

Three-dimensional changes to the upper airway after maxillomandibular advancement with counterclockwise rotation: a systematic review and meta-analysis

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R. S. Louro, J. A. Calasans-Maia, C. T. Mattos, D. Masterson, M. D. Calasans-Maia, L. C. Maia: Three-dimensional changes to the upper airway after maxillomandibular advancement with counterclockwise rotation: a systematic review and meta-analysis. Int. J. Oral Maxillofac. Surg. 2017; xxx: xxx–xxx. © 2017 International Association of Oral and Maxillofacial Surgeons. Published by Elsevier Ltd. All rights reserved.

Abstract. The aim of this study was to evaluate the effect of counterclockwise (CCW) rotation and maxillomandibular advancement (MMA) on the upper airway space using three-dimensional images. An electronic search was performed in the PubMed, Cochrane Library, Scopus, Virtual Health Library, Web of Science, and OpenGrey databases (end date July 2016); a hand-search of primary study reference lists was also conducted. The inclusion criteria encompassed computed tomography evaluations of the upper airway spaces of adult patients undergoing orthognathic surgery with CCW rotation and MMA. The articles were evaluated for risk of bias with a tool for before-and-after studies. A meta-analysis was performed with the mean differences using a random-effects model. Heterogeneity was assessed with the *Q*-test and the *I*² index. The meta-analysis revealed significant ($P < 0.001$) increases in both the total airway volume (effect size of 6832 mm³ and confidence interval of 5554–8109 mm³) and the minimum axial area (effect size of 92 mm² and confidence interval of 70–113 mm²). The heterogeneity was low in both comparisons (*I*² = 38% and 7%, respectively). The technique of mandibular advancement with CCW rotation produced significant increases in the volumes and areas of the upper airway spaces.

Key words: upper airway; orthognathic surgery; systematic review; meta-analysis.

Accepted for publication 10 November 2017

The improvement of airway function during the treatment of dentofacial deformities is one of the goals required to achieve a good outcome. Research into the upper airways is a leading topic of study for the different medical professionals working in the maxillofacial region, primarily due to the association between morphological and volumetric changes after surgical treatments in this area.

Orthognathic surgery is performed to correct bone and soft tissue discrepancies. Maxillary and/or mandibular surgeries can cause different changes in the upper airway area and the volume of the oral and

nasal cavities, depending on the magnitude and direction of the correction¹⁻¹⁵. One of the most important procedures related to the improvement of airway volume is maxillomandibular advancement (MMA), which can also influence quality of life and the quality of sleep in many patients^{16,17}.

A recent technique in the performance of MMA is counterclockwise (CCW) rotation of the occlusal plane, which has been used widely to improve the aesthetic profile^{9,12,14}. This technique enhances the aesthetic profile of class II patients by optimizing the advancement of pogonion,

leading to a natural and harmonic morphology of the chin area. CCW rotation of the occlusal plane associated with MMA has been reported to provide better results in terms of airway function compared with MMA alone^{9,12,14}; however no systematic review has yet been reported in the literature on this specific type of surgery.

The evaluation of orthognathic surgery outcomes has traditionally been based on two-dimensional (2D) images, such as cephalometric X-rays, but the representation of the airways and other three-dimensional (3D) structures in 2D has its limitations^{13,18-22}. As an alternative, 3D

Table 1. The search strategy used for each database.

Database	Search strategy
PubMed	((((((((((((((((((Mandibular Advancement[MeSH Terms]) OR Mandibular Advancement[Title/Abstract]) OR Orthognathic Surgical Procedures[MeSH Terms]) OR Orthognathic Surg*[Title/Abstract]) OR Maxillary Osteotomy [MeSH Terms]) OR Maxillary Osteotomy[Title/Abstract]) OR Counterclockwise[Title/Abstract]) OR Counterclockwise[Title/Abstract]) OR Anti-clockwise[Title/Abstract]) OR Clockwise[Title/Abstract]) OR Jaw Surg*[Title/Abstract]) OR Bimaxillary Surgery[Title/Abstract]))) AND (((((((((((((((Cone-Beam Computed Tomography [MeSH Terms]) OR Cone-Beam Computed Tomography [Title/Abstract]) OR Imaging, Three-Dimensional[MeSH Terms]) OR Three-Dimensional*[Title/Abstract]) OR CAT Scan X-Ray[Title/Abstract]) OR 3-D Imag*[Title/Abstract]) OR Cone-Beam Computed Tomography[MeSH Terms]) OR CT Scan Cone-Beam*[Title/Abstract]) OR Tomography Cone-Beam Computed[Title/Abstract]) OR CAT Scans Cone-Beam[Title/Abstract]) OR I-CAT[Title/Abstract]) OR ICAT[Title/Abstract]) OR Tomography Cone-Beam Computerized[Title/Abstract]) OR CT Cone-Beam[Title/Abstract]) OR Volume CT[Title/Abstract]) OR CT Volume[Title/Abstract]) OR CBCT[Title/Abstract]) OR Cone beam computed tomography[Title/Abstract]) OR Cone Beam CT*[Title/Abstract]))
Scopus	(TITLE-ABS-KEY ((“Mandibular Advancement” OR “Orthognathic Surgery” OR “Maxillary Osteotomy” OR counterclockwise OR counter-clockwise OR anti-clockwise OR clockwise OR “Jaw Surgery” OR “Bimaxillary Surgery”))) AND (TITLE-ABS-KEY ((“Cone-Beam Computed Tomography” OR “Imaging Three-Dimensional” OR “CAT Scan X-Ray” OR 3-d OR 3d OR “Cone-Beam Computed Tomography” OR “CT Scan Cone-Beam” OR cone-beam* OR “Tomography Cone-Beam Computed” OR “CAT Scans Cone-Beam”))) OR (TITLE-ABS-KEY ((i-cat* OR icat* OR “Tomography Cone-Beam Computerized” OR “CT Cone-Beam” OR “Volume CT” OR “CT Volume” OR cbct OR “Cone beam computed tomography” OR “Cone Beam CT”)))
Web of Science	((“Mandibular Advancement” OR “Orthognathic Surgery” OR “Maxillary Osteotomy” OR Counterclockwise OR Counter-clockwise OR Anti-clockwise OR Clockwise OR “Jaw Surgery” OR “Bimaxillary Surgery”)) AND Tópico: ((“Cone-Beam Computed Tomography” OR “Imaging Three-Dimensional” OR “CAT Scan X-Ray” OR 3-d OR 3d OR “Cone-Beam Computed Tomography” OR “CT Scan Cone-Beam” OR cone-beam* OR “Tomography Cone-Beam Computed” OR “CAT Scans Cone-Beam” OR i-cat* OR icat* OR “Tomography Cone-Beam Computerized” OR “CT Cone-Beam” OR “Volume CT” OR “CT Volume” OR cbct OR “Cone beam computed tomography” OR “Cone Beam CT”))
Virtual Health Library	(tw:((tw:(mh:“Mandibular Advancement” OR mandibular advancement OR mh:“Orthognathic Surgical Procedures” OR orthognathic surg* OR mh:“Maxillary Osteotomy” OR maxillary osteotomy OR counterclockwise OR counter-clockwise OR anti-clockwise OR clockwise OR jaw surg* OR bimaxillary surgery)))) AND (tw:((tw: ((mh:“Cone-Beam Computed Tomography” OR cone-beam computed tomography OR mh:“Imaging, Three-Dimensional” OR three-dimensional* OR cat scan x-ray OR 3-d imag* OR ct scan cone-beam* OR tomography cone-beam computed OR cat scans cone-beam OR i-cat OR icat OR tomography cone-beam computerized OR ct cone-beam OR volume ct OR ct volume OR cbct OR cone beam computed tomography OR cone beam ct*)))) AND (instance: “regional”) AND (db:(“LILACS” OR “BBO” OR “IBECs”))
Cochrane Library	((((((((((((((((((Mandibular Advancement[MeSH Terms]) OR Mandibular Advancement[Title/Abstract]) OR Orthognathic Surgical Procedures[MeSH Terms]) OR Orthognathic Surg*[Title/Abstract]) OR Maxillary Osteotomy [MeSH Terms]) OR Maxillary Osteotomy[Title/Abstract]) OR Counterclockwise[Title/Abstract]) OR Counterclockwise[Title/Abstract]) OR Anti-clockwise[Title/Abstract]) OR Clockwise[Title/Abstract]) OR Jaw Surg*[Title/Abstract]) OR Bimaxillary Surgery[Title/Abstract]))) AND (((((((((((((((Cone-Beam Computed Tomography [MeSH Terms]) OR Cone-Beam Computed Tomography [Title/Abstract]) OR Imaging, Three-Dimensional[MeSH Terms]) OR Three-Dimensional*[Title/Abstract]) OR CAT Scan X-Ray[Title/Abstract]) OR 3-D Imag*[Title/Abstract]) OR Cone-Beam Computed Tomography[MeSH Terms]) OR CT Scan Cone-Beam*[Title/Abstract]) OR Tomography Cone-Beam Computed[Title/Abstract]) OR CAT Scans Cone-Beam[Title/Abstract]) OR I-CAT[Title/Abstract]) OR ICAT[Title/Abstract]) OR Tomography Cone-Beam Computerized[Title/Abstract]) OR CT Cone-Beam[Title/Abstract]) OR Volume CT[Title/Abstract]) OR CT Volume[Title/Abstract]) OR CBCT[Title/Abstract]) OR Cone beam computed tomography[Title/Abstract]) OR Cone Beam CT*[Title/Abstract]))

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