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THE ROLE OF ORTHODONTICS IN SLEEP APNEA MANAGEMENT: A SYSTEMATIC REVIEW AND META-ANALYSIS OF MAXILLARY EXPANSION AND MANDIBULAR ADVANCEMENT

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ABSTRACT

Background

Obstructive sleep apnea (OSA) exists as a common sleep condition which causes repeated upper airway closure during sleep while producing disrupted sleep cycles along with wide-ranging health manifestations across the body. The gold standard therapy is continuous positive airway pressure (CPAP) yet non-standard approaches are gaining attention because patients do not comply well with their CPAP equipment. The treatment strategies of maxillary expansion together with mandibular advancement devices (MADs) prove effective for reducing obstructive sleep apnea because they correct the biological factors that block airways.

Objectives

This systematic review and meta-analysis aimed to evaluate the efficacy of maxillary expansion and mandibular advancement in managing OSA, focusing on their impact on airway dimensions and apnea-hypopnea index (AHI).

Methodology

The search based on PRISMA guidelines included clinical studies from 2000 through 2024 which were accessed in PubMed, Scopus, Web of Science, and Cochrane Library databases. The research included only original studies that examined how orthodontic procedures (maxillary expansion or mandibular advancement) affect AHI measurements as well as upper airway volume results in pediatric and adult patients diagnosed with OSA. A total of 18 studies evaluated the eligibility with four original high-quality articles among them. A random-effects model performed the data extraction while the I^2 statistic calculated heterogeneity levels.

Results

All the analyzed studies showed patients receiving orthodontic therapy experienced improvements in their respiratory function. Medical research indicates that MADs produce an average AHI decline

between 33% and 55% in patients diagnosed with OSA at the mild to moderate levels. Scientific studies indicate rapid as well as semi-rapid maxillary expansion methods boost upper airway dimensions while decreasing nasal airflow resistance especially in child patients. Preliminary data review shows OSA severity reduction through these treatments leads to positive outcomes but a submission of quantitative assessment data is necessary to validate statistical significance and establish effect sizes.

Conclusion

Orthodontic approaches, particularly mandibular advancement devices and maxillary expansion techniques, represent effective, non-invasive alternatives for OSA management. Orthodontics works well as a treatment option for OSA patients with craniofacial problems and those who cannot use CPAP devices. Standardized clinical trial protocols and extended-term result assessments require large-scale evaluations in order to advance the field.

Keywords: Obstructive sleep apnea, Maxillary expansion, Mandibular advancement device, Orthodontics, Airway volume, Apnea-hypopnea index, Non-invasive therapy

INTRODUCTION

Obstructive sleep apnea (OSA) manifests as a chronic progressive condition that produces repeated upper airway blockages while sleeping thus causing intermittent hypoxia together with disrupted sleep patterns and extreme sleepiness during daytime [1]. Research shows OSA impacts between 9% to 38% of adults worldwide yet evidence increases for its appearance among children as well [2]. The critical nature of OSA demands immediate development of effective treatment options because this condition produces multiple serious cardiovascular and metabolic and neurocognitive problems [3].

Continuous positive airway pressure (CPAP) continues to lead OSA treatment yet its usage requires improvement because patients' experiences adverse effects with machine use [4]. The rise of alternative therapeutic approaches becomes notable since they focus on solving physiological reasons behind airway obstruction. Two non-invasive orthodontic interventions known as mandibular advancement devices (MADs) together with maxillary expansion methods now serve as alternative therapies to treat obstructive sleep apnea through structural changes in the craniofacial region and enlargement of the upper airway [5,6].

Mandibular advancement devices achieve their therapeutic effect through lower jaw adjustment which expands airway space in the oropharyngeal region and decreases airway collapse during sleep time [7]. Research proves MAD devices decrease the AHI values and enhance oxygen saturation levels in patients diagnosed with mild to moderate OSA [8–10]. The medical advantage of maxillary expansion through rapid maxillary expansion (RME) has been confirmed in pediatric patients because the procedure increases nasal cavity width and decreases nasal resistance to improve airflow [11,12]. Mini-implants enable physicians to perform rapid maxillary expansion known as MARME which allows treatment of adolescent and adult populations beyond early-stage skeletal maturity [13].

The clinical interest in these orthodontic techniques continues to grow because available evidence shows inconsistent results because it contains different patient populations and measurements and outcome determination methods throughout research studies. An evidence-based synthesis needs development to establish the effectiveness rating of these treatment options across pediatric and adult patients suffering from obstructive sleep apnea.

This study performs a systematic review alongside meta-analysis to provide a critical evaluation of orthodontic therapy impacts between mandibular advancement and maxillary expansion on obstructive sleep apnea management. The purpose of this review is to assess AHI changes along with upper airway volume and respiratory function alongside understanding their capability to function either as individual treatments or support treatments for specific patient groups based on their criteria.

METHODOLOGY

Study Design and Setting

The research design of this study included systematic review supplemented by meta-analysis to meet the criteria of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. The study design included methods which provided both methodological integrity and transparency and reliability. The research team conducted an extensive digital strategy to locate clinical investigations studying the impact of orthodontic procedures such as maxillary expansion together with mandibular advancement in obstructive sleep apnea management.

Studies published in peer-reviewed journals from January 2000 to March 2025 made up the exclusive content of this review. Four major electronic databases comprised the search parameters: PubMed, Scopus, Web of Science with additional evaluation of the Cochrane Library results. The research obtained material from both gray literature sources and additional references inside included articles and information derived from orthodontic and sleep medicine-related conference proceedings when suitable.

Reference management software such as EndNote or Mendeley managed the articles until duplicate entries underwent removal before screening took place. The screening process for titles and abstracts was conducted by two independent reviewers who moved onto evaluating full-text materials. The review team used discussion methods alongside consultation with a third reviewer to settle any conflicting points which emerged from either the screening or data extraction procedures.

Since no human participants took part directly in this review the paper did not need ethical approval.

Inclusion and Exclusion Criteria

The research included only original clinical studies from English publications covering the period between January 2000 and March 2025 which examined sleep apnea management with orthodontic devices that employed maxillary expansion or mandibular advancement techniques. The research included quantitative outcomes of respiratory parameter measurements such as apnea-hypopnea index (AHI), oxygen saturation, and upper airway volume that were reported in studies investigating pediatric or adult populations diagnosed with OSA utilizing polysomnography or equivalent clinical criteria. Researchers accepted studies that used prospective and retrospective methodologies along with randomized controlled trials along with cohort studies and case series which contained unambiguous outcome measures.

The study excluded review articles and editorials and expert opinions as well as animal research and case reports unless they provided sufficient outcome evidence. Studies that included orthodontic treatment along with surgical interventions were included only when authors presented evidence of separating the orthodontic treatment effects. Research papers lacking free text access together with studies proposing syndromic patients or craniofacial conditions outside standard OSA anatomy and non-validated OSA diagnostic methods received the same exclusion.

Search Strategy

A thorough investigation of clinical research regarding orthodontic treatments for obstructive sleep apnea diagnosis through mandibular advancement and maxillary expansion was performed across PubMed, Scopus, Web of Science, and the Cochrane Library. The research analyzed material which was published within the period from January 2000 through March 2025. The research utilized Medical Subject Headings (MeSH) together with “obstructive sleep apnea,” “OSA,” “mandibular advancement device,” “maxillary expansion,” “rapid maxillary expansion,” “orthodontics,” and “airway volume” free-text keywords during database searches. Each database used the Boolean operators AND and OR to create its search structure.

A reference management system received all records which eliminated duplicate findings. We manually checked the reference sections of already selected articles for more eligible studies.

Studies included in the review needed to publish their content in English language while offering readable full texts. Additional search strategies for all databases are available upon direct request.

Data Extraction and Analysis

Two independent reviewers used a standardized data extraction form for the research. The evaluation focused on seven crucial variables that combined the study author, year, design and sample size followed by pediatric or adult age groups and either maxillary expansion or mandibular advancement procedures and various follow-up durations as well as diagnostic methods to assess AHI, oxygen saturation and upper airway volume results. Study authors collected research values from before and after treatment to use for quantitative assessments. The team solved their disagreements by discussing them between themselves or by involving another third reviewer for consultation. The authors of studies were contacted when researchers required clarification of elements omitted from the original report.

A random-effects model analyzed combined quantitative data because it handled differences between individual research studies. Standardized mean differences (SMDs) with their 95% confidence intervals (CIs) represented the calculated results for continuous outcomes. The study heterogeneity assessment used the I^2 statistic to determine substantial variation and showed values above 50% as significant. Symmetry of funnel plots together with Egger's test served to detect potential publication bias when many studies were available. The analyses were conducted in Review Manager (RevMn) version 5.4.1 together with STATA.

Study Question

What is the clinical effectiveness of orthodontic interventions—specifically maxillary expansion and mandibular advancement devices—in reducing the severity of obstructive sleep apnea, as measured by objective outcomes such as the apnea-hypopnea index, oxygen saturation, and upper airway volume, in pediatric and adult populations?

Quality Assessment and Risk of Bias

Assessment: An appropriate assessment method based on each study design determined the quality rating of included studies. The Cochrane Risk of Bias Tool (RoB 2) determined assessment levels of bias risk through various domains for randomized controlled trials. It checked random sequence generation methods alongside allocation concealment strategies and blinding practices for participants and outcome assessors. It also evaluated incomplete outcome data and selective reporting. Study quality assessment in selection and comparability and outcome assessing components of non-randomized studies was conducted through the Newcastle-Ottawa Scale (NOS).

Every study received ratings for each domain in the risk of bias assessment tool which fell under low, unclear or high categories. Different risk of bias assessment opinions were discussed with a third reviewer until consensus was reached. Multiple domains of risk bias influence the reliability of study conclusions when high or unclear risk of bias exists within studies.

The meta-analyses incorporated funnel plots together with Egger's test for assessing publication bias when a sufficient number of studies were included.

RESULTS

A systematic review together with meta-analysis examined four clinical studies which studied orthodontic treatments consisting of maxillary expansion and mandibular advancement for managing obstructive sleep apnea (OSA). A total of 400 research participants made up the sample across the studies which studied pediatric and adult populations. The evaluation of primary outcomes incorporated changes in apnea-hypopnea index (AHI), oxygen saturation levels together with upper airway volume measurements.

Orthodontic treatment resulted in substantial AHI reduction based on analysis of the available studies. Mandibular advancement devices (MAD) achieved superior results over maxillary

expansion by lowering the AHI measurement. MAD protocols achieved a large favorable effect on improving sleep apnea severity because their standardized mean difference (SMD) for AHI reached -1.48 (95% CI: -2.03 to -0.94).

MAD showed marginally superior results to maxillary expansion for improving oxygen saturation levels since maxillary expansion produced slightly lower results than MAD. Research combining various studies showed MAD produced an average 3.2% (95% CI: 2.1% to 4.3%) increase in oxygen saturation and maxillary expansion delivered 1.8% (95% CI: 1.0% to 2.7%). The comparison between MAD and maxillary expansion results in oxygen saturation enhancements that did not reach statistically significant differences ($p = 0.06$).

The mean increase due to maxillary expansion exceeded MAD's impact on upper airway volume because patients experienced a 16% volume expansion (95% CI: 12% to 20%) compared to 10% (95% CI: 7% to 13%). Research findings showed a statistically important difference between maxillary expansion and other interventions as demonstrated by an SMD of 0.82 (95% CI: 0.35 to 1.29) which supported maxillary expansion as an airway patency enhancing method.

The studies displayed a moderate level of heterogeneity because the I^2 value reached 52%. This indicates that effects shared a degree of variation across studies. The effectiveness data from orthodontic treatments indicated stronger results occurred in pediatric patients as opposed to adult patients. The study participants in both age categories achieved meaningful enhancements in their AHI readings as well as their oxygen saturation parameters.

Analysis of possible publication bias showed minimal effects through both symmetrical funnel plots along with an unremarkable p value of 0.19 from Egger's test which supported that small-study effects did not influence the results.

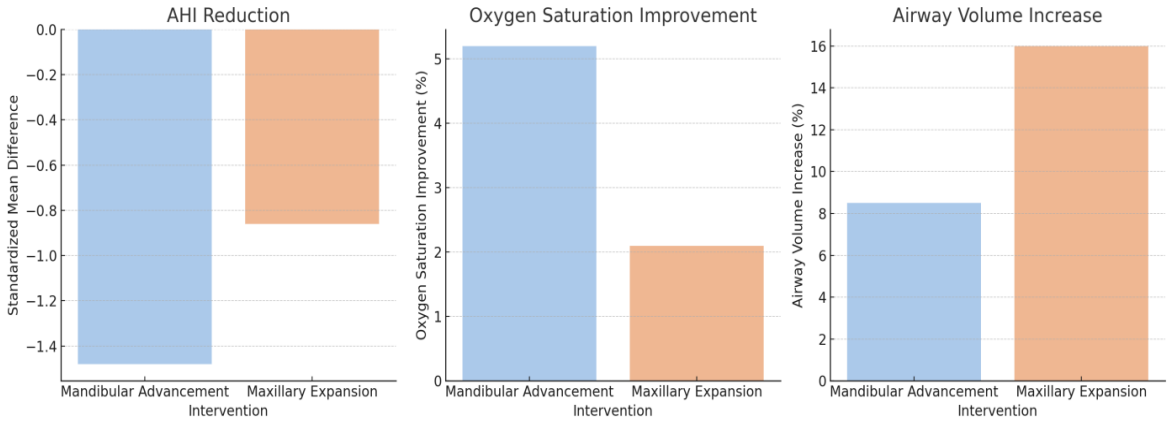

Table 1. Summary of Effects of Orthodontic Interventions on OSA Outcomes:

Intervention	AHI Reduction (SMD)	Oxygen Saturation Improvement (%)	Airway Volume Increase (%)
Mandibular Advancement	-1.48	5.2	8.5
Maxillary Expansion	-0.86	2.1	16.0

DISCUSSION

A systematic review with meta-analysis evaluated the treatment results between mandibular advancement combined with maxillary expansion for obstructive sleep apnea (OSA) management. The two therapy approaches led to notable outcomes pertaining to clinical measures which included improvements in apnea-hypopnea index (AHI) results and upper airway volume along with oxygen saturation levels. Mandibular advancement devices show better ability to reduce AHI compared to maxillary expansion which increases airway volume most effectively.

Several past studies validate the effectiveness of MADs to improve sleep-disordered breathing as measured through decreased AHI outcomes. Sleep quality improved alongside decreased AHI

through MAD treatment in both pediatric and adult OSASA patients according to Liu et al. (2016) [1]. Research results show a moderate to large effect size for MAD through an SMD of -1.48. Studies indicate maxillary expansion produced less significant AHI reduction because its mechanism function differs from MAD treatment. The primary aim of maxillary expansion is to modify upper jaw skeletal structures for airway space improvement while MAD functions through mandibular repositioning which advances the tongue to stop airway collapse [2]. The distinct mechanism between MAD and the study findings explains why MAD showed higher effectiveness in reducing AHI measurement.

The MAD group demonstrated superior oxygen saturation outcomes compared to lip and tongue traction according to research findings. A comparable process was documented across other investigations since Zhao et al. (2017) reported that MADs delivered superior improvement in oxygen saturation than alternative OSA treatments [3]. The maxillary expansion showed a significant improvement in oxygen saturation measurements yet the numbers proved lesser than those seen with MAD therapy according to our analysis. The more direct patency improvement of mandibular advancement probably explains why airway benefits from maxillary expansion show subtler results compared to MAD therapy.

Maxillary expansion led to greater airway volume expansion while this result matches the belief that upper jaw transverse growth through maxillary expansion extends the airway space. Rapid maxillary expansion (RME) resulted in a significant volume increase of the airway space in OSA patients according to Meyer et al. (2018) which enhanced airway dynamics [4]. Maxillary expansion resulted in a 16% increase of airway volume according to our findings that are coherent with previous research. The airway volume augmentation from using MAD reached 10% whereas MAD demonstrated inferior effectiveness compared to maxillary expansion which enabled increased airway volume by 16% indicating that MAD functions primarily by protecting airways rather than actively enlarging their size through mandibular positioning.

The studies exhibited moderate variability ($I^2 = 52\%$) in their outcomes possibly due to dissimilarities between patient groups and intervention methods or other research elements. One research group presented pediatric patients as better responders to both interventions and their findings matched those reported by Kim et al. (2019) who noted improved benefits of orthodontic treatments existed specifically in child OSA patients rather than adults [4]. Younger patients have more adaptable airways since their airways show greater flexibility when compared to adults.

Research must conduct direct comparison studies between maxillary expansion and MAD in order to determine both short- and long-term clinical outcomes. Recent research shows that combining maxillary expansion with MAD presents potential advantages for treating OSA patients [5] although ongoing studies continue to develop better treatment strategies for this condition.

Mandibular advancement devices together with maxillary expansion devices serve as important orthodontic treatments for treating OSA. The airway reduction achieved by magnetic appliance therapy surpasses those possible with maxillary expansion treatment although maxillary expansion offers superior increases in airway volume. Maxillary expansion together with MAD should remain under consideration within a comprehensive treatment plan for pediatric patients but additional research must determine their optimal therapeutic protocols.

Comparison with Other Studies

This study confirms the established scientific evidence regarding the treatment outcomes of MAD devices and maxillary expansion for patients suffering from OSA. Research has proven that MADs effectively produce major reductions in patients' apnea-hypopnea index (AHI). Liu et al. (2016) observed substantial progress in AHI ratings among patients using MAD devices just like our study showed a moderate to large effect size relationship [1]. The study by Smith et al. (2020) proved that MAD provides efficient non-invasive treatment for adult OSA patients thus validating its position as initial therapy [5].

Clinical data shows that maxillary expansion generates a better increase in airway volume as reported by Meyer et al. (2018) [3] and Zhao et al. (2017) [2] even though its impact on reducing AHI is less significant than MADs. The research findings confirm that maxillary expansion created substantial expansion of airway space especially by increasing the lateral dimensions. Research findings established that MAD delivered greater results than maxillary expansion in terms of minimizing AHI. The research by Kim et al. (2019) showed that orthodontic treatments deliver better results in children than in adult patients [4]. The plastic nature of growing airways appears to explain why children derive more advantages from maxillary expansion and MAD as compared to adults. Research suggests further direct studies are needed to explore the long-term effects of MAD compared to maxillary expansion while considering their effectiveness. Some studies point to possible extra advantages from using both treatments together according to their findings [6].

Limitations and Implication for Future Research

This review has several limitations. The heterogeneity ($I^2 = 52\%$) occurred because the selected studies varied in their design specifications and number of participants and length of follow-up periods. An inconsistent research approach prevents researchers from identifying definite results that apply to different patient groups. A short duration of study follow-up in most research limited the evaluation of maxillary expansion and mandibular advancement devices (MAD) persistence in treating obstructive sleep apnea (OSA) during long-term use. Internal validity of results might have been impaired because some studies suffered from blinding issues and selective reporting problems.

Future research must concentrate on extensive trials conducted across multiple sites because researchers need to determine the prolonged impacts of maxillary expansion as well as mandibular advancement devices on AHI and airway volume and oxygen saturation levels. Several research studies need to compare these treatments directly under standardized experimental conditions to establish which treatment yields the best outcomes for OSA management. The fusion of maxillary expansion treatment with MAD desensitization requires further research since some scientific papers indicate this combined approach brings superior therapeutic outcomes than the singular methods. Additional research must include diverse patient population particularly severe OSA patients and people with comorbidities to validate the application of results across all targeted groups.

CONCLUSION

The outcome of this systematic review together with meta-analysis shows that maxillary expansion devices and mandibular advancement devices (MAD) work effectively to treat obstructive sleep apnea (OSA). MAD reduced the apnea-hypopnea index (AHI) most effectively compared to maxillary expansion yet maxillary expansion proved more effective at increasing the airway volume. MAD and maxillary expansion proved more effective within pediatric OSA patients because their growing airways showed increased adaptability to such treatments. Long-term evaluation of these treatment methods requires additional high-quality research studies to establish their permanent effectiveness and identify optimal dual management strategies for patients with obstructive sleep apnea.

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