 to 30 years.

In the current study, the group of adolescents (13 to 17 years old) had greater palatal thickness and lower variation in thickness in relation to the other points compared to the groups of children and adults. In contrast, Becker et al.[29] examined 30 patients, comprised of 22 females with a mean age of 20.1 ± 13.1 years and eight males with a mean age of 13.5 ± 5 years, and found no significant difference in relation to age.

Similarly, Marquezan et al.[8] did not find any significant difference in age in their sample consisting of 36 patients aged 12 to 52 years, eight of whom were male. The small sample size and lack of homogeneity for the gender variable probably influenced the results for age.

Wang et al.[4] divided their sample into two groups, with group 1 consisting of 51 adolescents and group 2 including 56 adults, and also found no significant differences despite a more balanced distribution between the sexes. Gracco et al.[28] divided their sample of 80 males and 82 females into three groups, 10 to 15 years, 15 to 20 years and 20 to 44 years, and concluded that there was no difference in relation to age. Other variables may have influenced these data, such as the nationality of the patients, with two recent studies conducted in Korean and Italian patients. These data are clinically relevant, as the placement of mini-implants in the palate region of children and adolescents should be avoided because ossification may not be complete. In this case, the paramedian regions are preferred[1,11]. In the present study, a greater bone thickness was found in the C9 region of adolescents (bilaterally).

A recent study on the relationship between palate thickness and gender showed that the palatal bone thickness was greater in males[6], similar to the present research. Other authors have also confirmed these findings, such as Holm et al.[33], who found that the bone thickness of females is generally 1.23 mm less than males[10, 33]. However, other studies did not reveal whether there was a significant interaction between patient sex and palatal bone thickness[28, 29].

In the sagittal and coronal (C0) reconstructions of the median palatal medulla region, the bone thickness was found to decrease in the anteroposterior direction, but at 12 mm there was an increase in thickness. This is consistent with a study by Kang et al.[10], who found an increased thickness at a mediolateral distance of 1 mm, followed by a slight reduction then a consecutive increase in the posterior direction.

In other mediolateral variables, the values lowered toward the posterior direction, which corroborates our findings for the other points of C3, C6 and C9, where there was a reduction in thickness from the anterior to posterior directions. These results are similar to most studies in the literature[6, 10, 28, 33]. Becker et al.[29] found a greater thickness between the first and second premolars in the region of the PMS, but did not distinguish between the sides. However, Holm et al.[33] found that the thickness increased in the mid-sagittal plane. Thus, mechanical orthodontics should preferably be placed in the anterior region when greater bone thickness is required. This statement is particularly relevant for cases in which the diagnosis and treatment plan can be considered.

The greatest variability between studies is in the median and paramedic regions, as this is where there is greatest divergence in results[4, 6, 8, 10, 28, 29, 33]. Kang et al.[10] describe a reduction in thickness in the lateral direction of the suture, which differs from the study by Holm et al.[33] which reported a smaller thickness in the midpalatal suture with a lateral increase within this structure. Becker et al.[29] reported that the thickness of the paramedian region (3 and 6 mm) was greatest in the median region. This variability could be due to differences in the methodologies used by each study.

In the present study, the regions to be measured were chosen based on other studies, as most analyzed distances of 3 and 6 mm lateral to the suture[6, 8, 28, 29]. However, it is also interesting to include a coronal view at a distance of 9 mm to better define the bone thickness behavior in this reconstruction, the latter of which is more lateral and coincides with the anatomical regions of teeth that are most important for orthodontic mecanical. For sagittal reconstruction, the 4 mm posterior point and incisive foramen were chosen to avoid damage to the nasopalatine nerve and the greater palatal artery. It is also recommended that insertion of devices in this area be avoided up to 3 mm in the posterior direction. A distance of 12 mm was not exceeded, as this region is not clinically favorable for the application of mechanical orthodontics. In addition, the bone height tends to decrease toward the posterior region[10, 16, 28].

A greater thickness was found in the median and paramedian regions, 9 mm lateral to the suture. Although the greatest thickness was found in the 9 mm region, this is not a clinically favorable region for the placement of mini-implants as there is a greater risk of perforating the roots of the teeth. In cases where there are dental absences or the need for other procedures, such as the removal of material for grafting, this information must be taken into account.

Marquezan et al.[8] showed a reduction in thickness 3 mm in the lateral direction of the suture and an increase at 6 mm. However, as the most indicated area for the placement of mini-implants that located 4 mm posterior the incisor foramen, in the median or paramedian regions, and 3 mm adjacent to the suture, due to the greater amount of cortical bone. The results of this study showed that the 9 mm region lateral to the suture obteined greater thickness; however, given its proximity to the roots of the teeth, this could be an applicable clinical resource.

There were no significant differences in the thickness of the palate in the right and left sides, as reported by other previous studies[4, 10, 33]. This suggests that, in clinical practice, other functions should be considered when choosing the side, such as dental absences, the root anatomy of the teeth present, mechanics that will be employed, dental axial inclinations and technical support.

Two examiners performed quantitative measurements in the present study and established a consensus standard for analysis. Training was conducted prior to the evaluations, and the ICC showed a high level of reliability for the analyses, the highest of which was 0.90[37]. Use of a methodology with two examiners increases the use of the measurements performed and guarantees more accurate results. However, most studies in the literature use only one examiner[4, 8, 10, 33]. The lowest agreement between the two examiners was observed for the C0 region, but it was still considered excellent (0.907). This variation can be attributed to the difficulty in making measurements in the midpalatal suture region or some error in considering the region most posterior the incisor foramen in the sagittal reconstruction.

The unbalanced distributions of patient ages within our sample, as well as the anatomical changes inherent to each individual were limitations found by the authors. However, the measurements performed were highly reliable because using the consensual standard between two trained examiners. Regarding gender, the sample was highly homogeneous, with 25 females and 25 males.

In conclusion, the anterior region is the most thickness being the distance of 4 mm posterior the incisor foramen the largest bone volume. There was a significant difference in bone thickness between patients of different sexes and age groups. Males had a most bone thickness compared to females. In general, in the previous regions and in the average the bone thickness was smallest in children; however, the average thickness found in adolescents was highest when compared with the three groups, in all regions studied.

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Table 1 Average of the total results of the distances in each bone thickness by the analysis in ANOVA 2-way models

Distance (mm)	Total (sex*distance)							
	Sagittal	C0	C3	C6	C9	C3	C6	C9
			Right Side			Left Side		
4	5.6[5.1;6.1]	5.8[5.3;6.2]	4.3a[3.9;4.7]	4.2a[3.7;4.6]	5.7a[5.1;6.3]	4.5a[4.1;4.9]	4.3a[3.9;4.7]	5.7a[5.1;6.3]
8	4.8[4.3;5.2]	5.0[4.6;5.5]	3.3b[2.9;3.7]	2.9b[2.4;3.3]	3.7b[3.1;4.2]	3.4b[3.0;3.8]	2.8b[2.4;3.2]	3.6b[3.0;4.2]
12	4.9[4.4;5.4]	5.2[4.8;5.7]	3.1b[2.7;3.5]	2.2b[1.7;2.6]	2.8bc[2.2;3.4]	3.0b[2.6;3.4]	2.3b[1.8;2.7]	3.1b[2.5;3.7]
14	5.1[4.6;5.5]	5.2[4.7;5.6]	3.1b[2.7;3.5]	2.1b[1.6;2.5]	2.4c[1.8;3.0]	3.0b[2.6;3.4]	2.0b[1.6;2.4]	2.6b[1.9;3.2]
p distance	0.082	0.102	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Distance (mm)	**Total (age bracket*distance)**							
	Sagittal	C0	C3	C6	C9	C3	C6	C9
			Right Side			Left Side		
4	5.4[4.8;5.9]	5.7[5.1;6.2]	4.2a[3.7;4.6]	4.0a[3.5;4.5]	5.5a[4.8;6.1]	4.3a[3.9;4.8]	4.1a[3.6;4.6]	5.3a[4.6;6.0]
8	4.6[4.1;5.1]	4.0[4.4;5.4]	3.1b[2.7;3.6]	2.7b[2.2;3.2]	3.4b[2.8;4.1]	3.2b[2.8;3.7]	2.5b[2.1;3.0]	3.3b[2.6;4.0]
12	4.9[4.4;5.4]	5.1[4.6;5.6]	3.0b[2.5;3.5]	2.0b[1.5;2.6]	2.6b[1.9;3.2]	2.9b[2.4;3.4]	2.2b[1.7;2.7]	2.8b[2.2;3.5]
14	5.1[4.6;5.6]	5.0[4.5;5.6]	3.0b[2.5;3.5]	2.0b[1.5;2.5]	2.2b[1.6;2.9]	3.0b[2.5;3.4]	1.9b[1.4;2.4]	2.3b[1.6;3.0]
p distance	0.203	0.157	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Model 1 - ANOVA 2-way analyzing the factors sex, distance and interaction (sex * distance). Unpublished results of the main effect and sexual interaction.
Model 2 – ANOVA 2-way analyzing the age, distance and interaction factors (age * distance). Results of the main effect of the unpublished age range and interaction.
Different lowercase letters in the columns represent different statistical means.

Table 2 Comparison of the average bone thickness (95% CI) between males and females and between regions, as well as the interaction between these variables (sex * distance) for the total sample

Distance (mm)	Female							
	Sagittal	C0	C3	C6	C9	C3	C6	C9
			Right Side			Left Side		
4	4.9 [4.2;5.5]	5.1[4.5;5.7]	3.6[3.1;4.2]	3.7[3.1;4.3]	5.3[4.5;6.1]	3.8[3.2;4.4]	3.5[2.6;4.5]	5.1[4.2;5.9]
8	4.2[3.6;4.9]	4.7[4.0;5.3]	2.8[2.2;3.4]	2.5[1.9;3.1]	3.0[2.2;3.9]	2.9[2.3;3.4]	2.0[1.1;3.0]	3.0[2.1;3.8]
12	4.6[4.0;5.3]	4.8[4.2;5.4]	2.7[2.1;3.3]	1.8[1.2;2.4]	2.4[1.6;3.2]	2.6[2.1;3.2]	2.1[1.2;3.1]	2.6[1.7;3.4]
14	4.9[4.3;5.6]	5.0[4.4;5.6]	2.8[2.2;3.3]	1.9[1.3;2.5]	2.1[1.2;2.9]	2.7[2.1;3.2]	1.7[0.7;2.6]	2.1[1.3;3.0]
Total	4.6A[4.3;5.0]	4.9A[4.6;5.2]	3.0A[2.7;3.3]	2.5A[2.2;2.8]	3.2A[2.8;3.6]	3.0A[2.7;3.3]	2.4A[2.1;2.7]	3.2A[2.8;3.6]
p sex	<0.001	<0.001	<0.001	0.002	0.003	<0.001	<0.001	<0.001
p interaction	0.315	0.408	0.577	0.835	0.922	0.535	0.848	0.961
Distance (mm)	Male							
	Sagittal	C0	C3	C6	C9	C3	C6	C9
			Right Side			Left side		
4	6.3[5.6;7.0]	6.5[5.8;7.1]	5.0[4.4;5.6]	4.7[4.0;5.3]	6.0[5.2;6.9]	5.3[4.7;5.9]	4.7[4.1;5.3]	6.3[5.4;7.2]
8	5.3[4.7;6.0]	5.4[4.8;6.1]	3.8[3.3;4.4]	3.3[2.6;3.9]	4.3[3.4;5.1]	3.9[3.3;4.5]	3.2[2.6;3.8]	4.3[3.4;5.1]
12	5.2[4.5;5.9]	5.7[5.0;6.3]	3.5[2.9;4.1]	2.6[1.9;3.2]	3.3[2.4;4.1]	3.4[2.8;4.0]	2.5[1.9;3.1]	3.7[2.8;4.6]
14	5.2[4.5;5.9]	5.3[4.7;6.0]	3.3[2.8;3.9]	2.3[1.6;2.9]	2.8[1.9;3.6]	3.3[2.7;3.9]	2.2[1.6;2.8]	3.0[2.1;3.9]
Total	5.5B[5.2;5.9]	5.7B[5.4;6.0]	3.9B[3.6;4.2]	3.2B[2.9;3.5]	4.1B[3.7;4.5]	4.0B[3.7;4.3]	3.2B[2.9;3.6]	4.3B[3.9;4.7]
p sex	<0.001	<0.001	<0.001	0.002	0.003	<0.001	<0.001	<0.001
p interaction	0.315	0.408	0.577	0.835	0.922	0.535	0.848	0.961

Model 1 – ANOVA 2-way analyzing the factors of sex, distance and interaction (sex * distance). Different capital letters represent different media among sex totals.

Table 3 Comparison of mean bone thickness (95% CI) between the different age groups and regions and the interaction between these variables (age * distance) for each group

Distance Mm	Group 1 - Children (< 13 years)							
	Sagittal	C0	C3	C6	C9	C3	C6	C9
			Right Side			Left Side		
4	4.6 [3.5;5.6]	5.2 [4.2;6.2]	4.0 [3.1;4.9]	3.8 [2.9;4.8]	5.5 [4.2;6.8]	3.9 [3.0;4.8]	3.5 [2.6;4.5]	4.9 [3.6;6.3]
8	3.8 [2.8;4.9]	4.5 [6.5;5.5]	3.1 [2.2;4.0]	2.5 [1.5;3.5]	3.1 [1.9;4.4]	2.9 [1.9;3.8]	2.0 [1.1;3.0]	2.8 [1.5;4.1]
12	4.4 [3.4;5.4]	4.9 [3.9;5.9]	3.0 [2.1;3.9]	1.8 [0.8;2.8]	2.2 [1.0;3.5]	2.8 [1.9;3.8]	2.1 [1.2;3.1]	2.4 [1.1;3.7]
14	4.9 [3.9;5.9]	5.1 [4.1;6.1]	3.2 [2.3;4.1]	2.3 [1.3;3.3]	1.9 [0.6;3.2]	3.0 [2.1;3.9]	1.7 [0.7;2.6]	2.0 [0.7;3.3]
p age	0.02	0.072	0.149	0.096	0.017	0.141	0.006	<0.001
p interaction	0.763	0.951	0.983	0.977	0.999	0.954	0.94	0.998
Distance Mm	Group 2 - Adolescents (13 to 17 years)							
	Sagittal	C0	C3	C6	C9	C3	C6	C9
			Right Side			Left Side		
4	6.0 [5.3;6.6]	5.2 [4.2;6.2]	4.0 [3.1;4.9]	3.8 [2.9;4.8]	5.5 [4.2;6.8]	4.8 [4.2;5.4]	4.7 [4.1;5.3]	6.3 [5.5;7.1]
8	5.1 [4.4;5.7]	4.5 [3.5;5.5]	3.1 [2.2;4.0]	2.5 [1.5;3.5]	3.1 [1.9;4.4]	3.6 [3.1;4.2]	3.2 [2.6;3.8]	4.1 [3.3;4.9]
12	5.0 [4.4;5.6]	4.9 [3.9;5.9]	3.0 [2.1;3.9]	1.8 [0.8;2.8]	2.2 [1.0;3.5]	3.2 [2.6;3.8]	2.5 [1.9;3.1]	3.6 [2.8;4.4]
14	5.0 [4.3;5.6]	5.1 [4.1;6.1]	3.2 [2.3;4.1]	2.3 [1.3;3.3]	1.9 [0.6;3.2]	3.0 [2.4;3.6]	2.2 [1.6;2.8]	3.0 [2.1;3.8]
p age	0.02	0.072	0.149	0.096	0.017	0.141	0.006	<0.001
p interaction	0.763	0.951	0.983	0.977	0.999	0.954	0.94	0.998
Distance mm	Group 3 - Adults (≥18 years)							
	Sagittal	C0	C3	C6	C9	C3	C6	C9
			Right Side			Left Side		
4	5.6 [4.5;6.6]	5.9 [4.9;6.8]	4.0 [3.1;4.9]	3.8 [2.8;4.8]	5.0 [3.8;6.3]	4.4 [3.4;5.3]	4.0 [3.1;5.0]	4.7 [3.4;6.0]
8	4.8 [3.8;5.9]	4.8 [3.8;5.8]	2.8 [1.9;3.7]	2.5 [1.5;3.5]	3.0 [1.8;4.3]	3.2 [2.3;4.1]	2.4 [1.5;3.4]	3.0 [1.7;4.3]
12	5.2 [4.2;6.2]	4.8 [3.8;5.8]	2.8 [1.9;3.7]	1.9 [0.9;2.9]	2.3 [1.0;3.5]	2.8 [1.8;3.7]	1.9 [0.9;2.8]	2.5 [1.2;3.9]
14	5.4 [4.4;6.5]	4.7 [3.7;5.7]	2.7 [1.8;3.7]	1.7 [0.7;2.6]	2.0 [0.7;3.2]	2.8 [1.9;3.8]	1.7 [0.8;2.7]	2.0 [0.7;3.3]
p age	0.02	0.072	0.149	0.096	0.017	0.141	0.006	<0.001
p interaction	0.763	0.951	0.983	0.977	0.999	0.954	0.94	0.998

Model 2 – ANOVA 2-way analyzing the age, distance and interaction factors (age * distance).

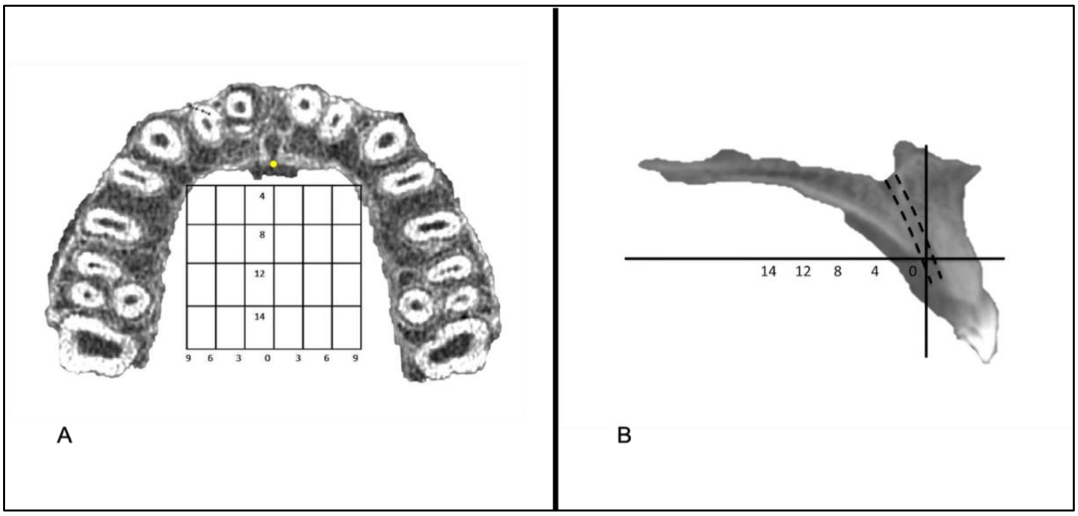

Figure 1 Reference lines to measure palatal bone thickness at predetermined points in the axial (A) and sagittal (B) reconstructions.

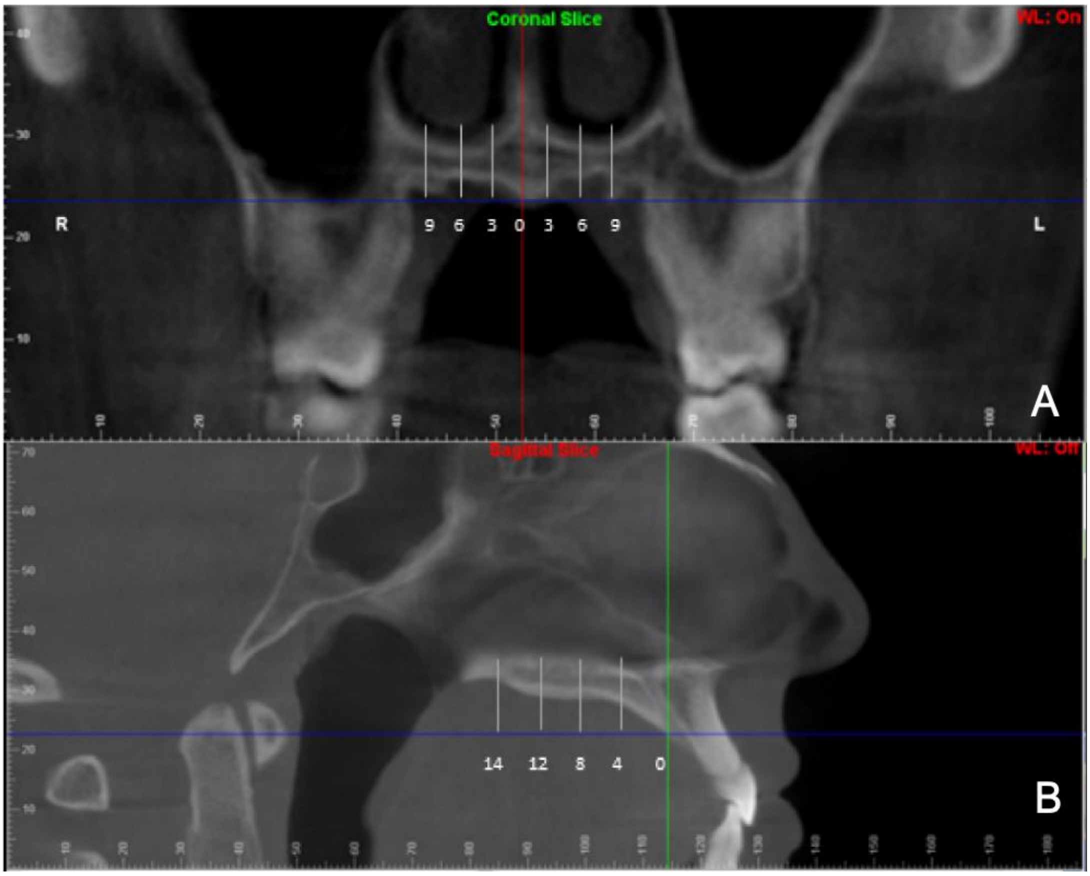

Figure 2 Coronal (A) and sagittal (B) reconstructions showing how measurements were made at predefined points lateral to the medial palatal suture (A) and from the posterior edge of the incisor foramen (B).

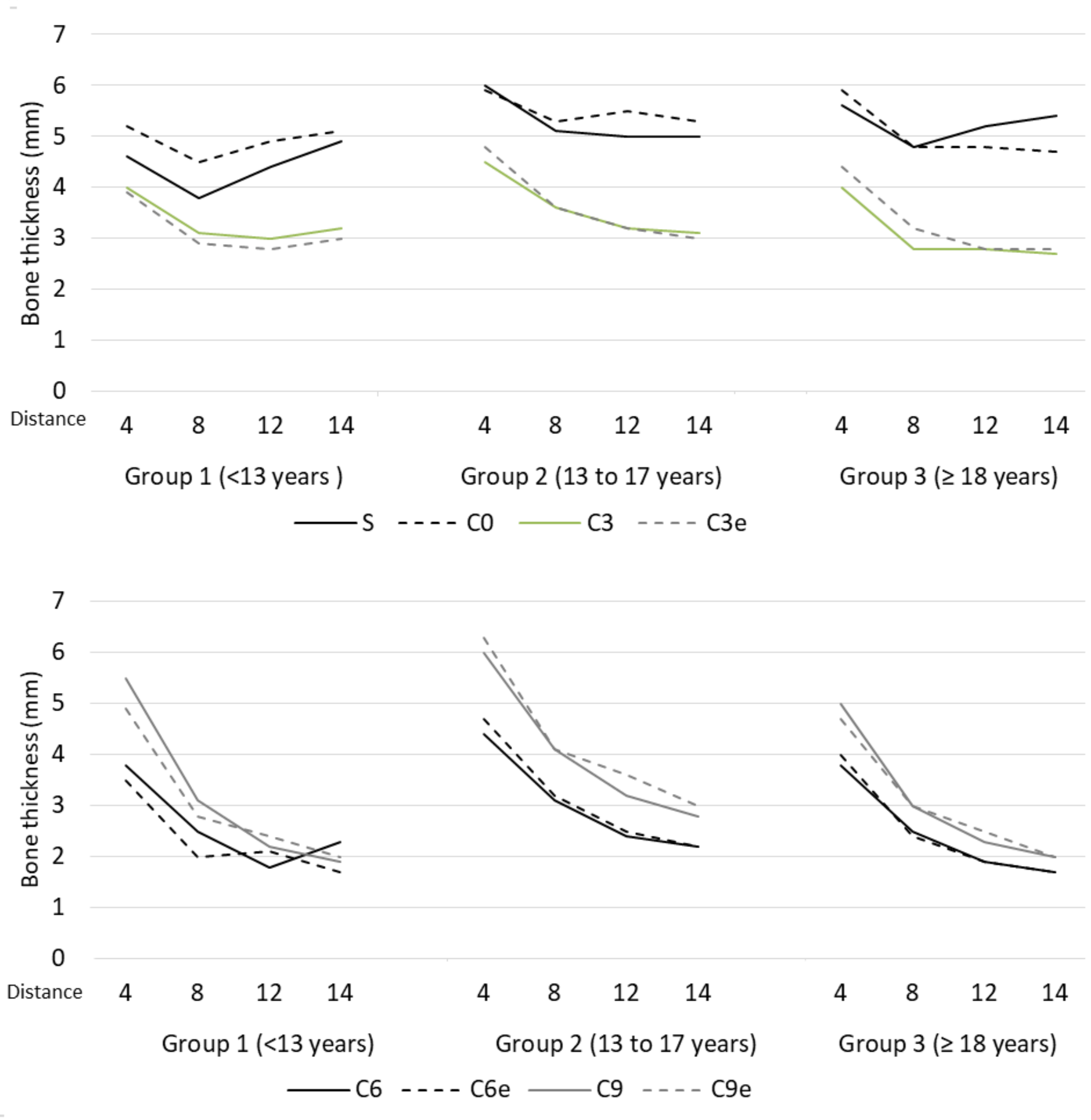

Figure 3 Comparison of the average bone thickness between the groups according to the measured region.

4.2 ARTIGO 2

New method for assessing bone density and reliability of orthodontists in qualitative analysis of bone palate.

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ABSTRACT

INTRODUCTION: The objective of this study was to evaluate the performance of orthodontists with different levels of experience in the qualitative evaluation of the palatal bone regions by means of cone beam computed tomography (CBCT). **METHODS:** The sample consisted of 50 CBCT exams and 24 orthodontists. A questionnaire with questions related to the evaluation of the bone palate was answered using a template with images from 50 CBCT exams. The analysis was carried out in 3 moments, with an interval of 15 days. The correct answers were determined by two researchers, and a quantitative analysis of bone density was performed. Categorical variables were represented by absolute and relative frequency. The Generalized Estimation Equations model (GEE model) was used to compare the proportions of correct answers and the Kappa index was calculated to determine intra- and interobserver reproducibility. The level of significance was 0.05 and the program used for the analysis was SPSS version 25. **RESULTS:** There was no significant difference in performance between groups ($p > 0.05$). The question regarding the median palatal suture (MPS) received the fewest correct answers, and the question about the area of highest bone quality received the most correct answers. The intraobserver Kappa coefficient was substantial ($K = 0.651$) and the interobserver agreement was fair between group 1 and the others, and moderate between groups 2 and 3. Quantitative analysis was able to quantify the intensity of gray values. **CONCLUSION:** The level of experience did not influence the interpretation of tomographic images and the measurement of gray values was an effective method for the clinical assessment of bone quality in an objective way.

KEY WORDS: Palate, Orthodontics, Reliability, Tomography

INTRODUCTION

The palatal bone has been investigated in several studies[1-3] in order to better understand its dimensions, thickness and functionality. However, its three-dimensional anatomy and difficulty in interpreting volumetric examinations mean that such investigations are often not performed correctly.

Several clinical indications require accurate analysis of the palatal bone and its related structures. One should not associate the study of palate bone just for the use of mini-implant insertion (MI), as there are other treatment options, such as palatal dysjunction, orthodontic tooth movement and orthognathic surgery, whether complementary or not [4,5]. The classification of the median palatal suture into five stages of maturation, as proposed by Angelieri et al[5], is still widely used by orthodontists and requires an accurate analysis of the palatal bone. The skeletal architecture of some malocclusions can directly interfere with the thickness of this bone[6]. Thus, the bone palate provides a wide spectrum of information through its anatomical configuration, median palatal suture and bone dimensions.

The advent of cone beam computed tomography (CBCT) with a lower dose of ionizing radiation when compared with multidetector computed tomography (MDCT), uses the bone palate in three dimensions, with high definition, low noise and high diagnostic accuracy images when compared with two-dimensional examinations[7-9].

The examiner's degree of knowledge in relation to the interpretation of tomographic images can influence treatment planning, considering that the exams that generate three-dimensional images, require experiences and visual acuity. However, there is controversy in the studies found in the literature regarding the interference of the experience in Orthodontics related to the performance in evaluating images of CBCT[10,11].

In addition to understanding the advantages of CBCT for dentistry, and specifically orthodontics, it is necessary for examiners to respect the limitations of this exam. An analysis of the bone palate can be done subjectively and objectively, as long as you know the limits of the exam. The impossibility of determining bone density using Hounsfield units (HU) is an important deficiency of CBCT[12-16]. This means that there is necessity that other ways of assessing the bone density of the palate are needed for different orthodontic purposes, becoming the pre-treatment analysis more accurate and less subjective. The present study thus considered the knowledge of orthodontists with different levels of experience in relation to their interpretation of CBCT images, in addition to suggesting a method of evaluating bone density in a quantitative way that could be used in clinical practice.

MATERIALS AND METHODS

Study design and ethical assessment

This was a cross-sectional study approved by the Research Ethics Committee [redacted] (3.217.506/2019).

Sample characterization

The sample consisted of 50 CBCT exams belonging to the database of an Orthodontics Service and a group of 24 postgraduate students in orthodontics. The sample size calculation was performed using the WinPepi program (PEPI-for-Windows) [17] for epidemiologists. Since the 24 examiners were subdivided into three groups, the total sample size calculated was 1200 responses, that is, 400 responses per group and, thus, 50 CBCT exams were used. This sample was able to detect a difference of 0.6 deviations between the averages, considering the unitary standard deviation. For this calculation, a power of 80% and a significance level of 5% were adopted.

Eligible exams were considered to be those belonging to patients over 10 years of age, either male or female, and without a history of orthodontic treatment prior to acquisition of the tomographic image. Examinations of patients with craniofacial malformations visible on the tomographic image, who had pathological processes in the maxilla and missing teeth or dental retentions in the upper arch were excluded.

The included exams were storaged using optical media in DICOM format (digital images and communications in medical format) in the Dolphin Imaging program, version 11.7 Premium (Dolphin Imaging, Chatsworth, California, USA). After standardizing the positioning of the head, images of the bone palate were selected in sagittal, coronal and axial reconstructions to make the models to be sent to the participants.

Participants with postgraduate degrees in orthodontics with different levels of training/professional experience were subdivided into three groups: GP1 (8 new specialists, without experience); GP2 (8 specialists, with less than 5 years of experience) and GP3 (8 specialists, with more than 5 years of experience).

Clinical / qualitative assessment

The three groups (GP1, GP2, GP3) performed all clinical/qualitative assessments. In the first assessment (T1), an analysis of tomographic images was performed to determine the participants' general knowledge about oral radiology, including questions about tomographic interpretation.

A second questionnaire (T2) referring to the analysis of the CBCT exams of the patients in the sample (n = 50) was also given to the participants. The questions referred to the anatomical classification of the palatal bone, according to Sassouni[18], the stage of fusion of the median palatal suture[5] and bone quality in each pre-specified region according to the shade of gray and the appearance of the palatal bone (Figure 1).

To qualitatively assess the palatal bone density, a gray scale and a schematic drawing modified according to Misch[19] were used as reference. Thus, the bone was classified into: D1 (dense cortical bone; excellent quality); D2 (porous and dense trabecular cortical bone; good quality); D3 (porous cortical bone associated with fine trabeculation; low quality) (Figure 2).

This assessment took place on two different occasions, with only 25 exams being made available to participants at a time, to avoid visual fatigue. It is known that the human eye is able to examine only 25 exams at a time without a negative impact on the result [20,21]. The interval between these analyses was 15 days. After 30 days (T3), the participants reevaluated 20% of the sample (n = 10) to establish the intra-observer agreement[20].

Two experienced researchers (TSL and MAV) answered the questionnaires (T1 and T2) and, by consensus, established the correct answers (except for question 5 of T2, referring to bone quality, which was verified through quantitative analysis).

Quantitative assessment

To quantitatively check the results of the bone quality assessment in question 5 of T2, and to determine an effective method for objective clinical analysis of density in CBCT images, the intensity of the gray values, through the numerical values of the image voxels were analyzed, using the ImageJ/Fiji program, version 1.50d (NIH, Bethesda, USA). Thus, it was possible to define the average density value of the region, without utilized to the standardized values of the HU density scale.

A single experienced examiner (TSL) performed objective measurements on the tomographic images. Using the X and Y coordinates of the ImageJ/Fiji program, the same section and the same region demarcated in the clinical evaluation was selected for objective evaluation. For each specific anterior region in the clinical evaluation, a standardized 46 x 46 mm ROI (region of interest) was established and the gray values were calculated using a tool that determines the average gray intensity from a histogram (Figure 3).

Statistical analysis

For qualitative analysis, the categorical variables were represented by absolute and relative frequency. The Generalized Estimation Equations model (GEE model)[22] was used to compare the proportions of hits. For this model, a binomial distribution with a probit link function was used. Two models were constructed:

Model 1: to test the main effect of questions between levels of experience.

Model 2: to test the main effect of the level of experience between the categories of questions.

The model was composed of an independent work correlation matrix and a robust estimator covariance matrix. When significant, the Bonferroni test was used as a post-hoc test to identify distinct categories.

The Kappa index was used to verify intra- and interobserver reproducibility. Agreement was classified as follows: poor agreement (0–0.19), fair agreement (0.20–0.39), moderate agreement (0.40–0.59), substantial agreement (0, 60–0.79) and almost perfect agreement (0.80–1.00)[23]. The level of significance was set at 0.05 and the program used was SPSS (Version 25).

RESULTS

A descriptive analysis in relation to the responses to T1 (regarding the principles of tomographic interpretation) revealed 100% correct responses for items Ia and Ic. Item IV received the fewest correct responses (54.2%). For the remaining questions, the percentage of correct answers ranged from 66.7% to 95.8%. There was no significant difference between the levels of experience ($p > 0.05$).

The percentage of correct answers in the GEE model, in relation to the examiner's level of experience (T2) is presented in Table I. There was no significant effect of the level of experience on the responses to each question ($p > 0.05$). In general, in T2, when questions addressed the area of best bone quality (question 4), presented more hits (85.3%) followed by question 5 regarding bone classification in D1, D2 and D3 (73.2%). The question with the lowest percentage of correct answers was question 2, based on the stage of classification of the median palatal suture (32.3%). It is important to note that these behaviors differed between examiners with different levels of experience, as described in Table I.

Tables II and III present the intra- and interobserver agreement, respectively.

DISCUSSION

There is great interest in the structure of the bone palate in relation to placing orthodontic mini-implants [3,24,25], as it brings many benefits to the mechanics employed. However, other techniques may be suitable in this region, such as palatal dysjunction, orthodontic movement of retained teeth and orthognathic surgery.

In the 1990s, CBCT acquired notoriety in the field of orthodontics, being used for the diagnosis, treatment and evaluation of pre- and post-treatment skeletal relationships[26,27]. It is still widely used in orthodontic planning, and therefore, the results of questionnaire 1 (T1), related to the principles of tomographic interpretation, are important.

The T1 questionnaire showed no difference in performance in relation to the level of experience ($p > 0.05$), but the low percentage of correct reponses to question IV revealed that the analysis and identification of some reconstructions remains difficult. Thus, the ideal scenario would be for the orthodontist to know how to analyze the images of the CBCT, as it should be indicated when are necessary information about bone volume in pre-surgical moments or in retained teeth analysis[28].

The percentage of correct answers in the reassessment (T3) of orthodontists with no experience (59.5%) was lower than that of orthodontists with more than 5 years of experience (66.3%). This may be related to the lack of orthodontists habits to standardize the image interpretation process, which makes the diagnosis by image dependent on the operator, and then, several factors intrinsic to the examiner become possible bias of knowledge.

Although there was no significant difference between T2 (p=0.332) and T3 (p=0.601) in relation to experience levels, a higher total percentage of correct answers was given by specialists with more than 5 years of experience, which has important clinical implications.

Another factor that may be related to the reduction in the performance of examiners is the difficulty in evaluating the region of the median palatal suture[29-31]. Angelieri et al[5] showed high reproducibility and almost perfect agreement in an analysis of the median palatal suture, and a high Kappa value (0.82 to 0.93), but only assessed three orthodontists, all experienced and highly qualified in CBCT assessment and diagnosis, unlike in our study of 24 participants with different levels of experience in orthodontics. In addition, the proposed conventional method[5] present limitations, such as the possibility of displaying different images, depending the position that can be defined the cursor for the axial reconstruction, leading to errors of judgment about the maturation stage of the median palatal suture[31] and, also, a need for extensive training of examiners to achieve an adequate level of proficiency[30].

When were compared the levels of experience in each question, there was no significant statistical difference ($p > 0.05$). However, when comparing wheter the questions have different percentages of hits between levels of experience, significance was found ($p < 0.05$). That is, the level of clinical experience does not always guarantee better performance. In a previous study that used the cervical maturation method to determine skeletal age, the group with the least experience in orthodontics showed the best performance[10]. In the study of Martina et al[11], the clinical experience of orthodontists did not influence on performance, corroborating the present study and disagreeing with Rongo et al[32], who found that examiners with less clinical experience performed worse than the most experienced examiners.

Previous studies that used CBCT for bone palate analysis performed tests for intra- and inter-examiner reliability[3,25,33]. The results were statistically significant for intra- and inter-examiner analyses, however, with only one or two examiners. Thus, despite showing good results, the small number of examiners and their skills at interpreting images of the CBCT, means that the results should be interpreted with caution.

In the present study, there was substantial intraobserver agreement and fair interobserver agreement between orthodontists with no experience (GP1) and those who had some degree of experience (GP2 and GP3), and moderate agreement between specialists with less (GP2) and more than 5 years of experience (GP3). Pachêco-Pereira et al[9] showed poor intraobserver (K = 0.44) and excellent (ICC = 0.941) interobserver agreement for 3D image evaluation, but did not take into account the examiners' experience.

Cho[21] found substantial intraobserver agreement (K = 0.66) and moderate interobserver (K = 0.53) agreement when using dentistry students to assess condylar fracture in 2D images. Rongo et al[32] obtained variable intraobserver agreement of 0.36 to 1 in 2D images and 0.22 to 0.69 in 3D images, with a general intraobserver agreement of 0.63 in 2D and 0.5 in 3D. This demonstrates a greater correlation in the analysis of two-dimensional images. It is worth mentioning that no other studies were found that compared examiners in relation to the evaluation of palate bone examination, emphasizing the importance of the present study, since this region is constantly researched by orthodontists.

CBCT is indicated to evaluate the qualitative and quantitative aspects of palatal bone thickness before the placement of orthodontic mini-implants[3,24,25]. However, due to the high variability between bone palatal thickness described in the literature, which vary with sex, age of patients and anatomical region, making it impossible to perform general recommendations in relation to the ideal insertion sites[3,24]. Often, individualized qualitative analysis can raise doubts regarding bone quality.

In the present study, a qualitative/clinical analysis of the ideal sites for placing the mini-implant (question 3) showed a wide variety of responses. There was no significant difference between groups, that is, clinical experience did not necessarily imply the best performance. However, within the group with less than 5 years of experience, question 3 had the lowest percentage of hit after the suture question (question 2). This variety found in the answers between the groups may be related for the fact that the evaluation was not performed in the entire tomographic volume, making it difficult to analyze the ideal site for the insertion of the mini-implant.

In most of the studies already published, the anterior regions, medians and paramedian, they are the places with the greatest bone thickness, being the best sites for the placement of mini-implants[3,24,25]. Wehrbein et al[1] studied palatal bone quality in the median region and demonstrated that the highest failure rates in relation to the installation of mini-implants are more related to the healing period instead of the density of the bone region chosen. According to Wehrbein in 2008[2], bone quality is safely determined only during the surgical procedure.

Determining the quality of bone objectively, using images from the CBCT remains a limitation of this method of examination. The correlation between the gray values of the anatomical regions and the Hounsfield scale can be used for density analysis only in MDCT exams[12,15]. The equivalence of the values of the gray Hounsfield units in the CBCT is inaccurate[16,24,34]. Therefore, it would be impossible to confirm the degree of density of the regions evaluated clinically by orthodontists is real.

To confirm a clinical question present in T2, which referred to the bone classification of the area marked in D1, D2 and D3 (question 5), the present study used the ImageJ/Fiji program to evaluate the gray values, this method is being used in the clinical routine and in several previous orthodontic studies[35-37]. When comparing a qualitative assessment of question 5 with the quantitative assessment, carried out by the program, got perfect agreement between the places defined such as D1, D2 and D3 in the questionnaire with the averages of the values in these regions, shown in the histogram.

A limitation of the study may be the fact that the evaluators did not have access to the tomographic volume, but only to the models made by the researchers. The main contribution, on the other hand, is the proposal of a new way of assessing bone density, using the average gray values, in tomographic images, obtained using a free and easily accessible program. In addition, it was possible to verify that there is no relationship between clinical experience in orthodontics and the best performance in the evaluation of images of the CBCT. Finally, both groups performed well on issues related to bone quality but showed greater difficulty in classifying the median palatal suture.

CONCLUSIONS

The level of experience of orthodontists did not influence their performance in the interpretation of tomographic images or the classification of the median palatal suture, which orthodontists still find difficult.

An analysis of the gray values proved to be an effective and practical alternative for objective assessment of bone quality.

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Table I Comparison of the total percentage values of each T2 question, between the levels of experience, according to the GEE model.

Question	Total	Experience Level			P[1]
		Without Experience	< 5 years	≥5 years	
		n (p) [IC95%]	n (p) [IC95%]	n (p) [IC95%]	
1	673 (**56,2**)B	209 (**52,3**)B	230 (**57,9**)B	234 (**58,3**)B	**0,340**
	[52,4; 59,9]	[45,8; 58,7]	[51,6; 64,0]	[52,2; 64,3]	
2	398 (**32,3**)A	125 (**30,2**)A	138 (**32,9**)A	135 (**33,7**)A	**0,609**
	[29,1; 35,6]	[25,7; 35,0]	[27,5; 38,7]	[28,0; 40,0]	
3	682 (**58,4**)B	223 (**57,3**)B	200 (**52,3**)AB	259 (**65,6**)BC	**0,481**
	[50,2; 66,3]	[47,6; 66,6]	[38,3; 66,0]	[48,8; 79,8]	
4	1.013(**85,3**)C	344 (**86,2**)C	302 (**77,3**)B	367 (**92,5**)C	**0,166**
	[75,1; 92,3]	[62,9; 96,8]	[57,7; 90,4]	[83,7; 97,1]	
5	879 (**73,2**)B	283 (**70,2**)B	292 (**73,8**)B	304 (**75,6**)B	**0,914**
	[61,8; 82,6]	[47,2; 87,1]	[52,9;88,5]	[59,1; 87,7]	
P[2]	**<0,001**	**<0,001**	**<0,001**	**<0,001**	
Total	3.645 (60,8)	1.184 (**59,2**)	1.162 (**58,1**)	1.299 (**65**)	**0,332**
		[51,0; 67,1]	[50,6; 66,7]	[59,3; 70,7]	

n = sample size; p = Percentage estimated by the GEE Model; 95% CI = 95% confidence interval.
P1 = GEE model (comparison of experience level between each question).
P2 = GEE model (comparison of questions between each level of experience).
#Different lowercase letters represent different proportions of the level of experience that fixes the issue.
#Different capital letters represent different proportions of each question, setting the level of experience.

Table II Intraobserver agreement for the variables in T2 and T3.

	Agreement (%)	Kappa (p)	Level of agreement
General	74.0%	0.651(<0.001)	Substantial
GP1 (Without Experience)	75.0%	0.663(<0.001)	Substantial
GP2 (<5 years)	71.5%	0.618(<0.001)	Substantial
GP3 (≥ 5 years)	75.5%	0.673(<0.001)	Substantial

Tabela III Interobserver agreement for the variables in T2.

Goups	Agreement (%)	Kappa (p)	Level of agreement
GP1 x GP2	50.3%	0.332 (<0.001)	fair agreement
GP1 x GP3	54.5%	0.389 (<0.001)	fair agreement
GP2 x GP3	58.8%	0.449 (<0.001)	moderate agreement

QUIZ 1 (T1)

Evaluator: ____

( )Without experience
( ) Specialist – less than 5 years of experience
( ) Specialist – more than 5 years of experience

I.For which of these mechanics can you request CT scan of the bone palate region (One more option can be checked):
( ) Simple orthodontic movement
( ) Palatal disjunction with MARPE
( ) Traction of tooth included
( ) Insertion of orthodontic mini-implants
( ) Space closure

II.Which region is marked in the images, respectively:
a)( ) Axial reconstruction, Sagittal reconstruction and Coronal reconstruction
b)( ) Coronal reconstruction, Sagittal reconstruction and Axial reconstruction
c)( ) Axial reconstruction, coronal reconstruction and sagittal reconstruction

III.Which region is more median in the upper-lower direction:
a)( ) Region 1 b) ( ) Region 2 c) ( ) Region 3

IV.Which region is more median in the anteroposterior direction:
a)( ) Region 1 b) ( ) Region 2 c) ( ) Region 3

V.Which region is more median in the lateral-lateral direction:
a)( ) Region 1 b) ( ) Region 2 c) ( ) Region 3

QUIZ 2 (T2)

Evaluator:___________________________________

( )Without experience
( ) Specialist – less than 5 years of experience
( ) Specialist – more than 5 years of experience

Patiente:

1. How do we classify this bony palate:
a)( )Concave b) ( )Convex c)( )Horizontal

2. Which stage of classification of the median palatal suture:
a)( )Stage A b) ( ) Stage B c) ( ) Stage C d)( ) Stage D e) ( ) Stage E

3. Which bone region is ideal for placing mini-implants:
a)( )Yellow b) ( )Green c) ( )Red

4. What is the area of best bone quality:
a)( )Yellow b) ( )Green c) ( )Red

5. How do you classify the demarcated area according to bone quality for regions 1,2 and 3:
a)( )D1, D2 and D3 b)( )D2, D1 and D3 c)( )D3, D2 and D1 d)( )D2,D3 and D1

Figure 1 Schematic table showing the questionnaire carried out in T1 and T2.

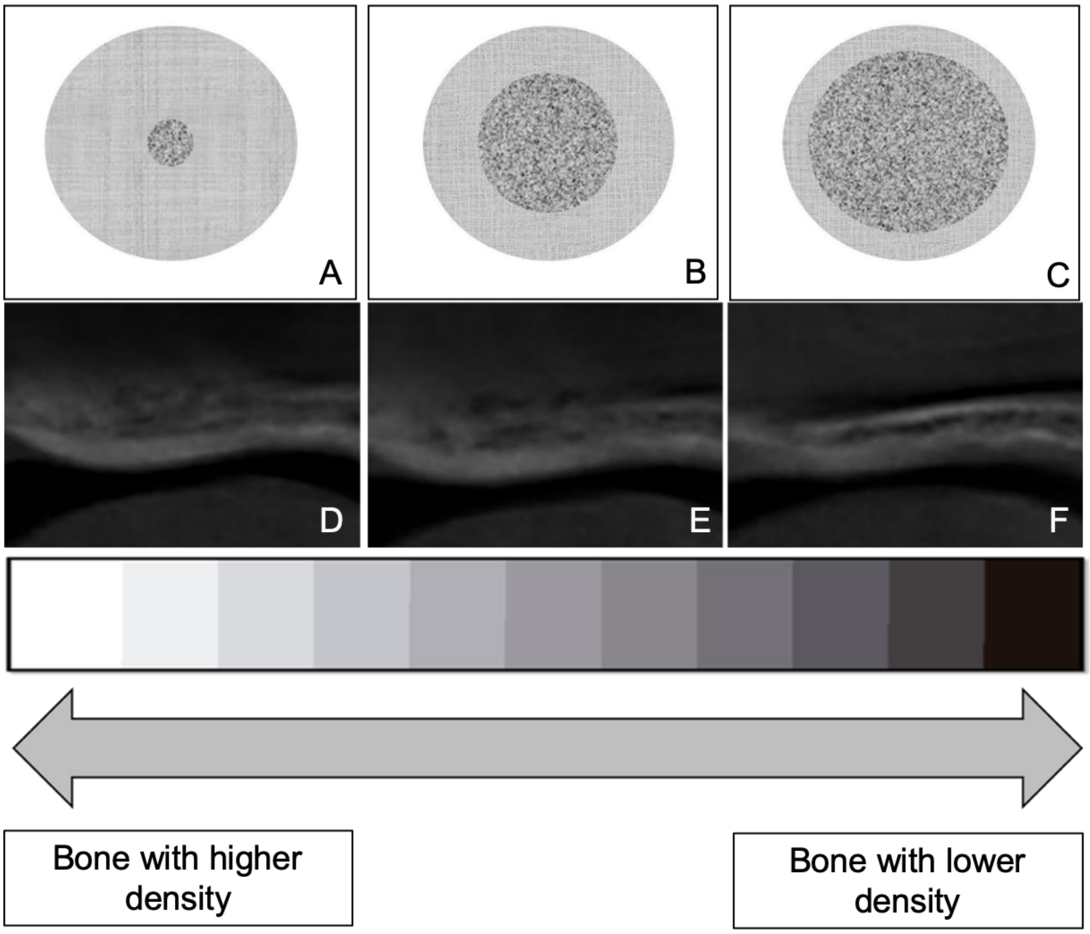

Figure 2 Modified schematic drawing and bone tomographic reconstructions exemplifying bone quality according to a gray scale. D1 - dense cortical bone; excellent quality (A and D); D2 - porous and dense trabecular cortical bone; good quality (B and E); D3 - porous and thin trabecular cortical bone; low quality (C and F).

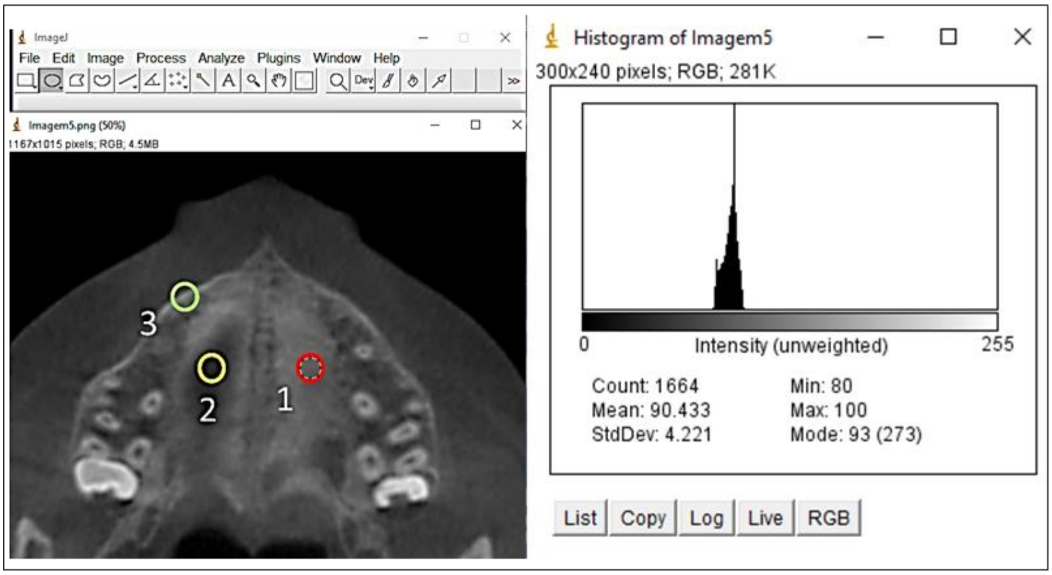

Figure 3 ImageJ / Fiji® program interface, version 1.50d (NIH, Bethesda, USA), where numerical values of voxels were calculated within the same question 5 areas of the questionnaire.

5 CONCLUSÃO

Com base nos resultados do presente estudo, pôde-se concluir que:

5.1 As maiores espessuras do palato ósseo foram encontradas na região anterior, na sutura palatal e lateralmente a ela na distância de 9 mm. A média total da espessura nos adolescentes (13 a 17 anos) foi maior em relação aos demais grupos e o sexo masculino apresentou espessura óssea palatal maior em relação ao feminino.

5.2 A avaliação qualitativa do conhecimento do ortodontista demonstrou que o nível de experiência dvb não influenciou na interpretação de imagens de TCFC da região do palato ósseo.

5.3 A metodologia para avaliação dos valores de cinza, utilizando o programa ImageJ/Fiji®, mostrou-se eficaz, podendo ser indicada na rotina clínica, especialmente devido à facilidade de manuseio e gratuidade do programa, que possui livre domínio.

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7 ANEXOS

7.1 Utilização do banco de dados

UNIVERSIDADE FEDERAL DO RIO DE JANEIRO
FACULDADE DE ODONTOLOGIA
DEPARTAMENTO DE ODONTOPEDIATRIA E ORTODONTIA

UTILIZAÇÃO DO BANCO DE DADOS DA DISCIPLINA DE ORTODONTIA

Eu, Margareth Maria Gomes de Souza , vice-coordenadora do Programa de Pós-graduação em Odontologia da Universidade Federal do Rio de Janeiro – UFRJ, autorizo acesso ao arquivo da Clínica da Disciplina de Ortodontia da Faculdade de Odontologia da UFRJ, localizada na Av. Professor Rodolpho Paulo Rocco, 325 Ilha do Fundão – Rio de Janeiro-RJ-Brasil, para fins de pesquisa de Dissertação de Mestrado Intitulada: "*Avaliação quantitativa e qualitativa do palato ósseo por meio de tomografia computadorizada de feixe cônico*".

Responsabilizo-me, juntamente com Mônica Tirre de Souza Araújo, Maria Augusta Portella Guedes Visconti, Professoras Doutoras da Faculdade de Odontologia da UFRJ e Taiane dos Santos Lopes, aluna do Programa de Pós-Graduação em Odontologia - Ortodontia da UFRJ, a privacidade de seus conteúdos, como preconizam os Documentos Internacionais e a Res.196/96 do Ministério da Saúde e o Código Penal Brasileiro.

Rio de Janeiro, setembro, 17 de 2018.

MARGARETH MARIA GOMES DE SOUZA
Vice-coordenadora do Programa de Pós-graduação em Ortodontia
Faculdade de Odontologia - UFRJ

7.2 Aprovação no Comitê de Ética

UFRJ - HOSPITAL
UNIVERSITÁRIO CLEMENTINO
FRAGA FILHO DA

Plataforma Brasil

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Avaliação do palato ósseo por meio de exame tomográfico
Pesquisador: Maria Augusta Visconti Rocha Pinto
Área Temática:
Versão: 2
CAAE: 08045619.4.0000.5257
Instituição Proponente: UNIVERSIDADE FEDERAL DO RIO DE JANEIRO
Patrocinador Principal: UNIVERSIDADE FEDERAL DO RIO DE JANEIRO

DADOS DO PARECER

Número do Parecer: 3.296.739

Apresentação do Projeto:
Protocolo 055-19 do grupo III. Respostas recebidas em 11.4.2019.

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

Endereço: Rua Prof. Rodolpho Paulo Rocco N°255, 7° andar, Ala E
Bairro: Cidade Universitária **CEP:** 21.941-913
UF: RJ **Município:** RIO DE JANEIRO
Telefone: (21)3938-2480 **Fax:** (21)3938-2481 **E-mail:** cep@hucff.ufrj.br

RIO DE JANEIRO, 01 de Maio de 2019

Assinado por:
Carlos Alberto Guimarães
(Coordenador(a))

8 APÊNDICE

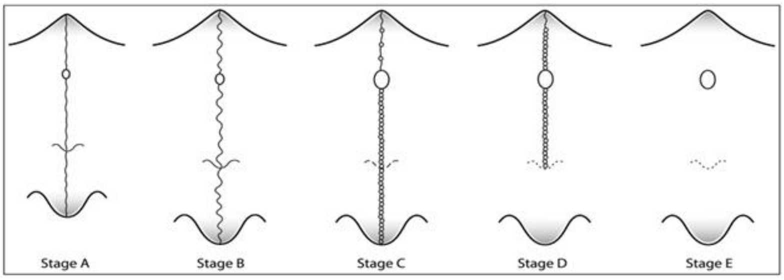
8.1 Guia para o questionário

Pergunta 1:

Palato côncavo   Palato convexo   Palato Horizontal

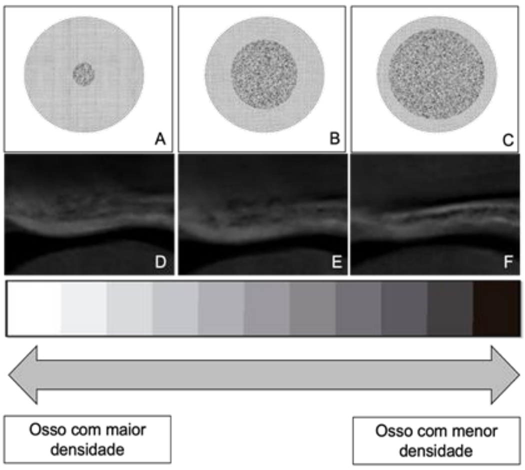
Extraído de Sassouni *et al.*

Pergunta 2:



Extraído de Angelieri *et al.*

Pergunta 3:



D1 Osso cortical denso , excelente qualidade
D2 Osso cortical poroso e trabecular denso, boa qualidade
D3 Osso cortical poroso e trabecular baixa qualidade

Adaptado de Misch *et al.*

8.2 Questionário T1

QUESTIONÁRIO I

Avaliador: ____

( )Sem experiência ( )Especialista - menos de 5 anos de experiência ( )Especialista - mais de 5 anos de experiência

I. **Para quais destas mecânicas você solicitaria Tomografia computadorizada da região do palato ósseo (Pode ser marcada mais de uma opção):**

a) ( )Movimentação ortodôntica simples

b) ( )Disjunção palatal com MARPE

c) ( )Tracionamento de dente incluso

d) ( )Inserção de mini-implantes ortodônticos

e) ( )Fechamento de espaço

II. **Qual região está demarcada nas imagens, respectivamente:**

a) ( )Reconstrução axial, Reconstrução sagital e Reconstrução coronal

b) ( ) Reconstrução coronal, Reconstrução sagital e Reconstrução axial

c) ( ) Reconstrução axial, Reconstrução coronal e Reconstrução sagital

III. **Qual região é mais mediana no sentido súpero-inferior:**

a) ( )Região 1 b) ( )Região 2 c) ( )Região 3

IV. **Qual região é mais mediana no sentido ântero-posterior:**

a) ( )Região 1 b) ( )Região 2 c) ( )Região 3

V. **Qual região é mais mediana no sentido látero-lateral:**

a) ( )Região 1 b) ( )Região 2 c) ( )Região 3

8.3 Questionário T2 e T3

QUESTIONÁRIO II

Avaliador: ____

( )Sem experiência ( )Especialista - menos de 5 anos de experiência ( )Especialista - mais de 5 anos de experiência

Paciente: 01

1. **Como classificamos este palato ósseo:**
   a) ( )Côncavo b) ( )Convexo c)( )Horizontal

2. **Qual estágio de classificação da sutura palatina mediana:**
   a) ( )Estágio A b) ( ) Estágio B c) ( ) Estágio C d) ( ) Estágio D e) ( ) Estágio E

3. **Qual região óssea ideal para colocação de mini-implantes:**
   a) ( )Amarela b) ( )Verde c) ( )Vermelha

4. **Qual a área de melhor qualidade óssea:**
   a) ( )Amarela b) ( )Verde c) ( )Vermelha

5. **Como você classificaria a área demarcada de acordo com a qualidade óssea referente às regiões 1,2 e 3:**
   a) ( )D1, D2 e D3 b) ( )D2, D1 e D3 c) ( )D3, D2 e D1 d) D2,D3 e D1

Paciente:02

1. **Como classificamos este palato ósseo:**
   a) ( )Côncavo b) ( )Convexo c)( )Horizontal

2. **Qual estágio de classificação da sutura palatina mediana:**
   a) ( )Estágio A b) ( ) Estágio B c) ( ) Estágio C d) ( ) Estágio D e) ( ) Estágio E

3. **Qual região óssea ideal para colocação de mini-implantes:**
   a) ( )Amarela b) ( )Verde c) ( )Vermelha
   0

4. **Qual a área de melhor qualidade óssea:**
   a) ( )Amarela b) ( )Verde c) ( )Vermelha

5. **Como você classificaria a área demarcada de acordo com a qualidade óssea referente às regiões 1,2 e 3:**
   a) ( )D1, D2 e D3 b) ( )D2, D1 e D3 c) ( )D3, D2 e D1 d) D2,D3 e D1