UNIVERSIDADE FEDERAL FLUMINENSE

FACULDADE DE ODONTOLOGIA

DIMENSÕES DAS VIAS AÉREAS SUPERIORES DE PACIENTES SUBMETIDOS À CIRURGIA ORTOGNÁTICA AVALIADAS EM IMAGENS 3D: UMA REVISÃO SISTEMÁTICA E META-ANÁLISE

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Dissertação apresentada à Faculdade de Odontologia da Universidade Federal Fluminense, como parte dos requisitos para obtenção do título de Mestre, pelo Programa de Pós-Graduação em Odontologia.

Área de Concentração: Ortodontia

Orientadora: Prof[a]. Dr[a]. Claudia Trindade Mattos. Co-orientadora: Prof[a]. Dr[a]. Adriana de Alcantara Cury-Saramago

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2015

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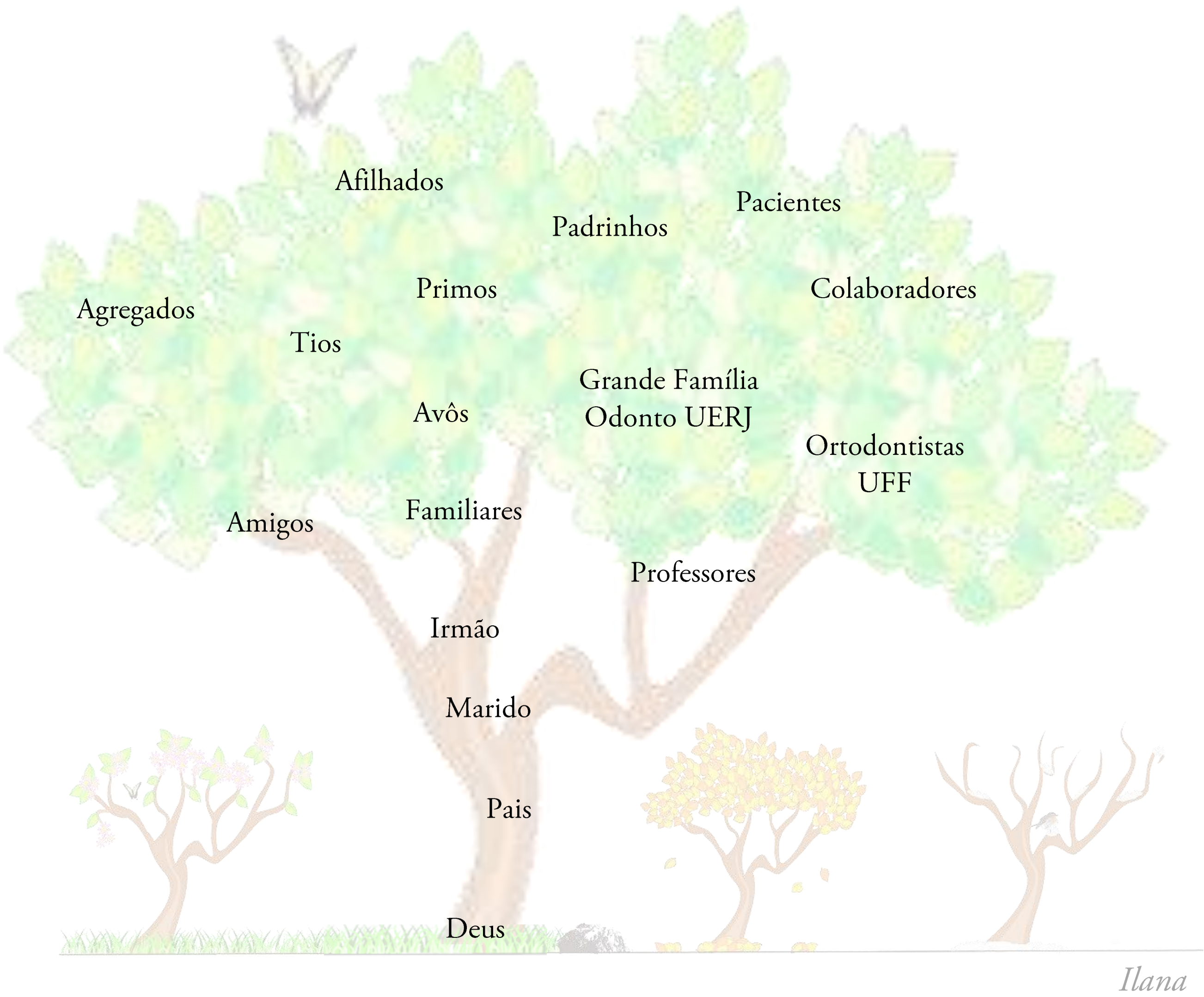

LISTA DE ABREVIATURAS

3D – tridimensional, do inglês *three dimensional image;*

CSA – *cross-sectional area*;

CT – *computed tomography*;

MdA – avanço mandibular, do inglês *mandibular advancement*;

MdS – recuo mandibular, do inglês *mandibular setback*;

MMA – avanço maxilomandibular, do inglês *maxillomandibular advancement*;

MRI – ressonância magnética, do inglês *magnetic ressonance image*;

MxA – avanço maxilar, do inglês *maxillary advancement*;

MxA+MdS – avanço maxilar com recuo mandibular, do inglês *maxillary advancement with mandibular setback*;

OSAS – *obstructive sleep apnea syndrome*;

RCTs – *randomized clinical trials*;

RL – retrolingual;

RM – ressonância magnética;

RP – retropalatal;

SAOS – síndrome da apneia obstrutiva do sono;

TC – tomografia computadorizada;

RESUMO

Christovam, IFO; Lisboa, CO; Cury-Saramago, AA; Mattos, CT. Dimensões das vias aéreas superiores de pacientes submetidos à cirurgia ortognáticas avaliadas em imagens 3D: uma revisão sistemática e meta-análise. Niterói: Universidade Federal Fluminense, Faculdade de Odontologia; 2015.

O objetivo desta revisão sistemática foi avaliar o efeito dos diferentes tipos de cirurgias ortognáticas, realizadas na correção de deformidades faciais, sobre as dimensões das vias aéreas, através de imagens tridimensionais. A busca eletrônica foi feita nas seguintes bases de dados: Cochrane Library, Medline (via PubMed), Scopus, VHL (Lilacs e BBO), Web of Science, e System for Information on Grey Literature in Europe (Open Grey) para encontrar artigos publicados até janeiro de 2015. Os critérios de inclusão foram: estudos clínicos prospectivos ou retrospectivos em humanos, pacientes maiores de 15 anos, submetidos à cirurgia de avanço ou recuo maxilar ou mandibular, isolada ou combinada; apresentação de medidas das vias aéreas superiores – volume e/ou área mínima axial das vias aéreas, das regiões retropalatal e/ou retrolingual (pré-cirúrgicas e pós-cirúrgicas; ou a diferença entre esses tempos, com o desvio padrão, ou outra medida de variabilidade, ou o valor de p), obtidas por tomografia computadorizada ou ressonância magnética. Buscas complementares foram realizadas nas referências dos artigos incluídos e no catálogo NLM (via Pubmed). A avaliação do risco de viéses foi realizada com base no CONSORT e os trabalhos foram classificados em alto, moderato e baixo risco de viéses. No total foram encontrados 1180 trabalhos, sendo que apenas 27 atendiam aos critérios de elegibilidade e não apresentavam alto risco de viéses. A meta-análise foi realizada e pode-se concluir, com evidência moderada, que a área mínima axial das vias aéreas aumentou significativamente (124,13 mm^2) depois do avanço maxilomandibular e não foi alterada significativamente após o avanço maxilar com recuo mandibular; e o volume total aumentou significativamente depois do avanço maxilomandibular (7416,10 mm^3) e avanço mandibular (7175,59 mm^3) e diminuiu significativamente após avanço maxilar com recuo mandibular (-1552,90 mm^3) e recuo mandibular isolado (-1894,65 mm^3).

Palavras-chave: cirurgia ortognática; faringe; imagem tridimensional.

ABSTRACT

Christovam, IFO; Lisboa, CO; Cury-Saramago, AA; Mattos, CT. Upper airways dimensions in patients submitted to orthognatic surgery assessed in 3D images: systematic review and meta-analysis. Niterói: Universidade Federal Fluminense, Faculdade de Odontologia; 2015.

The objective of this systematic review was to evaluate the effect of different types of orthognathic surgery on the dimensions of the upper airways through three dimensional images. The electronic search was carried out in the following databases: Cochrane Library, Medline (via PubMed), Scopus, VHL (Lilacs and BBO), Web of Science, and System for Information on Grey Literature in Europe (Open Grey) to find articles published until January 2015. Inclusion criteria were: prospective or retrospective clinical trials in humans, patients older than 15 years submitted to maxillary or mandibular of advancement or setback surgery, combined or isolated; presentation of measures of the upper airways - volume and/or minimum CSA from the whole upper airways, retropalatal and/or retrolingual regions (pre and post-surgical, or the difference between these times with the standard deviation, or other measure of variability, or the p value), obtained from computed tomography or magnetic resonance imaging. Additional searches were conducted in the references of included articles and NLM catalog (via PubMed). The assessment of the risk of bias was based on the CONSORT and the articles were classified in high, moderate and low risk of bias. A total of 1180 studies were retrieved, and only 27 met the eligibility criteria and did not present high risk of bias. The meta-analysis was performed and there is moderate evidence to conclude that the upper airway minimum cross-sectional area increased significantly after maxillomandibular advancement (124.13 mm^2) and was not altered significantly after maxillary advancement with mandibular setback; and the total volume increased significantly after maxillomandibular advancement (7416.10 mm^3) and mandibular advancement (7175.59 mm^3) and decreased significantly after maxillary advancement with mandibular setback (-1552.90 mm^3) and isolated mandibular setback (-1894.65 mm^3).

Keywords: orthognathic surgery; pharynx; imaging, three-dimensional.

SUMÁRIO

1. INTRODUÇÃO

O estudo das vias aéreas superiores desperta o interesse de diferentes profissionais que atuam na área de cabeça e pescoço. Isto se deve principalmente à estreita relação entre o desenvolvimento e a morfologia craniofacial, à configuração das vias aéreas superiores a às desordens respiratórias. [1-3]

Apesar das cirurgias ortognáticas serem realizadas para corrigir discrepâncias ósseas, inevitavelmente, afetam a relação entre os tecidos moles e esqueléticos. A cirurgia de reposicionamento maxilar e/ou mandibular pode causar diferentes mudanças de área e volume nas cavidades oral e nasal, de acordo com a magnitude e direção da correção. [1,4] Esses resultados, associados a fatores de risco, podem influenciar a qualidade de sono dos pacientes tratados ao longo prazo.

Segundo Mattos et al.,[5] o comprimento anteroposterior das vias aéreas pode ser alterado das seguintes maneiras: diminuição nas regiões de palato mole e base de língua, depois do recuo mandibular isolado (MdS, do inglês *mandibular setback*); aumento na região da espinha nasal posterior e diminuição nas regiões de palato mole, língua e valécula, depois da cirurgia combinada de avanço maxilar com recuo mandibular (MxA+MdS, do inglês *maxillary advancement with mandibular setback*); e aumento na região de palato mole após o avanço maxilar e mandibular (MMA, do inglês *maxillomandibular advancement*). No entanto, estes resultados foram baseados em análises cefalométricas.

A cefalometria tem sido o método de avaliação utilizado para o desenvolvimento craniofacial por muitos anos. Porém, a representação das vias aéreas e de outras estruturas tridimensionais (3D) em apenas duas dimensões, apresenta limitações.[2,6,7] Sabe-se que a tomografia computadorizada (TC) e a ressonância magnética (RM)[6] permitem uma avaliação linear, de área (axial) e de volume das vias aéreas superiores,[8,9] fornecendo informações completas, quantitativas e qualitativas, não disponíveis de outra forma. Os dois métodos vem sendo estudados e considerados confiáveis e reprodutíveis para a análise das vias aéreas superiores, quando baseados em parâmetros bem definidos.[6,9-12]

Nenhuma revisão sistemática sobre o assunto foi encontrada comparando as mudanças nas vias aéreas, resultantes dos diferentes tipos de cirurgia, exclusivamente, em exames 3D. A revisão sistemática de Mattos et al.[5] comparou os diferentes tipos de cirurgia ortognáticas e suas consequências nas dimensões das vias aéreas superiores, mas a meta-análise foi realizada apenas com dados de estudos bidimensionais, e os quatro artigos que utilizaram TC não foram passíveis de comparação. Fernandez-Ferrer et al.,[13] apesar de avaliarem imagens 3D (através da TC), analisaram somente resultados de um tipo de cirurgia – recuo mandibular – e não realizaram meta-análise. Vale salientar que mais de cinco novos estudos[14-19] foram publicados após o período final de busca realizada por esses artigos.[5,13] Observa-se uma tendência ao aumento deste tipo de avaliação desde a introdução desses métodos na rotina de cirurgiões e dentistas atrelado ao estudo da SAOS (Síndrome da Apneia Obstrutiva do Sono). A busca na base de dados da Scopus retornou um número crescente de publicações sobre o assunto, especialmente desde 2008.

O objetivo deste estudo foi reunir, através de uma revisão sistemática, evidência científica relacionada aos efeitos dos diferentes tipos de cirurgia ortognática na área mínima axial e volume das vias aéreas, avaliadas na TC e RM.

2. MATERIAL E MÉTODO

O relato desta revisão foi baseado no "*Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement*".[20,21] O protocolo de revisão desta pesquisa foi registrado na base de dados da PROSPERO através do número CRD42014013323 (http://www.crd.york.ac.uk/PROSPERO).

Os critérios de inclusão foram: ensaios clínicos prospectivos ou retrospectivos em humanos, pacientes maiores de 15 anos, submetidos à cirurgia de avanço ou recuo maxilar ou mandibular, isolados ou combinados; apresentação de medidas das vias aéreas superiores – volume e/ou área mínima axial das vias aéreas ou das regiões retropalatal e/ou retrolingual (pré-cirúrgicas e pós-cirúrgicas, ou a diferença entre estes tempos, com o desvio padrão, ou outra medida de variabilidade, ou o p valor), obtidas por TC ou RM. Os critérios de exclusão foram: relatos de caso, séries de caso, artigos de revisão, editoriais, opiniões, livros; artigos de validação e/ou comparação de métodos e programas de avaliação; artigos apresentando apenas a área mínima axial em níveis específicos; pacientes com fissura de lábio e/ou palato, comprometidos sistematicamente ou sindrômicos, exceto com a SAOS; indivíduos submetidos a cirurgias ortognáticas envolvendo correções transversas, correção do excesso vertical da maxila ou distração osteogênica. A busca eletrônica foi realizada nas seguintes bases de dados: Cochrane Library, Medline (via PubMed), Scopus, VHL (Lilacs and BBO), Web of Science, e System for Information on Grey Literature in Europe (Open Grey), com o intuito de encontrar estudos elegíveis que respondessem a questão PICO (Tabela 1).O período da busca limitou-se a 9 de janeiro de 2015. Estratégias específicas foram desenvolvidas para cada base de dados com a orientação de uma bibliotecária (DMTPF). A estratégia da Medline (via Pubmed) foi apresentada na Tabela 2, e as demais estratégias estão disponíveis no artigo (página 30). Uma busca complementar foi realizada nos jornais referenciados no catálogo NLM (via Pubmed), que, por sua vez, contém os jornais referenciados na base de dados NCBI, usando a expressão ***oral and maxillofacial surg****. As revistas que possuíam o título em inglês e que já foram indexadas ao Pubmed e atualmente não estavam indexadas, foram selecionadas para uma busca adicional. A busca manual na lista de referências dos estudos incluídos nesta revisão também foi conduzida.

Tabela 1. PICO

P- População	Pacientes submetidos à cirurgia ortognática
I- Intervenção	Correções cirúrgicas que envolvam o aspecto anteroposterior da maxila e/ou mandíbula
C- Comparação	Entre os diferentes tipos de cirurgia ortognática
O- "Outcome" – Resultados Esperados	Alterações das dimensões das vias aéreas superiores (área mínima axial e volume) medidas em tomografia computadorizada ou ressonância magnética
Pergunta	Quais são os efeitos da cirurgia ortognática para correção anteroposterior da maxila e/ou mandíbula nas dimensões das vias aéreas superiores, avaliados em imagens 3D?

Após a remoção dos artigos em duplicata, dois revisores (IFOC e COL) fizeram uma análise independente da lista de títulos e resumos para a inclusão. Se o título e o resumo não fornecessem informações suficientes para esta etapa de seleção, o trabalho foi examinado na íntegra. As divergências entre os dois revisores foram sanadas com um terceiro revisor (CTM) em reunião de consenso. Os autores de alguns estudos foram contatados por e-mail ou por rede social para confirmar os critérios de elegibilidade e fornecer dados ausentes ou informações acerca de sobreposição de amostras, incluindo a idade dos pacientes.[15,22-33] Quando os artigos não apresentavam a idade mínima dos pacientes e os autores não responderam às tentativas de contato, só foram incluídos se mencionaram que os pacientes eram adultos e/ou apresentaram a média da idade (x) e o desvio padrão (σ) e [x - 2 (σ)]> 15 anos.

Tabela 2. Estratégia de busca da base de dados Medline (via Pubmed)

Medline	((((((((((((((((((((((Orthognathic Surgery[MeSH Terms]) OR "Orthognathic Surgery"[Title/Abstract]) OR Orthognathic Surgical Procedures[MeSH Terms]) OR "Orthognathic Surgical Procedures"[Title/Abstract]) OR Surgery, Oral[MeSH Terms]) OR Maxillofacial Abnormalities[MeSH Terms]) OR Maxillofacial Abnormalities[Title/Abstract]) OR Maxillofacial Development[MeSH Terms]) OR Mandibular Advancement[MeSH Terms]) OR Orthodontics[MeSH Terms]) OR Mandible[MeSH Terms]) OR Maxilla[MeSH Terms]) OR "jaw surgery"[Title/Abstract]) OR "bimaxillary surgery"[Title/Abstract]) OR "maxillo mandibular advancement"[Title/Abstract]) OR "surgical orthodontic treatment"[Title/Abstract])))) OR (((Advancement[Title/Abstract] OR setback[Title/Abstract] OR surger*[Title/Abstract]) AND (Mandibular[Title/Abstract] OR

Maxillary[Title/Abstract]))))) AND ((((((((((((((((((pharynx[MeSH Terms]) OR pharyn*[Title/Abstract]) OR nasopharynx[MeSH Terms]) OR nasopharyn*[Title/Abstract]) OR hypopharynx[MeSH Terms]) OR hypopharyn*[Title/Abstract]) OR oropharynx[MeSH Terms]) OR oropharyn*[Title/Abstract]) OR airway obstruction[MeSH Terms]) OR "airway obstruction"[Title/Abstract])OR sleep apnea syndromes[MeSH Terms]) OR "Sleep Disordered Breathing"[Title/Abstract]) OR laryngopharyn*[Title/Abstract]) OR "posterior airway space"[Title/Abstract]) OR "air space"[Title/Abstract]) OR "upper airway"[Title/Abstract]) OR "oral airway"[Title/Abstract]) OR "nasal airway"[Title/Abstract]))) AND ((((((((((((((((((((((((((Tomography, X-Ray Computed[MeSH Terms]) OR "Cone-Beam Computed Tomography"[Title/Abstract]) OR CBCT[Title/Abstract]) OR Multidetector Computed Tomography[MeSH Terms]) OR "Multidetector Computed Tomography"[Title/Abstract]) OR Imaging, Three-Dimensional[MeSH Terms]) OR "Three-Dimensional Image"[Title/Abstract]) OR "3-D Imaging"[Title/Abstract]) OR Magnetic Resonance Imaging[MeSH Terms]) OR "Magnetic Resonance"[Title/Abstract]) OR "Tomography MR"[Title/Abstract]) OR "Tomography NMR"[Title/Abstract]) OR "minimum axial area"[Title/Abstract]) OR volume[Title/Abstract]) OR area[Title/Abstract]) OR linear[Title/Abstract]) OR "airway cross section"[Title/Abstract]) OR "CBCT Scans"[Title/Abstract]) OR "CBCT Scan"[Title/Abstract]) OR "CAT Scans"[Title/Abstract]) OR "CAT Scan"[Title/Abstract]) OR "Cone Beam CT"[Title/Abstract]) OR "NMR Imaging"[Title/Abstract]) OR "MRI Scan"[Title/Abstract]) OR Invivo[Title/Abstract]) OR Dolphin[Title/Abstract]))))

Após avaliar o texto completo desses artigos em relação aos critérios de elegibilidade, os estudos incluídos foram submetidos à análise do risco de viéses por dois revisores (IFOC and COL) com base na avaliação de Mattos et al.[5] Alguns ajustes foram feitos (os itens correspondentes ao grupo controle e cegamento foram removidos e o cálculo amostral foi pontuado) e os artigos incluídos foram avaliados em seis categorias, descritas na Tabela 3. Cada artigo foi classificado como baixo risco de viéses (pontuação maior ou igual a 4,5), moderado risco de viéses (pontuação maior do que 2 e menor do que 4,5) e alto risco de viéses (pontuação menor ou igual a 2). Estudos com alto risco de viéses foram excluídos. Qualquer discordância durante esta etapa foi resolvida em consenso com um terceiro revisor (AAC).

Os dados dos estudos selecionados foram extraídos e apresentados em tabela. A meta-análise foi realizada no *Comprehensive Meta-Analysis software* (version 3.2.00089, USA), com *random effect model* quando cinco ou mais estudos foram comparados em cada subgrupo; e *fixed effect model* quando um número menor de estudos foi avaliado. O coeficiente de comparação foi estimado a partir dos estudos que apresentaram as médias dos valores pré-cirúrgicos e pós-cirúrgicos das medidas (área mínima axial e volume total) e a média da diferença (pós-cirúrgica menos pré-cirúrgicas) com o desvio padrão.[16,25,29,34,35] O maior período de acompanhamento foi utilizado quando duas ou mais opções foram apresentadas. A heterogeneidade foi testada pelo Q-value, I^2 index and Tau^2. As análises de sensibilidade foram realizadas quando a comparação apresentou alta heterogeneidade e estão disponíveis nos anexos (página 55). Os estudos foram comparados (com o tipo de cirurgia como subgrupo) de acordo com as mudanças das seguintes medidas: volume total, volume retropalatal, volume retrolingual, área mínima axial, área mínima axial retropalatal, área mínima axial retrolingual. Foi realizada uma comparação das alterações do volume total entre MdS e MxA+MdS, coletando os dados de estudos que apresentavam esses dois grupos (subtraindo as mudanças: MxA+MdS menos MdS).

Tabela 3. Análise do risco de viéses

Categoria (ítem)	Risco de viéses	Pontos	Definição
1. Critérios de elegibilidade dos pacientes descritos	BAIXO	1,0	Critérios de inclusão e exclusão descritos
	MODERADO	0,5	Sem descrição dos critérios, mas a seleção foi feita pela idade e tipo de cirurgia
	ALTO	0	Sem descrição dos critérios de seleção
2. Análise estatística realizada	BAIXO	1,0	Tratamento estatístico completamente descrito e adequado, incluindo o cálculo amostral
	MODERADO	0,5	Tratamento estatístico não descrito completamente ou inadequado
	ALTO	0	Sem tratamento estatístico
3. Confiabilidade das medidas testadas	BAIXO	1,0	Medidas repetidas e análise estatística aplicada
	MODERADO	0,5	Medidas repetidas e inadequadas ou nenhum teste aplicado
	ALTO	0	Medidas não repetidas
4. Relato de *drop-out*	BAIXO	1,0	*Drop-outs* relatados e causa explícita
	MODERADO	0,5	*Drop-outs* relatados sem explicação
	ALTO	0	Sem descrição dos *drop-outs*
5. Tempo de acompanhamento relatado	BAIXO	1,0	Tempo de acompanhamento relatado
	ALTO	0	Sem descrição do tempo de acompanhamento e o mesmo não está claro
6. Potencial de viéses e limitações clínicas	BAIXO	1,0	Descrição do potencial de viéses e das limitações
	ALTO	0	Sem descrição do potencial de viéses e das limitações

3. ARTIGO PRODUZIDO

Title: Upper airways dimensions in patients submitted to orthognatic surgery: systematic review and meta-analysis

Short Title: Effect of orthognathic surgery on airway

Keywords: upper airways; orthognatic surgery; imaging, three-dimensional

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ABSTRACT

The objective of this systematic review was to evaluate the effect of different types of orthognathic surgery on the dimensions of the upper airways through three-dimensional images. The electronic search was performed in Cochrane Library, Medline (via PubMed), Scopus, VHL, Web of Science, and System for Information on Grey Literature in Europe until January 2015. Inclusion criteria: clinical studies in humans, patients older than 15 years, submitted to maxillary or mandibular advancement or setback surgery, isolated or combined; presentation of airway measures - volume and/or minimum cross-sectional area (CSA), obtained from computed tomography or magnetic resonance. Additional searches were conducted in the references of included articles and NLM catalog. An assessment of the risk of bias was performed. A total of 1180 studies was retrieved, 28 met the eligibility criteria, one was excluded for presenting high risk of bias. A meta-analysis was performed. There is moderate evidence to conclude that the upper airway minimum CSA increased significantly (124.13 mm^2) after maxillomandibular advancement (MMA) and was not altered significantly after maxillary advancement with mandibular setback (MxA+MdS); the total volume increased significantly after MMA (7416.10 mm^3) and mandibular advancement (7175.59 mm^3), decreased significantly after MxA+MdS (-1552.90 mm^3) and isolated mandibular setback (-1894.65 mm^3).

INTRODUCTION

The study of the upper airways arouses the interest of different professionals who work with the head and neck area. This is due mainly to the narrow relation between the craniofacial development and morphology, the upper airway configuration and respiratory disorders.[1-3]

Although orthognathic surgeries are performed to correct bone discrepancies, they inevitably affect the relation between soft and skeletal tissues. Maxillary and/or mandibular surgical replacement can cause different changes of area and volume in the oral and nasal cavities, according to the magnitude and direction of correction.[1,4] These results, associated with risk factors, may influence the quality of sleep of treated patients in the long term.

According to Mattos et al.[5], the airway anteroposterior length may be altered in the following ways: decrease in the regions of the soft palate and base of tongue after isolated mandibular setback (MdS) surgery; increase in the posterior nasal spine region and decrease in the soft palate, tongue and vallecula regions after combined surgery of maxillary advancement with mandibular setback (MxA+MdS); and increase in the soft palate region after maxillomandibular advancement (MMA) surgery. However, these results were based in cephalometric analyses.

Cephalometry has been the reference method for craniofacial development analysis for many years. Nevertheless, the representation of the airways and other three dimensional (3D) structures in two dimensions has limitations.[2,6,7] It is known that the computed tomography (CT) and magnetic resonance (MRI)[6] allow a linear, cross-sectional area (CSA) and volumetric assessment of the upper airways,[8,9] providing quantitative and qualitative useful information not available otherwise. Both, CT and MRI, have been extensively studied and are considered reliable and reproducible assessment methods for upper airways analysis, when based on well-defined parameters.[6,9-12]

No systematic review was found on the subject comparing changes in the airways resulting from different orthognathic surgeries exclusively in 3D exams. The systematic review from Mattos et al.[5] compared different types of orthognathic surgery and its consequences in the upper airway dimensions, but the meta-analysis obtained used only data from two-dimensional images, as the four articles with CT retrieved were not comparable. Fernandez-Ferrer et al.,[13] although assessing 3D images (CT), analyzed only results from one type of surgery – mandibular setback – and no meta-analysis was performed. It is also worth it to emphasize that more than five new studies[14-19] were published after the end of the search from these articles.[5,13] There is a tendency of increase in this kind of surgical assessment due to the introduction of these methods in the routine of surgeons and dentists and the study of OSAS (obstructive sleep apnea syndrome). A search in Scopus database depicted a growing number of publications on the subject, especially since 2008.

The aim of this study was to assemble, through a systematic review, scientific evidence related to the effects of different types of orthognathic surgery on the minimum cross-sectional area and volume of the upper airways, assessed in CT or MRI.

MATERIALS AND METHODS

The report of this review was based on "*Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement*".[20,21] The review protocol for this research was registered in the PROSPERO database under the number CRD42014013323 (http://www.crd.york.ac.uk/PROSPERO).

The inclusion criteria were: prospective or retrospective clinical studies in humans; patients older than 15 years, submitted to surgeries of maxillary or mandibular advancement or setback, isolated or combined; measurements of upper airways - volume and/or minimum CSA from the whole upper airways, retropalatal and/or retrolingual regions (pre and post-surgical, or the difference between these times with the standard deviation, or other variability measure or the p value) obtained from CT or MRI. Exclusion criteria were: case reports, case series, review articles, editorials, reviews, books; articles of reliability and/or comparison of methods or programs of assessment; articles presenting only axial area of specific levels; patients with lip and/or cleft palate, systemically compromised or syndromic patients, except with OSAS; individuals submitted to orthognathic surgery involving transverse corrections, maxillary vertical excess correction, or distraction osteogenesis. The electronic search was conducted in following databases: Cochrane Library, Medline (via PubMed), Scopus, VHL (Lilacs and BBO), Web of Science and System for Information on Grey Literature in Europe (Open Grey) in order to find eligible studies that answer the PICO question (Table 1, page 29). The period for the search was limited to January 9, 2015. Specific strategies were developed for each database with the guidance of a Librarian (DMTPF) and are presented in Table 2 (page 30). Complementary search was performed in journals referenced on NLM catalog (via PubMed), which contains the journals referenced in NCBI database, using the expression **oral and maxillofacial surg***. The journals with their title in English which had been indexed in Pubmed but were not currently indexed anymore were selected for this additional search. A manual search of the reference lists of studies included in this systematic review was also performed.

After removal of the duplicate articles, two reviewers (IFOC and COL) independently examined the list of titles and abstracts according to the eligibility criteria. If the title and abstract did not provide sufficient information, the article was reviewed in full. Disagreements between the two reviewers were resolved with a third reviewer (CTM) in consensus meeting. The authors of some studies were contacted by e-mail or social network to check eligibility criteria and to provide missing data or information about sample overlapping, including the patients age.[15,22-33] When articles did not present the patients' minimum age and the authors did not respond to our contact attempts, they were only included if they mentioned that patients were adults and/or presented the average age (x) and standard deviation (σ) and [x - 2 (σ)]> 15 years.

After checking the full text of the articles for eligibility criteria, the studies included were submitted to a risk of bias analysis, which was performed by two reviewers (IFOC and COL) based on the quality assessment of Mattos et al.[5]. Some adjustments were made (the items corresponding to control group and blinding assessment were removed and the sample size calculation was scored) and included papers were evaluated in six categories described in Table 3 (page 35). Each article was classified as low risk of bias (score greater than or equal to 4.5), moderate risk of bias (score greater than 2 and less than 4.5) and high risk of bias (score less than or equal to 2). High-risk studies were excluded from the review. Any disagreement was solved during this step in consensus with a third reviewer (AAC).

The data of the selected articles were extracted and presented in a table. A meta-analysis was performed in the *Comprehensive Meta-Analysis software* (version 3.2.00089, USA) through the random effect model when five or more studies were comparable in each subgroup and the fixed effect model when less studies were available. The correlation coefficient for comparison was estimated from the studies which presented pre and post-surgical mean of the volume and minimum CSA and the mean difference (post minus pre) with their standard deviation.[16,25,29,34,35] The values for the longest follow-up was considered when two or more options were exposed. Heterogeneity was tested by the Q-value, I^2 index and Tau^2 and in comparisons with high heterogeneity the sensibility analysis was performedStudies were compared (with the type of surgery as a subgroup) for the change of the following measurements: total volume, retropalatal volume, retrolingual volume, minimum CSA, retropalatal minimum CSA and retrolingual minimum CSA. A comparison for the total volume change between MdS and MxA+MdS was performed collecting data from studies which presented these two groups (subtracting the changes in the MdS group from the changes in MxA+MdS group).

RESULTS

Search results are shown in the flow diagram (Figure 1, page 41). After duplicates removal, the search strategies retrieved 1180 titles and abstracts, 70 complete articles were read, and 28 were selected for this systematic review. An additional search was performed and one article[36] was found in the following journals identified in the NLM catalog: Journal of the Korean Association of Oral and Maxillofacial Surgeons, Journal of Maxillofacial and Oral Surgery and Atlas of the Oral and Maxillofacial Surgery Clinics of North America. No article was included through manual search. After attempting to contact authors without answer, one article[24] was excluded for not presenting the pre-established age information. The total number of articles included was 28.[14-19,23,25-45]

The risk of bias assessment is shown in Table 4 (page 36). Only seven studies were classified as low,[15,19,27,29,33,34,41] most of them were moderate whereas one study [39] presented high risk of bias. This last one was excluded. The least scored items and the main cause of high risk of bias in the articles were blinding followed by drop-out report. Although most articles presented an adequate statistical analysis, only Brunetto et al.[15] performed the sample size calculation.

Information regarding the study, patients, surgery, follow-up, measurements, and results from each study are in Table 5 (page 37). The patients' age varied from 16 to 62 years. The most recurrent surgical procedure evaluated by the studies was MxA+MdS. The most common comparison between surgeries in the same study[19,34,42] was MxA+MdS versus MdS. Only one[38] included study assessed the upper airways through MRI.

Two authors, Kim M. and Wang H., apparently used the same group of patients or overlapping samples in two different articles for each one.[31,32,35,44] In order to confirm the previous information, we tried contact with the authors with no success. Therefore, the data obtained from these four articles were presented. In the meta-analysis, however, only one of the articles[31,35] from each author was included to avoid duplication or bias in the analysis.

In the meta-analysis, the correlation coefficient used to compare changes in the total/partial volume and minimum CSA of the airways was 0.786 and 0.622, respectively. The unit of measurement used in the data entered in the software was mm^3 for volume and mm^2 for area. When the authors presented data in a different unit, the values were transformed accordingly and contact was made with the authors when necessary or inferred by the researches. Mean and standard deviation were calculated for studies which did not present them.[14,18,23,30,37]

In the meta-analysis, the comparison of total volume changes included 22 studies divided in subgroups. The changes were: a significant increase (mean 7175.59 mm^3) for the mandibular advancement (MdA), a significant decrease (mean -1894.65 mm^3) for MdS, a significant increase (mean 7416.10 mm^3) for MMA and a significant decrease (mean -1552.90 mm^3) for MxA+MdS. As the heterogeneity was high for almost all subgroups, a sensitivity analysis was performed. In the MMA subgroup, when the articles of Zinser et al.,[33] which was the only study that included the nasal cavity on the volumetric calculation, and the articles of Abramson et al.[43] and de Souza Carvalho et al.,[37] which reported genioplasty concomitant with MMA, were excluded, the heterogeneity decreased significantly (*Anexo 1*, page 55). Therefore, only this last comparison was considered (Figure 2, page 42). The sensitivity analysis for the other subgroups did not justify exclusion of any articles as the heterogeneity remained high.

The comparison of regional volume changes, in the retropalatal region, the changes were: not significant for MdS, a significant increase (mean 727.44 mm^3) for MMA and a significant decrease (mean -4566.87 mm^3) for MxA+MdS (Figure 3, page 43). In the retrolingual region, the changes were: a significant decrease (mean -2461.60 mm^3) for MdS, a significant increase (mean 2530.05 mm^3) for MMA and a significant increase (mean 1430.40 mm^3) for MxA+MdS (Figure 4, page 44). In the sensitivity analysis of RL region, the study from Zinser et al.[33] was removed for the same reason mentioned above (*Anexo 2*, page 56).

When studies that compared total volume of MdS versus MxA+MdS were analyzed, heterogeneity among studies was lower and the difference was not significant (Figure 5, page 45).

The minimum CSA for the whole upper airway was compared in 8 studies divided in subgroups. The changes in the minimum CSA for the whole upper airways were: not significant for MxA+MdS (Figure 6, page 46) and a significant increase (mean 124.13 mm^2) for the MMA. The heterogeneity was high in the MMA and a sensibility analysis was performed. When the articles of Brunetto et al.[15] and Zinser et al.[33] were excluded because of the different anatomical limits presented – fourth cervical vertebra as the lower limit and nasal cavity as the upper limit, respectively – the decrease in the heterogeneity was considerable (*Anexo 3*, page 57). Therefore, only the last comparison was considered (Figure 7, page 47).

In the comparison of regional minimum CSA changes for the retropalatal region, the changes were: a significant decrease (-23.30 mm^2) for MdS, a significant increase (118.63 mm^2) for MMA (Figure 8, page 48). In the retrolingual region, the change was: a significant increase (94.84 mm^2) for MMA (Figure 9, page 49).

DISCUSSION

The three dimensional analysis of the upper airways is currently a well-known, reliable and reproducible method used by dental professionals.[2,7,8,38,46] In a previous systematic review about the same subject, the authors suggested the need for more studies using three dimensional analysis to assess the effects of orthognathic surgery on the airways.[5] Therefore, in our systematic review only studies that used CT or MRI as an airway evaluation method were included. CT, especially CBCT, implies lower cost for the patient, possibility of using varied position (sitting and lying) and allows a more detailed study of pre and post-surgical cases.[8,47,48] The MRI provides high quality images of the airways that allow accurate measurements of area and volume without exposing patient to radiation; however, it implies higher cost and lower accessibility than CT.[11,12,38,49]

Randomized clinical trials (RCTs) represent the ideal selection of studies for a systematic review. However, when assessing the effects of orthognathic surgery, there is an ethical aspect that limits the development of this type of research. Since the patients must have the best treatment option for their case and in most instances surgeries are not interchangeable, the surgical procedure cannot be randomized. Blinding is also not feasible for patients and professionals due to the nature of the procedure and is, therefore, restricted to evaluators or the statistician. Therefore, in this review, non-randomized clinical studies were selected. Most of them were retrospective (23) and only 4 were prospective.[19,38,40,41] In the review of Mattos et al.,[5] the methodological quality assessment performed was based on the CONSORT and used in our review. However, as the blinding assessment and the control group were presented in too few studies in that review, those items were removed from our analysis. Fernández-Ferrer et al.,[13] also used the CONSORT, while Alsufyani et al.[46] evaluated the risk of bias according to the following criteria: selection, detection or measurement, analysis or interpretation and performance. The risk of bias we attributed to each article must then be considered in the context of studies that are viable in orthognathic surgery. According to this, papers included and classified as presenting low risk of bias in our review provide less scientific evidence than RCTs, because randomization and blinding were not scored. This could be considered a limitation in this review. However, every effort was made to obtain the best available evidence on the subject.

Dental professionals should know that the airway dimensions may be affected by skeletal patterns.[8,50,51] Therefore, when surgery is considered, it is advisable that potential airway dimensional changes be studied for each patient. According to Schendel et al.,[52] who studied growth and development in a three dimensional analysis, the size and length of the airway increase until 20 years of age, followed by a period of stability. Their results show a major increase (approximately 3210 mm^3) in the average airway volume from the age group of 12 to 14 years to the age group of 15 to 17 years, which was the major difference between two subsequent groups from 6 to 60 years. That was the reason why we selected the age above 15 years as an inclusion criterion in our review.

In relation to the gender of patients, two studies included only women in their sample[43,45] and other two included only men.[14,16] There are studies in the literature that reported differences between the genders when analyzing the upper airways.[29,53] However, Degerliyurt et al.[54] divided the patients according to gender and surgical procedure and reported no statistically significant differences between the genders

($p<0.05$). Since there is no consensus, all studies were considered together in this review. However, if this proves to be a limitation, new studies should ponder gender in the analysis.

According to Lenza et al.,[8] linear, area and volumetric measurements should be considered for a professional to perform a complete analysis of the airways. Alsufyani et al.[46] reported the total volume and minimum CSA measurements as the most common airway parameters evaluated. This is probably due to the relevance of the total volume, which represents the amount of air that can occupy the airways, as well as the minimum CSA, which represents the region of greatest constriction and is the smallest area of fair passage. According to Schendel et al.,[18] there is a relation between the minimum area of the airways and the occurrence of obstructive sleep apnea, as the lower the minimum area is, the greater the predisposition to apnea. In our systematic review, the measurements evaluated were the minimum axial area and volume, and the volumetric was the most recurrent measurement in the included articles.[14-18,23-38,40-45]

On the MMA surgery, which is indicated for the treatment of severe cases of obstructive sleep apnea,[55] the effect size of meta-analysis, when the upper airways were considered, was a significant increase in the total volume and in the retropalatal and retrolingual regions. Alsufyani et al.[46] showed similar results, with increase of total volume. The effect size of minimum CSA was a significant increase in upper airways and in the retropalatal and retrolingual regions. It is compatible with the results from Caples et al.[56] and Holty et al.,[55] who present this surgical procedure effective due to the considerable decrease of the apnea-hypopnea index observed in surgically treated patients.

On the MdA surgery, which is usually indicated for patients with mandibular deficiency, the effect size was also a significant volume increase and its magnitude was similar to the one observed in MMA (Figure 2, page 42). However, there are substantially less studies assessing this kind of surgery.[23,26]

The effect size on the MxA+MdS surgery was a significant volume decrease. However, when volume was assessed by regions, a significant decrease was observed in the retropalatal region and a significant increase in the retrolingual region, which is quite contradictory and exactly the opposite someone would expect. Brunetto et al.[15] pointed out that surgeries where both jaws move in the same direction tend to have more predictable outcomes and they also mention that when the base of the tongue moves backward, the soft palate can be pushed in the same direction, decreasing the retropalatal volume. The effect size for minimum CSA was not significant and maybe the parameter we should take into account. The article from Kim and Park.,[24] which was not included in our review, presented a different format, dividing patients in extraction and nonextraction groups. In the extraction group the total volume decreased like our meta-analysis pointed out, and in the nonextraction group it remained practically stable. None of the studies we included showed this division or reported whether the patients were submitted to extraction, but this may be an interesting topic for future studies to check, especially in borderline cases.

On the MdS surgery, the effect size for the volume was a significant decrease for total volume, not significant in the retropalatal region, and a significant decrease in the retrolingual region. Fernández-Ferrer et al.[13] also observed a significant decrease in total volume. The effect size for the minimum CSA was a significant decrease in the retropalatal region.

Both MxA+MdS and MdS surgeries may be indicated in mandibular prognathism and/or maxillary deficiency. Those are, therefore, the two kinds of orthognathic surgery more frequently compared in the same study. In this meta-analysis, in the comparison between MxA+MdS and MdS, although the volume of upper airways decreased less in combined surgery than in the mandibular setback, the effect size was not significant. The evidence found on this comparison could guide clinical decisions, especially in difficult cases, where the surgeon could opt by either surgery when airways are concerned. Uesugi et al.[19] reported no differences in the apnea-hypopnea index between the two groups, which further emphasizes this consideration. However, the authors emphasized that It is important to assess each case individually, considering obesity and the amount of mandibular setback.

According to the results of our analysis, the consequences of orthognathic surgery tend to be more impactful to benefit airway dimensions – in cases of maxilla and/or mandibular advancement – than to impair them – in cases of mandibular setback. That than be inferred from the magnitude of volume increase in both MMA and MdA (approximately 7000 mm^3) compared to the decrease in MdA+MdS and MdS (between 1500 and 2000 mm^3); and also to the minimum CSA increase (124.13 mm^2) in MMA and not significant change in MxA+MdS.

The area alterations have been evaluated in a lower number of studies compared to volume, and the minimum CSA could not be compared between all of these studies because some authors calculated this measurement in different regions of the airways, not considering the upper airways in its entirety. In the study of Schendel et al.,[18] it was possible to calculate mean and standard deviation of minimum CSA since the authors provided pre and post-surgical values for each patient in RP and RL regions. Nonetheless, future studies should focus in presenting the minimum CSA for the whole upper airways and not only for specific regions as this information is extremely relevant and is not necessarily inferred from the regional mean.

One of the limitations of our review was the high heterogeneity observed in many comparisons in the meta-analysis. This heterogeneity is probably due to methodological differences. The most evident difference was regarding the anatomical limits, which varied greatly among studies. The upper limits described were: hard palate, soft palate, the upper point of pharynx, the posterior nasal spine and the first cervical vertebra; the lower limits were: hyoid, epiglottis, the third and fourth cervical vertebra, vallecula, vocal cord and larynx. These limits were either parallel to the Frankfurt plane or inclined. The name, number and boundaries of regions also varied. There is no specific standard used by all researchers to evaluate the upper airway. Previous systematic reviews[2,13] mentioned this limitation and Guijarro-Martinez and Swennen[57] proposed clinical 3D anatomical limits for upper airway subregions. Nonetheless, standardization is still necessary.

There is moderate evidence to conclude that the upper airway minimum CSA increased significantly after MMA and was not altered significantly after MxA+MdS; and the total volume increased significantly after MMA and MdA and decreased significantly after MxA+MdS and isolated MdS, as assessed through 3D images.

Table 1. PICO

P- Population	Patients submitted to orthognathic surgery
I- Intervention	Surgical correction involving the anteroposterior aspects of maxilla and/or mandible
C- Comparison	Between the different types of orthognathic surgery
O- “Outcome”	Dimensional changes of the upper airway (minimum cross-sectional area and volume) measured in CT or MRI
Question	What are the effects of orthognathic surgery for anteroposterior correction of the maxilla and/or mandible on the dimensions of upper airways assessed in 3D images?

Table 2. Specific search strategy for each database

Cochrane	#1	"Orthognathic Surgery":ti,ab,kw (Word variations have been searched)
	#2	MeSH descriptor: [Orthognathic Surgery] explode all trees
	#3	"Orthognathic Surgical Procedures":ti,ab,kw (Word variations have been searched)
	#4	MeSH descriptor: [Orthognathic Surgical Procedures] explode all trees
	#5	MeSH descriptor: [Surgery, Oral] explode all trees
	#6	"surgical orthodontic treatment":ti,ab,kw
	#7	#1 or #2 or #3 or #4 or #5 or #6
	#8	MeSH descriptor: [Mandibular Advancement] explode all trees
	#9	"Mandibular Advancement":ti,ab,kw (Word variations have been searched)
	#10	"jaw surgery":ti,ab,kw (Word variations have been searched)
	#11	"bimaxillary surgery":ti,ab,kw (Word variations have been searched)
	#12	"maxillo mandibular advancement":ti,ab,kw (Word variations have been searched)
	#13	"mandibular surgery":ti,ab,kw (Word variations have been searched)
	#14	"mandibular setback":ti,ab,kw (Word variations have been searched)
	#15	"maxillary advancement":ti,ab,kw (Word variations have been searched)
	#16	"maxillary surgery":ti,ab,kw (Word variations have been searched)
	#17	"maxillary setback":ti,ab,kw (Word variations have been searched)
	#18	#8 or #9 or #13 or #14
	#19	#10 or #15 or #16 or #17
	#20	#11 or #12
	#21	MeSH descriptor: [Maxillofacial Abnormalities] explode all trees
	#22	"Maxillofacial Abnormalities":ti,ab,kw (Word variations have been searched)
	#23	#21 or #22
	#24	MeSH descriptor: [Orthodontics] explode all trees
	#25	MeSH descriptor: [Mandible] explode all trees
	#26	MeSH descriptor: [Maxilla] explode all trees
	#27	MeSH descriptor: [Maxillofacial Development] explode all trees
	#28	#23 or #27
	#29	#24 or #25 or #26
	#30	#7 or #18 or #19 or #20 or #28 or #29
	#31	MeSH descriptor: [Pharynx] explode all trees
	#32	"pharynx":ti,ab,kw (Word variations have been searched)
	#33	"pharyngeal":ti,ab,kw (Word variations have been searched)
	#34	#31 or #32 or #33
	#35	MeSH descriptor: [Nasopharynx] explode all trees
	#36	"nasopharynx":ti,ab,kw (Word variations have been searched)
	#37	"nasopharyngeal":ti,ab,kw (Word variations have been searched)
	#38	#35 or #36 or #37
	#39	MeSH descriptor: [Hypopharynx] explode all trees
	#40	"hypopharynx":ti,ab,kw (Word variations have been searched)
	#41	"hypopharyngeal":ti,ab,kw (Word variations have been searched)
	#42	#39 or #40 or #41
	#43	MeSH descriptor: [Oropharynx] explode all trees
	#44	Oropharynx:ti,ab,kw (Word variations have been searched)
	#45	"oropharyngeal":ti,ab,kw (Word variations have been searched)
	#46	#43 or #44 or #45
	#47	MeSH descriptor: [Sleep Apnea Syndromes] explode all trees
	#48	"sleep disordered breathing":ti,ab,kw (Word variations have been searched)

	#49 #47 or #48 #50 laryngopharynx:ti,ab,kw (Word variations have been searched) #51 "laryngopharyngeal":ti,ab,kw (Word variations have been searched) #52 #50 or #51 #53 #34 or #38 or #42 or #46 or #52 #54 MeSH descriptor: [Airway Obstruction] explode all trees #55 "Airway Obstruction":ti,ab,kw (Word variations have been searched) #56 #54 or #55 #57 "posterior airway space":ti,ab,kw (Word variations have been searched) #58 "air space":ti,ab,kw (Word variations have been searched) #59 "upper airway":ti,ab,kw (Word variations have been searched) #60 "oral airway":ti,ab,kw (Word variations have been searched) #61 "nasal airway":ti,ab,kw (Word variations have been searched) #62 #56 or #57 or #58 or #59 or #60 or #61 #63 #49 or #53 or #62 #64 MeSH descriptor: [Tomography, X-Ray Computed] explode all trees #65 MeSH descriptor: [Multidetector Computed Tomography] explode all trees #66 "Multidetector Computed Tomography":ti,ab,kw (Word variations have been searched) #67 "cone beam computed tomography":ti,ab,kw (Word variations have been searched) #68 "CBCT":ti,ab,kw (Word variations have been searched) #69 "CBCT scan":ti,ab,kw (Word variations have been searched) #70 "CBCT scans":ti,ab,kw (Word variations have been searched) #71 "CAT scan":ti,ab,kw (Word variations have been searched) #72 "CAT scans":ti,ab,kw (Word variations have been searched) #73 "Cone Beam CT":ti,ab,kw (Word variations have been searched) #74 #64 or #65 or #66 or #67 or #68 or #69 or #70 or #71 or #72 or #73 #75 MeSH descriptor: [Imaging, Three-Dimensional] explode all trees #76 "three-dimensional image":ti,ab,kw (Word variations have been searched) #77 "3-D Imaging":ti,ab,kw (Word variations have been searched) #78 #75 or #76 or #77 #79 MeSH descriptor: [Magnetic Resonance Imaging] explode all trees #80 "Magnetic Resonance Imaging":ti,ab,kw (Word variations have been searched) #81 "magnetic resonance":ti,ab,kw (Word variations have been searched) #82 "Tomography MR":ti,ab,kw (Word variations have been searched) #83 "Tomography NMR":ti,ab,kw (Word variations have been searched) #84 "NMR Imaging":ti,ab,kw (Word variations have been searched) #85 "MRI Scan":ti,ab,kw (Word variations have been searched) #86 #79 or #80 or #81 or #82 or #83 or #84 or #85 #87 "minimum axial area":ti,ab,kw (Word variations have been searched) #88 volume:ti,ab,kw (Word variations have been searched) #89 area:ti,ab,kw (Word variations have been searched) #90 "linear":ti,ab,kw (Word variations have been searched) #91 "airway cross section":ti,ab,kw (Word variations have been searched) #92 #87 or #88 or #89 or #90 or #91 #93 #74 or #78 or #86 or #92 #94 #30 and #63 and #93
Medline (via Pubmed)	((((((((((((((((((((((Orthognathic Surgery[MeSH Terms]) OR “Orthognathic Surgery”[Title/Abstract]) OR Orthognathic Surgical Procedures[MeSH Terms]) OR

	“Orthognathic Surgical Procedures”[Title/Abstract]) OR Surgery, Oral[MeSH Terms]) OR Maxillofacial Abnormalities[MeSH Terms]) OR Maxillofacial Abnormalities[Title/Abstract]) OR Maxillofacial Development[MeSH Terms]) OR Mandibular Advancement[MeSH Terms]) OR Orthodontics[MeSH Terms]) OR Mandible[MeSH Terms]) OR Maxilla[MeSH Terms]) OR “jaw surgery”[Title/Abstract]) OR “bimaxillary surgery”[Title/Abstract]) OR “maxillo mandibular advancement”[Title/Abstract]) OR “surgical orthodontic treatment”[Title/Abstract])))) OR (((Advancement[Title/Abstract] OR setback[Title/Abstract] OR surger*[Title/Abstract]) AND (Mandibular[Title/Abstract] OR Maxillary[Title/Abstract]))))) AND (((((((((((((((((pharynx[MeSH Terms]) OR pharyn*[Title/Abstract]) OR nasopharynx[MeSH Terms]) OR nasopharyn*[Title/Abstract]) OR hypopharynx[MeSH Terms]) OR hypopharyn*[Title/Abstract]) OR oropharynx[MeSH Terms]) OR oropharyn*[Title/Abstract]) OR airway obstruction[MeSH Terms]) OR “airway obstruction”[Title/Abstract])OR sleep apnea syndromes[MeSH Terms]) OR “Sleep Disordered Breathing”[Title/Abstract]) OR laryngopharyn*[Title/Abstract]) OR “posterior airway space”[Title/Abstract]) OR “air space”[Title/Abstract]) OR “upper airway”[Title/Abstract]) OR “oral airway”[Title/Abstract]) OR “nasal airway”[Title/Abstract]))) AND (((((((((((((((((((((((((Tomography, X-Ray Computed[MeSH Terms]) OR “Cone-Beam Computed Tomography”[Title/Abstract]) OR CBCT[Title/Abstract]) OR Multidetector Computed Tomography[MeSH Terms]) OR “Multidetector Computed Tomography”[Title/Abstract]) OR Imaging, Three-Dimensional[MeSH Terms]) OR “Three-Dimensional Image”[Title/Abstract]) OR “3-D Imaging”[Title/Abstract]) OR Magnetic Resonance Imaging[MeSH Terms]) OR “Magnetic Resonance”[Title/Abstract]) OR “Tomography MR”[Title/Abstract]) OR “Tomography NMR”[Title/Abstract]) OR “minimum axial area”[Title/Abstract]) OR volume[Title/Abstract]) OR area[Title/Abstract]) OR linear[Title/Abstract]) OR “airway cross section”[Title/Abstract]) OR “CBCT Scans”[Title/Abstract]) OR “CBCT Scan”[Title/Abstract]) OR “CAT Scans”[Title/Abstract]) OR “CAT Scan”[Title/Abstract]) OR “Cone Beam CT”[Title/Abstract]) OR “NMR Imaging”[Title/Abstract]) OR “MRI Scan”[Title/Abstract]) OR Invivo[Title/Abstract]) OR Dolphin[Title/Abstract]))))
Open Grey	airway* AND (orthognatic OR surg*)
Scopus	(TITLE-ABS-KEY("Orthognathic Surgery" OR "Orthognathic Surgical Procedures" OR "Maxillofacial Abnormalities" OR "jaw surgery" OR "bimaxillary surgery" OR "maxillo mandibular advancement" OR "surgical orthodontic treatment") OR (TITLE-ABS-KEY(advancement OR setback OR surger*) AND (TITLE-ABS-KEY(mandibular OR maxillary)))) AND (TITLE-ABS-KEY(pharyn* OR nasopharyn* OR hypopharyn* OR oropharyn* OR "airway obstruction" OR "Sleep Disordered Breathing" OR laryngopharyn* OR "posterior airway

	space" OR "air space" OR "upper airway" OR "oral airway" OR "nasal airway")) AND (TITLE-ABS-KEY("Cone-Beam Computed Tomography" OR cbct OR "Multidetector Computed Tomography" OR "Three-Dimensional Image" OR "3-D Imaging" OR "Magnetic Resonance" OR "Tomography MR" OR "Tomography NMR" OR "minimum axial area"OR volume OR area OR linear OR "airway cross section" OR "CBCT Scans" OR "CBCT Scan" OR "CAT Scans" OR "CAT Scan" OR "Cone Beam CT" OR "NMR Imaging" OR "MRI Scan"))
VHL	(tw:((("Procedimentos Cirúrgicos Ortognáticos"(mh) OR "Cirurgia Ortognática"(mh) OR "Cirurgia Bucal"(mh) OR "Anormalidades Maxilofaciais"(mh) OR "Desenvolvimento Maxilofacial"(mh) OR "Avanço Mandibular"(mh) OR "Ortodontia"(mh) OR "Mandíbula"(mh) OR "Maxila" OR "Orthognatic Surgery" OR "Cirurgia Ortognática" OR "Cirurgía Ortognática" OR "Orthognathic Surgical Procedures" OR "Procedimentos Cirúrgicos Ortognáticos" OR "Procedimientos Quirúrgicos Ortognáticos" OR "Maxillofacial Abnormalities" OR "Anormalidades Maxilofaciais" OR "Anomalías Maxilofaciales" OR "jaw surgery" OR "cirurgia maxilar" OR "madíbula cirurgía" OR "bimaxillary surgery" OR "cirurgia bimaxilar" OR "cirurgía bimaxilar" OR "maxilo mandibular advancement" OR "avanço maxilo mandibular" OR "avanzo mandibular maxilo" OR "surgical orthodontic treatment" OR "tratamento orto-cirúrgico" OR "tratamiento orto-quirúrgica") OR ((advancement OR avanço OR avanzo OR setback OR recuo OR surger* OR cirurg* OR cirugía OR quirúrgico) AND (mandibular OR mandibular OR maxillary OR maxilar))))) AND (tw:("Faringe"(mh) OR "Nasofaringe"(mh) OR "Hipofaringe"(mh) OR "Orofaringe"(mh) OR "Obstrução das Vias Respiratórias"(mh) OR "Sindromes da Apneia do Sono"(mh) OR pharyn* OR faring* OR nasopharyn* OR nasofarin* OR hypophary* OR hipofaring* OR orofaring* OR "airway obstruction" OR "Obstrução das Vias Respiratórias" OR "Obstrucción de las Vias Aéreas" OR "Sleep Disordered Breathing" OR "Distúrbio Respiratório do Sono" OR "Transtornos respiratorios del sueño" OR laryngopharyn* OR laringofaring* OR "posterior airway space" OR "espaço aéreo posterior" OR "posterior del espacio de la vía aérea" OR "air space" OR "vias aéreas" OR "vías respiratorias" OR "upper airway" OR "vias aéreas superiores" OR "vías respiratórias superiores" OR "oral airway" OR "vias aéreas orais" OR "vías respiratórias oral" OR "nasal airway" OR "vias aéreas nasais" OR "vías respiratórias nasal")) AND (instance:"regional")
Web of Science	#1) ("Orthognathic Surgery" OR "Orthognathic Surgical Procedures" OR "Maxillofacial Abnormalities" OR "jaw surgery" OR "bimaxillary surgery" OR "maxillo mandibular advancement" OR "surgical orthodontic treatment" OR (advancement OR setback OR surger*) AND ((mandibular OR maxillary))) #2) (pharyn* OR nasopharyn* OR hypopharyn* OR oropharyn* OR "airway obstruction" OR "Sleep Disordered Breathing" OR laryngopharyn* OR "posterior airway space" OR "air space" OR "upper airway" OR "oral airway" OR "nasal airway")

	#3) ("Cone-Beam Computed Tomography" OR cbct OR "Multidetector Computed Tomography" OR "Three-Dimensional Image" OR "3-D Imaging" OR "Magnetic Resonance" OR "Tomography MR" OR "Tomography NMR" OR "minimum axial area"OR volume OR area OR linear OR "airway cross section" OR "CBCT Scans" OR "CBCT Scan" OR "CAT Scans" OR "CAT Scan" OR "Cone Beam CT" OR "NMR Imaging" OR "MRI Scan") #4) #3 AND #2 AND #1

Table 3. Risk of bias assessment modified from Mattos et al.[5]

Component	Risk of bias	Points	Definition
1. Eligible criteria for participants described	LOW	1.0	Inclusion and/or exclusion criteria described
	MODERATE	0.5	No description of criteria, but selection done at least by age and type of surgery
	HIGH	0	No description of criteria for selection
2. Statistical treatment performed	LOW	1.0	Statistical treatment fully described, including sample size calculation, and adequate
	MODERATE	0.5	Statistical treatment not fully described or inadequate
	HIGH	0	No statistical treatment applied
3. Reliability of measures tested	LOW	1.0	Measures repeated and statistical test applied
	MODERATE	0.5	Measures repeated and inadequate or no statistical tests applied
	HIGH	0	Measures not repeated
4. Drop-outs reported	LOW	1.0	Drop-outs reported with explanation
	MODERATE	0.5	Drop-outs reported with no explanation
	HIGH	0	No description of drop-outs
5. Follow-up period reported	LOW	1.0	Follow-up period reported
	HIGH	0	No description or unclearness of follow-up period
6. Potential bias and trial limitations addressed	LOW	1.0	Description of potential bias and trial limitations acknowledging them
	HIGH	0	No description of potential bias or trial limitations

Table 4. Results of the methodological quality (risk of bias) assessment

Study	Eligible criteria for participants described	Statistical treatment performed	Reliability of measures tested	Drop-outs reported	Follow-up period reported	Potential bias and trial limitations addressed	Total points	Risk of bias
Abramson et al,[43] 2011	1	0.5	0	1	0	1	3.5	Moderate
Biachi et al,[14] 2014	1	0.5	0	0	1	1	3.5	Moderate
Brunetto et al,[15] 2014	1	1	1	0	1	1	5.0	Low
de Souza Carvalho et al,[37] 2012	1	0.5	0	0	1	0	2.5	Moderate
Faria et al,[38] 2013	1	0.5	0	0	1	0	2.5	Moderate
Gokce et al,[16] 2014	1	0.5	1	0	1	0	3.5	Moderate
Gordina et al,[39] 2013	1	0	0	0	1	0	2	High
Hernández-Alfaro et al,[23] 2011	1	0.5	0	0	1	1	3.5	Moderate
Hong et al,[34] 2011	1	0.5	1	0	1	1	4.5	Low
Hsieh et al,[40] 2014	1	0.5	1	0	1	0	3.5	Moderate
Jakobsone et al,[41] 2010	1	0.5	1	1	1	1	5.5	Low
Kim et al,[25] 2010	1	0.5	0	0	1	0	2.5	Moderate
Kim et al,[31] 2013	1	0.5	1	0	1	0	3.5	Moderate
Kim et al,[32] 2014	1	0.5	1	0	1	1	4.5	Moderate
Kim et al,[17] 2014b	1	0.5	0	0	1	0	2.5	Moderate
Kochel et al,[26] 2013	1	0.5	1	0	1	0	3.5	Moderate
Kwon et al,[36] 2012	1	0.5	0	0	1	1	3.5	Moderate
Lee et al,[27] 2009	1	0.5	1	0	1	1	4.5	Low
Li et al,[45] 2014	1	0.5	1	0	1	0	3.5	Moderate
Panou et al,[29] 2013	1	0.5	1	0	1	1	4.5	Low
Park et al,[28] 2010	1	0.5	0.5	0	1	1	4.0	Moderate
Park et al,[42] 2012	1	0.5	0.5	0	1	0	3.0	Moderate
Raffaini and Pisani,[30] 2013	1	0.5	0	0	1	1	3.5	Moderate
Schendel et al,[18] 2014	1	0.5	0	0	1	1	3.5	Moderate
Uesugi et al,[19] 2014	1	0.5	1	1	1	0	4.5	Low
Wang et al,[35] 2012	1	0.5	0	0	1	0	2.5	Moderate
Wang et al,[44] 2012b	1	0.5	0	0	1	0	2.5	Moderate
Zinser et al,[33] 2013	1	0.5	1	0	1	1	4.5	Low

Low risk of bias: more than 4 points; Moderate: 2.5 to 4 points; High: less than 2.5 points

Table 5 – Data from studies included

Author, year	Type of study	Patients		Intervention		Measurements		Outcomes		
		n gender	age (mean)	type of surgery	follow-up (mean)	area (CSA)	volume	area	volume	statistical significance
Abramson et al.,[43] 2011	R	9M	21-55y (38.9y)	MMA + GTA	3 to 6 months	Mean / Minimum / RP / RL	Total	Increased	Increased	- Pre x Post: increase in volume (p=0.02), CSA mean (p=0.01), minimum (p=0.01), RP (p<0.01), RL (p=0.04)
Bianchi et al.,[14] 2014	R	10M	16-59y (45y)	MMA	6 months		Total		Increased	- Mean volume increased (p = 0.005) - Inverse relation between Pre volume and the percentage increase Post (p = 0.001)
Brunetto et al.,[15] 2014	R	18M 24F (Gr1: 22 Gr2: 20)	18-30y (Gr1: 23.02 y Gr2: 24.77 y)	- Gr1: MxA + MdS - Gr2: MMA	5 to 8 months	Minimum	S / I / Total	Decreased: Gr1 Increased: Gr2	- Gr1 (S, T) and Gr2: increased	- Difference on the volume (S) percentage variation in the groups (p≤0.001)
de Souza Carvalho et al.,[37] 2012	R	11M 9F	19-57y	MMA (anticlockwise rotation)	At least 6 months		Total		Increased	- Pre x Post immediate (p<0.001) - Difference among Pre and late Post (p<0.001) - Difference among Post immediate and late Post (p = 0.022)
Faria et al.,[38] 2013	P	15M 5F	26-60y	MMA	6 months		RP / RL		Increased	- Pre x Post volume in RP (p<0.01) and RL (p=0.01) regions
Gokce et al.,[16] 2014	R	25M	19-35y (21.6y)	MxA + MdS	At least 1 year	NP / RP / OP / HP	S / M / I / Total	Increased: NP and RP Decreased: OP and HP	Increased: S and Total Decreased : M and I	- Pre x Post CSA in all measurements (p<0.05): increase in NP and RP, decrease in OP and HP - Pre x Post volume: increase in S (p<0.001), and T (p<0.005); decrease in M and I (p<0.05) between Pre and Post
Hernández-Alfaro et al.,[23] 2011	R	22F 8M (10 per group)	18-36y (32y)	Gr1: MMA Gr2:MxA Gr3: MdA	(133.5 days)		Total		Increased	- Increase in all groups (p<0.05)
Hong et al.,[34] 2011	R	14M 7F (Gr1: 12 Gr2: 9)	18-30y (Gr 1: 23.20y Gr2: 22y)	Gr1: MdS Gr2: MxA + MdS	2 months	Level of: PNS / SP / EP	Total	Decreased in all measurements, except in Gr2 at CSA - PNS	Decreased	- Pre x Post CSA: decrease in SP and EP in Gr1; decrease of the volume in both groups (p<0.05)

CSA: cross-sectional area; R: restropective; M: male; y: years; MMA: maxillomandibular advancement; GTA: genial tubercle advancement; RP: retropalatal; P; RL: Retrolingual: prospective; G: Group; Pre: preoperative; Post: postoperative; F: female; MxA+MdS: maxillary advancement with mandibular setback; S: superior; I: inferior; P: prospective; NP: nasopharyngeal; OP: oropharyngeal; HP: hypopharyngeal; M: middle; MxA: maxillary advancement; MdA: mandibular advancement; MdS: mandibular setback; MxA: maxillary advancement; PNS: posterior nasal spine; SP: soft palate;
EP: Epiglottis; NaP: nasopalatal; VP: velopharyngeal; LP: laringopharyngeal; CV: cervical vertebra; PP: palatopharyngeal; ; GP: glossopharyngeal.

Table 5 – Data from studies included (continuation)

Author, year	Type of study	Patients		Intervention		Measurements		Outcomes		
		n gender	age (mean)	type of surgery	follow-up (mean)	area (CSA)	volume	area	volume	statistical significance
Hsieh et al.,[40] 2014	P	12M 4F	22-48y (33y)	MMA modified	At least 6 months (12 months)	- 10 levels - Minimum: VP / OP / HP	VP / OP / HP / Total	Increased	Increased	- Increase in CSA from 1 to 9 level ($p<0.01$) - Increase of the volume and minimum CSA (VP, OP, HP) ($p<0.01$)
Jakobsone et al.[41], 2010	P	8M 6F	17.4-24.9y (20.3y)	MxA + MdS	6 months	RP / OP / HP	NaP / OP / HP / Total	Increased: RP and HP Decreased: CSA - OP	Increased: OP, HP and total Decreased: RP	- Pre x Post: increase of the volume in OP and HP
Kim et al.,[25] 2010	R	12M 8F	(21.53y)	MdS	- 2.3 months -12 months		NP / OP / HP / Total		Decreased	- Pre x Post: decrease in 2.3 months total and OP ($p<0.001$), NP and HP ($p<0.01$); in 12 months total and OP ($p>0.001$), NP ($p<0.05$) and HP ($p<0.01$)
Kim et al.,[31] 2013	R	14M 11F	17.2-48.1y (30.04y)	MxA + MdS (with clockwise rotation)	- 2-4 months - 5-8 months		NP / OP / HP / Total		Decreased	- Pre x Post: volume decrease (both follow-ups) in T, NP and HP ($p<0.001$)
Kim et al.,[32] 2014	R	14M 11F	17.2-48.1y (30.04y)	MxA + MdS (with clockwise rotation)	5-8 months		NP / OP / HP / sub-pharyngeal /Total		Decreased Increased: HP	- Pre x Post: decrease NP and OP ($p<0.05$)
Kim et al.,[17] 2014b	R	26M 34F (Gr1:30 Gr2: 30)	18-32y (23y)	Gr1: MxS, impaction + MdS Gr2: maxilla impaction + MdS	At least 6 months	Minimum: RP	RP	Increased: Gr1 Decreased: Gr2	Increased: Gr1 Decreased: Gr2	- Increase: Gr1 of the volume ($p<0.01$) and Min CSA ($p<0.05$) - Decrease: Gr2 of the volume and minimum CSA ($p<0.01$)
Kochel et al.,[26] 2013	R	75F 27M	17.08-55y (31.8y)	MdA	5 weeks	Minimum / PNS / SP / EP	S / M / I / Total	Increased	Increased	- Pre x Post: increased in all volume and area measurements ($p<0.001$)

CSA: cross-sectional area; R: restropective; M: male; y: years; MMA: maxillomandibular advancement; GTA: genial tubercle advancement; RP: retropalatal; P; RL: Retrolingual: prospective; G: Group; Pre: preoperative; Post: postoperative; F: female; MxA+MdS: maxillary advancement with mandibular setback; S: superior; I: inferior; P: prospective; NP: nasopharyngeal; OP: oropharyngeal; HP: hypopharyngeal; M: middle; MxA: maxillary advancement; MdA: mandibular advancement; MdS: mandibular setback; MxA: maxillary advancement; PNS: posterior nasal spine; SP: soft palate;
EP: Epiglottis; NaP: nasopalatal; VP: velopharyngeal; LP: laringopharyngeal; CV: cervical vertebra; PP: palatopharyngeal; ; GP: glossopharyngeal.

Table 5 – Data from studies included (continuation)

Author, year	Type of study	Patients		Intervention		Measurements		Outcomes		
		n gender	age (mean)	type of surgery	follow-up (mean)	area (CSA)	volume	area	volume	statistical significance
Kwon et al.,[36] 2012	R	8M 10F	17-43y (28.7y)	MxS or impaction + MdS	6 months	Minimum: OP / LP	NP / OP / LP / Total	Decreased	Decreased: total and OP Increased: NP	- Pre x Post: decreased in volume total and NP; minimum CSA - OP ($p<0.05$)
Lee et al.,[27] 2009	R	4M 8F	Mini-mum: 19y (M:23.5y F:21.4y)	MxA + MdS	1 year		Total		Decreased	- Pre x Post: decreased in volume ($p<0.001$)
Li et al.,[45] 2014	R	29F	18-35y (23.6y)	MxA + MdS	6 months	Level of: PNS / SP /EP	NP / OP / Total	Increased: CSA PNS Decreased : CSA SP and EP	Increased: NP Decreased: OP and total	- Pre x Post: decrease in volume total and OP ($p<0.05$), CSA SP ($p<0.05$)
Panou et al.,[29] 2013	R	6M 11F	17-34y (22,59y)	MxA + MdS	10-22 weeks	- Minimum	S / I / Total	Increased	Increased: U Decreased: I and total	- Pre x Post: decrease in volume total and I (males) ($p=0.028$)
Park et al.,[28] 2010	R	5M 7F	(25.5y)	MdS	6 months	PNS / CV2 / CV3	NP / OP / Pharynx (total)	Decreased	Decreased	- No significance changes in volume and CSA
Park et al.,[42] 2012	R	23M 13F (Gr1: 20 Gr2: 16)	19-29y (22.97y)	Gr1: MdS Gr2: MxA + MdS	- 4.6 months (4.6 moths) - 1.4 years (16.6 months)	PNS_Vomer / CV1 / CV2 / CV3 / CV4	NP / OP / HP / Total	Decreased: all groups, except in PNS_Vomer, Gr2 CV; Between both follow-up: increased in Gr2 CV3; decreased in PSN_Vomer, CV1	Decreased: Gr1 (maintained in 1.4y, except NP); Gr2, except NP, (not maintained in 1.4y) Increased: 1.4y except NP	- Comparison among Pre and 2 times follow-up: Gr1 CSA CV1, CV2 and volume HP ($p<0.05$), CSA CV3, CV4, volume OP and total ($p<0.01$); Gr2 CSA CV1 ($p<0.01$), volume OP ($p<0.05$)
Raffaini and Pisani,[30] 2013	R	10F	17-35y (22y)	MMA (with anticlockwise rotation)	6-12 months	Minimum	VP / OP / HP / Total	Increased	Increased	- Increased in minimum CSA and volume ($p<0.05$)

CSA: cross-sectional area; R: restropective; M: male; y: years; MMA: maxillomandibular advancement; GTA: genial tubercle advancement; RP: retropalatal; P; RL: Retrolingual: prospective; G: Group; Pre: preoperative; Post: postoperative; F: female; MxA+MdS: maxillary advancement with mandibular setback; S: superior; I: inferior; P: prospective; NP: nasopharyngeal; OP: oropharyngeal; HP: hypopharyngeal; M: middle; MxA: maxillary advancement; MdA: mandibular advancement; MdS: mandibular setback; MxA: maxillary advancement; PNS: posterior nasal spine; SP: soft palate;
EP: Epiglottis; NaP: nasopalatal; VP: velopharyngeal; LP: laringopharyngeal; CV: cervical vertebra; PP: palatopharyngeal; ; GP: glossopharyngeal.

Table 5 – Data from studies included (continuation)

Author, year	Type of study	Patients		Intervention		Measurements		Outcomes		
		n gender	**age (mean)**	**type of surgery**	**follow-up (mean)**	**area (CSA)**	**volume**	**area**	**volume**	**statistical significance**
Schendel et al.,[18] 2014	R	8M 2F	35-62y (mean 46.4y)	MMA	At least 3 months	Minimum: RP / RL	RP / RL	Increased, except in one patient	Increased, except in one patient	- Increased: volume upper airways
Uesugi et al.,[19] 2014	P	21M 19F (Gr1: 22 Gr 2: 18)	16-54y (23y)	Gr1: MdS Gr2: MxA + MdS	At least 6 months (9 months)	- Average - nasal / palatal / OP / tongue	NP / OP / Total	Decreased: Gr1, except in CSA nasal and Gr2, except in CSA nasal and palatal	Decreased, except NP	- Decrease: Gr1 of the volume total and OP; of the CSA average, OP and tongue ($p<0.01$)
Wang et al.,[35] 2012	R	9M 11F	18-21y	MdS	6 months	Minimum: PP / GP / HP	PP / GP / HP / Total	Decreased	Decreased	- Pre x Post: decreased in CSA PP, HP and volume HP, total ($p<0.05$); in CSA GP and volume PP, GP ($p<0.01$)
Wang et al.,[44] 2012.b	R	9M 11F	18-24y	MdS	6 months	Minimum: PP / GL / HP	PP / GL / HP / Total	Decreased	Decreased	- Pre x Post: decreased in CSA PP, HP and volume HP, total ($p<0.05$); in CSA GP and volume PP, GP ($p<0.01$)
Zinser et al.,[33] 2013	R	10M 7F	25-63y (38.64y)	MMA modified + anti-clockwise rotation	3 to 6 months	NP / OP / HP / Minimum / Maximum / Average	Nasal / NP /OP / HP / Total	Increased	Increased	- Pre x Post: increased in all volume and CSA measurements ($p<0.005$, except volume NP where $p<0.003$), except to CSA NP

CSA: cross-sectional area; R: restropective; M: male; y: years; MMA: maxillomandibular advancement; GTA: genial tubercle advancement; RP: retropalatal; P; RL: Retrolingual: prospective; G: Group; Pre: preoperative; Post: postoperative; F: female; MxA+MdS: maxillary advancement with mandibular setback; S: superior; I: inferior; P: prospective; NP: nasopharyngeal; OP: oropharyngeal; HP: hypopharyngeal; M: middle; MxA: maxillary advancement; MdA: mandibular advancement; MdS: mandibular setback; MxA: maxillary advancement; PNS: posterior nasal spine; SP: soft palate;
EP: Epiglottis; NaP: nasopalatal; VP: velopharyngeal; LP: laringopharyngeal; CV: cervical vertebra; PP: palatopharyngeal; ; GP: glossopharyngeal.

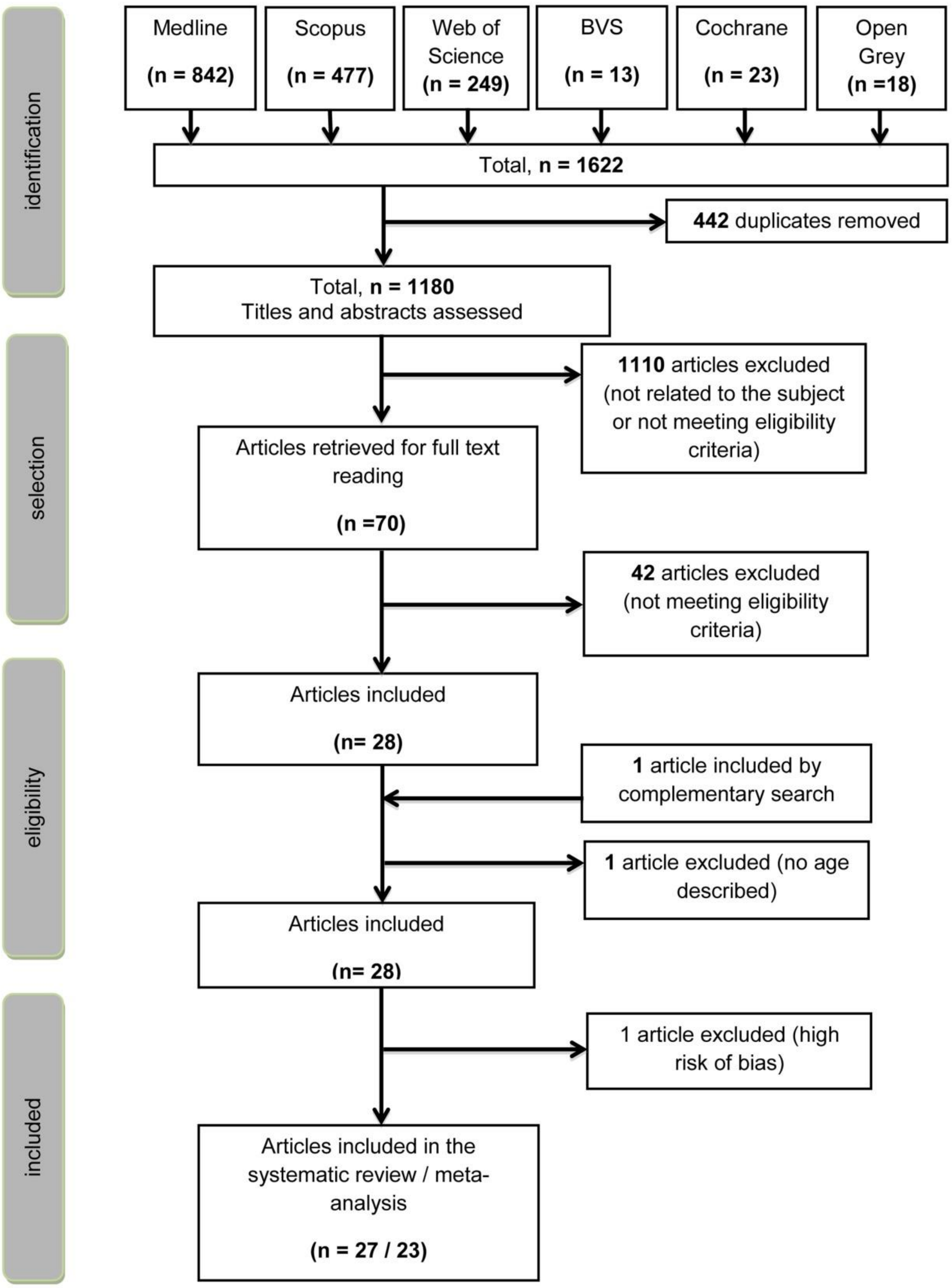
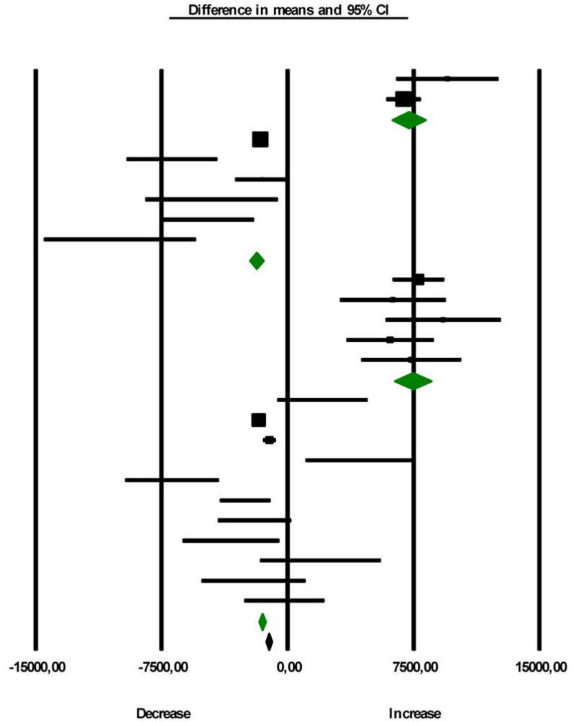


Figure 1. Flow diagram of selected studies (PRISMA)

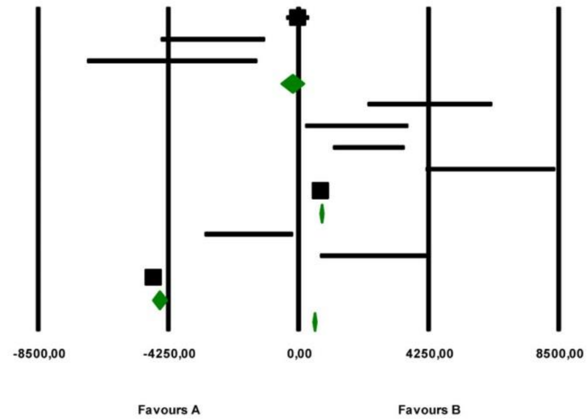
Group by Subgroup within study	Study name	Difference in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
MdA	Hernández-Alfaro et al. 2011	9511,810	1565,004	2449237,352	6444,459	12579,161	6,078	0,000
MdA	Kochel et al. 2013	6905,700	531,930	282949,847	5863,136	7948,264	12,982	0,000
MdA		7175,593	503,634	253647,091	6188,489	8162,697	14,248	0,000
MdS	Hong et al. 2011	-1625,170	218,585	47779,320	-2053,588	-1196,752	-7,435	0,000
MdS	Kim et al. 2010	-6899,090	1385,231	1918864,080	-9614,092	-4184,088	-4,980	0,000
MdS	Park et al. 2010	-1540,000	814,598	663570,267	-3136,583	56,583	-1,891	0,059
MdS	Park et al. 2012	-4529,630	2022,099	4088884,770	-8492,871	-566,389	-2,240	0,025
MdS	Uesugi et al. 2014	-4800,000	1434,799	2058647,273	-7612,154	-1987,846	-3,345	0,001
MdS	Wang et al. 2012	-9991,000	2314,778	5358195,200	-14527,881	-5454,119	-4,316	0,000
MdS		-1894,659	204,659	41885,432	-2295,783	-1493,534	-9,258	0,000
MMA	Bianchi et al. 2014	7790,000	790,260	624510,245	6241,120	9338,880	9,858	0,000
MMA	Brunetto et al. 2014	6268,100	1620,288	2625333,618	3092,394	9443,806	3,869	0,000
MMA	Hernández-Alfaro et al. 2011	9267,390	1757,110	3087436,823	5823,517	12711,263	5,274	0,000
MMA	Hsieh et al. 2014	6100,000	1333,739	1778860,000	3485,919	8714,081	4,574	0,000
MMA	Raffaini and Pisani 2013	7366,430	1530,945	2343794,037	4365,832	10367,028	4,812	0,000
MMA		7416,101	550,910	303502,255	6336,337	8495,866	13,462	0,000
MxA + MdS	Brunetto et al. 2014	2062,910	1377,300	1896954,943	-636,548	4762,368	1,498	0,134
MxA + MdS	Gokce et al. 2014	-1712,000	113,200	12814,240	-1933,868	-1490,132	-15,124	0,000
MxA + MdS	Hong et al. 2011	-1085,750	197,697	39083,972	-1473,228	-698,272	-5,492	0,000
MxA + MdS	Jakobsone et al. 2010	4270,000	1640,984	2692828,571	1053,730	7486,270	2,602	0,009
MxA + MdS	Kim et al. 2013	-6883,480	1431,754	2049919,517	-9689,666	-4077,294	-4,808	0,000
MxA + MdS	Lee et al. 2009	-2522,860	782,806	612785,447	-4057,132	-988,588	-3,223	0,001
MxA + MdS	Li et al. 2014	-1970,000	1120,982	1256599,724	-4167,084	227,084	-1,757	0,079
MxA + MdS	Panou et al. 2013 men	-3375,530	1479,765	2189705,435	-6275,817	-475,243	-2,281	0,023
MxA + MdS	Panou et al. 2013 women	1955,570	1844,586	3402497,895	-1659,752	5570,892	1,060	0,289
MxA + MdS	Park et al. 2012	-2031,080	1588,866	2524495,024	-5145,200	1083,040	-1,278	0,201
MxA + MdS	Uesugi et al. 2014	-200,000	1226,096	1503311,111	-2603,104	2203,104	-0,163	0,870
MxA + MdS		-1552,907	95,673	9153,314	-1740,423	-1365,392	-16,231	0,000
Overall		-1155,332	84,406	7124,433	-1320,765	-989,898	-13,688	0,000



Heterogeneity: MdA - Q-value: 2.48, p-value: 0.11, I2: 59%, Tau2: 2029811.06 , Tau: 1424.71; MdS - Q-value: 32.79, p-value: 0.00, I2: 84%, Tau2: 5140667.11, Tau: 2267.30; MMA - Q-value: 2.81, p-value: 0.59, I2: 0%, Tau2: 0.00, Tau: 0.00; MxA+MdS - Q-value: 49.02, p-value: 0.00, I2: 79%, Tau2: 822001.76, Tau: 906.64;

Figure 2. Comparison of the total volume changes (different subgroups)

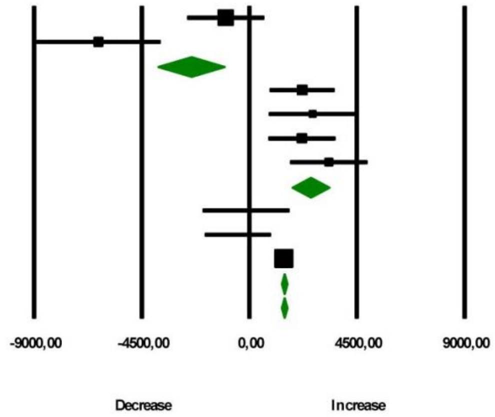
Group by Subgroup within study	Study name	Statistics for each study						
		Difference in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
RP_MdS	Kim etal, 2014b	-30,000	192,134	36915,653	-406,577	346,577	-0,156	0,876
RP_MdS	Park etal. 2012	-2793,950	871,981	760350,372	-4503,001	-1084,899	-3,204	0,001
RP_MdS	Wang etal. 2012	-4126,000	1419,456	2014855,200	-6908,083	-1343,917	-2,907	0,004
RP_MdS		-226,123	186,015	34601,745	-590,706	138,461	-1,216	0,224
RP_MMA	Brunetto etal. 2014	4288,050	1042,244	1086273,322	2245,289	6330,811	4,114	0,000
RP_MMA	Faria etal. 2013	1900,000	860,701	740806,480	213,057	3586,943	2,208	0,027
RP_MMA	Hsieh etal. 2014	2300,000	602,833	363407,500	1118,469	3481,531	3,815	0,000
RP_MMA	Schendel etal. 2014	6267,000	1081,869	1170440,390	4146,576	8387,424	5,793	0,000
RP_MMA	Zinser etal. 2013	720,000	23,121	534,588	674,683	765,317	31,140	0,000
RP_MMA		727,442	23,085	532,914	682,196	772,688	31,512	0,000
RP_MxA + MdS	Park etal. 2012	-1624,460	739,499	546858,033	-3073,850	-175,070	-2,197	0,028
RP_MxA + MdS	Brunetto etal. 2014	2493,130	917,127	841121,114	695,595	4290,665	2,718	0,007
RP_MxA + MdS	Gokce etal. 2014	-4744,000	113,400	12859,560	-4966,260	-4521,740	-41,834	0,000
RP_MxA + MdS		-4566,871	111,262	12379,198	-4784,940	-4348,801	-41,046	0,000
Overall		498,237	22,438	503,485	454,259	542,216	22,205	0,000



Heterogeneity: RP_MdS - Q-value:17.26, p-value:0.00, I2:88%, Tau2:4435352.78, Tau:2106.02; RP_MMA - Q-value:46.65, p-value:0.00, I2:91%, Tau2:3636620.34, Tau:1906.99;
RP_MxA+MdS - Q-value:77.53, p-value:0.00, I2:97%, Tau2:12881583.6, Tau:3589.09;

Figure 3. Comparison of the regional volume changes (retropalatal)

Group by Subgroup within study	Study name	Statistics for each study						
		Difference in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
RL_MdS	Park et al. 2012	-984,560	826,975	683887,070	-2605,401	636,281	-1,191	0,234
RL_MdS	Wang et al. 2012	-6304,000	1333,815	1779061,250	-8918,228	-3689,772	-4,726	0,000
RL_MdS		-2461,609	702,846	493992,089	-3839,162	-1084,057	-3,502	0,000
RL_MMA	Brunetto et al. 2014	2213,050	699,200	488880,172	842,644	3583,456	3,165	0,002
RL_MMA	Faria et al. 2013	2650,000	941,766	886923,720	804,172	4495,828	2,814	0,005
RL_MMA	Hsieh et al. 2014	2200,000	722,551	522080,000	783,826	3616,174	3,045	0,002
RL_MMA	Schendel et al. 2014	3324,000	832,560	693155,402	1692,213	4955,787	3,993	0,000
RL_MMA		2530,058	391,298	153114,106	1763,128	3296,988	6,466	0,000
RL_MxA + MdS	Park et al. 2012	-138,780	930,111	865105,774	-1961,763	1684,203	-0,149	0,881
RL_MxA + MdS	Brunetto et al. 2014	-480,910	706,298	498856,261	-1865,228	903,408	-0,681	0,496
RL_MxA + MdS	Gokce et al. 2014	1449,000	57,400	3294,760	1336,498	1561,502	25,244	0,000
RL_MxA + MdS		1430,400	57,103	3260,805	1318,480	1542,321	25,049	0,000
Overall		1428,190	56,323	3172,305	1317,799	1538,581	25,357	0,000

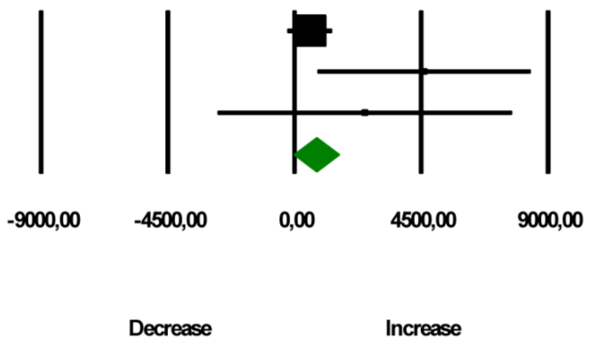


Heterogeneity: RL_MdS - Q-value:11.48, p-value:0.00, I2:91%, Tau2:12916746.7, Tau:3593.98; RL_MMA - Q-value:1.34, p-value:0.72, I2:0%, Tau2:0,00, Tau:0.00; RL_MxA+MdS - Q-value:10.27, p-value:0.00, I2:80%, Tau2:1319445.68, Tau:1148.67;

Figure 4. Comparison of the regional volume changes (retrolingual)

Study name	Subgroup within study	Difference in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Hong et al. 2011	MdS x MxA+MdS	539,420	408,019	166479,801	-260,283	1339,123	1,322	0,186
Uesugi et al. 2014	MdS x MxA+MdS	4600,000	1936,738	3750952,259	804,064	8395,936	2,375	0,018
Park et al. 2012 (1,4 years)	MdS x MxA+MdS	2498,550	2673,185	7145917,340	-2740,796	7737,896	0,935	0,350
		750,967	394,875	155926,605	-22,975	1524,908	1,902	0,057

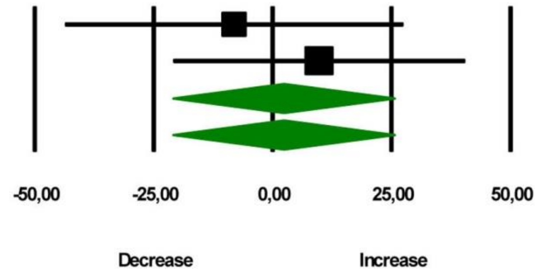
Difference in means and 95% CI



Heterogeneity. Q-value:4.64, p-value:0.09, I2:56%, Tau2:3422107.95, Tau:1849.89

Figure 5. Comparison of the total volume changes of MdS versus MxA+MdS

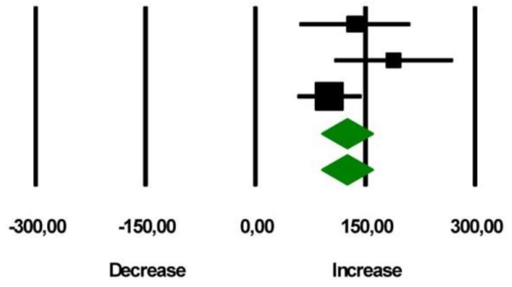
Group by Subgroup within study	Study name	Difference in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
		Statistics for each study						
MxA + MdS	Brunetto et al. 2014	-8,100	18,164	329,937	-43,701	27,501	-0,446	0,656
MxA + MdS	Panou et al. 2013	9,790	15,680	245,860	-20,942	40,522	0,624	0,532
MxA + MdS		2,151	11,869	140,880	-21,112	25,415	0,181	0,856
Overall		2,151	11,869	140,880	-21,112	25,415	0,181	0,856



Heterogeneity. Q-value:0.55, p-value:0.45, I2:0%, Tau:0.00, Tau:0.00;

Figure 6. Comparison of the minimum CSA changes (MxA+MdS subgroup)

Group by Subgroup within study	Study name	Statistics for each study						
		Difference in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
MMA	Abramson et al. 2011	135,700	38,767	1502,865	59,718	211,682	3,500	0,000
MMA	Raffaini and Pisani 2013	188,650	41,423	1715,855	107,463	269,837	4,554	0,000
MMA	Schendel et al. 2014	101,103	22,548	508,402	56,910	145,296	4,484	0,000
MMA		124,132	17,636	311,028	89,567	158,698	7,039	0,000
Overall		124,132	17,636	311,028	89,567	158,698	7,039	0,000

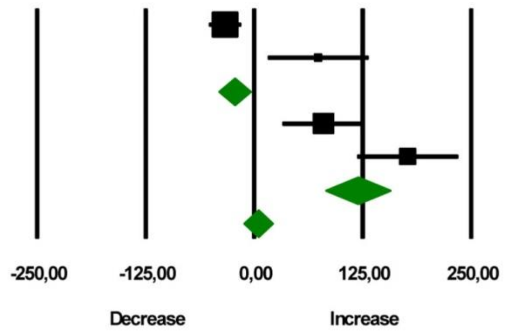


Heterogeneity: Q-value:3.55, p-value:0.16, I2:43%, Tau2:881.06, Tau:29.68;

Figure 7. Comparison of the minimum CSA changes (MMA subgroup)

Group by Subgroup within study	Study name	Difference in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
RP_MdS	Kim et al. 2014b	-33,450	9,639	92,911	-52,342	-14,558	-3,470	0,001
RP_MdS	Wang et al. 2012	73,600	29,784	887,112	15,224	131,976	2,471	0,013
RP_MdS		-23,301	9,171	84,103	-41,275	-5,327	-2,541	0,011
RP_MMA	Hsieh et al. 2014	80,000	24,331	592,000	32,312	127,688	3,288	0,001
RP_MMA	Schendel et al. 2014	176,879	29,876	892,597	118,322	235,436	5,920	0,000
RP_MMA		118,632	18,866	355,933	81,655	155,609	6,288	0,000
Overall		3,826	8,248	68,028	-12,340	19,992	0,464	0,643

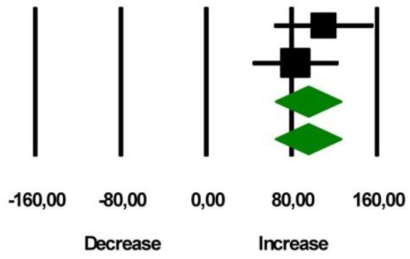
Statistics for each study



Heterogeneity. RP_MdS - Q-value: 11.69, p-value: 0.00, I2: 91%, Tau2: 5239.84, Tau: 72.38; RP_MMA - Q-value: 6.32, p-value: 0.01, I2: 84%, Tau2: 3950.47, Tau: 62.85;

Figure 8. Comparison of the regional minimum CSA changes (retropalatal)

Group by Subgroup within study	Study name	Difference in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
		Statistics for each study						
RL_MMA	Hsieh et al. 2014	110,000	23,802	566,550	63,348	156,652	4,621	0,000
RL_MMA	Schendel et al. 2014	83,590	20,517	420,927	43,378	123,802	4,074	0,000
RL_MMA		94,848	15,540	241,500	64,389	125,306	6,103	0,000
Overall		94,848	15,540	241,500	64,389	125,306	6,103	0,000



Heterogeneity: Q-value:0.70, p-value:0.40, I2:0%, Tau2:0.00, Tau:0.00;

Figure 9. Comparison of the regional minimum CSA changes (retrolingual)

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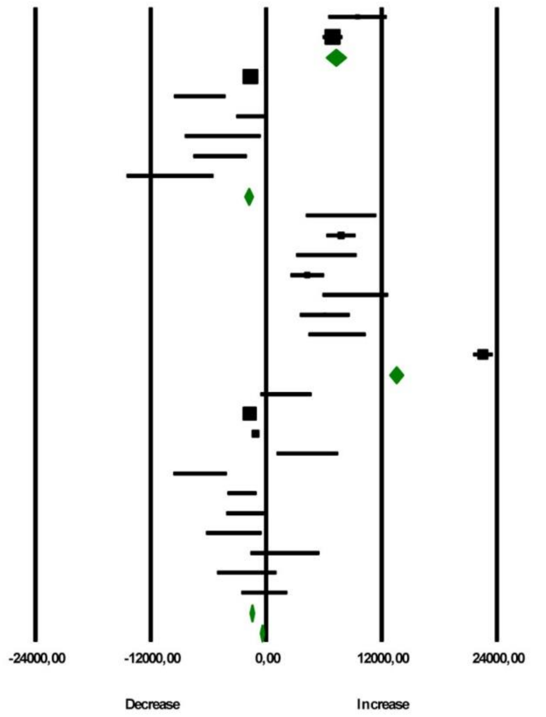
4. CONCLUSÕES

Pode-se concluir, com evidência moderada, em relação às dimensões das vias aéreas de pacientes submetidos à cirurgia ortognáticas avaliadas em imagens 3D que:

- no avanço maxilo-mandibular houve aumento da área mínima axial e do volume;
- no avanço maxilar com recuo mandibular não houve alteração da área mínima axial e houve diminuição do volume;
- no avanço mandibular houve aumento do volume;
- no recuo mandibular houve diminuição do volume.

Group by Subgroup within study	Study name	Difference in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
MdA	Hernández-Alfaro et al. 2011	9511,810	1565,004	2449237,352	6444,459	12579,161	6,078	0,000
MdA	Kochel et al. 2013	6905,700	531,930	282949,847	5863,136	7948,264	12,982	0,000
MdA		7175,593	503,634	253647,091	6188,489	8162,697	14,248	0,000
MdS	Hong et al. 2011	-1625,170	218,585	47779,320	-2053,588	-1196,752	-7,435	0,000
MdS	Kim et al. 2010	-6899,090	1385,231	1918864,080	-9614,092	-4184,088	-4,980	0,000
MdS	Park et al. 2010	-1540,000	814,598	663570,267	-3136,583	56,583	-1,891	0,059
MdS	Park et al. 2012	-4529,630	2022,099	4088884,770	-8492,871	-566,389	-2,240	0,025
MdS	Uesugi et al. 2014	-4800,000	1434,799	2058647,273	-7612,154	-1987,846	-3,345	0,001
MdS	Wang et al. 2012	-9991,000	2314,778	5358195,200	-14527,881	-5454,119	-4,316	0,000
MdS		-1894,659	204,659	41885,432	-2295,783	-1493,534	-9,258	0,000
MMA	Abramson et al. 2011	7800,000	1884,155	3550040,000	4107,124	11492,876	4,140	0,000
MMA	Bianchi et al. 2014	7790,000	790,260	624510,245	6241,120	9338,880	9,858	0,000
MMA	Brunetto et al. 2014	6268,100	1620,288	2625333,618	3092,394	9443,806	3,869	0,000
MMA	de Souza Carvalho et al. 2012	4271,960	894,988	801002,980	2517,816	6026,104	4,773	0,000
MMA	Hernández-Alfaro et al. 2011	9267,390	1757,110	3087436,823	5823,517	12711,263	5,274	0,000
MMA	Hsieh et al. 2014	6100,000	1333,739	1778860,000	3485,919	8714,081	4,574	0,000
MMA	Raffaini and Pisani 2013	7366,430	1530,945	2343794,037	4365,832	10367,028	4,812	0,000
MMA	Zinser et al. 2013	22540,000	525,261	275898,824	21510,508	23569,492	42,912	0,000
MMA		13451,922	344,020	118350,096	12777,654	14126,190	39,102	0,000
MxA + MdS	Brunetto et al. 2014	2062,910	1377,300	1896954,943	-636,548	4762,368	1,498	0,134
MxA + MdS	Gokce et al. 2014	-1712,000	113,200	12814,240	-1933,868	-1490,132	-15,124	0,000
MxA + MdS	Hong et al. 2011	-1085,750	197,697	39083,972	-1473,228	-698,272	-5,492	0,000
MxA + MdS	Jakobsone et al. 2010	4270,000	1640,984	2692828,571	1053,730	7486,270	2,602	0,009
MxA + MdS	Kim et al. 2013	-6883,480	1431,754	2049919,517	-9689,666	-4077,294	-4,808	0,000
MxA + MdS	Lee et al. 2009	-2522,860	782,806	612785,447	-4057,132	-988,588	-3,223	0,001
MxA + MdS	Li et al. 2014	-1970,000	1120,982	1256599,724	-4167,084	227,084	-1,757	0,079
MxA + MdS	Panou et al. 2013 men	-3375,530	1479,765	2189705,435	-6275,817	-475,243	-2,281	0,023
MxA + MdS	Panou et al. 2013 women	1955,570	1844,586	3402497,895	-1659,752	5570,892	1,060	0,289
MxA + MdS	Park et al. 2012	-2031,080	1588,866	2524495,024	-5145,200	1083,040	-1,278	0,201
MxA + MdS	Uesugi et al. 2014	-200,000	1226,096	1503311,111	-2603,104	2203,104	-0,163	0,870
MxA + MdS		-1552,907	95,673	9153,314	-1740,423	-1365,392	-16,231	0,000
Overall		-501,233	82,898	6872,064	-663,710	-338,756	-6,046	0,000

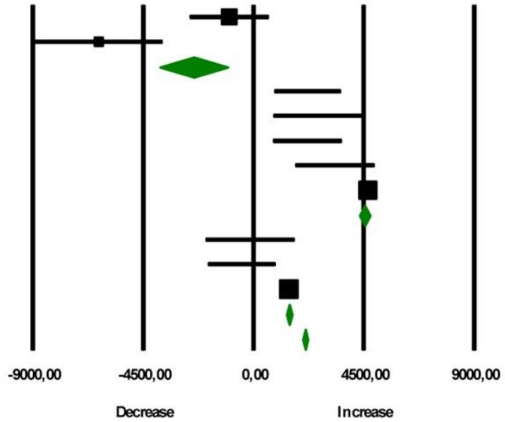
Difference in means and 95% CI



Heterogeneity: MdA - Q-value:2.48, p-value:0.11, I2:59%, Tau2:2029811.06, Tau:1424.71; MdS - Q-value:32.79, p-value:0.00, I2:84%, Tau5140667.11, Tau:2267.30; MMA - Q-value:536.41, p-value:0.00, I2:98%, Tau2:83915319.3, Tau:9160.53; MdA+MdS - Q-value:49.02, p-value:0.00, I2:79%, Tau2:822001.76, Tau:906.64;

Anexo 1. Análise de sensibilidade – Comparação das alterações do volume total (diferentes subgupos)

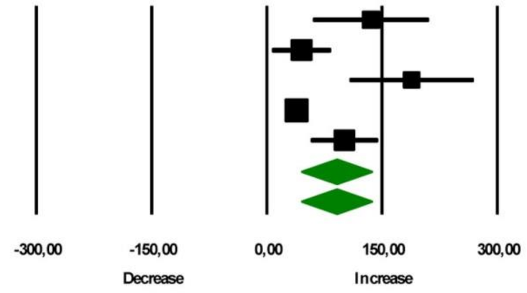
Group by / Subgroup within study	Study name	Difference in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
RL_MdS	Park et al. 2012	-984,560	826,975	683887,070	-2605,401	636,281	-1,191	0,234
RL_MdS	Wang et al. 2012	-6304,000	1333,815	1779061,250	-8918,228	-3689,772	-4,726	0,000
RL_MdS		-2461,609	702,846	493992,089	-3839,162	-1084,057	-3,502	0,000
RL_MMA	Brunetto et al. 2014	2213,050	699,200	488880,172	842,644	3583,456	3,165	0,002
RL_MMA	Faria et al. 2013	2650,000	941,766	886923,720	804,172	4495,828	2,814	0,005
RL_MMA	Hsieh et al. 2014	2200,000	722,551	522080,000	783,826	3616,174	3,045	0,002
RL_MMA	Schendel et al. 2014	3324,000	832,560	693155,402	1692,213	4955,787	3,993	0,000
RL_MMA	Zinser et al. 2013	4670,000	111,920	12526,118	4450,641	4889,359	41,726	0,000
RL_MMA		4508,172	107,605	11578,862	4297,270	4719,075	41,896	0,000
RL_MxA + MdS	Park et al. 2012	-138,780	930,111	865105,774	-1961,763	1684,203	-0,149	0,881
RL_MxA + MdS	Brunetto et al. 2014	-480,910	706,298	498856,261	-1865,228	903,408	-0,681	0,496
RL_MxA + MdS	Gokce et al. 2014	1449,000	57,400	3294,760	1336,498	1561,502	25,244	0,000
RL_MxA + MdS		1430,400	57,103	3260,805	1318,480	1542,321	25,049	0,000
Overall		2083,288	50,312	2531,252	1984,680	2181,897	41,408	0,000



Heterogeneity: RL_MdS - Q-value:11.48, p-value:0.00, I2:91%, Tau2:12916746.7, Tau:3593.98; RL_MMA - Q-value:28.98, p-value:0.00, I2:86%, Tau2:2008776.91, Tau:1417.31;
RL_MxA+MdS - Q-value:10.27, p-value:0.00, I2:80%, Tau2:1319445.68, Tau:1148.67;

Anexo 2. Análise de sensibilidade – Comparação das alterações do volume por regiões (retrolingual)

Group by Subgroup within study	Study name	Statistics for each study						
		Difference in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
MMA	Abramson et al. 2011	135,700	38,767	1502,865	59,718	211,682	3,500	0,000
MMA	Brunetto et al. 2014	45,400	19,779	391,203	6,634	84,166	2,295	0,022
MMA	Raffaini and Pisani 2013	188,650	41,423	1715,855	107,463	269,837	4,554	0,000
MMA	Zinser et al. 2013	39,000	2,660	7,077	33,786	44,214	14,660	0,000
MMA	Schendel et al. 2014	101,103	22,548	508,402	56,910	145,296	4,484	0,000
MMA		89,946	23,091	533,202	44,688	135,203	3,895	0,000
Overall		89,946	23,091	533,202	44,688	135,203	3,895	0,000



Heterogeneity: Q-value:26.39, p-value:0.00, I2:84%, Tau2:1992.19, Tau:44.63;

Anexo 3. Análise de sensibilidade – Comparação das alterações da área mínima axial (subgrupo MMA)