Review Article

Maxillo-Mandibular Advancement Surgery for Obstructive Sleep Apnea in Adults: Evidence from Overview of Systematic Reviews and Meta-Analyses

Ogundipe Olufemi[1], Okorie Oji[1], Ssentongo John[2]

[1]Department of Oral & Maxillofacial Surgery, Obafemi Awolowo University, Ile-Ife, Nigeria. Email: okogundipe@oauife.edu.ng
[2]Faculty of Medicine, Community Health Department. Mbarara University of Science and Technology. Email: 2023mph041@std.must.ac.ug.

Abstract

MMA surgery is used for the treatment of OSA. An overview of systematic reviews published regarding the single-stage MMA in the management of OSA was conducted. The Cochrane Library and PubMed/MEDLINE databases were searched. A qualitative data analysis was undertaken, with quality assessment completed using the Assessment of Multiple Systematic Reviews (AMSTAR) tool. The initial search yielded 814 articles, the titles and abstracts of 787 articles were screened and the full texts of 128 articles were assessed for eligibility. Twenty-five articles met the inclusion criteria while thirteen were excluded because the systematic reviews included surgical procedures other than single-stage MMA. Finally, twelve systematic reviews were analyzed. The AMSTAR score ranged from 2-11. Only two of the SRs included **randomized controlled trials (RCTs)**, **while the majority of the included primary studies were retrospective in design**. The umbrella review presents significant insights into the strengths and limitations of the current systematic reviews on the role of single-stage MMA in the treatment of OSA, uncovers gaps in knowledge, and highlights the need for higher-quality prospective studies to strengthen the evidence base

Keywords: Obstructive sleep apnea, orthognathic surgery, maxillomandibular advancement, systematic review overview, surgical outcomes

Introduction

Obstructive sleep apnea (OSA) is a prevalent condition characterized by repetitive episodes of partial or complete obstruction of the upper airway during sleep, leading to oxygen desaturation, disrupted sleep and associated morbidities[1, 2].

This condition is associated with significant health risks, including hypertension, cardiovascular disease, stroke, and impaired neurocognitive function[3].

Maxillomandibular advancement (MMA) is an integral part of the surgical treatment of obstructive sleep apnea[4]. This extra-pharyngeal procedure, involves a Le Fort I osteotomy of the maxilla and bilateral sagittal split osteotomies of the mandible to advances the maxilla, mandible, and attached anterior pharyngeal tissues (including the soft palate and tongue) thereby expanding the velo-orohypopharynx structurally and enhancing pharyngeal dilator muscle tone physiologically to alleviate airway obstruction[2, 5].

The American Academy of Sleep Medicine Practice parameters for the treatment of obstructive sleep apnea syndrome in adults by surgical modification of the upper airway published in 1996, updated in 2010[6], limits MMA to

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Address for correspondence: Ssentongo John. Faculty of Medicine, Community Health Department. Mbarara University of Science and Technology. Email: 2023mph041@std.must.ac.ug. Phone: +256771485915

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severe OSA cases as a last resort after other surgical approaches have failed. The evidence for the effectiveness of MMA as single stage procedure remains unresolved therefore, systematic and methodical investigations are needed to improve the quality of evidence, assess additional outcome measures, and determine which OSA severity will most likely to benefit from MMA procedure. An overview of systematic reviews analyzes and summarizes the available data to understand the information in MMA systematic reviews in order to make objective, evidence-based decisions in treatment planning and to identify any weaknesses, inconsistencies or unanswered questions regarding the role of single stage MMA in the surgical treatment of OSA.

Hence, this article aimed to synthesize current evidence from systematic reviews regarding MMA FOR OSA and to assesses the methodological quality of published SRs.

Methodology

The reporting of this overview of systematic reviews adheres to the Cochrane's recommendation on overview of systematic reviews[7], and the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement [8, 9]where relevant. A review protocol was developed and registered with PROSPERO; registration number CRD42016046484 (http://www.crd. york.ac.uk/prospero/display_record.asp?ID=CRD42016046484).

Search method

The electronic databases PubMed/MEDLINE, Web of Science, and Cochrane Library were searched using the search strategy outlined in Table 1. The search strategy was designed to identify SRs that focused on single stage MMA for the treatment of OSA. Systematic reviews of cleft/ syndromic patients / distraction osteogenesis were excluded from this overview. The last search was performed on 22nd April 2025. The complete electronic search strategies for all databases are available from the authors upon reasonable request.

Table 1: Electronic databases search strategy

ELECTRONIC DATABASES	SEARCH STRATEGY
PubMed/MEDLINE	(Systematic review OR review OR overview OR meta -analysis OR evidence-based medicine OR evidence -based dentistry OR revi ew literature OR literature review)
	AND
Web of Science	(obstructive OR "obstructive sleep apn*ea") OR (OSA)) OR ("sleep disordered breathing")) OR ("Sleep apn*ea syndrome")) OR ("apn*ea syndrome")
Cochrane Library	**AND**
	(mandibulo-maxillary surgery OR ("bimaxillary advancement")) OR ("maxillomandibular advancement")) OR ("two -jaw surgery")) OR ("double-jaw surgery")) OR ("orthognathic surgery")) OR ("mandibular advancement")) OR ("single -jaw surgery")) OR ("double-jaw surgery"))

Selection of reviews

The search results were exported into Endnote XXI (Thomson Reuters, CA, USA) and duplicates were removed. Two authors (O.K, SS) who were experienced knowledge synthesis methodologists, independently screened all titles and abstracts that were found in multiple searches to identify potentially eligible articles for inclusion. The reference lists of included reviews were screened manually for further relevant articles. Full text articles of all potentially eligible SRs were then selected based on inclusion and exclusion criteria. Disagreement was resolved by discussion among the investigators. The inclusion criteria were systematic reviews with or without meta-analysis, published in peer-reviewed journals and addresses the research question. Narrative reviews, scoping reviews were excluded. The study selection process was conducted and reported in accordance with the PRISMA 2020 guidelines

Data extraction and management

Two authors (OK, SS) extracted the following data from eligible systematic reviews independently: authors, publication year and title, method of analysis, number and study design of included studies, sample population (number, age and gender of patients), type of interventions, outcome measures and main findings, and follow up period. Any disagreement was resolved by consensus of all authors to ensure consistency and reliability of extracted data.

Assessment of overlap of primary studies

Overlap of primary studies across included systematic reviews was assessed qualitatively by examining the reference lists of all included reviews to identify repeated inclusion of the same primary studies. Given the substantial chronological overlap and shared core literature across systematic reviews of maxillomandibular advancement for OSA, a moderate degree of overlap was anticipated. This overlap was considered during interpretation of findings to avoid double counting of evidence and overestimation of effect sizes.

Management of discordant findings

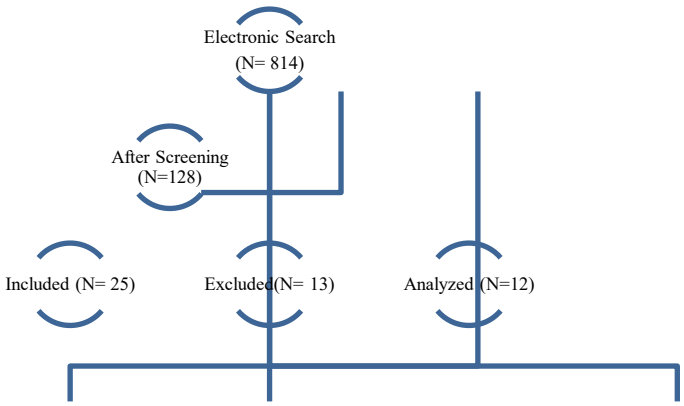
Where discrepancies existed between the findings or conclusions of included systematic reviews, greater interpretive weight was given to reviews with higher methodological quality (AMSTAR score ≥ 9), more recent publication dates, larger pooled sample sizes, and those that included meta-analyses. Conclusions were therefore based on consistency of evidence across higher-quality reviews rather than on isolated findings from lower-quality or older systematic reviews.

Assessment of methodological quality and risk of bias assessments of included reviews

The methodological quality of each identified SR was assessed independently by OK and SS, using the Assessment of Multiple Systematic Reviews (AMSTAR) tool[10]. The original AMSTAR tool was selected because several of the included systematic reviews predated the development of AMSTAR 2 and did not report all items required for critical domain appraisal under AMSTAR 2

Data synthesis

The findings from the overview of the included systematic reviews were summarized per narrative.

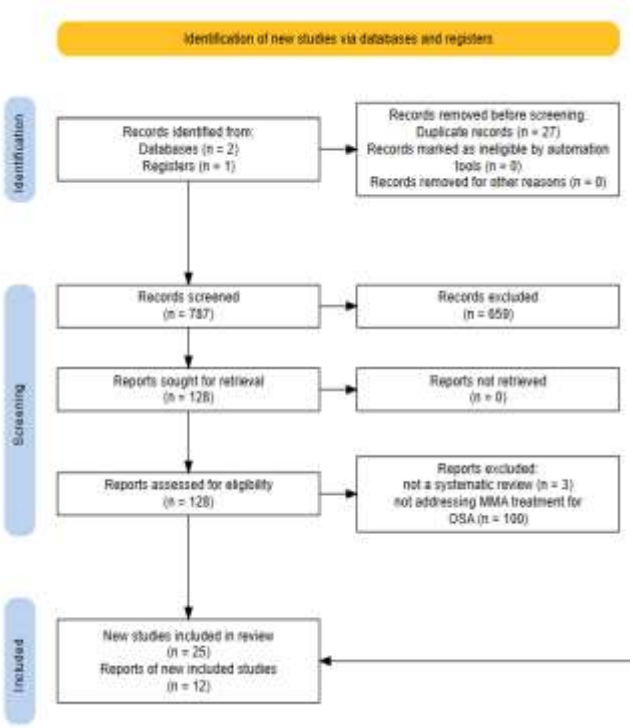


Generative AI Use: No generative artificial intelligence or AI-assisted technologies were used in the writing of this manuscript, production of images, or analysis of data.

Results

The search of electronic databases generated a total of 814 citations. Titles and abstracts of 787 articles were screened after removing duplicates. Full texts of 128 relevant articles were retrieved and assessed for their inclusion eligibility. Twenty-five articles have fulfilled both inclusion and exclusion criteria. Finally, thirteen articles were excluded [6,11-22,28,34-40]. Reasons for exclusion included inclusion of surgical interventions other than single-stage maxillomandibular advancement, inclusion of pediatric populations, absence of extractable outcome data specific to MMA, and narrative reviews without systematic methodology, while twelve articles [23-34] were included for further analyses. The study selection process is summarized in Fig 1[35].

Figure 1 presents the PRISMA 2020 flow diagram summarizing the study selection process. Following database searching, duplicate records were removed, after which titles and abstracts were screened for relevance. Full-text articles were subsequently assessed for eligibility, leading to the inclusion of twelve systematic reviews in the final qualitative synthesis



All the included systematic reviews reported data on the efficacy of MMA in improving objective and subjective sleep parameter, four [26, 27, 29, 34] of these systematic reviews focused on post-surgical airway changes, while one each investigated patient-reported Health-Related Quality of Life[23], long term outcome[24], outcome measure in obesity[25], outcome by dento-facial classification[31], outcome by racial variation[33] and outcome by technique of MMA[32] respectively. The characteristics of the included articles are shown in Table 2.

Table 2: Characteristics of the included systematic reviews

Authors, year, reference no	Type of Review	Database searched	Primary Studies					Follow up period	Quality Score	Findings	Reviewers' comments
	SR or MA		No of studies / subject	Type of study	M/F	Age range	Outcome				
Al-Bayyati, 2025, [23]	SR and MA (4)	PubMed Medline	12/317	OS, CS	NA	NA	Health-Related Quality of Life (HRQoL)	NA	8/11		Focus HRQoL, MMA tech not provided
Camacho, 2019, [24]	SR and MA	Cochrane, Google Scholar, Embase, CINAH, PubMed Medline	6/120	RS, PS, CS, Case series	80%-20%	NA		(1–<4 yrs), (4–<8 yrs), (≥8 yrs)	8/11		long-term outcomes Caucasian patients,
Diemer, 2025/[25]	SR and MA	PubMed, Scopus, CINAHL, Cochrane Library	14/ 143	RCT, PS, RS, CS, case series	80.2 % / 19.8 %	17–69 years	AHI, LSAT, ESS, RDI, ODI, SNA, SNB, PAS, MPH.		9/11	MMA improved OSA outcomes in obese	specific to obese OSA populations., low bias risk, detailed subgroup analysis by obesity class.
Giralt-Hernando, 2019,[26]	SR and MA	PubMed, Embase, Google Scholar Cochrane	8/159	RS, PS,	116/ 28	33–61 years (mean 39).	AHI, PAS, PAV, success rate, cure rate .	mean ≈ 12 months	10/11	MMA amount given	Focus on airway change as marker for AHI reduction
Gottsauner-Wolf, 2018, [27]	SR	PubMed	15/190	PS, RS,	Male only	NA	PAS, AHI, LSAT.	2–49 months (mean ≈ 12 months	6/11	MMA increase PAS	Demonstrated positive correlation between radiologic airway enlargement and AHI reduction.
Holty, 2010/[28]	SR and MA	Medline	22/627	case series, CS	88% male.	mean 44 ± 9 years	AHI, SpO_2 nadir, Epworth Sleepiness Scale, PAS, surgical success	Mean ≈ 5.3 range 3–44 month.	4/11	MMA decrease dmean AHI success rate = 86.0%, cure rate = 43.2%.	evidence of MMA efficacy and safety in OSA
Hsieh, 2013, [29]	SR	PubMed	15/ NA	RS, PS	N/A		AHI/RDI, minimum SpO_2, PAS	6 wks – 21.8 months	8/11	MMA enlarged upper airway	variable timing and measurement definitions.
John, 2018, [30]	SR and MA	PubMed	20/ 462	RS, PS, RCT, case series.	394 /68 (5.8:1)	Mean age: 43.2 years.	AHI, RDI, ESS, LSAT, BMI, surgical success	2–66 months media n ≈ 6 months	9/11	MMA reduced AHI, RDI	detailed forest and funnel plots, low publication bias.
Khan, 2025/[31]	SR and MA	PubMed, Scopus, CINAHL	N/A	N/A	N/A	N/A	AHI, LSAT, ODI, ESS, BMI.	6–24 months	4/11	MMA reduced AHI, ODI, ESS and increased LSAT.	skeletal class effect — robust meta-regression.
Knudsen, 2015/[32]	SR and MA (4)	Medline, PubMed Cochrane – Feb 2014)	8 /?	RC, OS, CS,	N/A	N/A	AHI, LSAT, PAV	3–24 months	6/11	MMA improved AHI and LSAT.	meta-analysis comparing CCW -MMA vs MMA. improvement, irrespective of rotation technique.
Nanu, 2024, [33]	SR and MA	PubMed, Scopus, CINAHL, Cochrane	20/ 469	case series	83.1 %,-16.9 %	N/A	AHI, LSAT, ESS, SNA, SNB, success rate.	Mean 8 months (range: 1–24 months).	9/11	MMA improved sleep indices	stratify MMA outcomes by race/ethnicity. Demonstrates significant PSG an d cephalometric improvement across all groups, with superior outcomes in Asians.
Rojo-Sanchis, [34]	SR and MA(3)	PubMed, Scopus, Embase, Cochrane grey literature	26/650	CS, PS, RS, Case-contrl .	80:70	NA	PAV, AHI, RDI, O_2, ESS.	6–12 months.	10/11	MMA increase PAV, improve ΔAHI , ΔRDI ,ΔO_2	grey-literature search.

SR= Systematic review, MA = meta-analysis, PS = prospective study, RS = retrospective study, CH= cohort study, RCT= randomized control trial, OS= observational study, PAV= posterior airway volume, PAS= posterior airway space, NA= not available

Although six reviews [24, 26-28, 30, 33] declared no conflict of interest and no funding, two reviews[23, 34] did not declare on funding status while two[29, 32] were funded.

Quality of systematic reviews (AMSTAR)

The AMSTAR score ranged from 2 to 11, indicating variable methodological quality across the included systematic reviews.. Further analysis with the AMSTAR score revealed that only two systematic reviews with high scores of 10 [26, 34], while three each with scores of 9 [25, 30, 33] and 8 [23, 24, 29] respectively, whereas the remaining systematic reviews have scored 6 or less. All the included systematic reviews reported on an 'a priori' design, and performed a comprehensive literature search with at least one electronic database.

Quality of evidence from primary studies in included reviews

The majority of primary articles were retrospective studies with only two randomized controlled trial (one each reported by [30] and [25]). Different quality assessment tools were used to assess the quality of primary studies in the studies that reported this data. According to established hierarchies of evidence, the predominance of retrospective cohort studies and case series corresponds largely to Level IV evidence, while the two randomized controlled trials represent higher-level (Level I–II) evidence. Consequently, although the volume of evidence is substantial, the overall certainty of evidence remains moderate.

Table 3: Quality assessment of included systematic reviews with AMSTAR tool

AMSTAR criteria	Al-Bayyati 2025/ [23]	Camacho 2019/ [24]	Diemer 2025/ [25]	Giralt-Hernando / 2019/ [26]	Gottsauner-Wolf/ 2018/ [27]	Holty 2010, [28]	Hsieh 2013/ [29]	John 2018/ [30]	Khan 2025 [31]	Knudsen 2015 [32]	Nanu 2024/ [33]	Rojo-Sanchis, 2018[34]
1.Was an 'a priori' design provided?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2.Was there duplicate study selection and data extraction?	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes
3. Was a comprehensive literature search performed?	Yes	Yes	Yes	Yes	CA	No	CA	Yes	Yes	Yes	Yes	Yes
4.Was the status of publication (grey literature) used as an inclusion criterion?	No	No	No	Yes	No	No	No	No	No	No	No	Yes
5.Was a list of studies (included and excluded) provided?	Partial No	No	No	No	CA	No	Yes	CA	No	CA	CA	CA
6.Were the characteristics of the included studies provided?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	CA	Yes	Yes	Yes
7. Was the scientific quality of the included studies assessed and documented?	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	CA	No	Yes	Yes
8. Was the scientific quality of the included studies used appropriately in formulating conclusions?	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	CA	No	Yes	Yes
9. Were the methods used to combine the findings of studies appropriate?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
10.Was the likelihood of publication bias assessed?	No	No	Yes	Yes	No	No	No	Yes	CA	Yes	Yes	Yes
11.Was the conflict of interest stated	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	CA	Yes	Yes	Yes

Yes, No, can't answer, not applicable, * sys rev with meta-analysis

Discussion:

The discussion integrates findings across efficacy, airway changes, surgical parameters, and patient selection, focusing on areas of consistency and uncertainty within the evidence base. This overview synthesizes current evidence on single-stage MMA for OSA and highlights the methodological quality of the available systematic reviews.

Efficacy of Maxillomandibular Advancement (MMA)

The evidence supporting the efficacy of single-stage maxillomandibular advancement for obstructive sleep apnea is derived predominantly from meta-analyses of observational studies. While these reviews consistently demonstrate substantial improvements in objective sleep parameters, the limited number of randomized controlled trials restricts the certainty of causal inference and necessitates cautious interpretation of effect magnitude.

Substantial observational evidence supports the efficacy of MMA when used as a single stage procedure, primarily derived from high-quality meta-analyses of cohort studies and case series. The strongest evidence comes from objective clinical measures, which are associated with 80% reduction in the Apnea-Hypopnea Index (AHI), an overall success rate of 88%, and statistically significant increases in Lowest Oxygen Saturation (LSAT).

These improvements appear durable over the long term, with AHI and LSAT gains generally maintained for 4-8 years post-surgery. However, beyond 8 years, mean AHI values may gradually increase, potentially approaching the threshold for moderate OSA[24].

Beyond objective measures, moderate to high-quality evidence demonstrates that MMA significantly improves patient-reported health-related quality of life (HRQoL) [23]. Approximately 90% of patients report high satisfaction with their surgical outcomes, underscoring both the clinical and subjective benefits of this procedure.

Mechanism of action and Optimization of MMA

Four systematic reviews [26, 27, 29, 34] provide evidence that MMA increase post airway space MMA is believed to alleviate airway obstruction by anatomically enlarging the maxillofacial structures, which consistently and are associated with significant increases in pharyngeal airway volume (PAV). This volumetric expansion directly correlates with reductions in AHI, establishing the anatomical basis for clinical improvement.

Surgical Parameters and Success Factors

Standard MMA protocols involve maxillary advancement of 10–12 mm, with greater advancement serving as an independent predictor of surgical success. Enhanced outcomes can be achieved by combining MMA with counterclockwise rotation of the occlusal plane (CCWROP), which yields superior reductions in AHI and larger increases in airway volume compared to MMA alone [32]

Patient Selection and Expected Outcomes

Baseline OSA severity influences both success rates and improvement magnitude. Patients with lower preoperative AHI values (AHI <60 events/h) tend to have the highest probability of achieving surgical success and complete cure. Conversely, those with more severe OSA (AHI >60 events/h) show the greatest absolute reduction in AHI, though cure rates are lower in this population.

MMA is generally effective regardless of baseline obesity status, but patient weight serves both as a descriptive characteristic and a predictor of success[25].

MMA has demonstrated efficacy as a treatment for obstructive sleep apnea across diverse populations, including Caucasians, Asians, and Latinos. However, outcomes vary significantly by race and ethnicity, with Asian patients consistently showing greater postoperative improvements compared to Caucasian patients. These racial differences underscore the importance of individualized surgical planning that accounts for population-specific craniofacial anatomy. Recognizing and adapting to these underlying anatomical variations is essential for optimizing treatment outcomes across diverse patient populations.

Conclusion

The results of this overview of systematic reviews offer a better understanding of published systematic reviews regarding the efficacy of single stage MMA as a procedure for obstructive sleep apnea (OSA) and highlight the current state of the evidence. The large majority of the studies included in meta-analyses are retrospective or prospective cohort studies and case series (Level 4 evidence). The quantity of high-level evidence, such as prospective randomized controlled trials (RCTs) is low. Although, the procedural effectiveness is high, but the overall strength of evidence for wider generalizability is limited by methodological constraints thus well-designed RCTs are required to establish robust evidence-based guidelines. **Therefore,** the current evidence indicates that **single-stage MMA** can be **effective in appropriately selected patients,** but the overall strength of this evidence is moderate, precluding broad generalizability. Future high-quality, prospective, and standardized research is essential to define optimal patient selection and surgical protocols.

Ethics statement: As an overview of previously published systematic reviews, this study did not involve direct human or animal subjects. All data were extracted from publicly available literature.

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