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Systematic Review and Meta-Analysis
Orthognathic Surgery

Upper airway dimensions in patients undergoing orthognathic surgery: a systematic review and meta-analysis

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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 assessed using three-dimensional images. An electronic search was performed in Cochrane Library, Medline, Scopus, VHL, Web of Science, and the System for Information on Grey Literature in Europe, ending January 2015. Inclusion criteria encompassed clinical studies in humans, patient age >15 years, patients submitted to maxillary or mandibular advancement or setback surgery, isolated or in combination, and presentation of airway measures, specifically volume and/or minimum cross-sectional area (CSA), obtained from computed tomography or magnetic resonance imaging. Additional searches were conducted on the references of included articles and in the NLM catalogue. An assessment of the risk of bias was performed. A total of 1180 studies were retrieved, of which 28 met the eligibility criteria; one was later excluded as it presented a high risk of bias. A meta-analysis was performed. There is moderate evidence to conclude that the upper airway minimum CSA increases significantly (124.13 mm^2) after maxillomandibular advancement (MMA); the total volume increases significantly after MMA (7416.10 mm^3) and decreases significantly after maxillary advancement + mandibular setback (−1552.90 mm^3) and isolated mandibular setback (−1894.65 mm^3).

Key words: upper airways; orthognathic surgery; imaging; three-dimensional.

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The upper airways are of increasing interest to the different medical professionals working in the head and neck region, primarily due to the associations between 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 relationship between the soft and skeletal tissues. Maxillary and/or mandibular surgical replacement can cause different changes in the area and volume of the oral and nasal cavities, depending on the magnitude and direction of correction,[1,4] and subsequently may influence the quality of sleep of treated patients in the long term, when associated with risk factors.

According to Mattos et al.,[5] the airway anteroposterior length may be altered in the following ways: a decrease in the region of the soft palate and base of the tongue after isolated mandibular setback (MdS) surgery; an 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 an increase in the soft palate region after maxillomandibular advancement (MMA) surgery. However, these results were based on cephalometric analyses.

Although cephalometry has been the recommended method for the analysis of craniofacial development for many years, the representation of the airways and other three-dimensional (3D) structures in two dimensions has its limitations.[2,6,7] It is known that computed tomography (CT) and magnetic resonance imaging (MRI)[6] allow linear, cross-sectional area (CSA), and volumetric assessment of the upper airways,[8,9] providing the otherwise unavailable useful quantitative and qualitative information. Both of these methods have been studied extensively and are considered reliable for reproducible assessment of the upper airways when based on well-defined parameters.[6,9–12]

No systematic reviews comparing changes in the airways resulting from different orthognathic surgeries exclusively using 3D examination have yet been reported in the literature. The systematic review by Mattos et al.[5] compared different types of orthognathic surgery and their effects on the upper airway dimensions; however, the meta-analysis used data from two-dimensional images only, as the four articles using CT were not comparable. Fernández-Ferrer et al.[13] assessed 3D images (CT) to investigate the results of one type of surgery (mandibular setback) only, and no meta-analysis was performed. It should also be noted that more than five new studies[14–19] have been published since the completion of the literature search of these two previous reviews.[5,13] Recently, an increase in this type of surgical assessment has been observed due to the introduction of these methods in the routine practice of surgeons and dentists, and also because of an increase in research in the field of OSAS (obstructive sleep apnoea syndrome). A search conducted on the Scopus database indicated an increasing number of publications on the subject, particularly 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 CSA and volume of the upper airway as assessed using CT or MRI.

Materials and methods

This review was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[20,21] The review protocol for this study was registered in the PROSPERO database as CRD42014013323 (http://www.crd.york.ac.uk/PROSPERO).

The inclusion criteria were as follows: prospective or retrospective clinical studies in humans; patient age >15 years; patients submitted to surgeries of maxillary or mandibular advancement or setback, isolated or combined; measurements of the upper airways, including volume and/or the minimum CSA, from the whole upper airway, retropalatal and/or retrolingual regions (pre- and post-surgical, or the difference between these times, with the standard deviation, *P*-value, or any other variability measures) obtained from CT or MRI. The exclusion criteria were the following: case reports, case series, review articles, editorials, reviews, and books; articles on reliability and/or comparison of methods or programmes of assessment; articles presenting only the axial area of specific levels; studies concerning patients who had craniofacial anomalies, lip and/or cleft palate, or patients who were systemically compromised; and studies concerning individuals who underwent orthognathic surgery involving transverse corrections or distraction osteogenesis.

Eligible studies that answered the PICO question (Table 1) were identified by an electronic search conducted in the following databases: Cochrane Library, Medline (via PubMed), Scopus, VHL (Virtual Health Library–Lilacs and BBO), Web of Science, and the System for Information on Grey Literature in Europe (OpenGrey). The end-point of the search period was January 9, 2015. Specific search strategies were developed for each database with the guidance of a librarian (DMTPF); the PubMed strategy is presented in Table 2. Details of the searches for all databases are provided in a supplementary file (Supplementary Material, Table S1). A complementary search was performed of journals referenced in the National Library of Medicine (NLM) catalogue (via PubMed) containing the entries of journals referenced in the NCBI database using the term 'oral and maxillofacial surg*'. The journals with their title in English that were once indexed in PubMed but are no longer indexed were selected for this additional search. A manual search of the reference lists of studies included in this systematic review was also performed.

Supplementary Table S1 related to this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ijom.2015.10.018.

Specific search strategy for each database.

After the exclusion of duplicate articles, two reviewers (IOC and COL) independently examined the list of titles and abstracts according to the eligibility criteria. The article was reviewed in full if the

Table 1. PICO question.

P – Population	Patients submitted to orthognathic surgery
I – Intervention	Surgical correction involving the anteroposterior aspects of the 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 using CT or MRI images
Question	What are the effects of orthognathic surgery for anteroposterior correction of the maxilla and/or mandible on the dimensions of the upper airways assessed using 3D images?

CT, computed tomography; MRI, magnetic resonance imaging; 3D, three-dimensional.