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INFLUÊNCIA DA MORDIDA ABERTA NAS VIAS AÉREAS. ESTUDO EM TOMOGRAFIAS CONE BEAM

Porto Alegre

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Tese apresentada ao Programa de Pós-Graduação em Odontologia, da Universidade Federal do Rio Grande do Sul, linha de pesquisa Diagnóstico de Afecções Buco- Faciais, como pré-requisito final para a obtenção do título de Doutor em Clínica Odontológica/Ortodontia.

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Eu caminho devagar, mas nunca recuo.

Abraham Lincoln

Aprendi que o difícil não é chegar ao topo, mas nunca parar de subir.

Walt Disney

RESUMO

Vários aspectos são considerados nos estudos das vias aéreas, entre eles a relação das maloclusões e seu impacto na morfologia das vias aéreas associado a situações de risco, como síndrome da apneia obstrutiva do sono ou função respiratória e o desenvolvimento de alterações esqueléticas e dentárias. A faringe tem suporte limitado nos extremos e pode acontecer o colapso desta frente a dimensões reduzidas. Para o estudo diferencial da morfologia da via aérea relacionada a apneia obstrutiva é comumente utilizada a área de maior constrição na orofaringe. A obstrução geralmente acontece na orofaringe na região posterior do palato. A morfologia da região posterior da língua pode contribuir na obstrução, mas também a extensão até a epiglote nos estudos que consideram as dimensões do lúmen e comprimento determinantes para o colapso da via aérea. Estudos das vias aéreas têm sido realizados usando diferentes técnicas de imagem, na maioria das vezes através da CBCT (*Cone-Beam computed tomoography*), diferentes programas de medição e diferentes métodos de segmentação. A mordida aberta associada a alterações esqueléticas verticais, como a hiperdivergência, também pode influenciar o espaço faríngeo. Por essa razão, este estudo teve como objetivos: i) avaliar as variações nas dimensões lineares, de área e de volume das vias aéreas superiores em um grupo de indivíduos com e sem mordida aberta anterior em diferentes padrões esqueléticos; e, ii) avaliar as variações nas dimensões de volume e área de maior constrição de orofaringe em um grupo de indivíduos com e sem mordida aberta anterior, em diferentes padrões esqueléticos variando o modo de segmentação e limiar. Para o primeiro objetivo, foram avaliados 137 CBCT de indivíduos adultos, divididos em dois grupos, 47 com mordida aberta anterior e 90 sem mordida aberta anterior usando o programa Planmeca Romexis e para o segundo objetivo foram utilizados 60 CBCT de indivíduos adultos, divididos em dois grupos, 30 com mordida aberta anterior e 30 sem mordida aberta anterior usando para avaliação dois programas Planmeca Romexis modo automático e NemoStudio modo manual, com diferente limiar, sendo o menor valor selecionado o usado para Romexis. Utilizou-se o programa estatístico SPSS (Statistical package for social sciences) versão 22 para Windows para análise estatística. Os resultados do primeiro estudo não mostraram diferenças nas medições lineares e de volume das vias aéreas superiores entre os dois de grupos, mas encontrou-se diferença na área, com maior dimensão para o grupo com mordida aberta anterior. No estudo, o ângulo ANB foi a variável que influenciou o volume no nível da orofaringe e o volume total das vias aéreas superiores. Para o segundo objetivo proposto, os resultados mostraram-se de acordo com as condições do estudo, na comparação de programas em ambos os grupos, valores mais elevados para o volume e área de maior constrição de orofaringe no programa NemoStudio. No entanto, na análise individual dos grupos, não houve diferença significativa no grupo com mordida aberta anterior. Os resultados deste estudo devem ser considerados para o diagnóstico e planejamento do tratamento ortodôntico em relação às diferenças encontradas entre o grupo com e sem mordida aberta anterior, a influência do ângulo ANB, o programa de medição e limiar a ser utilizado na avaliação das vias aéreas superiores e a importância de usar um protocolo padronizado e limiar apropriado, especialmente em grupos sem mordida aberta anterior.

PALAVRAS - CHAVE: Vias aéreas. Mordida aberta. Tomografia computadorizada de feixe cônico. Software.

ABSTRACT

Several aspects have been considered in studies about airways as searching for the relation with malocclusions and their effect over airways morphology associated to a risk condition like obstructive sleep apnea syndrome or about breathing function and development of skeletal and dental disorders. The pharynx has limited support by extremes and it may collapse in front of reduced dimensions. To airway morphology differential study related to obstructive apnea the most constricted area of the oropharynx is usually used. Obstruction generally occurs at the posterior region of the palate at oropharynx. Morphology of the posterior region of the tongue may contribute to the obstruction, but also an extension to the epiglottis in studies that consider determinants of airway collapse lumen and length dimensions. Airways studies have been made using several image techniques frequently at last years through cone -beam computed tomography (CBCT), different measuring software programs and different segmentation methods. Open bite associated to vertical skeletal disorders like hyperdivergence also may influence pharyngeal space. For this reason this study had the aim to: i) evaluate changes on lineal, area and volume dimensions of upper airways in a group of individuals with and without an anterior open bite on different skeletal patterns and, ii) evaluate changes on volume and the most constricted area dimensions of the oropharynx in a group of individuals with and without an anterior open bite on different skeletal patterns modifying segmentation mode and threshold. For the first objective 137 CBCT of adults were evaluated, divided by two groups, 47 with an anterior open bite and 90 without an anterior open bite using Planmeca Romexis program, and for the second objective 60 CBCT of adults were evaluated, divided by two groups, 30 with an anterior open bite and 30 without an anterior open bite using for the evaluation two software programs, Romexis automatic mode and NemoStudio manual mode, with different threshold and using the lower threshold value selected with Romexis. For the statistical analysis, the statistical program SPSS (Statistical Package for Social Sciences) version 22.0 for Windows was used. The results for the first study showed no differences in linear and volume measurements of upper airways between both groups but there was difference at area measurement, it was found a greater area in the group with an anterior open bite. In the study, ANB angle was the variable that influenced over oropharynx volume and total volume of upper airways. For the second objective proposed the results showed according the study conditions greater values for volume and the most constricted area of oropharynx in the NemoStudio software when comparing programs in both groups, however when analyzed separately there was no significant difference in the group with an anterior open bite. The results of these studies must be considered for the diagnosis and orthodontic treatment planning related to the differences founded between the groups with and without an anterior open bite, ANB angle influence, measuring software and threshold selected for airways evaluation and the importance of using a standardized protocol and adequate threshold especially in groups without an anterior open bite.

KEY WORDS: Airways. Open bite. Cone-beam computed tomography. Software.

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LISTA DE ABREVIATURAS E SIGLAS

CBCT	Cone-Beam computed tomography / Tomografia computadorizada de feixe cônico
CI	Intervalo de confiança
cm	centímetro
DICOM	Digital Imaging and Communications in Medicine
Div	Divisão
3D	3 dimensões
EUA	Estados Unidos da América
ENA	Espinha nasal anterior
ENP	Espinha nasal posterior
et al	e colaboradores
FH	Frankfort Horizontal/ Horizontal de Frankfort
FOV	Field of View / Campo de visão
ICC	Intraclass correlation coefficient
kV	kilovolt
°	grados
mA	miliampere
mm	milímetro
NF	Nasofaringe
OF	Orofaringe
SD	Standard deviation/ Desvio-padrão
SPSS	Statistical package for social sciences
UFRGS	Universidade Federal do Rio Grande do Sul
UA/VAS	Upper airways/Vias Aéreas superiores
VC	Vértebra cervical
vs	versus

SUMÁRIO

INTRODUÇÃO

Os padrões de crescimento vertical facial são estabelecidos em uma idade precoce e alguns os consideram associados com mordida aberta anterior, apesar de não necessariamente ter uma relação direta. (1) A mordida aberta é definida como a ausência de contato entre as bordas dos incisivos do maxilar e da mandíbula com sobre mordida negativa, comumente, apresentada na área anterior (1, 2), no entanto, pode ocorrer perda de contato dentário vertical entre segmento anterior ou bucal. (3)

A mordida aberta como maloclusão vertical é classificada como verdadeira e falsa (4), ou como dentária, esquelética e combinada quando se considera etiologia.(5,6) Deficiências no crescimento vertical, crescimento muscular desproporcional ou anormalidades na função muscular e hábitos de sucção do polegar ou dedo são fatores etiológicos relacionados à mordida aberta.(7) Arriola et al (2016) mencionam que, em muitas ocasiões, a mordida aberta esquelética é camuflada pela sobre erupção dos dentes anteriores, o que dificulta a classificação e, muitas vezes, essa maloclusão é o resultado de ambos os fatores.(8)

A diferenciação entre mordida aberta dentária e esquelética em relação ao plano de oclusão caracteriza a mordida aberta esquelética com contato apenas no nível molar com planos de oclusão maxilar e mandibular anteriormente divergentes e a mordida aberta dentária com planos divergentes do primeiro pré-molar.(1) As mordidas abertas com componentes esqueléticos são consideradas pela maioria dos pesquisadores como mordidas abertas esqueléticas. Schudy (1964) refere-se a estas como mordidas abertas hiperdivergentes com o conceito de divergência facial e seus extremos, a hiperdivergência e a hipo divergência. (9)

Björk (1969), Ngan e Fields (1997) e Buschang et al (2002) concordam que as características esqueléticas comuns de uma mordida aberta anterior são: diminuição da altura facial posterior, aumento da altura facial anterior, aumento da altura facial anterior inferior, altura do ramo da mandíbula curta, ângulo do gônio obtuso ou aberto, plano mandibular muito inclinado e plano palatal inclinado para cima anteriormente.(3,10,11) Outras características esqueléticas da mordida aberta consideradas por Björk (1969) são: inclinação distal do côndilo mandibular, decote antegonial, canal de mandíbula reto, sínfise longa e fina, excesso de altura maxilar, planos oclusais divergentes. (10) Para Ngan e Fields (1997) a rotação da mandíbula para baixo e para trás é considerada. (3)

Além disso, os achados mais consistentes na revisão da literatura de mordida aberta de Buschang et al,(2002) se encontram na maxila, como o ângulo do plano palatal achatado, tendência da maxila a ser mais curta e retrusiva, altura facial anterior superior diminuída, maxila estreita com uma tendência a mordida cruzada posterior e cavidade glenoide mais alta em relação à sela túrcica. Por outro lado, a maioria das alterações na morfologia estão na mandíbula. (11)

Finalmente, entre as características dentárias consideradas por Björk estão a inclinação aguda intermolar e inter-incisal com molares apresentando extrusão. (10) A altura dentoalveolar anterior e posterior em maxila com tendência ao excesso e aumento da altura dentoalveolar mandibular também são consideradas dentro das características dentárias das mordidas abertas esqueléticas. (3,11)

Em uma oclusão normal, o excesso de erupção molar é compensado pelo aumento do comprimento do ramo da mandíbula através de sua rotação protrusiva. (9) No entanto, quando há discrepância, o excesso de erupção molar e o crescimento vertical do ramo da mandíbula levam a uma rotação da mandíbula para trás se tornando mais retrusiva, acompanhada por mordida aberta anterior. (12)

Sassouni (1969) considera o tipo esquelético de mordida aberta com características de subdesenvolvimento dos músculos masseter e temporal, como também, em relação aos dentes, que são expostos a um componente mesial de forças que levam a uma biprotrusão dentária e um fechamento labial forçado, dando a aparência de queixo pequeno. Assim, podemos ver a relação entre função muscular, morfologia maxilofacial e maloclusão. (13)

Sato(2001) menciona que nestes tipos de esqueleto, as características morfológicas da relação vertical e anteroposterior são determinadas pela posição da maxila e pela adaptação funcional da mandíbula em resposta a esse posicionamento. Refere-se a 4 tipos de esqueleto craniofacial, que são Mesio-oclusão hiperdivergente, Mesio-oclusão hipodivergente, Disto-oclusão hiperdivergente, Disto-oclusão hipodivergente e os relaciona com a maloclusão e classificação de Sassouni, (mordida profunda esqueletal e mordida aberta esqueletal, Clase II esqueletal e Clase III esqueletal.) (12,13)

A divergência facial é comumente associada à dimensão vertical facial anterior e o aumento dessa dimensão é comumente referido com termos como dolicofacial, ângulo alto, leptoprosópico, rotador para trás, hiperdivergente, facie adenóidea, mordida aberta esquelética, síndrome de cara longa e excesso maxilar vertical. (1)

Buschang et al (2002) afirmam que na associação da mordida aberta com a hiperdivergência esquelética, não é comum encontrar a mordida aberta em Classe III hiperdivergente cujo tratamento é bastante difícil sem cirurgia. Consideram que a hiperdivergência é mais comum na Classe II, em casos graves, em que o tratamento cirúrgico é necessário para a correção nas diferentes estruturas comprometidas. (11)

Em casos de Classe III esquelética com mordida aberta, cujas características morfológicas são de pouco crescimento anteroposterior da base do crânio e ângulo craniano estreito (especialmente o ângulo occipito cranial), o efeito da posição de flexão da base do crânio é o deslocamento para baixo da maxila através do vômer, com um crescimento do diâmetro anteroposterior pequeno. A discrepância posterior desenvolvida causa erupção molar em excesso e, como resultado, o achatamento do plano oclusal, inclinação labial dos dentes anteriores da maxila e inclinação lingual dos dentes anteriores da mandíbula. (12,14) Comparando o desenvolvimento da Classe III invertida esquelética e a mordida aberta, o desequilíbrio entre uma dimensão vertical molar aumentada e a capacidade de crescimento do côndilo mandibular são características comuns. (12)

Os padrões hiperdivergentes relacionados à musculatura e força de mastigação fraca são geralmente associados com mordida aberta, no entanto, ainda não ficou claro se a força dos músculos mastigadores são determinantes primários do complexo dentofacial. Estudos sobre o tamanho e o tipo de fibras musculares envolvidas na força da mordida, o tempo de duração da força máxima de mordida, a orientação e características biomecânicas da musculatura têm mostrado pouca influência na mordida aberta. A musculatura ainda continua a suscitar controvérsia quanto aos conceitos de forma e função. (1,15,16,17)

Uma via aérea permeável é importante para o desenvolvimento adequado da anatomia e função muscular no complexo crânio facial. Afirma-se com base em estudos que a respiração está mais ligada a padrões de comportamento respiratório do que à anatomia. As crianças variam seu padrão de respiração, que às vezes pode ser nasal e em outras ocasiões pode ser tipo oral e essa alteração no padrão respiratório ao longo do tempo pode não ter um efeito clínico significativo sobre o complexo dentofacial. Há estudos que afirmam que cirurgias para mudar o padrão respiratório não seriam recomendadas uma vez que após a cirurgia, foram relatados casos em que o padrão não mudou. No entanto, estudos continuaram a relacionar as vias aéreas a dimensões craniofaciais, diferentes padrões esqueléticos e função. (1)

Os exames das vias aéreas requerem conhecimento da anatomia, pois não são exames de rotina e sua escolha depende dos objetivos do estudo. (18) Várias técnicas de imagem, como radiografia lateral, radiografia faringeal e coluna cervical, tomografia computadorizada, ressonância magnética, tomografia de coerência óptica, nasofaringoscopia flexível, faringometria acústica, videofluoroscopia, rinometria acústica e rinomanometria são aplicáveis para o estudo das vias aéreas superiores. O uso de exames de imagem para diagnóstico, como ferramenta auxiliar, está indicado quando há alterações anatômicas ou funcionais nos tecidos ao redor das vias aéreas superiores como em casos de síndrome da apnéia obstrutiva do sono. (19)

Os estudos com CBCT embora sejam de grande ajuda no estudo das vias aéreas, tanto Alsufyani et al,(2012) e Uribe et al (2015) concordam que a inexistência de um protocolo padronizado para o estudo das vias aéreas dificulta a conclusão em estudos. A validade e confiabilidade a modelos 3D de CBCT ainda necessitam estudos. (1,20)

Estudos das vias aéreas têm sido realizados em diferentes grupos raciais. Estes avaliam vários aspectos da morfologia das vias aéreas em diferentes padrões esqueléticos e as ferramentas usadas para estudá-los. Encontramos Yanagita et al em 2017 que quantificaram a relação entre morfologia craniofacial esqueletal e vias aéreas na região da faringe, bem como mudanças associadas à maturação esqueletal em uma amostra de adolescentes japoneses, utilizando CBCT. (21) Martins et al em 2017 avaliaram a correlação de medidas lineares e de área realizadas em determinadas regiões da via aérea em 2D e compararam com o volume em CBCT de amostra brasileira (Porto Alegre).(22) Pachêco-Pereira et al (2017) estudaram a correlação e confiabilidade do diagnóstico da segmentação automática do Dolphin Imaging para avaliar a hipertrofia da adenoide em uma amostra canadense, utilizando CBCT. (23)

Atia Abd Elwareth e Abd Elrazik Yousif em 2015, mediram a largura das vias aéreas faringeais superior e inferior em pacientes com diferentes padrões esqueléticos anteroposteriores (maloclusões esqueléticas Classe I, II, III) e verticais (hiper, hipo e normodivergente) e investigaram se há dimorfismo sexual nas larguras das vias aéreas faringeais em um grupo de pacientes egípcios, utilizando radiografias laterais. (24) Tazumi e Matsumoto em 2015 estudaram mudanças no espaço aéreo faríngeo de pacientes com mordida aberta esquelética após receberem tratamento ortodôntico, em uma amostra japonesa utilizando radiografias laterais. (25) Diamantidou et al em 2015, procuraram diferenças potenciais entre pacientes com diferentes maloclusões segundo Angle, em faringe, palato mole, amígdala faríngea e língua, em amostra grega, usando radiografias laterais. (26)

Di Carlo et al (2014) avaliaram a relação entre medições sagitais, verticais e transversais do complexo craniofacial, incluindo a posição do osso hioide com morfologia e dimensões de orofaringe e zona baixa da nasofaringe em adultos jovens usando CBCT em amostra da Dinamarca. (27) Celikoglu et al (2014) realizaram pesquisa sobre o volume de vias aéreas faringeais entre pacientes adultos com diferentes padrões esqueléticos verticais e um padrão esquelético sagital normal usando CBCT em uma amostra da Turquia. (28) Tam em 2014 avaliou os efeitos do tratamento ortodôntico com e sem extrações sobre as características anatômicas das vias aéreas superiores em adultos em amostra dos Estados Unidos da América (EUA) no Minnesota, utilizando CBCT. (29)

Silva et al (2014) realizaram estudo para correlacionar dados cefalométricos obtidos a partir de radiografias laterais com índice de apnéia-hipoapnéia do sono para detectar fatores preditivos da gravidade da síndrome da apnéia obstrutiva do sono em uma amostra do Brasil. (30) Borges et al (2014) correlacionaram medidas cefalométricas e antropométricas em apnéia obstrutiva a diferentes idades em amostra brasileira**.** (31)

Claudino et al (2013) realizaram estudo com o objetivo de caracterizar o volume e a morfologia da via aérea faríngea em adolescentes, relacionando-os com seu padrão facial esqueletal em amostra brasileira, em CBCT. (32) Alves Jr. et al (2012) avaliaram as dimensões do espaço das vias aéreas faringeais em crianças em pé e acordados com diferente padrão esqueletal anteroposterior, utilizando CBCT em amostra brasileira. (33) Alsufyani et al (2012) realizaram estudo voltado à revisão sistemática da literatura de pesquisa que usou CBCT para modelar automaticamente ou semi-automaticamente as vias aéreas superiores (incluindo as vias aéreas faringeal, nasal e paranasal) e avaliar sua validação e confiabilidade. (20) El e Palomo (2011) em seu estudo tiveram como objetivo avaliar a passagem nasal e o volume orofaríngeo de pacientes com diferentes padrões esqueléticos dento faciais na amostra dos EUA (Ohio), em CBCT. (34) Alves Jr et al (2011) avaliaram o espaço aéreo faríngeo em crianças com respiração oral e nasal em uma amostra brasileira (Rio de Janeiro), utilizando CBCT**.** (35)

Vizzotto et al (2011) avaliaram a precisão das medições das vias aéreas de cefalogramas laterais, reconstruções laterais da CBCT, planos axiais de CBCT, além de correlacionar os achados, com medidas de áreas adquiridas nas CBCT na amostra brasileira (Porto Alegre). (36)

Lenza et al (2010) correlacionaram as medidas lineares (sagitais e transversais), áreas de secção transversal e volumes da via aérea superior determinado no conjunto de dados de CBCT em amostra da Dinamarca. (37) Kim et al (2010) estudaram pré-adolescentes com diferentes padrões esqueléticos anteroposteriores e compararam o volume 3D de vias aéreas em crianças saudáveis com mandíbula retrognática e aqueles com crescimento craniofacial normal, bem como possíveis relações e correlações significativas entre as variáveis cefalométricas estudadas e a morfologia das vias aéreas nessas crianças na amostra de Coreia. (38) Dan Grauer et al (2009) avaliaram as diferenças na forma e no volume das vias aéreas entre indivíduos com vários padrões faciais na amostra dos EUA (California)**,** em CBCT**.** (39,40)

Lee et al (2007) formularam o propósito de avaliar o efeito do respirador oral na anatomia das vias aéreas superiores usando cefalometria lateral e nasofaringoscopia de fibra óptica na amostra sul-coreana. (41)

O interesse em compreender os mecanismos que definem a anatomia das vias aéreas e suas dimensões reais tanto na normalidade quanto quando há alteração fez com que as informações fossem acumuladas ao longo dos anos, no início através de ferramentas disponíveis, como radiografias laterais e, em seguida, CBCT. Com o passar dos anos, a tecnologia melhora as ferramentas que usamos para obter informações cada vez mais precisas, para chegar a um diagnóstico e tratamento corretos, seja este preventivo ou corretivo com a intenção de melhorar a qualidade de vida do indivíduo afetado.

A literatura sobre vias aéreas ainda é controversa em alguns aspectos. A afirmação de que a morfologia crânio facial tem uma grande influência na morfologia faríngea (37) deve considerar em que estágios esse efeito ocorre e, portanto, deve considerar-se que a idade é importante na condução de um estudo sobre esta questão.

A função respiratória como desencadeador de alterações no desenvolvimento dentofacial também é fonte de controvérsia entre pesquisadores (42) uma vez que nos estudos realizados nem sempre ocorre a alteração esperada.

Assim, a presença de maloclusões também faz parte das controvérsias, pois para alguns autores há uma relação entre morfologia faríngea e maloclusão e para outros não. A posição do osso hióide foi incluída dentro de possíveis influências na morfologia das vias aéreas. Alguns pesquisadores afirmam que é provável que a controvérsia seja por causa da seleção de diferentes parâmetros para caracterizar a morfologia.

Estudos realizados em indivíduos com maloclusões Classe I e Classe II sem crescimento ou em indivíduos pré-adolescentes ou com hiperdivergência mostraram diferenças que influenciariam o volume de vias aéreas e espaço faríngeo. (9) A mordida aberta como maloclusão vertical associada a problemas anteroposteriores requer avaliação sobre a influência que pode ter sobre as vias aéreas, levando em conta as ferramentas utilizadas para medições em CBCT. Isso justifica um estudo sob essas condições e a avaliação dos riscos que poderiam existir em relação às dimensões das vias aéreas. Por outro lado, os programas utilizados para medições de vias aéreas são continuamente modificados de acordo com o avanço da tecnologia e, embora os resultados obtidos mostrem confiabilidade, também foi constatado que eles nem sempre se correlacionam adequadamente com outras referências ou outros tipos de exames. Assim, o estudo deve considerar as diferentes variações, na medição, que poderiam influenciar os resultados. É importante verificar se os problemas identificados em estudos anteriores continuam, apesar dos avanços tecnológicos a fim de prevenir e controlar as condições na avaliação das vias aéreas.

OBJETIVOS

Geral:

Avaliar a influência da mordida aberta nas vias aéreas superiores a partir de exames de imagens de CBCT.

Específicos:

Artigo 1

i. Avaliar as variações lineares, de área e de volume das vias aéreas que podem existir em indivíduos com e sem mordida aberta anterior, com diferentes padrões esqueléticos.

Artigo 2

ii. Avaliar as variações na área de maior constrição e volume de orofaringe que podem existir em indivíduos com e sem mordida aberta anterior, com padrões esqueléticos diferentes, usando dois programas com limiares diferentes e modo de segmentação diferente.

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Upper airways evaluation in young adults with an anterior open bite: A CBCT retrospective controlled and cross-sectional study

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Keywords
Airways
Open bite
Cone-beam computed tomography

Summary

Objective > To compare the dimensions of the upper airway in young adults with anterior open bite versus matched individuals with an adequate overbite (control group) using different measurement approaches (linear, area, and volume measures).
Materials and methods > The sample included 137 cone-beam computed tomographies (CBCTs) of young adults (74 men and 63 women) divided into two groups: 47 CBCTs of individuals (mean age 27.89) with open bite (overbite depth indicator (ODI) 56.84° ± 9.48° and Frankfort mandibular plane angle (FMA) 31.21° ± 6.44°) and 90 CBCTs of individuals (mean age 26.87) without an open bite (ODI 62.24° ± 9.47°, FMA 26.79° ± 5.81°). Two trained and calibrated orthodontists made all linear, area, and volume measurements on the CBCT records of the upper airways using Planmeca Romexis software. The Mann-Whitney U-test, chi-squared test, and multiple linear regression were applied. Significance was set at $P < 0.05$.
Results > There were no differences in linear or volume measurements between groups, but there was a greater area in the open bite group (greater mean difference between groups 928.3 mm^2) than the control group. No variable influenced nasopharyngeal airway volume, but ANB angle affected oropharyngeal airway volume ($\beta = -623.87$) and total airway volume ($\beta = -651.48$).
Conclusions > Orthodontists should be aware that the airways diagnosis can vary depending on the measurement approach used, the volumetric method being the gold standard. The pharyngeal airway volume was similar in individuals with vs. without an open bite and is mainly influenced by ANB angle in both groups.

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Introduction

The airways are a structure responsible for one of the major vital functions of the human body, as respiration is an important functional process that can have a profound impact on adequate craniofacial development, occlusion, and quality of life [1]. Changes in normal airways function during the period of active facial growth can have a significant impact on facial development [2].

Craniofacial morphology seems to have a direct influence on pharyngeal morphology, although there are still controversies in this regard [3]. Craniofacial anomalies, such as maxillary or mandibular retrognathism, a short mandibular body, downward and backward mandibular rotation, and a vertical facial growth pattern, can lead to reduced pharyngeal air space, generating difficulty breathing, obstructive sleep apnea, and airways obstruction [4]. The relationship between narrowing of the upper airways (UA) and the development of obstructive sleep apnea syndrome seems clear [1,5,6].

Many studies have used lateral cephalograms to evaluate the UA [4], reporting a relationship between Class II, division 1 malocclusion and mouth breathing, revealing a narrower anteroposterior dimension at the hard palate level in the nasopharynx and the tip of the soft palate in the oropharynx, currently considered a triggering factor for obstructive sleep apnea [7]. A systematic review conducted in 2014 revealed that 75% of cases do not present differences in the nasopharynx dimensions between different skeletal patterns. However, the results were less certain as to the oropharynx dimensions, concluding that the evidence is insufficient to affirm that there are differences between different skeletal patterns. The review highlighted that 45% of the studies considered used lateral radiographs [8]. Lateral cephalometric radiography for evaluation of the airways is of limited worth because it yields values in two dimensions of three-dimensional (3D) anatomical structures [2,6].

The introduction and use of cone-beam computed tomography (CBCT) in orthodontics to measure airway volume in different skeletal patterns has been increasing. Recently, different skeletal patterns were compared in their airflow, nasal resistance, and UA, showing significant differences between skeletal patterns of Classes I and III and between Classes II and III [9]. Moreover, studies on Class III patterns with and without the presence of asymmetry have revealed that the shape of the airways is greatly affected by asymmetry [10,11]. To our knowledge, no studies have evaluated the UA of individuals with open bite, even though this condition may favour mouth breathing or modify the tongue position, which may be a contributing factor to worsening of the malocclusion in some cases and which could also generate changes in the UA as a result of the compensatory or adaptive process.

Considering the lack of evidence on this topic and the possible causal relationship between UA and open bite, the present study sought to compare the upper airways with different measurement methods (linear, area, and volume) in young adults with anterior open bite versus a control group using CBCT.

Materials

The present retrospective and cross-sectional study was approved by the Research and Ethics Committee of Federal University of Rio Grande do Sul (Universidade Federal do Rio Grande do Sul–UFRGS) and by the Ethics in Research Committee of the School of Dentistry of the Cientifica del Sur University (approval number: 2018-00014). This study included 137 CBCTs that met the selection criteria and were done for reasons other than this study in a private radiological centre in Lima, Peru. The sample was divided into two groups: 47 tomographies of individuals with anterior open bite and 90 tomographies of matched individuals with adequate overbite (control group). The way of obtaining the sample is scrutinized in the following flowchart (*figure 1*). In the cephalograms derived from CBCT, the skeletal relationship (ANB angle), facial divergence (Frankfort mandibular plane (FMA) angle), and vertical overbite depth indicator (ODI) were evaluated to describe the sagittal and vertical features in the sample (*table I*). Both groups included anteroposterior skeletal patterns Class I, II, and III, with the following characteristics: Class I, ANB angle = $2 \pm 2°$; Class II, ANB angle $\geq 4°$; and Class III, ANB angle $\leq 0°$. For the group with open bite, the overbite was 0 mm or negative, and for the control group, the overbite was positive.

The inclusion criteria were CBCT scans of individuals of either sex, aged 15 to 60 years, that allowed observation of the anatomy of the cervical vertebrae from the frontonasal suture to the fourth cervical vertebrae and the chin. CBCTs from individuals undergoing active or previous orthodontic or orthopaedic treatment, with previous orthognathic surgery, who were completely or partially edentulous in the anterior region, or who had bone alterations were excluded.

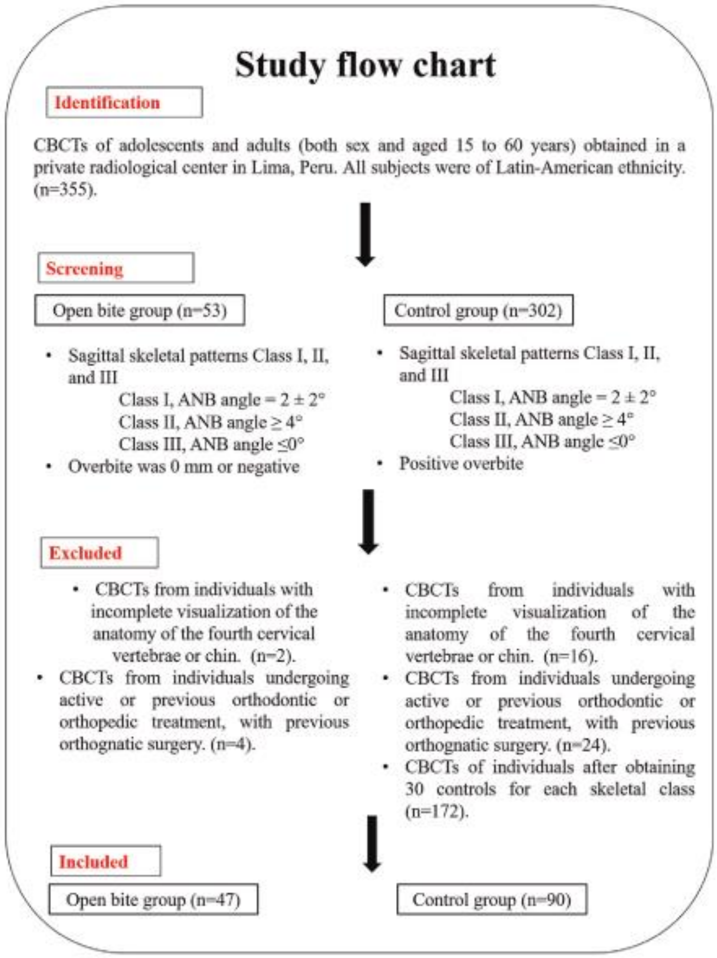

FIGURE 1

Flowchart of the sample collection in both groups

TABLE I
Sample initial characteristics.

Variable	Group	*n*	Mean	SD	*P*
Age (years)	Open bite	47	27.89	11.50	0.440
	Adequate overbite	90	26.87	7.28	
SNA (°)	Open bite	47	83.69	3.54	0.049*
	Adequate overbite	90	85.14	3.97	
SNB (°)	Open bite	47	81.38	6.43	0.160
	Adequate overbite	90	83.05	5.18	
ANB (°)	Open bite	47	2.31	6.05	0.849
	Adequate overbite	90	2.09	3.83	
FMA (°)	Open bite	47	31.21	6.44	0.001*
	Adequate overbite	90	26.79	5.81	
ODI (°)	Open bite	47	56.84	9.48	0.003*
	Adequate overbite	90	62.24	9.47	

Mann-Whitney U test.
*Significant $P < 0.05$.

Methods

Image acquisition

The CBCTs were obtained according to the standardization protocol of the radiological centre, with the patient in a seated and erect position. The craniocervical alignment was 90-110°, and anatomical points were positioned that contemplate the sagittal midline, the Frankfort plane, the occlusal plane, and the incisor line. Patients were instructed to keep the eyes open, not to move the head, not to swallow, and to breath slowly during scanning. They were in maximum intercuspation.

The tomographies were acquired with a Vatech E-WOO Picasso Master 3D scanner (Vatech, Hwaseong, South Korea) with the following settings: 8 mA, 90 kVp, Flat Panel 25 × 20 cm, 30 × 30 cm, with a 20 × 19 cm field of view, 0.3 mm isotropic voxel size, and exposure time of 20 seconds. The CBCT images were converted to DICOM format and were processed using Planmeca Romexis software, version 5.1.1.R. From each tomography, a lateral view was obtained for performing cephalometric measurements.

Airway assessment

Two trained and calibrated orthodontists made all linear, area, and volume measurements on the CBCT records of the upper airways using Planmeca-Romexis software. The post processing of the images was standardized by orienting the head in sagittal and coronal views such that the Frankfort plane coincided with the horizontal guide line, leaving the Orbital and Porion points of both sides aligned in the reconstruction of the 3D image. In the axial section, both pupils were aligned with the horizontal guide line, and the anterior and the posterior nasal spine (ANS-PNS) were aligned with the vertical guide line.

The anterior limit of the nasopharynx and oropharynx was a vertical plane through the PNS perpendicular to the sagittal plane at the lower edge of the vomer and posteriorly the posterior wall of the pharynx. Laterally, the lateral walls of

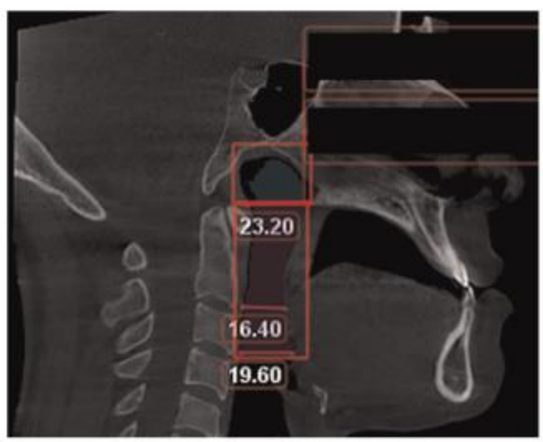

FIGURE 2
Linear measurements in millimeters at oropharynx: a: posterior nasal spine; b: C2; c: C3

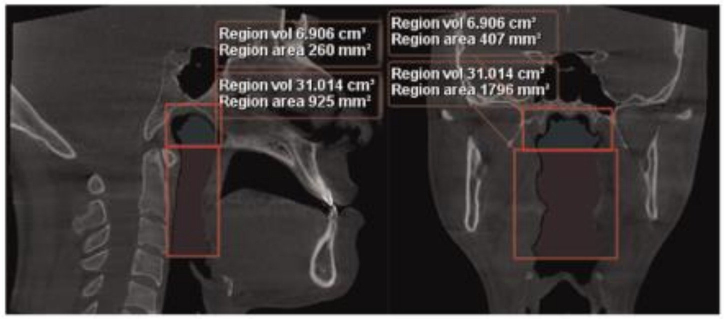

FIGURE 3

Nasopharyngeal and oropharyngeal area and volume on sagittal and coronal sections

the pharynx included the total extensions of the lateral projections. The lower limit of the nasopharynx and upper limit of the oropharynx was a plane perpendicular to the sagittal plane with the PNS included, and the highest point of the nasopharynx was the upper limit, coinciding with the posterior choana and with the anterior limit. A plane tangent to the most caudal medial projection of the C3 vertebrae perpendicular to the sagittal plane was used as the lower limit of the oropharynx.

To make the linear measurements, the upper and lower limits of the oropharyngeal airways were used in sagittal view. Additionally, a line parallel to the aforementioned lower limit was used, at the height of the lower edge of the second vertebrae projected to the anterior wall of the pharynx (*figure 2*).

The airways area was determined using the software after setting the limits of the nasopharyngeal and oropharyngeal airways and performing manual correction when necessary to encompass the entire area in the different sections (*figure 3*). The UA volume was determined by dividing them into an upper part delimiting the nasopharyngeal airway and a lower one for the oropharyngeal airway through segmentation during the reconstruction of the 3D image (*figure 3*). The "3D growth region" tool was used, choosing the "air cavity" option and setting the "threshold" option to 300.

Statistical analyses

The Statistical Package for the Social Sciences (SPSS) version 22.0 for Windows (IBM, Armonk, NY, USA) was used. The normality of the quantitative variables was evaluated with the Shapiro-Wilk test. The Mann-Whitney U test was used to compare the linear, area, and volume measurements of the UA between the groups with and without anterior open bite. Finally, the influence of the predictive variables (sex, age, group, SNA, SNB, ANB, skeletal class, FMA and ODI) on the UA volume was evaluated by multiple linear regression using the overfit method (this method includes two regressions, the first with all the variables and the second including only the variables that reached a value of P □ 0.25). All tests were performed at a level of significance of $P < 0.05$.

Results

The intraclass correlation coefficient tests showed almost perfect intra-observer and inter-observer agreement for the linear, area, and volume measurements (ICC > 0.9, CI to 95% 0.800–0.999).

table I shows the initial characteristics of the sample. Significant differences were observed mainly in the SNA angle, with greater maxillary protrusion in the group with adequate overbite ($85^\circ \pm 3.97^\circ$) compared to the group with open bite ($83^\circ \pm 3.54^\circ$). The age and SNB angle were similar in both groups. A difference was found in the FMA and the ODI, with the mean FMA being higher and the mean ODI being lower in the group with open bite.

table II shows that the two comparison groups had a similar sex and skeletal class distribution.

table III shows the comparison of the linear, area, and volume measurements of the UA between the open bite and control groups. No significant differences were found in the linear measurement or in the volume. Differences were found between the areas, with larger area in individuals with open bites (the greatest mean difference between groups was 928.3 mm^2).

table IV shows the influence of all the predictive variables on the volume of the UA (nasopharynx, oropharynx, and total). The oropharynx volume and total volume were negatively correlated with the ANB angle. The ANB angle influenced the oropharyngeal airway volume ($\beta = -623.87$) and the total airway volume ($\beta = -651.48$).

Table II

Association between group and skeletal class and sex.

Group	Skeletal class			Total	P
	Class I	Class II	Class III		
Open bite	11	19	17	47	0.467*
Adequate overbite	30	30	30	90	
Total	41	49	47	137	
Group	**Sex**			**Total**	**P**
	Male	Female			
Open bite	22	25		47	0.279**
Adequate overbite	52	38		90	
Total	74	63		137	

*Chi square test.
**Fisher test.

Table III

Comparative evaluation of upper airways (distances, areas, and volumes) between open bite versus the control group.

Variable	Group	n	Mean	SD	P	Mean differences	95% CI Lower limit	95% CI Upper Limit
Oropharyngeal distance (mm) (PNS level)	Open bite	47	19.31	3.85	0.248	-2.29	−6.97	2.39
	Adequate overbite	90	21.59	15.96				
Oropharyngeal distance (mm) (C2 level)	Open bite	47	12.15	5.29	0.588	-0.48	−4.07	3.10
	Adequate overbite	90	12.63	11.81				
Oropharyngeal distance (C3 level)	Open bite	47	11.26	4.60	0.766	−0.72	−3.49	2.07
	Adequate overbite	90	11.98	9.04				
Nasopharyngeal sagittal area (mm^2)	Open bite	47	536.45	343.87	0.001**	208.08	115.57	300.59
	Adequate overbite	90	328.37	203.35				
Nasopharyngeal coronal area (mm^2)	Open bite	47	544.38	415.42	0.015*	196.17	86.38	305.96
	Adequate overbite	90	348.21	234.81				
Oropharyngeal sagittal area (mm^2)	Open bite	47	1578.17	1036.48	< 0.001***	716.20	455.16	977.25
	Adequate overbite	90	861.97	510.62				
Oropharyngeal coronal area (mm^2)	Open bite	47	2595.64	1755.53	0.002*	928.30	452.84	1403.75
	Adequate overbite	90	1667.34	1055.46				
Nasopharyngeal volume (mm^3)	Open bite	47	7064.49	2285.49	0.710	101.85	−70.10	410.15
	Adequate overbite	90	6962.64	2259.99				
Oropharyngeal volume (mm^3)	Open bite	47	17834.94	8685.36	0.377	1497.49	−1170.21	4170.23
	Adequate overbite	90	16337.07	6807.68				
Pharyngeal airway volume (mm^3)	Open bite	47	24963.45	9811.01	0.285	1845.48	-1404.04	4776.00
	Adequate overbite	90	23117.97	8421.86				

Mann-Whitney U test.
*Significant: $P < 0.05$.
**Significant: $P \leq 0.01$.
***Significant: $P \leq 0.001$.

Table IV
Multiple linear regression to evaluate the influence of predictive variables on airway volume.

Independent variables	B	*P*	95% confidence level	
			Lower limit	Upper limit
Nasopharyngeal volume (mm³) (R^2 = 0.022)				
Constant	7110.43	0.231	−4570.18	18791.04
Sex	−549.09	0.189	−1372.17	273.98
Age	16.52	0.472	−28.84	61.88
Group	−38.18	0.934	−952.77	876.40
SNA	−3.14	0.955	−114.06	107.78
ANB	−17.72	0.821	−172.19	136.74
Skeletal Class	1.63	0.996	−591.06	594.32
FMA	15.47	0.716	−68.48	99.41
ODI	−6.96	0.833	−71.95	58.04
Oropharyngeal volume (mm³)(R^2 = 0.123)				
Constant	7734.28	0.678	−28983.10	44451.65
Sex	−1135.28	0.387	−3722.58	1452.02
Age	40.81	0.572	−101.77	183.39
Group	−1105.38	0.448	−3980.34	1769.57
SNA	25.25	0.886	−323.42	373.92
ANB	−623.87	0.012*	−1109.41	−138.32
Skeletal Class	32.51	0.973	−1830.58	1895.60
FMA	200.59	0.135	−63.28	464.47
ODI	45.64	0.659	−158.66	249.95
Pharyngeal airway volume (mm³) (R^2 = 0.120)				
Constant	17740.17	0.424	−26016.54	61496.88
Sex	−1976.88	0.207	−5060.21	1106.44
Age	69.47	0.420	−100.45	239.38
Group	−1296.95	0.455	−4723.08	2129.18
SNA	3.04	0.988	−412.48	418.56
ANB	−651.48	0.028*	−1230.11	−72.84
Skeletal Class	−103.18	0.927	−2323.45	2117.10
FMA	214.19	0.180	−100.28	528.66
ODI	17.88	0.885	−225.59	261.36

*Significant: $P < 0.05$.

Discussion

To our knowledge, no studies have compared the airways between individuals with and without open bite. The pharyngeal volume can be modified in individuals with open bite given their unique cephalometric characteristics, particularly when the origin is skeletal, which includes a hyperdivergent mandibular growth direction, with counterclockwise rotation of the maxilla [12–17]. In addition, open bite is related to a respiratory function and tongue position adapted to malocclusion, and both situations can directly affect the UA. This is corroborated during surgical planning to determine the anteroposterior position of the maxilla and mandible in the different skeletal patterns, as it can affect the airways and therefore the respiratory function of patients [18,19]. Therefore, the purpose of this study was to three-dimensionally compare the UAs in fully-grown individuals with and without anterior open bite using CBCT. We also decided to compare linear measurements, areas, and volumes in different regions of the airways because variations can be found in a specific measurement that may alter the diagnosis of the airways, which clinicians can consider when planning treatments in these specific cases.

The UA undergoes periods of accelerated growth during adolescence [20,21]. When comparing the pharyngeal airways, changes are observed even in late adolescence [22]. Changes at the airspace level continue to occur even at maturity, with periods of increase, relative stability, and decrease in growth [23], although the likelihood of change is lower. The present study included individuals in adulthood, the age group in whom changes over time are rarely observed, which allowed a more accurate comparison between the evaluated groups.

Studies of the upper and lower airways in lateral head radiographs of nose breathers with different anteroposterior and vertical skeletal patterns conclude that they are narrower in hyperdivergent than in hypodivergent and normodivergent subjects [24]. Likewise, the CBCT results are similar in patients with the same skeletal patterns, especially among women [25]. When assessing UA volume in adults, one group observed a greater cross-sectional area in the lower part of the UA and a greater volume in the upper part of the UA in individuals with Class III skeletal malocclusion compared to Class I [26]. Other studies using lateral head radiographs and CBCTs to compare the UA volume in the different skeletal malocclusions showed that the total UA volume in Class I and III subjects was higher than in Class II subjects, mainly because the latter individuals usually present with mandibular retrusion, which leads to decreased airway volume. However, all these studies evaluated the UA in subjects with adequate overbite [27–29], while in subjects with open bite, the result could be different regardless of how the sagittal position of the tongue has adapted to this malocclusion that is established at an early age. In our study, the open bite group showed ODI and FMA values that had a greater tendency toward a skeletal origin compared to the control group, who were more normodivergent. This finding helps us to understand whether the condition of having an open bite with a skeletal tendency that modifies the position of the tongue, could have an influence on the airways when compared with individuals with typical growth.

The results of the present study showed no significant differences in the evaluated linear measures or pharyngeal volumes between groups. However, there was difference in the pharyngeal area, which was higher in the open bite group than the control group. This diagnostic variation suggests that there may be different results in the diagnosis of the UA depending on the evaluation method used. It is important to make clear that the volumetric diagnosis is the ideal measurement method when evaluating the airways because the area is only a section of a volumetric structure, i.e., a part of a whole, and therefore could lead to an incorrect diagnosis especially now that it is known that patients with respiratory disorders have different bone anatomical structures [30]. Nevertheless, on the other hand, there may be some restrictive sections leading to difficulty breathing [31,32]. These considerations should be taken into account by the orthodontist seeking to make an accurate diagnosis of the UA and thus optimize the treatment plan.

In our study, both evaluated groups did not present mandibular retrognathism; this condition is interesting because it could modify the interpretation of our study, as mandibular retrusion leads to reduced pharyngeal volume [7,33]. This variation could be evaluated in future studies comparing individuals with mandibular retrusion and anterior open bite versus adequate mandibular size and open bite, and those results would be worth comparing with the present results. The sample selection in this study could present a selection bias since the sample evaluated mainly skeletal open bite individuals, therefore the result could be different under other open bite conditions, this situation could be considered for future studies. Finally, based on the evaluated sample of young adults with different anteroposterior jaw relationships, with no retrognathic tendency or differences by sex, the open bite group more often had a skeletal origin based on the FMA and ODI vertical characteristics in comparison to the group with adequate overbite. Neither the linear dimensions nor the volume of the airways presented significant differences from the control group. However, when evaluating the airways with different indicators, differences can be detected between the evaluated methods; in this study, they were mainly found when area was used, being greater in subjects with open bite than the controls. This result contrasts with the diagnosis of the UA using linear and volumetric measurements, but it must be taken into account that the gold standard for this variable continues to be the volumetric evaluation and is currently the method with greater accuracy when evaluating the UA. Nonetheless, further studies should be performed to clarify the results found here.

Conclusions

The upper airways area was increased in individuals with open bite, but the linear and volume measurements were similar. Orthodontists should know that the airways diagnosis can vary depending on the measurement method used. The volumetric method is still the gold standard. The pharyngeal airway volume was mainly influenced by ANB angle in both groups. This cephalometric measurement should be considered by orthodontists when planning the treatment of open-bite patients.

Ethics approval and consent to participate: this study was approved by the Ethics in Research Committee of the School of Dentistry of the Cientifica del Sur University (approval number: 2018-00014).

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Disclosure of interest: the authors declare that they have no competing interest.

Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.ortho.2020.02.007.

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ARTIGO 2

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The influence of software on the volumetric and cross-sectional assessment of the oropharyngeal airway of patients with and without an open bite. A CBCT study.

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Summary

Introduction: The aim of this study was to compare the volume and the most constricted area of the oropharynx in individuals with and without an open bite using two software programs used for cone beam computed tomography (CBCT).

Methods: For this comparative study, the sample included 60 cases selected from 137 CBCT scans divided by the presence or absence of an open bite, and each group included adults of both sexes (30 women and 30 men; age of the open bite group, 27.57 years ± 11.85; age of the group without an open bite 26.23 years ± 6.78). The oropharyngeal volume and the most constricted area were measured with two 3D software programs, Planmeca Romexis and Nemotec/NemoStudio. Two calibrated orthodontists trained in the use of the software performed the measurements. The statistical tests used were Student's t tests for independent and paired samples, with $p<0.05$. The intraclass correlation coefficient was applied for both programs.

Results: In general, the oropharynx volume measurements obtained with NemoStudio software were significantly higher ($p=0.020$) than those obtained with Romexis (19007.17mm3 ± 8005.79 and 17823.47 mm3 ± 7148.62, respectively). However, when the groups were analyzed separately, the measurements of the group with an open bite did not differ according to the software used ($p=0.352$). Likewise, the measurements of the most constricted area (MCA) of the oropharynx were significantly higher ($p=0.005$) when obtained by NemoStudio software (mean difference 19.02 mm2). In the same way, in the open bite group, no difference in the MCA results of the two software programs were found (p=0.728). The intraclass correlation coefficient (ICC) for the intra-observer showed for volume and the most constricted area with Romexis values of 0,999 and 0,994 respectively and the inter-observer showed for volume with Romexis values of 0.982 and for the most constricted area values of 0.888. The ICC for the intra-observer showed for volume with NemoStudio values of 0,994 and for the most constricted area values of 0,995 and for the inter-observer with NemoStudio for volume and the most constricted area 0,997.

Conclusion: The software influences the volumetric and cross-sectional assessment of the oropharyngeal airway, particularly in patients without an open bite.

key words: Airways. Software. Cone-beam Computed Tomography.

L'influence du logiciel sur l'évaluation volumétrique et transversale des voies respiratoires oropharyngées des patients avec et sans occlusion ouverte. Une étude CBCT.

Résumé

Introduction: Le but de cette étude était de comparer le volume et la zone la plus resserrée de l'oropharynx chez des individus avec et sans occlusion ouverte en utilisant deux logiciels utilisés pour la tomodensitométrie à faisceau conique (CBCT).

Méthodes: Pour cette étude comparative, l'échantillon comprenait 60 cas sélectionnés à partir de 137 scans CBCT divisés par la présence ou l'absence d'une occlusion ouverte, et chaque groupe comprenait des adultes des deux sexes (30 femmes et 30 hommes; âge du groupe occlusion ouverte, 27,57 ans ± 11,85; âge du groupe sans occlusion ouverte 26,23 ans ± 6,78). Le volume oropharyngé et la zone la plus restreinte ont été mesurés avec deux logiciels 3D, Planmeca Romexis et Nemotec / NemoStudio. Deux orthodontistes calibrés formés à l'utilisation du logiciel ont effectué les mesures. Les tests statistiques utilisés étaient des tests t de Student pour des échantillons indépendants et appariés, avec $p < 0,05$. Le coefficient de corrélation intraclasse a été appliqué pour les deux programmes.

Résultats: En général, les mesures de volume d'oropharynx obtenues avec le logiciel NemoStudio étaient significativement plus élevées (p = 0,020) que celles obtenues avec Romexis (19007,17 mm3 ± 8005,79 et 17823,47 mm3 ± 7148,62, respectivement).

Cependant, lorsque les groupes ont été analysés séparément, les mesures du groupe avec une occlusion ouverte ne différaient pas selon le logiciel utilisé (p = 0,352). De même, les mesures de la zone el plus resserrée (MCA) de l'oropharynx étaient significativement plus élevées (p = 0,005) lorsqu'elles étaient obtenues par le logiciel NemoStudio (différence moyenne 19,02 mm2). De la même manière, dans le groupe à morsure ouverte, aucune différence dans les résultats MCA des deux logiciels n'a été trouvée (p = 0,728). Le coefficient de corrélation intraclasse pour intra-observateur a donné comme résultat pour Romexis un volume et la zone la plus restreinte de 0,999 et 0,994 respectivement et pour l'interobservateur de Romexis un volume de 0,982 et la zone la plus restreinte de 0,888. Le coefficient de corrélation intraclasse pour intra-observateur a donné comme résultat pour NemoStudio un volume de 0,994 et la zone la plus restreinte de 0,995 et pour l'interobservateur de NemoStudio un volume et la zone la plus restreinte de 0,997.

Conclusions: Le logiciel influence l'évaluation volumétrique et transversale des voies respiratoires oropharyngées, en particulier chez les patients sans occlusion ouverte.

mots-clés: Airways. Logiciels. Tomographie à faisceau conique.

Introduction

According to a systematic review and meta-analysis, craniofacial disharmony is considered a predisposing factor for respiratory disorders during sleep in children [1]. The symptoms of respiratory disorders are reportedly associated with facial and dental morphometry, [2] highlighting the importance of craniofacial and airway morphology [3]. Hence, an open bite accompanied by clockwise mandibular rotation and different associated factors, including the skeletal pattern, influence airway dimensions, and simply repositioning the mandible significantly affects these dimensions [4].

Therefore, conducting airway studies is important. Initially, these were performed using lateral radiographs; however, with the emergence and development of new technologies, they are currently performed with computed tomography [5, 6]. Measurement based on 2D images has been questioned because of the airway’s 3D structures. However, studies have found a similarity between the linear measurements obtained with lateral radiographs and those obtained with CBCT, [7] as well as a correlation of sagittal and axial areas with volume in 2D images [8]. In the search for more and better information about airways, research continues to be conducted, and recent findings have validated both the use of lateral radiographs and the information obtained from CBCT [9].

With technological advancement, different software programs for airway analysis have emerged. A systematic review in 2011 reported 18 software packages for airway studies [5, 10]. This review did not mention aspects such as the threshold (automatic or interactive) or the measurement method (automatic or manual) used. Few studies specify these aspects. In the literature, one study determined the ideal threshold for airway volume under experimental conditions; [11] thus; this threshold cannot be used as a standard protocol for airway assessment. Another study used a fixed threshold, which was the average based on a previously determined threshold for each tomography scan, with the objective of delimiting the airways using reliable references obtained in 3D images using Dolphin software to establish a protocol and obtain normative upper airway values for patients with the following characteristics: Caucasian, adult (23-35 years), healthy, Class I occlusion, and a Class I profile without asymmetries [12]. In terms of the measurement method used, studies have examined the use of different software programs and found high reliability for automatic measurements and differences compared to manual measurements [13]. Software programs are continually updated and improved, prompting the question of whether the above issues have been corrected. Several studies have used prototypes or phantoms to verify the results obtained [6,11,14,15]. Clearly, however, the materials used for these prototypes should be considered if they are used to represent the airways, and the materials should have the same density as soft tissues to ensure that the threshold values obtained with these prototypes are representative [16]. Furthermore, the use of different tomographs to scan the same tissue can lead to significant differences in the results of studies [17], and differences in voxel and artifact sizes can affect CBCT images [18,19]. Recently, a study comparing two software programs, InVivo and Dolphin, was conducted using fixed and interactive thresholds, respectively, to propose normative values for children for use in the diagnosis and early management of pediatric sleep apnea problems; this study found differences according to which software was used [20]. The same software programs were used to obtain measurements in adults and in prototypes as a control in another recent study measuring volume, the minimum area, and the location of the minimum area; that study also found overestimated values when Dolphin was used and underestimated values when InVivo was used, and both programs were considered reliable and strongly correlated but not the same [21]. The aforementioned issues raise the question of whether different methods using different thresholds, but within the range for airway recognition, would yield measurements of software programs that differed in a sample of patients with craniofacial disharmony in whom the dimensions of the airways may be altered. Therefore, the objective of this study was to determine the volume and the most constricted area of the oropharynx in individuals with and without an open bite and with different skeletal patterns using the automatic software mode for Planmeca Romexis and the manual mode for Nemotec/NemoStudio in 3D using different thresholds.

Materials

The present retrospective and cross-sectional study was approved by the Research Committee and Ethics Committee of the Federal University of Rio Grande do Sul and Universidad Científica del Sur (approval number 2018-00014), respectively. The sample for this study included 60 cases selected from 137 CBCT scans. Sex and skeletal pattern were considered inclusion criteria. Based on different skeletal patterns, both anteroposterior and vertical, the sample was divided into two groups of 30 CBCT images from individuals with open bites and 30 CBCT images from individuals without open bites. To describe the sagittal and vertical features of both groups were evaluated the skeletal relationship (ANB angle), facial divergence (Frankfort mandibular plane (FMA) angle), and vertical overbite depth indicator (ODI) shown in Table 1. For this purpose the cephalograms used were derived from CBCT. The anteroposterior skeletal patterns included in both groups were Class I, Class II and Class III and the following characteristics of overbite were considered: open bite group = 0 mm or negative and non-open bite group = positive. The CBCT images were taken from 30 males and 30 females aged between 15 and 56 years, with average ages of 27.57 years ± 11.85 for the open bite group and 26.23 years ± 6.78 for the group without an open bite. All excess CBCT images were excluded after the required number of 60 was obtained. The sample was obtained as scrutinized in the flow chart.(Fig.1)

Methods

Image acquisition

CBCT was performed according to the standardization protocol of the radiological center, and images were obtained by means of a Vatech E-woo model Picasso Master 3D scanner (Vatech, Hwaseong, South Korea).

The CBCTs were obtained with the patient in a seated and erect position and the craniocervical alignment was 90-110°. The sagittal midline, the Frankfort plane, the occlusal plane, and the incisor line were the anatomical points used to head position. Instructions were given to the patients as to keep the eyes open, not to move the head, not to swallow, to breath slowly and to be in maximum intercuspation during scanning.

The following settings were used to acquire the tomographies with 3D scanner: 8 mA, 90 kVp, Flat Panel 25x 20 cm, 30 x 30 cm, with a 20 x 19 cm field of view, 0.3 mm isotropic voxel size, and exposure time of 20 seconds. The CBCT images were converted to DICOM (Digital Imaging and Communications in Medicine) format and analyzed with the Planmeca Romexis program, version 5.1.1.R. and Nemotec/NemoStudio version 2017 (NemoFAB).

Calibration

In order to assure uniform intra and inter observer measuring procedures, a calibration process was performed previously. Ten CBCTs were randomly selected from the sample and variables of interest measuring were done twice with an interval of 15 days between them for both programs studied Romexis and NemoStudio.

Variables measurements

A Toshiba Satellite L845, Intel Core i3, 8:00 GB- RAM and operative system of 64 bits was used for the selected upper airways measurements.

The orientation of the head in the reconstruction of all 3D images was standardized by aligning the Frankfort plane (Po-Orb on both sides) with the horizontal guideline in the sagittal and coronal sections. The anterior and posterior nasal spines (ANS-PNS) were aligned with the vertical guideline, and the pupils were aligned with the horizontal guideline; both alignment procedures were performed in the axial section.

For detection of the airway at the level of the oropharynx, programs defined limits by prism

or cube, the location of the s-point (seed point), and a defined threshold or tolerance. For measurements of volume and the most constricted area in Romexis, the icon was used to perform the measurements in automatic mode. The procedure for demarcating the airway consisted of locating the vertical guide at the most central point possible in the oropharynx and perpendicular to the horizontal guide. Next, an s-point was located at the intersection of the vertical guide with the upper limit of the oropharynx, which begins in the PNS and then runs posteriorly towards the vertebrae. The horizontal guide was located at the lower limit of the oropharynx, tangent to vertebra C3 in its most caudal medial portion, which is directed forward. A second s-point was placed at the lower limit of the oropharynx following the projection of the first seed point at the intersection with the vertical guide. With this second point, the anterior limit of the oropharynx is automatically defined by the formation of a cube where the anterior vertical line starts from the PNS and extends towards the lower limit and where the posterior limit of the oropharynx is defined by a line parallel to the anterior limit located on the vertebrae. The lateral walls of the pharynx and the total extensions of the lateral projections were included automatically. Even the experts recommend the threshold of 500 for both programs used in this study it would vary depending on the image of the tomography. To standardize as part of the protocol the threshold used was 300 for all the images. The value was selected during establishment of the protocol. The low threshold possible was selected as the researcher could visualize all images of upper airways clearly. In NemoStudio, the NemoFAB component was used, which contains the tool for measuring the airways. In this program, the procedure was performed by demarcating the upper limit of the oropharynx. Starting at the PNS, the procedure continued in a posterior direction along the horizontal guide until the middle of the vertebra was visible at that height and then descended to the lower limit of the oropharynx, passing the horizontal guide line tangent to the middle caudal portion of C3; from this point, the procedure was directed forward until it reached a point that was in the direction of the PNS. From that point and in the direction of the upper limit of the oropharynx, the PNS was reached again, forming the prism. Next, an s-point was placed on the epiglottis within the demarcated area. The tolerance was defined as 500.

Statistical Analysis

For this study, the statistical program SPSS (Statistical Package for Social Sciences) version 22.0 for Windows (IBM, SPSS, Chicago, Illinois, USA) was used. Normality of the quantitative variables was verified with the Shapiro-Wilk test; therefore, the sample characteristics were evaluated by applying Student's t test for independent samples. To compare the means of the volume and the most constricted area of the oropharynx determined by the different software programs for both the total sample and each group, Student's t test was used for related samples. The statistical tests were performed at a significance level of $p<0.005$. A calibration process was performed previously by applying the intraclass correlation coefficient for both programs.

Results

The results from the ICC analysis for volume and the most constricted area showed intra-observer values of 0,999 and 0,994 respectively with Romexis and inter-observer volume values of 0,982 and the most constricted area values of 0,888. NemoStudio showed intra-observer values for volume and the most constricted area of 0,994 and 0,995 respectively. Inter-observer values for NemoStudio showed values of 0,997 for both variables.

Table I shows the characteristics of both groups, which tend to show maxillary protrusion and a well-positioned but slightly protruding mandible in the group without an open bite. The A point-nasion-B point (ANB) angle showed skeletal pattern variability in both directions, which was slightly more marked in the open bite group. The Frankfort-mandibular plane angle (FMA) showed that both groups were hyperdivergent, and the mean age indicated that the sample consisted of young adults. The only variable that presented a significant difference was the overbite depth indicator (ODI) angle; the open bite group presented more marked values of a skeletal open bite compared with the group without an open bite as well as skeletal open bite characteristics despite a lack of clinical expression of an open bite.

Table II compares the measurements of the volume and the cross-sectional assessment of the most constricted area of the oropharynx performed with the Romexis and NemoStudio programs. The table shows significant differences in the average volume for the entire sample between the two software programs ($p = 0.020$; Romexis (17823.47 mm3 ± 7148.62) and NemoStudio (19007.17 mm3 ± 8005.79)). The average of the most constricted area for the entire sample also showed significant differences between the two software programs ($p = 0.005$; Romexis (227.32 mm2 ± 102.61) and NemoStudio (246.34 mm2 ± 118.97)). For both volume and the most constricted area, higher values were observed with NemoStudio.

Table III compares the volume and the most constricted area of the oropharynx obtained with both programs for the group with an open bite and the group without an open bite. Significant differences were observed between the two software programs in terms of volume for the group without an open bite (p = 0.021; Romexis (17051.90 mm3 ± 7193.83) and NemoStudio (18747.00 mm3 ± 8496.91)) and for the group with an open bite (p = 0.352; Romexis (18595.03 mm3 ± 7140.37) and NemoStudio (19267.33 mm3 ± 7619.58)).

The group with an open bite did not show significant differences in volume; however, the volume values for this group were higher with both programs than the values obtained for the group without an open bite.

The difference in the most constricted area determined by the two software programs was more noticeable in the group without an open bite (p = 0.001; 216.43 mm2 ± 111.78 with Romexis and 251.68 mm2 ± 130.06 with NemoStudio), while in the open bite group (p =0.728), the areas were 238.20 mm2 ± 93.17 with Romexis and 240.99 mm2 ± 108.73 with NemoStudio.

Discussion

Despite the time elapsed and the efforts made, no gold standard is available for use as a reference for airway measurements [6]. The literature on airway analysis highlights the need to address several factors despite a lack of evidence. A thorough examination of airways that includes information only on volume would not help to identify the areas of greatest constriction [22,23]. Software packages to achieve reliability, validity, and efficiency in measurements of airways and comparisons of semiautomatic and manual methods used to obtain measurements,[24] are still issues of concern to researchers.

The upper airways changes are observed over adolescence and late adolescence because of growth periods.[25,26,27] At maturity the likelihood of changes is lower, for that reason the adult sample studied allows to compare accurately the groups.[28] Also studies performed to determine the accuracy of measurements of oropharyngeal morphology indicate that images obtained from Vatech equipment yield more precise measurements of volume and axial area;[6] therefore, although we do not have a norm for values obtained from CBCT, the sample obtained is likely to be precise. Knowledge of the program we are going to use is important. First of all, the computer characteristics must be according to the program is going to be used. Romexis tools for measurements of upper airways as volume, area and the most constricted area are easy to learn and apply. A jar icon is designated for manual segmentation and a human head icon for automatic segmentation. Other tools as for angle and linear measurements are also available. Obviously the user must be able to recognize anatomic structures and to establish a protocol for the measurements. NemoStudio have an organized protocol established since upper airways measurements are part of surgical procedures for treatment as NemoFAB is and it is divided by sections. NemoFAB upper airways measurement tools belongs to section E. An advantage for Romexis program in manual segmentation is that it is possible to verify all the airways to be taken before and after the measurements have been obtained in comparison to NemoFAB manual segnentation that verification is only possible after the measurements have been obtained. It may be translated in more or less time used to the measurement and it depends on researcher's desire to work. Studies of airway measurement software have mainly evaluated accuracy, precision, and reliability [10,14,15]. Several of these studies used phantoms or prototypes as the gold standard, resulting in an underestimation of the dimensions, although the software showed reliability for the data obtained [14,15,16]. Although the results were highly correlated, the software did not have good accuracy, which suggests systematic errors according to the study [13]. Other studies reveal that although some software programs provide underestimated results while others provide overestimations, they are still considered reliable [19,20]. The present study did not use a gold standard; consequently, the values may be underestimated or overestimated relative to reference values in the literature. It would be desirable that upper airways studies that include use of software programs must describe their characteristics since many of them are only commercially available and their information is oriented to selling but not on details of approaches, especially nothing about algorithms behavior in every program. Maybe doing that it would be possible to find the equivalence value for each program. The programs most frequently compared are Mimics and Dolphin to measure airway volume; [10] Amyra, 3Dyagnosis, and OnDemand 3D to measure volume, the minimum axial area, and airway length;[14] Mimics, ITK-snap, OsiriX, Dolphin 3D, InVivoDental, and OnDemand3D to measure airway volume;[15] 3dMD Vultus for the area, length, and volume of the airway;[16] and Dolphin 3D, InVivoDental, and OnDemand3D with OrthoSegment to measure upper airway volume [13]. One study compared the Beta Nemoceph 3D and Invivo5 programs with lateral cephalometric radiographs but only to determine the coincidence of reference points used in the study [29].Recently, a study compared Invivo5 and Romexis (version 3.8.2.R) programs to measure upper airway to test reliability [30]. The present study compared the Romexis and NemoStudio programs for measuring the volume and the most constricted area of the oropharynx; the first program uses automatic mode, and the second uses the manual NemoFAB airway measurement tool.

The results of the study comparing six programs revealed that segmentation is influenced by the threshold used, the algorithm of the program, and the complexity of the airway [15]. The study also revealed that when an interactive threshold was used, significant differences were found between the volume measurements of the different programs, and a lower error rate occurred due to underestimation of the volume compared to the gold standard. When a fixed threshold was used, the total differences were also significant, but the rate of error among the programs was greater even though the programs yielded the same results for the measurements of the phantom; this phenomenon may be due to differences in the algorithms used in each program to identify the most complex morphology of the oropharynx [15]. The results of the present study are consistent with investigations using a fixed threshold since the comparison of measurements performed with the Romexis and NemoStudio programs showed significant differences for the entire sample. However, the threshold used in both programs is within the values that can differentiate bone (250 to 1000 HU) from air (-600 to -1000 HU) [31]. CBCT is not a routine examination, since it has specific indications, and offers an advantage over MSCT, as it generates a lower dose of radiation and is less expensive. Airways can be evaluated with multislice computed tomography (MSCT), also known as multidetector computed tomography (MDCT), or with cone beam computed tomography (CBCT) [6]. Usually Hounsfield units are used for MDCT which characteristics are adequate for mA and kVp and HU use for CBCT is more commercial than real since pharyngeal evaluation in CBCT is made by program sensibility through gray tones scale and have great variability among different trades as the same tomographies equipment and different images acquisition. We found in studies diversity of values according to the airway measurement tool available trying to assess pharyngeal space. When the values obtained from the two software programs studied were compared, no significant differences were found for the open bite group. However, significant differences were found for the group without an open bite. This difference may be related to the sample since the airway dimensions determined by both software programs were smaller for this group. Due to intentional use of the lower threshold in Romexis software, the values remain lower than those determined using NemoStudio software, whose higher values correspond to the theory that "the higher the threshold used, the greater the value obtained", and vice versa [11]. Most likely, the configuration of the Romexis software algorithm compensates for using a low threshold in the automatic mode and did not show significant differences in the open bite group since the dimensions of the airways were greater in this group than in the group without an open bite regardless of the software used because of a tendency of maxillary protrusion and non retrognatic mandible sample and a less value for ANB angle in open bite group. The aforementioned issue is just for a better understanding but focus of this study is about the software program influence and there is no intention to draw attention to findings in a previous study. [32]

Since the group without an open bite had smaller dimensions according to both software packages and given the intentional use of a higher threshold for the manual mode in the NemoStudio software and the relationship of this threshold with the algorithm configuration of this software, the values were higher, leading to a significant difference in the measurements in this group.

Other studies measuring other structures suggested that the influence of the threshold on the systematic error in the voxel measurement method of the programs will affect measurements in small structures but not in large structures;[19] however, this would require a true value to obtain a constant value, which is generally provided by measurement of a prototype or phantom as a gold standard, which did not occur in this study. Nonetheless, we might consider the possibility that this could occur in the airways due to their complexity and would be particularly likely in the group without an open bite because the airways in that group would be smaller. The literature also mentions the effect of partial volume and density detected by a voxel in software depending on the threshold, where high threshold values would underestimate the measurement, and low values would overestimate the measurement by forming a hybrid voxel when it includes two structures of different densities [19]. In the present study, this theory would not apply since the Romexis program used a lower threshold than the NemoStudio program. According to the literature, the ideal threshold value for measuring volume has not been standardized since airway volume has been found to vary according to the selected threshold [11,13], and larger or smaller measurements of airway volume result from an increase or a decrease in the threshold, respectively [11]. The present study supports this direct relationship between a greater threshold and greater volume. Finally, differences between these two programs about the time used to obtain measurements also depends on the computer characteristics as using an ideal graphic video card and the individual capability of the user. Even though, we can say based on time registration during establishment of protocol for manual and automatic segmentation through development of videos that the time spent for measurements depends also on head positioning and to the extension of structures selected. Obtaining information of Romexis automatic segmentation is faster than the manual segmentation. It is comparable to NemoFAB manual segmentation on time since verification only can be done after the measurement have been obtained and if an ideal graphic video card is used. An advantage for NemoStudio program is that it can delineate soft palate. Then, regarding the time required to perform airway measurements, the automatic mode depending on computer characteristics would have an advantage over the manual mode as reported in the literature for other software programs. [24] Additionally, Romexis facilitates visual identification of the most constricted area through the use of color differentiation to indicate its location and value (Fig. 2), whereas NemoStudio uses solid colors and values that only appear outside the image (Fig. 3). Both software programs require the user to follow a standardized protocol in addition to the interactive thresholds reported in the literature [15] to ensure a low error rate in the measurements of structures. The sample of skeletal and clinical open bite group was not easy to find in CBCT records. From a clinical point of view, it must be taken special careful treatment planning with extractions or for orthodontic treatment combined with surgical procedures for the group with the open bite which tongue position usually is more anterior and adapted according the malocclusion for the risk to modify soft palate position commonly affected with treatment. Also respiratory function therapy to face the new condition must take in account considering relation between volume and ANB angle. It is important to pay attention to both groups especially non open bite group being structures with small dimensions because risk situations may go unnoticed by the influence of threshold or segmentation mode during diagnosis and only orthodontic treatment planning or combined with surgical treatment planning.

Conclusions

The software used influences volumetric and cross-sectional assessments of the oropharyngeal airway, particularly in patients without an open bite.

Study flow chart

CBCTs of young adults between 15 to 56 years, obtained from 137 CBCT collected. (n =137)

↓

Open bite group (n= 47)

- Skeletal pattern Class I,II,III

Class I: ANB:2°+/-2°
Class II: ANB: >4°
Class III: ANB: <0°

- Overbite: 0 mm or negative

Non-Open bite group (n=90)

- Skeletal pattern Class I,II,III

Class I: ANB: 2°+/-2°
Class II: ANB: >4°
Class III: ANB: <0°

- Overbite: Positive

↓

Exclusion criteria

- CBCTs of individuals after obtaining 15 males and 15 females data, 10 for each skeletal pattern. (n=17)
- CBCTs of individuals after obtaining 15 males and 15 females data, 10 for each skeletal pattern. (n=60)

Inclusion criteria

Open bite group (n=30)

Non-Open bite group (n=30)

Fig.1. Flow chart of the simple collection

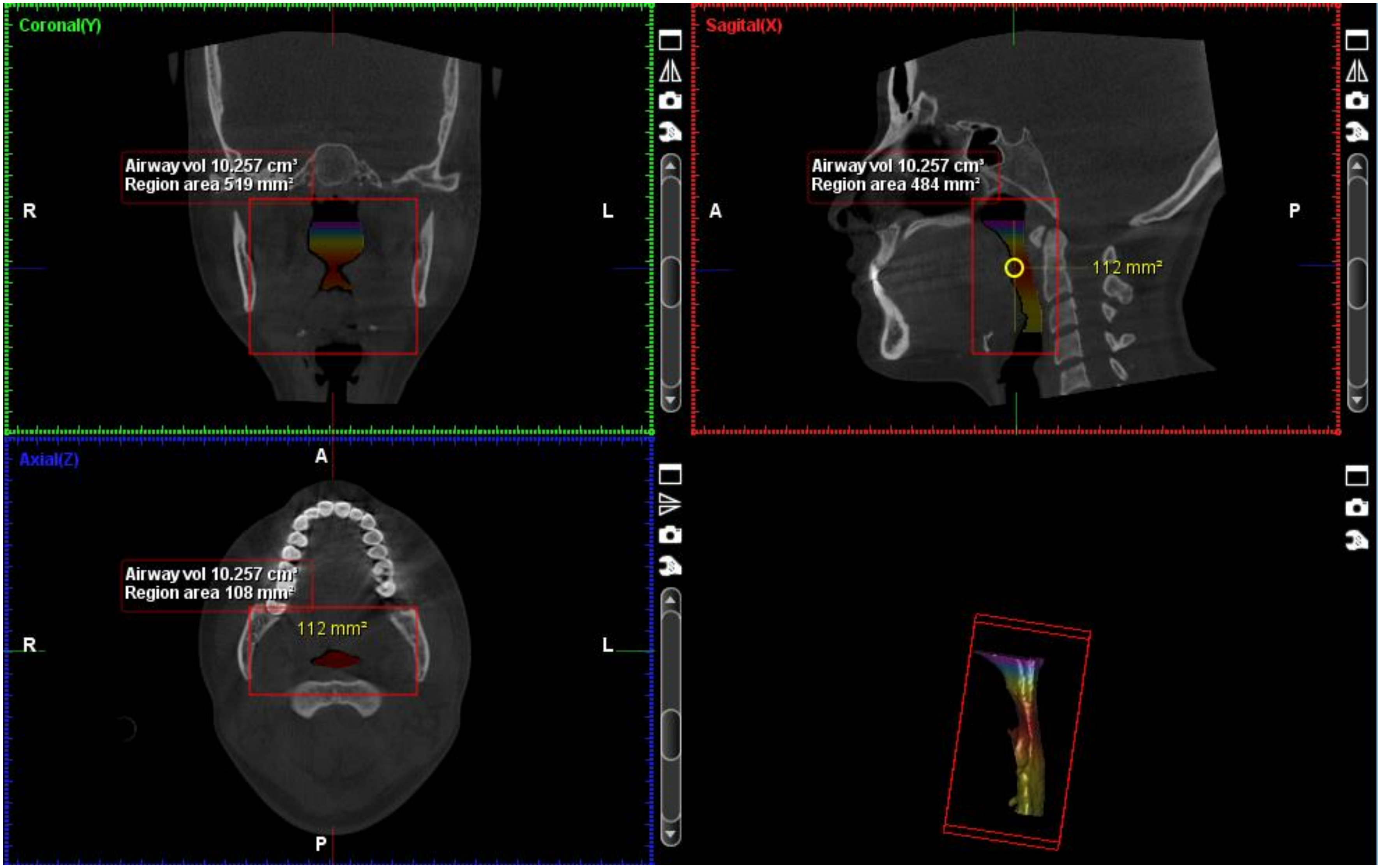

Figure 2. Evaluation using Romexis software: Upper Airways- Oropharynx –Volume and most constricted area

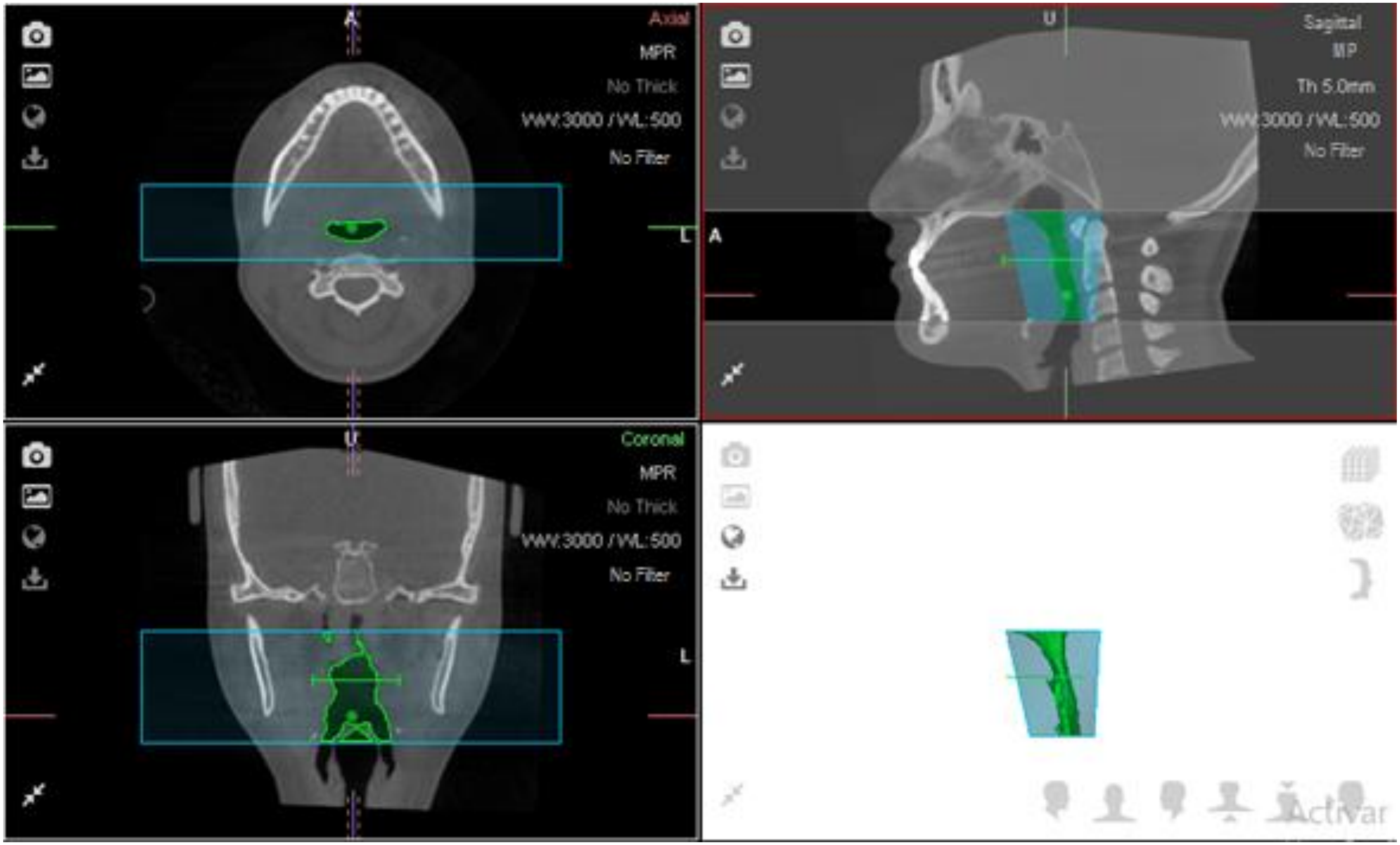

Figure 3. Evaluation using NemoStudio software: Upper Airways -Oropharynx –Volume and most constricted area.

Table I
Sample Initial characteristics in both groups

Measurement	Group	N	Mean	SD	p
SNA(°)	Non Open bite	30	85.30	4.48	0.112
	Open bite	30	83.64	3.41	
SNB(°)	Non Open bite	30	82.90	5.88	0.571
	Open bite	30	82.02	6.08	
ANB(°)	Non Open bite	30	2.41	3.81	0.501
	Open bite	30	1.63	5.01	
FMA(°)	Non Open bite	30	29.27	5.76	0.244
	Open bite	30	31.05	5.98	
ODI(°)	Non Open bite	30	61.70	10.36	0.042*
	Open bite	30	56.65	8.31	
Age(years)	Non Open bite	30	26.23	6.78	0.595
	Open bite	30	27.57	11.85	

Independent t-test
*Significant $P<0.05$.

Table II

Comparison of oropharyngeal volume and most constricted area between the two evaluated softwares

Measurement	N	Mean	SD	p	Mean difference	CI to 95%	
						LL	UL
Volume with RS (mm^3)	60	17823.47	7148.62	0.020*	-1183.70	-2178.01	-189.39
Volume with NS (mm^3)	60	19007.17	8005.79				
MCA with RS (mm^2)	60	227.32	102.61	0.005*	-19.02	-31.95	-6.09
MCA with NS (mm^2)	60	246.34	118.97				

Paired t-test
*Significant $P<0.05$.
RS = Romexis Software
NS= NemoStudio Software
MCA= Most constricted area

Table III

Comparison of oropharyngeal volume and most constricted area between the two evaluated softwares in both groups

Group	Measurement	N	Mean	SD	p	Mean difference	CI to 95% LL	CI to 95% UL
Non Open bite	Volume with RS (mm^3)	30	17051.90	7193.83	0.021*	-1695.10	-3113.99	-276.21
	Volume with NS (mm^3)	30	18747.00	8496.91				
	MCA with RS (mm^2)	30	216.43	111.78	0.001*	-35.25	-54.50	-16.00
	MCA with NS (mm^2)	30	251.68	130.06				
Open bite	Volume with RS (mm^3)	30	18595.03	7140.37	0.352	-672.30	-2126.25	781.65
	Volume with NS (mm^3)	30	19267.33	7619.58				
	MCA with RS (mm^2)	30	238.20	93.17	0.728	-2.79	-19.04	13.46
	MCA with NS (mm^2)	30	240.99	108.73				

Paired t-test

*Significant P<0.05

RS = Romexis Software

NS= NemoStudio Software

MCA= Most constricted area

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CONSIDERAÇÕES FINAIS

A mordida aberta, maloclusão do tipo vertical, quando associada a componentes esqueléticos é relacionada à morfologia das vias aéreas e o risco de afetar a função respiratória. Esta maloclusão é considerada um desafio para o tratamento ortodôntico, uma vez que, sendo multifatorial, o prognóstico é reservado e apresenta alta probabilidade de recidiva se não identificada adequadamente a causa.

A complexidade anatómica das vias aéreas superiores, suas dimensões e áreas expostas a umidade pela presença de secreções, nos diferentes padrões esqueléticos, faz com que nos estudos de imagens de radiografias laterais e/ou TCFC apresentem variabilidade nos resultados. A presença da mordida aberta nas imagens de TCFC, avaliadas sob as condições deste estudo, mostraram a adaptação gerada nas estruturas em concordância com a maloclusão presente.

Os resultados do estudo, quando comparados os grupos com e sem mordida aberta, não mostraram diferenças significativas no volume nem nas medidas lineares. No que se refere à área, mesmo que corresponda a uma secção da via aérea, uma diminuição nas suas dimensões pode significar una restrição respiratória. Neste estudo o grupo com mordida aberta mostrou uma maior área nas dimensões das vias aéreas superiores.

Estes resultados devem ser levados em conta para o planejamento dos tratamentos ortodônticos com extrações e/ou tratamentos ortodônticos em combinação com cirurgia, devido ao risco de diminuição das dimensões considerando a correlação existente do volume com o ângulo ANB em ambos os grupos. Ainda mais, deve-se considerar a necessidade de incluir uma fase preparatória para a readaptação da função respiratória à nova condição.

Existem vários aspectos que podem influir na medição das vias aéreas e devem ser considerados. Durante a avaliação das vias aéreas superiores é importante ter conhecimento das propriedades do software e o protocolo a seguir, assim como, as ferramentas de segmentação e de medição do programa, especialmente ao limiar selecionado, tendo em vista que quanto maior o limiar utilizado os valores das medições foram maiores e vice-versa.

As medidas de volume e/ou área de maior constrição apresentaram diferenças significativas entre os programas avaliados no grupo sem mordida aberta. No aspecto clínico, deve-se atentar para este grupo já que poderiam passar despercebidas situações de risco pela influência do software utilizado para a medição, em função da escolha do limiar e o modo de segmentação.

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ANEXO A

----- Mensagem encaminhada -----
De: rodrigoarthur.ufrgs@gmail.com <rodrigoarthur.ufrgs@gmail.com>
Para: "mari_vizzotto@yahoo.com.br" <mari_vizzotto@yahoo.com.br>
Enviado: terça-feira, 10 de abril de 2018 13:26:08 BRT
Assunto: Projeto de Pesquisa na Comissão de Pesquisa de Odontologia

Prezado Pesquisador MARIANA BOESSIO VIZZOTTO,

Informamos que o projeto de pesquisa INFLUENCIA DE LA MORDIDA ABIERTA EN LAS VIAS AÉREAS. ESTUDIO EN TOMOGRAFÍAS CONE BEAM encaminhado para análise em 27/02/2018 foi aprovado quanto ao mérito pela Comissão de Pesquisa de Odontologia com o seguinte parecer:

O objetivo do presente estudo é avaliar a influência que a mordida aberta pode exercer sobre as vias aéreas de padrões esqueléticos distintos do tipo Classe I, Classe II ou Classe III. Tomografias computadorizadas de feixe conico de cada tipo esquelético (com e sem a presença de mordida aberta) serão obtidas a partir de banco de imagens de um centro radiológico de Lima. Tomografia de indivíduos com oclusão normal serão utilizadas como padrão ouro. Por meio de um software, os pesquisadores avaliarão medidas lineares e de área e volume das vias aéreas superiores. Trata-se de proposta de pesquisa a ser realizada em colaboração com la Universidad Científica del Sur (Lima-Perú). O protocolo de pesquisa já foi analisado e aprovado sob seus aspectos éticos pelo comitê de ética de la Universidad Científica del Sur (parecer 00014) conforme consta em documento anexado com data de janeiro de 2018. Há carta de anuência do Centro Radiológico (Peru) que fornecerá as imagens de tomografia computadorizada de feixe cônico de indivíduos portadores de mordida aberta. O presente projeto de pesquisa foi aprovado quanto ao mérito pela Comissão de Pesquisa

Devido as suas características este projeto foi encaminhado nesta data para avaliação por .

Atenciosamente, Comissão de Pesquisa de Odontologia

ANEXO B

CIENTÍFICA
UNIVERSIDAD CIENTÍFICA DEL SUR

CARTA Nª 006-DACE-DAFCS-U. CIENTIFICA-2018

Miraflores, 16 de enero del 2018

Mg. Esp.
Patricia Vidal Manyari
Presente.-

ASUNTO: Constancia de inscripción y aprobación ética de trabajos de investigación.

De mi consideración:

Por medio del presente documento lo saludo cordialmente y en atención al asunto de la referencia la comisión de ética e investigación para trabajos de investigación de la Carrera de Estomatología de la Universidad Científica del Sur, Lima-Perú, señala que el trabajo de investigación titulado: **"Influencia de la mordida abierta en las vías aéreas. Estudio en tomografía computarizada de haz cónico"**, ha sido inscrito en nuestra Carrera y ha sido aprobado en los aspectos éticos que involucra la aplicación del mismo, con el número de aprobación **00014.**

Agradeciendo la atención brindada a la presente, quedo de usted.

Atentamente,

CARRERA DE ESTOMATOLOGÍA • COORDINACIÓN DE INVESTIGACIÓN • UNIVERSIDAD CIENTÍFICA DEL SUR

Mg. Luis Arriola Guillén
Coordinador de Investigación
Carrera de Estomatología
Universidad Científica del Sur

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ANEXO C

IDM

Instituto de Diagnóstico Maxilofacial

Miraflores, 16 de enero del 2017

Estimada
Mg. Patricia Aurora Vidal Manyari
Coordinadora de la Especialidad de Ortodoncia y Ortopedia Maxilar de la Universidad Científica del Sur.

De mi mayo consideración:

Por la presente reciba un cordial saludo y a la vez manifestarle que, en respuesta a su solicitud presentada a nuestra Institución, solicitando el acceso a nuestra base de datos y el uso del software Romexis, para la elaboración de su proyecto de investigación, queda aprobado.

Cabe resaltar que los volúmenes tomográficos no deben ser manipulados para otros fines que no se académicos y que se respete la confidencialidad y el aspecto ético de las mismas.

Atentamente,

Dr. Andrés Agurto Huerta
Director General IDM
ESPECIALISTA EN RADIOLOGIA BUCAL Y MAXILOFACIAL
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