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Research Article

Comparison Of Adjustable And Fixed Oral Appliances For The Treatment Of Obstructive Sleep Apnoea- A Systematic Review.

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ABSTRACT

Introduction: Sleep apnea is defined as frequent episodes of apnea and hypopnea and functional impairment which could be life threatening. Obstructive sleep apnea (OSA) may be mild, moderate or severe. The treatment options available for the treatment of OSA is use of oral appliances in cases of mild to moderate sleep apnea and use of continuous positive airway pressure (CPAP) or surgery in cases of severe sleep apnea. Though CPAP is the gold standard for the treatment of severe sleep apnea, it lacks patient's compliance. Oral appliances are preferred by these patients as they are more convenient to use. The aim of the study was to compare the efficacy of two implant-retained Mandibular advancement devices in completely edentulous patients with Obstructive sleep apnea.

Materials and methods: A PRISMA-based systematic review was conducted. The checklist (Reporting Items for Systematic Reviews and Meta-Analyses) was used. A thorough computerized database search was carried out. EBSCO and PubMed were used. The keywords used in the search included "Obstructive sleep apnea" in addition to "Oral appliance" PLUS "Dentistry. Only full-text articles published in English are accepted and with a publication date within the previous ten years The years 2008-2023 were included.

Studies comparing fixed and removable oral appliances were taken into consideration. Another filter applied to the database search only returned articles about patients who are human. Following that, the titles and the significance of the abstracts of all papers in terms of the effectiveness and efficacy of oral appliances. If an abstract did not give enough information to decide whether to include or exclude it, the full text of the paper was retrieved for a more thorough evaluation. The initial search in the electronic database PubMed, using the keywords "Obstructive sleep apnea" AND "Oral appliance" AND "Dentistry," yielded 217 papers; the same search in the EBSCO database yielded 45 articles. As a result, the electronic database search yielded a total of 262 documents. Based on the title and abstract review, 190 papers were removed, leaving 72 suitable articles. The remaining 72 papers were submitted to a complete text examination, with 57 being eliminated. As a result, 15 studies were included in the current systematic review.

Results: The type of oral appliance employed in the research varies greatly. Ten of the studies utilized custom-made MADs, two used the Twin Bloc, two used prefabricated MADs, and one used a modified full denture. The quality of the evidence was moderate for ESS, AHI, and usage compliance due to the risk of bias of the included studies. The quality of the evidence was low for the outcomes SF-36 mental health sub score, physical functioning sub score, EDSI, and FOSQ due to risk of bias and small number of studies with small sample size; low evidence grading indicates that further research is very likely to have an important impact on our confidence in the estimate of effect and it is likely to change the estimate. The meta-analysis of SF-36 physical component summary and emotional quality of life as well as Trail Making B (cognitive function) provided very low quality of

evidence due to risk of bias, inconsistency, and imprecision; for those outcomes, we are very uncertain about the estimate.

Conclusion: The mandibular advancement device, as demonstrated in the current systematic review, is beneficial in delivering a successful treatment by improving the Apnea Hypopnea Index and the subjective symptoms of patients with obstructive sleep apnea and snoring. In the future, dentists should be more proactive in detecting patients with obstructive sleep apnea and offering dental appliance therapy as a viable alternative to existing treatment options.

Keywords: Mandibular advancement device, mechanical appliance, sleep apnea

INTRODUCTION

Simple snoring, upper airway resistance syndrome (UARS), and sleep apnea are all referred to as "sleep-disordered breathing" (SDB). According to previous studies, sleep apnea is characterized by frequent episodes of apnea (cessations) and hypopnea (discrete reductions) and symptoms of functional impairment that may be life-threatening and are linked to extreme daytime hyper somnolence, dysfunction, discernments in health-related quality of life, car accidents, and cardiovascular morbidity and mortality. (Terry Young, Peppard & Gottileb, 2002)(Young et al., 2002). Sleep apnea, which can be central, obstructive, or mixed, is the most common of all upper airway disorders (Brown, 1994). Obstructive sleep apnea, which can be mild, moderate, or severe, is a condition marked by frequent closure and reopening of the upper airway when a person is sleeping.(Kaambwa et al., 2024) This interferes with ventilation and can lead to periodic hypoxemia and hypercapnia. According to Partinen et al. (1988), OSA is also linked to increased risks for hypertension, ischemic heart disease, stroke, and death (Partinen et al., 1988).Obstructive sleep apnea is caused by repetitive upper airway obstruction during sleep as a result of narrowing of the respiratory passages.(Beri et al., 2023)
Initially, partial obstruction may occur and lead to snoring. As tissues collapse further or the patient rolls over on his or her back, the airway may become completely obstructed. Whether the obstruction is incomplete (hypopnea) or total (apnea), the patient struggles to breathe and is aroused from sleep. Often, arousals are only partial and are unrecognized by the patient, even if they occur hundreds of times a night. Obstructive episodes are often associated with a reduction in oxyhemoglobin saturation.(Mansour et al., 2023)
The diagnosis of OSA starts with a sleep history that is typically obtained in one of three settings: first, as part of routine health maintenance evaluation, second, as part of an evaluation of symptoms of obstructive sleep apnea, and third, as part of the comprehensive evaluation of patients at high risk for OSA.(Ou et al., 2023)
A diagnosis of OSA must be established by an acceptable method (Standard). The two accepted methods of objective testing are in-laboratory polysomnography (PSG) and home testing with portable monitors (PM). Polysomnography is a current gold standard diagnostic aid for sleep disorder breathing (Zou, Grote, Peker, Lindblad, Hedner, 2006). It provides data on respiratory effort, airflow, sleep state, and other variables.
Various treatments:
Behavioral Strategies: Behavioral treatment options include weight loss, ideally to a BMI of 25 kg/m2 or less; exercise; positional therapy; and avoidance of alcohol and sedatives before bedtime.
PAP: First described by Sullivan in 1981, PAP provides pneumatic splinting of the upper airway and is effective in reducing the AHI.PAP may be delivered in continuous (CPAP), bi-level (BPAP), or auto titrating (APAP) modes.
Oral appliance (OA) therapy. Oral appliance devices (OAs), which increase pharyngeal space by protruding the mandible and advancing the tongue thereby preventing pharyngeal collapse. The American Academy of Sleep Medicine practice parameters recommend the use of oral appliances as an alternative to CPAP for patients who prefer oral appliances or refuse or are unable to tolerate CPAP, particularly in mild to moderate OSA.
Surgical treatment: Surgical therapy includes a variety of upper airway reconstructive or bypass procedures, often site-directed and/or staged.(Ilea et al., 2021)
The preliminary subjective evaluation was done with the Epworth sleepiness scale (Johns, 1992), and the objective evaluation was done by a Nine channel study which recorded the apnea-hypopnea index (AHI) of the subject.

AIM AND OBJECTIVES:

Aim: The study aimed to evaluate the effectiveness of two implant-retained mandibular advancement devices, the MPA (mandibular positioning appliance) and MDSA (medical and dental sleep appliance), in patients with complete dentures who had obstructive sleep apnea.

Objective: The study's goal was to assess the effectiveness of two implant-retained mandibular advancement devices, the MPA (mandibular positioning appliance) and MDSA (Medical and dental sleep appliance), in patients with complete edentulousness and obstructive sleep apnea using the primary outcomes of the Apnea-Hypopnea index (AHI), oxygen desaturation level, heart rate, snoring, and the Epworth Sleepiness

MATERIALS AND METHODS:

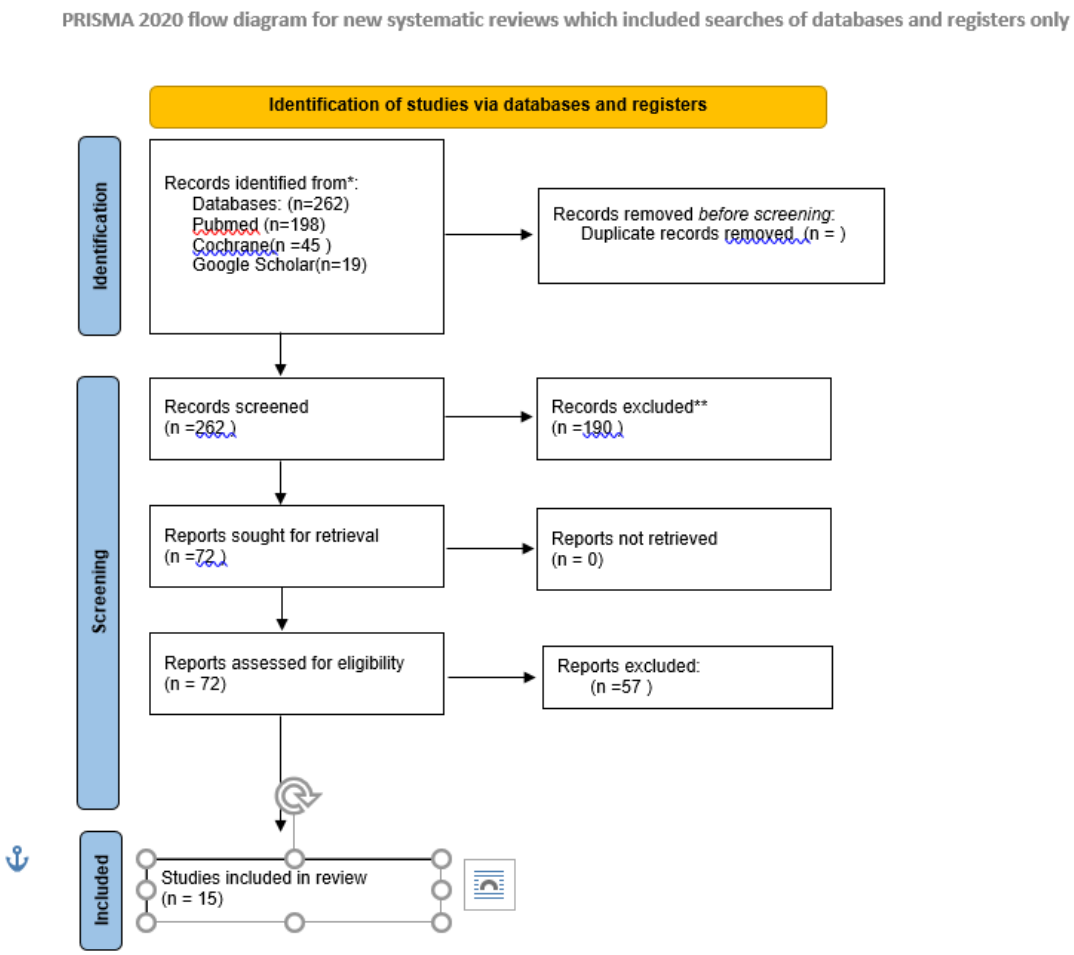
A PRISMA-based systematic review was conducted. The checklist (Reporting Items for Systematic Reviews and Meta-Analyses) was used. A thorough computerized database search was carried out. EBSCO and PubMed were used. The keywords used in the search included "Obstructive sleep apnea" in addition to "Oral appliance" PLUS "Dentistry. only full-text articles published in English are accepted and with a publication date within the previous ten years The years 2008-2023 were included.
Studies comparing fixed and removable oral appliances were taken into consideration. Another filter applied to the database search only returned articles about patients who are human. Following that, the titles and the significance of the abstracts of all papers in terms of the effectiveness and efficacy of oral appliances. If an abstract did not give enough information to decide whether to include or exclude it, the full text of the paper was retrieved for a more thorough evaluation. The initial search in the electronic database PubMed, using the keywords "Obstructive sleep apnea" AND "Oral appliance" AND "Dentistry," yielded 217 papers; the same search in the EBSCO database yielded 45 articles. As a result, the electronic database search yielded a total of 262 documents. Based on the title and abstract review, 190 papers were removed, leaving 72 suitable articles. The remaining 72 papers were submitted to a complete text examination, with 57 being eliminated. As a result, 15 studies were included in the current systematic review.
PubMed:
P: (((((((((OBSTRUCTIVE SLEEP APNEA) OR (SLEEP APNEA)) OR (SNORING)) OR (APNOEA)) OR (SLEEPINESS SCALE)) OR (sleep disordered breathing)) OR (sleep hypopnea syndrome)) OR (upper airway obstruction)) OR (sleep apnea syndrome)) OR (mixed sleep apnea)
I: (((((((Oral Appliance) OR (Adjustable devices)) OR (Thornton Adjustable Positioner)) OR (treatable mandibular appliances)) OR (customized mandibular appliances)) OR (mandibular advancement device)) OR (Treatable devices)) OR (mandibular advancement appliances)) OR (mandibular repositioning appliances)
C: ((((Oral Appliance) OR (Fixed devices)) OR (laminate acrylic material)) OR (bonded appliance OR (implant-retained mandibular advancement devices))
O: ((((((((((quality of life) OR (sleepiness)) OR (functional outcomes)) OR (foes)) OR (cognitive outcomes)) OR (Trail Making Test)) OR (efficacy)) OR (ahi)) OR (efficiency)) OR (compliance)) OR (adverse effects)) OR (side effects)) OR (complications)
Yielded 137 RCTs, 204 clinical trials

Inclusion criteria

- Only full text articles written in the English language and with the publication date within the last 10 years
- Articles which involved human patients were only used
- Studies on the effectiveness of CPAP versus MAD treatments in adults with obstructive sleep apnea were restricted to RCTs.
- Editorials, letters to the editor, case studies, animal studies, cost-effectiveness studies, pharmacokinetic research, and clinical guidelines were also eliminated, along with systematic reviews and literature reviews.

Exclusion Criteria

- In case the abstract did not provide sufficient information
- AHI of less than 5
- Studies done on children and articles that were not available in English were also excluded.



.Prisma Flow Diagram

Outcomes evaluated:

Quality of life

One of the primary outcomes was QoL of the patient, as measured by the 36-Item Short Form Survey (SF36). The SF-36 was designed for use in clinical practice and research, health policy evaluations, and general population surveys. In 36 questions, the form assesses eight health concepts including limitations on physical and social activities, pain, mental and emotional problems, as well as vitality and perceptions in health. The survey produces eight separate categories scores: a score of 0 for a high level of disability up to a 100 for no disability.

Sleepiness

Another outcome was sleepiness measured with the ESS or the Excessive Daytime Sleepiness Index (EDSI). In the ESS score, the total of points on a scale of 0 to 24 is added and interpreted; 0–5 is lower normal; 6–10 is higher normal; 11–12 is mild; 13–15 is moderate; 16–24 is severe.

Functional outcomes

The FOSQ is a comprehensive self-administered questionnaire that assesses the impact of excessive sleepiness on functional outcomes relevant to daily behaviors and sleep-related quality of life. It consists of 30 questions that take approximately 15 min to complete. The total value of FOSQ is between 0 (most severe impact in daily activities) and 120 (no impact on daily activities). An increase in FOSQ suggests an improvement in QoL.

Cognitive outcomes

The Trail Making Test is a neuropsychological assessment, which measures how fast a person can connect dots arranged numerically or alphabetically. Trail Making A uses only numbers, and Trail Making B uses numbers and letters. Higher scores correspond to better performance

Efficacy

Other outcomes reported in the eligible studies included the AHI measured with polysomnography during a sleep study. The AASM defines the AHI as the average of apneas and hypopneas on an hour during sleep. It is categorized as follows: AHI of 5–15 events/hour as mild; AHI of 15– 30 as moderate; AHI > 30 as severe.

Usage compliance, withdrawals, and side effects

Four included studies reported on objective usage compliance (downloaded data from CPAP) and two on self-reported compliance with CPAP; six of the included studies provided self-reported compliance with MAD. Withdrawals related to the intervention in each study group (CPAP or MAD) were also reported in some studies and included in a meta-analysis. Finally, adverse effects in both treatment groups were presented in table form.

Selection of studies, data extraction, and management

The title and abstracts of articles and reports resulting from the search strategy were screened by three review authors (M.S., L.A., and Y.L.H.). Full reports were obtained where trials met the inclusion criteria or where a clear decision could not be made from the title or abstract. Disagreements were resolved by discussion. Studies rejected at this or subsequent stages were recorded along with reasons for exclusion. Reviews and systematic reviews as well as all included studies were scanned for relevant trials. Data were extracted, independently and in triplicate, using a previously prepared data extraction form, which included the characteristics of trial participants, interventions, control groups if appropriate, and outcomes.

Table 1. Characteristics of Included Studies.

Reference	Year of publication. country	Study design, interventions and sample size (number of patients randomized and who completed the study)	Length of Tx (each Tx)	CPAP device	MAD details	Severity of OSA	Outcomes reported in the study
Aarab et al. 2011 [35]	2011 The Netherlands	RCT CPAP: 22 MAD 21 Placebo: 21	6 months	REMstar Pro System (Respironics, Herrsching, Germany). Manual titration	Adjustable mandibular protrusive	Mild to moderate	EDSI AHI SF-36
Barnes et al. 2004 [24]	2004 Australia	Crossover CPAP 97 MAD 99 Placebo 98	3 months	Sullivan Elite (ResMed. Australia).	Medical dental sleep appliance (R. J. and V.K. Bird. Australia)	Mild to Moderate	ESS AHI SF-36 FOSQ Trail Making B Minimum SpO2 (%)
Clark et al. 1996 [36]	1996 Israel	Crossover N - 23 random N=21 completed	2 weeks	CPAP device (Respironics, Murrysville PA. USA). Manual titration	Herbst device advanced the mandible 65% of the maximum protrusive range	AHI 15	EDSI AHI Minimum SpO2 (%)

Dal-Fabbro et al. 2014 [37]	2014 Brazil	Crossover 39 random N 29 completed	4 weeks	REMstar Plus (Respironics Murrysville, PA. USA). Auto titration	BRD is a MAD made of acrylic resin with two expanders to allow progressive mandibular protrusion	Moderate to severe	ESS AHI
Engleman et al. 2002 [28]	2002 UK	Crossover N 51 random N 48 completed	8 weeks	No details were specified about the device	Two MAD with and without occlusal coverage	AHI 5	ESS AHI SF-36 FOSQ
Ferguson et al. 1997 [38]	1997 Canada	Crossover N 24 random completed	4 months	REMstar Choice (Respironics, Murrysville, PA. USA) Tranquility Plus (Healthdyne Technologies Marietta, Georgia, USA).	Anterior mandibular positioner	Mild to moderate	ESS AHI
Gagnadoux et al. 2009 [25]	2009 France	Crossover N 59 random N= 56 completed	8 weeks	Sullivan S6 Elite (ResMed. Bella Vista, NSW, Australia). Manual titration.	Adjustable bi-bloc acrylic oral appliance (AMCTM: Artech Medical, Pantin, France)	(AHI): 34 13 events/hour	AHI Qol. Minimum SpO2 (%)
Hockema et al. 2008 [29]	2008 Netherlands	RCT CPAP. 52 MAD. 51	8 weeks	No details reported.	No details reported	No details reported	ESS AHI FOSQ SF-36

Lam al 2007 [26]	2007 China	RCT CPAP sleep hygiene. n 34 MAD sleep hygiene. . - 34 Sleep hygiene, 33	10 weeks	ARIA LX (Respironi cs, Atlanta. Georgia, USA) at a pre-titrated pressure	MAD modified from a function al activator (Harvold type)	Mild to moderate	ESS AHI SF-36 Minimum SpO2 (%)
Phillips et al. 2013 [27]	2013 Australi a	Crossover N = 126 random N 108 completed	4 weeks	ResMed Autoset S8 (ResMed, Bella Vista, Australia).	Somnod ent (Somno Med Ltd. Sydney, Australia). a custom	Moderate to severe	ESS AHI

Statistical analyses

The RCTs comparing CPAP to MAD intervention, reporting similar outcomes, were pooled into a paired meta-analysis. Trial authors were contacted to retrieve missing data when necessary. The analyses included only the available data (ignoring missing data). Clinical heterogeneity was assessed by examining the participants, interventions, and outcomes measures included in the trials. Statistical heterogeneity was assessed by means of Cochran's test for heterogeneity and quantified by the I 2 statistic. Estimates of effect were combined using a random-effects model if statistical heterogeneity was found (Q p value < .10); otherwise, the fixed effect model was used. All the outcomes reported in this review were continuous variables. Review authors calculated estimates of effect as mean differences of post-treatment data for all outcomes. Sensitivity analyses were conducted as follows: when baseline and post-treatment data were available, the change in the measured outcome from baseline to post-treatment was also calculated and reported as the BStandardized Difference of Means^ (SDM) as the effect measure. Pooled results with SDM as the effect measure were very similar to the results with BDifference in means^ for post-treatment data and only reported when the overall result differed significantly. SDM results are available upon request. Statistical analyses were conducted with the Comprehensive Meta-Analysis software version 2 (Biostat, Englewood, NJ, USA).

Levels of evidence and summary of the review findings

The quality of evidence assessment and summary of the review findings were conducted with the software GRADE profiler© (Grader©), following the Cochrane Collaboration and GRADE Working Group recommendations. Results Search results The initial search in July 2016 of three electronic databases yielded 240 unduplicated references, which were assessed independently by three review authors (M.S., L.A., and Y.L.H.). Based on the abstracts and titles, these were reduced to 14 relevant manuscripts. The main reasons for exclusion of these 226 references were that the study was not published in English (n = 1); or not a RCT (n = 24); or abstract lacked details for thorough review (n = 5); or was an editorial opinion (n = 5); or source reported a different outcome (n = 19); or included a different intervention, not comparing CPAP with MAD (n = 58); or included different population (either children, elderly, or adults with additional conditions such as epilepsy, Down syndrome, bariatric patients, pregnant women, or menopausal women) (n = 10); or included a different condition, not OSA patients (n = 8); or the reference reported clinical guidelines (n = 8); or a systematic review (n = 17). Finally, we excluded reviews (n = 69) and book chapters (n = 2) as they are secondary research data, not primary sources. The update of the search in March 30, 2017, yielded only one new study which was rejected, as it was a long-term study and it also used different parameters in evaluation of quality of life. All the 14 manuscripts identified as relevant to our question were searched for full-text and analyzed for inclusion independently by three review authors. Twelve manuscripts were relevant for inclusion. One reference was excluded after a fulltext review due to the fact that it was an abstract of a conference and not a full article; the second reference was excluded after a full-text review because it had a different outcome (blood pressure). The PRISMA flowchart shows a summary of our results.

Summary of included studies

Twelve studies were eligible for qualitative analysis where CPAP and MAD were used as intervention and their effect on OSA patients was compared. The studies included in this systematic review were randomized crossover trials or randomized parallel controlled trials comparing CPAP to MAD. A few of the studies included a third intervention group, in particular, a placebo oral appliance, placebo lactose tablet, conservative measures (sleep hygiene), or physical exercise. The total number of randomized participants ranged from 23 subjects in one study to 126 participants. The total randomized number of participants included in this systematic review is 743. The inclusion criteria among all eligible studies comprise patients with a history of mild or moderate to

severe obstructive sleep apnea. Most of the studies used only one treatment centre, with a few having two centres or three centres. The studies were open to adults over 18 years old, but the reported ages of the patients ranged from 30 to 65 years old.
In all included RCTs, all subjects underwent a baseline assessment including polysomnography first and then they were randomized to any of the possible options of treatment available (MAD, CPAP, or, if applicable, a third group—placebo treatment or other treatment) for a pre-determinate amount of time (2 weeks up to 6 months). Various types of CPAP and MADs were used in the studies (Table 1) with different titration protocols. The outcome measurements reported were quality of life and health perception (Short-Form General Health Survey, SF-36) , sleepiness (measured with the ESS or EDSI, FOSQ (Functional Outcomes of Sleep Questionnaire), cognitive performance, AHI, respiratory and sleep variables, anxiety and depression scores, objective or selfreported usage compliance, snoring, dropouts related to the intervention , and ambulatory blood pressure.

Summary of the risk of bias

A risk of bias table and a summary of risk of bias graph are presented in this review. The random sequence generation method was described in five studies, and those studies were assessed at low risk of bias. Study authors used block randomization, or a random permutation of a sequence, or a randomization list generated by the statistical analysis system. Six studies were identified as having unclear risk of bias, because the authors reported that the patients were randomized but did not provide any details on the method of randomization. One study was identified at high risk of bias, because the authors were not able to maintain the randomization through the clinical trial due to timing of dental device fabrication and patient preference, therefore breaking the randomization sequence. Allocation concealment was reported by three studies which were assessed at low risk of bias. Study authors used sealed envelopes to hide the sequence, or patients blindly selected a paper, or the randomization sequence was kept in a locked drawer by an independent co-worker. These techniques were used to conceal the allocations from the patients and the principal investigator. The allocation concealment was not stated in seven studies, and they were scored at unclear risk. One study was identified at high risk of bias because there was no allocation concealment described and the treatment order design was based on the patients' preference and timing of delivery of appliances.

Blinding

Is difficult when there are two different interventions (CPAP and dental device) given to the participants. Ten of the 12 trials were at unclear risk of bias, as the authors failed to report how blinding was achieved for all parties involved in the studies (participants, personnel delivering the intervention, outcome assessors, data analysts). Risk of bias assessment for blinding was high in one study [36]; this study did not follow the randomization sequence and took into account the patient's preferences to allocate patients to a treatment group; therefore, blinding was not possible for both participants and personnel delivering the intervention.

Meta-analyses

Only RCT studies on OSA patients comparing similar outcomes with the same interventions (CPAP and MAD) were included in the meta-analyses. The effect estimate was the difference in means for all the outcomes reported. When statistical heterogeneity was found (Q p value < .10), the random-effects model was used to report pooled results. Sensitivity analyses were conducted for the change in outcome between baseline and post-treatment using a different effect measure (standardized difference in means). Results of sensitivity analyses were only shown when results differed significantly from the mean differences (i.e., ESS)

RESULTS

Sleepiness outcomes

- Epworth sleepiness scale

Of the 12 eligible studies, all but two reported means and standard deviations (or standard error of the mean) of baseline and post-treatment ESS; ten studies were included in the meta-analyses. Statistical heterogeneity was found (Q p = .011; I 2 = 58%). There was no statistically significant improvement in sleepiness (ESS score) with CPAP compared to MAD users (random-effects model: difference in means = − 0.589; 95% CI = − 1.496 to 0.319; p = .203) (Fig. 3a). Sensitivity analysis with the effect measure reported as the standardized difference in means [SDM]: the SDM can adjust for differences in scale between studies as well as adjusts for differences in baseline ESS scores between CPAP and MAD groups. Statistical heterogeneity was found (Q p < .001; I 2 = 73%). The ESS improved significantly in the CPAP group from baseline to post-treatment compared to MAD users (random-effects model: SDM = − 0.267; 95% CI = − 0.530 to 0.003; p = .047). The improvement with treatment in each group might be better captured in the SDM analysis than the analysis using the difference in means, as it adjusts for a possible imbalance in baseline ESS. To better understand which analysis is more robust, we conducted cumulative analysis and Bone-study-removed analysis^ for the difference in means and the standardized difference in means. One concludes that we need more studies with balanced baseline ESS to understand if there is truly a statistical difference in ESS between groups.

-Excessive Daytime Sleepiness Index
Two studies reported post-treatment EDSI with no statistical heterogeneity among the two studies [36, 40]. There was no statistically significant improvement in EDSI with CPAP compared to MAD users (fixed-effect model: difference in means = 0.171; 95% CI = − 0.190 to 0.532; p = .354)

Polysomnographic outcomes

- Apnea–hypopnea index

Eleven studies reported mean and standard deviation of post-treatment AHI, and one study reported the mean and standard deviation of the change in AHI in each group. Statistical heterogeneity was found (Q p < .001; I 2 = 96%). CPAP decreased AHI significantly compared to MAD users (random-effects: difference in means = − 8.243; 95% CI = − 13.132 to − 3.354; p < .001)

Treatment compliance outcomes

Compliance usage (in hours per night)
Six studies included the patient's self-reported use of MAD in hours per night Of those six studies, four studies reported objective compliance with CPAP (time of use downloaded from the internal memory of the device) and two included subjective self-reported compliance with CPAP.
Quality of life (SF-36)
The 36-Item Short Form Survey (SF-36) scores are reported in a scale from 0 to 100, with 0 representing a very low level of quality of life score and 100 representing a very positive response. In consequence, an increase in a SF-36 score with treatment is interpreted as an increase in QoL in that item. Seven studies reported SF-36 outcomes ; however, two studies could not be included in the meta-analyses due to missing data.

Functional and cognitive outcomes

Functional outcomes of sleep questionnaire
Four studies reported mean and standard deviation of FOSQ after treatment. An increase in FOSQ suggests an increase in QoL. Statistical heterogeneity was not found (Q p = .597; I 2 = 0%), and the fixed-effect model was used. There was no statistically significant difference in mean FOSQ between CPAP and MAD users (difference in means = 0.033; 95% CI = − 0.206 to 0.271; p = .788)
Cognitive performance (Trail Making B)
Two studies reported data on post-treatment Trail Making B in seconds. Statistical heterogeneity was not found (Q p = .790; I 2 = 0%). There was no statistically significant difference in mean cognitive performance measured with Trail Making B test between CPAP and MAD users (difference in means = − 3.458; 95% CI = − 11.424 to 4.507; p = .395)

Summary of the evidence and quality of the findings (GRADE)

The quality of the evidence was moderate for ESS, AHI, and usage compliance due to the risk of bias of the included studies. The quality of the evidence was low for the outcomes SF-36 mental health subscore, physical functioning subscore, EDSI, and FOSQ due to risk of bias and small number of studies with small sample size; low evidence grading indicates that further research is very likely to have an important impact on our confidence in the estimate of effect and it is likely to change the estimate. The meta-analysis of SF-36 physical component summary and emotional quality of life as well as Trail Making B (cognitive function) provided very low quality of evidence due to risk of bias, inconsistency, and imprecision; for those outcomes, we are very uncertain about the estimate.

Table 2. Quality of Evidence

Outcomes	No. of participants (studies) Follow up	Quality of the evidence (GRADE)	Anticipated absolute effects Risk difference with the MAD group (95% CI)
Epworth Sleepiness Scale (ESS)	950 (10 studies) 1-4 months	OODO Moderate due to the risk of bias	The mean ESS in the CPAP groups was 0.589 units lower (1.496 lower to 0.319 higher), favors CPAP
Excessive.Daytime Sleepiness Index (EDSI)	90 (2 studies) 2-4 weeks	++++ Low2, due to the risk of bias, imprecision	The mean EDSI in the CPAP groups was 0.171 units higher (0.190 lower to 0.532 higher)
Change in SF-36 mental health score SF-36	386 (4 studies) 4-10 weeks	++++ Low2 b due to the risk of bias, imprecision	The mean SF-36 mental health score in the CPAP groups was 1.987 units lower (5.285 lower to 1.310 higher)
Change in SF-36 physical functioning score SF-36	386 (4 studies) 4-10 weeks	++++ Low2 b due to the risk of bias, imprecision	The mean SF-36 physical functioning score in the CPAP groups was 0.364 units higher (2.839 lower to 3.568 higher)
Change in SF-36 mental component summary SF-36	264 (2 studies) 1-2 months	+eee Very low2 b. c due to the risk of bias,	The mean SF-36 mental component score in the CPAP groups was 0.030

		inconsistency, and imprecision	units higher (7.307 lower to 7.367 higher)
Change in SF-36 physical component summary SF-36	264 (2 studies) 1-2 months	++++ Very low2, b. c due to the risk of bias, inconsistency, and imprecision	The mean SF-36 physical component summary score in the CPAP groups was 0.393 units lower (3.913 lower to 3.127 higher)
Functional Outcomes of Sleep Questionnaire (FOSQ)	559 (4 studies) 1-3 months	++++ Moderate due to the risk of bias	The mean FOSQ in the CPAP groups was 0.033 units higher (0.206 lower to 0.271 higher)
Trail Making B (cognitive function)	244 (2 studies) 2-3 months	++++ Very low b. c due to the risk of bias, inconsistency, and imprecision	The mean Trail Making B time (cognitive function) in the CPAP groups was 3.458 S lower (11.424 lower to 4.507 higher)
Apnea-hypopnea index (AHI) (events/hour)	824 (12 studies) 2-24 weeks	++++ Moderate due to the risk of bias	The mean AHI in the CPAP groups was 8.243 events/hour lower (13.132 to 3.354 lower), favors CPAP
Usage compliance hours per night	525 (6 studies) 4-12 weeks	++++ Moderate due to the risk of bias	The mean usage compliance in the CPAP groups was 1.101 h per night lower (1.844 to 0.358 lower), favors MAD

DISCUSSION

In summary, there were no statistically significant differences in quality of life, functional outcomes, or cognitive function outcomes in patients using CPAP versus MAD; however, CPAP was more efficacious decreasing AHI and oral appliance users showed significantly higher compliance (p = .004) than CPAP users.(L. Sharples et al., 2014) Results for ESS were unclear, with one meta-analysis (change in ESS from baseline measured with SDM) showing a significant difference favorable to CPAP (p = .047) and a second meta-analysis (difference in the mean post-treatment ESS) showing no statistically significant difference (p = .203). The main differences with prior reviews are sensitivity analyses conducted with two effect measures (difference in means and standardized difference in means) which showed contradictory results for ESS; we also did include the two sleepiness score questionnaires: ESS and EDSI; and conducted sensitivity analysis to adjust for possible discrepancy of over an hour between subjective and objective CPAP and discrepancy of 30 min for MAD use.(McDaid et al., 2009) Finally, we included multiple secondary outcomes not just QoL outcomes (SF36) as reported by Kunh et al. Tree databases were searched: MEDLINE, Cochrane Library, and Web of Science. We hand-searched the included studies and reviews to find any additional eligible studies. The results of this systematic review are applicable to adult patients of both genders with mild to severe OSA. (Kostrzewa-Janicka et al., 2017)The reported age of the participants ranged between 30 to 65 years old. Since the reported treatment duration ranged from 2 weeks to 6 months, this review cannot comment on the long-term efficacy of CPAP versus MAD.(Jonas et al., 2017) The studies were conducted in eight countries including Canada, China, France, and Israel, two in the Netherlands, two in Australia, two in Brazil, and two in the UK.(White & Shafazand, 2013) Only randomized controlled trials were included in this systematic review by choice of the authors, as high-quality RCTs can provide the best evidence in comparing the effects in quality of life and other outcomes between CPAP and MAD.(Quinnell et al., 2014) However, of the 12 RCTs included in the qualitative analysis, 7 of the studies were at overall unclear risk of bias, 5 were at high risk, and none was at low risk of bias.(Vanderveken et al., 2017) The quality of the evidence was very low to moderate due to the risk of bias, small total sample size below 400 participants, small number of eligible studies in each meta-analysis due to heterogeneity of the outcomes reported, and, in some cases, wide variance of point estimates and statistical heterogeneity.(L. D. Sharples et al., 2016) This systematic review included only RCTs comparing CPAP with MAD with similar reported outcomes. The main outcomes were SF-36, ESS, EDSI, FOQS, Trail Making B, AHI, compliance and withdrawals. These outcomes were mainly measured with polysomnography (objective outcomes) and questionnaires (subjective outcomes) before and at the end of each treatment.(McMillan et al., 2015) The patients' severity of OSA ranged from mild to severe. Some degree of clinical heterogeneity was found in terms of numerous factors. The studies included in this review had different study designs and treatment duration which ranged from 2 weeks to 6 months for each intervention.(Bratton et al., 2015) Different types of CPAP and MAD were utilized in the included studies with varied characteristics and titration procedures. The small number of included studies precluded subgroup analyses by type of CPAP device or MAD, treatment duration, and severity of OSA, to name a few.(Quinnell et al., 2014)

Agreements and disagreements with other studies or reviews:

This review of the evidence has shown that both MAD and CPAP improved AHI but CPAP was statistically significantly more efficacious, which agrees with previous review articles. For the quality of life (SF-36 score), our results indicated that both CPAP and MAD had similar improvement in mental health and physical functioning, which is also in agreement with previous reviews.(Law et al., 2023) In terms of functional outcomes, the results have shown that both CPAP and MAD improved the FOSQ scores with no statistically

significant differences, which agrees with previous review studies. With respect to sleepiness measured with ESS, prior reviews showed that both CPAP and MAD improve sleepiness symptoms equally though one review was close to statistical significance (p = .09) .(Ou et al., 2023) In this systematic review, results for sleepiness (ESS) are unclear: sensitivity analyses show a no significant difference in sleepiness in the CPAP group compared to the MAD users when using the ESS mean difference as effect size (p = .203) with ten studies and a statistically significant difference favorable to CPAP groups when using SDM as the effect measure (p = .047).(O'Toole et al., 2023) Change in ESS reported with the SDM is more sensitive to a possible imbalance of the groups at baseline taking into account the change in ESS from baseline to post-treatment, not just comparing the post-treatment data. Further studies are needed to clarify these results. A significant higher compliance with MAD than CPAP of 1.1 h per night was found in this systematic review which disagrees with Li et al. who found no statistical differences but agrees with Sutherland et al. No objective data were available for the MAD treatment use.(Belkhode et al., 2022) A possible bias in the meta-analysis is the fact that we are comparing subjective self-reported compliance in MAD users in all six studies with four studies reporting objective compliance (CPAP downloaded data) and two studies with self-reported CPAP usage. Therefore, we conducted a sensitivity analysis adjusting all self-reported average CPAP use by 1 h and all self-reported MAD use by 30 min with similar results (patients significantly more compliant with MAD by 0.9 h). Side effects were mostly mild to moderate in both groups except one study with severe adverse effects in 15% of the CPAP-treated subjects.(Segù et al., 2022) Though initial reviews with a small number of studies reported a significantly larger number of patients withdrawing from MAD groups compared to CPAP , our results confirm one recent review which found no significant difference in withdrawals.(Ilea et al., 2021) Though patients using CPAP show less compliance than MAD users by 1.1 h per night, they do not drop out of the study significantly. However, it has been shown that only about 50% of the patients use CPAP at least 4 h per night after 6 months. Longterm prospective clinical trials are needed to investigate whether or not patients using CPAP are more likely to withdraw than MAD users due to adverse effects. Additional studies are also needed to explore the effect of possible sources of heterogeneity including differences in CPAP and MAD devices, titration procedure, length of treatment, and OSA severity.(Aarab et al., 2020) These studies must use a 566 Sleep Breath (2018) 22:555–568 standardized methodology to assess objective and subjective outcomes and should try to minimize bias in the studies. The use of oral appliances as a viable alternative to treat patients suffering with mild to severe obstructive sleep apnea is a subject of great interest for dentists. In conclusion, although both CPAP and MAD improve the quality of life, sleepiness, and functional and cognitive outcomes in patients with OSA, this review presents a moderate quality of evidence to suggest a significant difference in favor of CPAP in reducing AHI.(Amaddeo et al., 2020) However, the level of self-reported usage compliance observed in the RCT's included in this review is favorable to the oral appliances. Our results confirm the conclusion of Sutherland et al. that BSimilar results in terms of health outcomes suggests that although the two treatments have different efficacy and treatment usage profiles, these result in similar overall effectiveness.(de Vries et al., 2019) As effectiveness is a combination of efficacy and treatment compliance, sleep medicine professionals should monitor treatment use and offer patients non-compliant with CPAP an oral appliance for treatment of OSA as recommended by the AADSM.(Saglam-Aydinatay & Taner, 2018) Further studies that evaluate the long-term effect of the patients' compliance and preferences over these two types of treatments are needed,as well as take into account the characteristics of each treatment (i.e., different types of devices, titration protocol) in order to better measure and compare the overall benefits that these devices have over quality of life and health of the patients suffering from OSA.(Saglam-Aydinatay & Taner, 2018)

CONCLUSION

The review highlights the effectiveness of mandibular advancement appliances (MADs) in improving sleep quality and addressing associated disorders like snoring, breathing pauses, and low oxygen saturation levels. MADs work by physically repositioning the lower jaw (mandible) forward during sleep, which in turn enlarges and stabilizes the airway passage, reducing the likelihood of obstruction. This advancement also stretches the soft tissues connected to the mandible, particularly the tongue, further preventing its collapse and obstruction of the airway. (Zou et al., 2006)The review mentioned suggests that adjustable MADs offer additional benefits compared to fixed devices. They not only result in significant reductions in obstructive events but are also more likely to provide successful therapy, particularly for individuals with moderate to severe obstructive sleep apnea (OSA).(Padma et al., 2007) By allowing for customization and fine-tuning of the mandibular advancement, adjustable MADs can better cater to individual needs and optimize treatment outcomes. Overall, this research underscores the effectiveness of MADs as a non-invasive treatment option for sleep-related breathing disorders, particularly OSA, by improving airflow and reducing the frequency of obstructive events during sleep.

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Conflicts of interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or nonfinancial interest (such as personal or professional relationships, affiliations, knowledge, or beliefs) in the subject matter or materials discussed in this manuscript.

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