

# Effect of Mandibular Advancement through Oral Appliance Therapy on Quality of Life in Obstructive Sleep Apnea: A Scoping Review

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## ABSTRACT

**Purpose:** The scoping review was conducted for the evaluation of effect of mandibular advancement through oral appliance therapy on quality of life in obstructive sleep apnea (OSA).

**Methods:** Strategic and thorough literature search using free text and MESH terms in three major database systems PubMed, SCOPUS, and Web of Science was undertaken till October 30, 2020, followed by PRISMA for the identification of studies for data extraction.

**Results and conclusions:** Summarization of evidence was done for study characteristics, and diagnostic methods for the evaluation of effect of mandibular advancement through oral appliance therapy on quality of life in OSA.

The literature supports that patients using mandibular advancement appliances (MADs) showed better adherence and compliance in comparison with those using continuous positive airway pressure (CPAP); along with the patients' compliance, the daytime sleepiness, state on waking, morning headache, oxygen saturation, frequency and intensity of snoring, and quality of sleep for both patients and their bed partners showed a marked improvement with MAD.

**Keywords:** Health status, MAD, Obstructive sleep apnea, Oral appliance, Quality of life, Scoping review.

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## INTRODUCTION

Recurrence of partial or complete upper airway obstruction during sleep leads to variable symptoms such as excessive daytime sleepiness,<sup>1</sup> snoring, gasping, snorting, insomnia, nocturia, bedwetting, memory loss or concentration issues, mood swings, irritation, and decreased libido.<sup>2</sup>

According to the Sleep Heart Health Study, the increased risk of moderate to severe obstructive sleep apnea (OSA) was 20% in blacks and 23% in American Indians compared with that of whites, that is, 17%.<sup>2</sup>

Higher risk for OSA was found in men than in women, even once women reach menopause risk for OSA increases similar in percentage to men.<sup>2</sup> The risk of OSA increases with age, and this may be due to a reduction in slow-wave sleep with age (i.e., deep sleep), which is a protective mechanism against sleep-disordered breathing and collapse of airway.

Comorbid conditions associated with OSA include stroke, hypertension, hyperlipidemia, myocardial infarction, glucose intolerance, diabetes, pulmonary hypertension, congestive heart failure, arrhythmias including atrial fibrillation, and depression. Patients suffering from moderate or severe OSA are at higher risk for these conditions.<sup>2</sup>

To assess the risk of OSA among the population, different questionnaires have been formulated, and the proposed notable ones among them are Berlin questionnaire (BQ), used in the setting for primary care, and the STOP-Bang Questionnaire, for the screening of preoperative procedures. The Epworth sleepiness scale (ESS) is used to assess sleepiness in both clinical practices and research work.

If clinically it is evaluated as OSA, it requires overnight testing for confirmatory diagnosis. The polysomnography (PSG) is the standard

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diagnostic test, in which monitoring of both sleep parameters and respiratory parameters is done. Behavioral modification measures, medical devices, and surgery are the treatments for OSA.<sup>3</sup>

Behavioral modifications include regular aerobic exercise, weight loss abstinence from alcohol, and not to sleep in supine position. In patients suffering from positional OSA [i.e., elevated apnea hypopnea index (AHI) predominantly in the supine position], avoid sleeping to the side or sleeping in prone position is the treatment. Other factors associated with improvement in severity of OSA are lifestyle interventions, bariatric surgery, and weight loss medication.<sup>3</sup>

Primary therapy for individuals with symptomatic OSA of any severity is continuous positive airway pressure (CPAP) as it keeps the upper airway patent during sleep. However, on a long-term basis, there is difficulty in patient tolerance and compliance to this treatment. Oral appliances have been proposed as an alternative

method to CPAP therapy. They are designed in such a way so that the upper airway is kept open by either forward advancement of the lower jaw or by keeping the mouth open during sleep.<sup>3</sup> Thus, OAs can be offered as alternate therapies due to side effects or inability to use CPAP.<sup>4</sup>

Therefore, this scoping review was conducted to evaluate the "Effect of mandibular advancement through oral appliance therapy on quality of life in obstructive sleep apnea (OSA)".

### SEARCH STRATEGY AND SELECTION CRITERIA

The scoping review was conducted to evaluate the "Effect of mandibular advancement through oral appliance therapy on quality of life in obstructive sleep apnea (OSA)". Considering the effect of oral appliances on the quality of life in OSA patients, this review included the publications that hold the search terms that were searched up till October 30, 2020. The PRISMA search strategy

was prepared using the MESH terms and Boolean terminology: ((obstructive AND sleep AND (apnoea OR apnea)) OR (sleep AND breathing AND disorder\* OR respiratory AND disorder\*)) OR "sleep-disordered breathing") AND ("Orthodontic Appliances" OR ((oral OR dental OR (mandib\* AND (advancement OR repositioning))) AND (device\* OR appliance\* OR splint) AND ("quality of life" OR qol OR "health status" OR "functional status" OR "self rated health" OR "self perceived health" OR nhp OR "SF-36 mental component" OR "SF-36 physical component" OR "FOSQ" OR "EuroQol" OR "SAQLI"). This search strategy was applied to the PUBMED, SCOPUS, and WEB OF SCIENCE databases. All types of studies are included. Using PICO (participants, intervention, comparator, and outcome) criteria, data extraction was done by two researchers individually, and discordance was addressed by the third researcher. Thorough screening of included articles was done, and the level of evidence was determined based on Oxford Centre for Evidence-based Medicine (OCEBM) (Table 1).

**Table 1:** Oxford Centre for Evidence-based Medicine 2011 Levels of Evidence

Question	Step 1 (Level 1*)	Step 2 (Level 2*)	Step 3 (Level 3*)	Step 4 (Level 4*)	Step 5 (Level 5)
<b>How common is the problem?</b>	Local and current random sample surveys (or censuses)	Systematic review of surveys that allow matching to local circumstances**	Local non-random sample**	Case-series**	n/a
<b>Is this diagnostic or monitoring test accurate?</b> (Diagnosis)	Systematic review of cross-sectional studies with consistently applied reference standard and blinding	Individual cross-sectional studies with consistently applied reference standard and blinding	Non-consecutive studies, or studies without consistently applied reference standards**	Case-control studies, or "poor or non-independent reference standard**	Mechanism-based reasoning
<b>What will happen if we do not add a therapy?</b> (Prognosis)	Systematic review of inception cohort studies	Inception cohort studies	Cohort study or control arm of randomized trial*	Case-series or case-control studies, or poor quality prognostic cohort study**	n/a
<b>Does this intervention help?</b> (Treatment Benefits)	Systematic review of randomized trials or n-of-1 trials	Randomized trial or observational study with dramatic effect	Non-randomized controlled cohort/follow-up study**	Case-series, case-control studies, or historically controlled studies**	Mechanism-based reasoning
<b>What are the COMMON harms?</b> (Treatment Harms)	Systematic review of randomized trials, systematic review of nested case-control studies, n-of-1 trial with the patient you are raising the question about, or observational study with dramatic effect	Individual randomized trial or (exceptionally) observational study with dramatic effect	Non-randomized controlled cohort/follow-up study (post-marketing surveillance) provided there are sufficient numbers to rule out a common harm. (For long-term harms the duration of follow-up must be sufficient.)**	Case-series, case-control, or historically controlled studies**	Mechanism-based reasoning
<b>What are the RARE harms?</b> (Treatment Harms)	Systematic review of randomized trials or n-of-1 trial	Randomized trial or (exceptionally) observational study with dramatic effect			
<b>Is this (early detection) test worthwhile?</b> (Screening)	Systematic review of randomized trials	Randomized trial	Non-randomized controlled cohort/follow-up study**	Case-series, case-control, or historically controlled studies**	Mechanism-based reasoning

\*Level may be graded down on the basis of study quality, imprecision, indirectness (study PICO does not match questions PICO), because of inconsistency between studies, or because the absolute effect size is very small; Level may be graded up if there is a large or very large effect size.

\*\*As always, a systematic review is generally better than an individual study.

**How to cite the Levels of Evidence Table**

OCEBM Levels of Evidence Working Group\*. "The Oxford 2011 Levels of Evidence". Oxford Centre for Evidence-based Medicine. <http://www.cebm.net/index.aspx?o=5653>

\*OCEBM Table of Evidence Working Group = Jeremy Howick, Iain Chalmers (James Lind Library), Paul Glasziou, Trish Greenhalgh, Carl Heneghan, Alessandro Liberati, Ivan Moschetti, Bob Phillips, Hazel Thornton, Olive Goddard and Mary Hodgkinson



## RESULTS

### Study Selection

A total of 3,202 articles were determined through search strategy and sources listed previously. After the removal of duplicates, 1,013 articles remained. After the titles had been screened, a total of 937 articles were rejected as they were not matching the search question. After the screening of abstracts, 10 articles were excluded as they had no relation to orthodontic appliance therapy, not explaining the quality of life, and were not in the English language. The remaining 66 articles were completely evaluated for the text, out of which 28 articles were excluded as they had no relation to oral appliance therapy, not explaining the quality of life, included surgical intervention, and were not in the English language. Finally, 38 articles were included in the review (Flowchart 1).

### Study Characteristics

Summarized methodological data and study results are mentioned in Table 2. The included articles were in English and published between 2011 and 2020. The articles included were on mandibular advancement appliances (MAD); comparison between the different designs of MAD; the effect of orthodontic appliances on temporomandibular joint (TMJ) and stomatognathic system; and comparison between positional therapy, CPAP, and oral appliances with their effects on quality of life. There were three pilot studies, one longitudinal follow-up study, one case-control study, two nonrandomized prospective studies, two prospective observational studies, one prospective study, three cohort studies, four clinical trials, 13 randomized controlled trials, one review article, four systematic reviews, and meta-analysis, and three network meta-analysis.

## DISCUSSION

This scoping review aimed to analyze the effectiveness, efficacy, different design features, side effects of the appliance, and patient selection for MAD therapy. Targeted symptoms are sleepiness, snoring, quality of life, and possible comorbidities. In this study, the

outcomes were evaluated by AHI, ESS, lowest oxygen saturation level, ODI, QD2A depression score, BQ variable, FOSQ, SF-36 physical component summary and mental component summary, QSQ, Pichot score, Pittsburg sleep quality index (PSQI), home sleep apnea test (HSAT), KIIEF-5, and SAQLI scores to check the effectiveness of MADs.

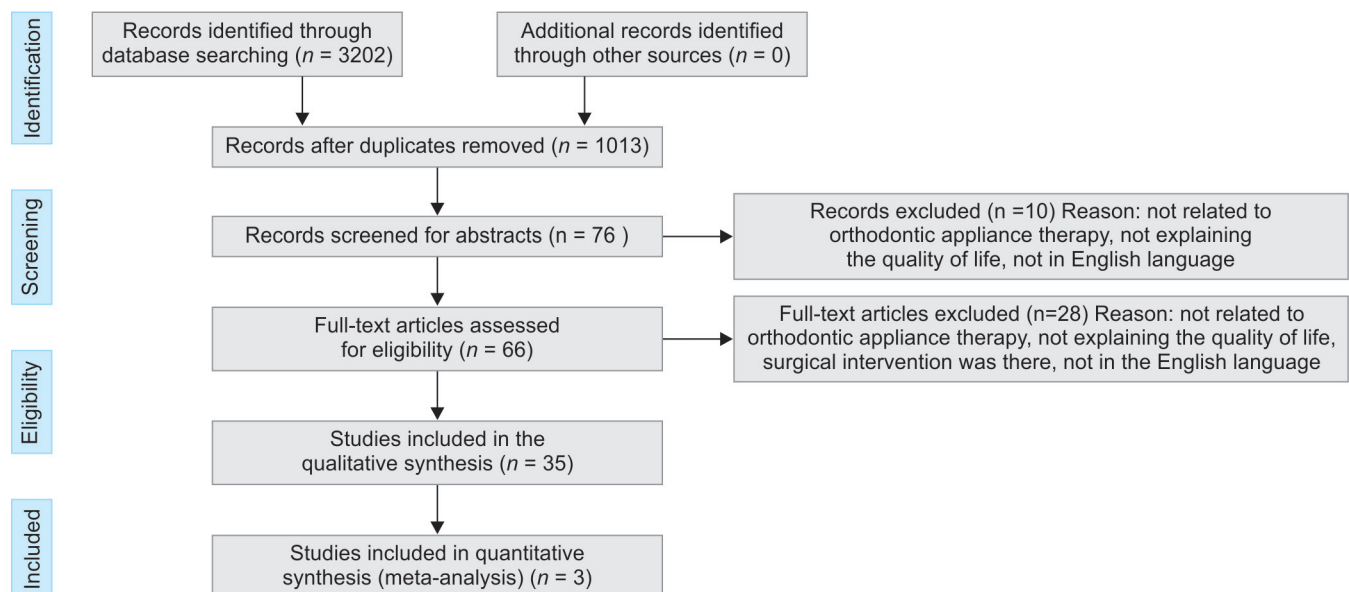
Different levels of evidence studies were selected to answer the clinical question proposed in this scoping review, and different studies used different designs of MADs. These were AT-MAD, elastomer appliance with an adjustable Herbst mechanism, titratable PAT-MAD, custom-made Narval MRDs, monoblock, and SILENT NITE appliances, TAP3, KLEARWAY, thermoplastic heat-molded titratable MAD, self-molded bespoke, semi-bespoke, and fully bespoke MAD.

According to the studies conducted by Banhiran et al.<sup>5</sup> and Agarwal et al.,<sup>6</sup> it was concluded that MAA resulted in a statistically significant reduction of baseline AHI index and the subjective outcomes with ESS scores (snoring intensity and frequency, and daytime sleepiness). The first study conducted among Asians by Banhiran et al.<sup>5</sup> demonstrated that an AT-MAD, if done properly, had good outcomes including improved quality of life (QOL) with a short-term treatment. Its advantages were cost-effectiveness and readily available. The continuous wearing of OAs reduces the AHI from severe to mild or moderate OSA along with the reduction of incidence of systemic complication and improvement in the life quality of the patients.

Follow-up studies by Attali et al.<sup>7</sup> and Vecchierini et al.<sup>8</sup> stated that libido disorders and polyuria resolved in 81 and 64% of the participants, respectively, and there was a significant improvement in visual analog scale scores for sleep, morning headache, and state on waking ( $p < 0.0001$ ) during MRD therapy.

Further, the effectiveness and efficacy of thermoplastic and custom-made MAD appliances were compared; various studies concluded that the titratable thermoplastic MAD is more efficacious in reducing SDB and associated symptoms in patients with mild to severe OSA and the effectiveness was the same for severity of symptoms, quality of life, and in reducing blood pressure but the

**Flowchart 1:** The search algorithm followed according to PRISMA statement



**Table 2:** Synopsis of the effect of mandibular advancement through oral appliance therapy on quality of life in obstructive sleep apnea (OSA)

Sl. No.	Outcomes	Results significant to the research topic
1	AHI Index, AI, HI	Decreased AHI <sup>5,9,11,14-35</sup> Decreased AI <sup>13,22-24</sup> Decreased HI <sup>22,23</sup>
2	Respiratory Disturbance Index (RDI)	No effect <sup>36</sup>
3	Epworth Sleepiness Scale (ESS)	Overall decreased <sup>5-7,11-13,15,16,20,22,24,25,27,28,30,34,35,37</sup> Improved daytime sleepiness <sup>8,9,14,18,21,38</sup> Improved neurobehavioral outcome <sup>17,26</sup> Improved snoring, daytime sleepiness <sup>23</sup>
4	Oxygen saturation (SpO <sub>2</sub> )	Increased <sup>7,15,17,24,30-32,39</sup> No significant effect <sup>8</sup>
5	SaO <sub>2</sub> nadir (lowest oxygen saturation)	Increased <sup>5,8,16,18,31,34,39</sup> Decreased <sup>7</sup>
6	Oxygen Desaturation Index (ODI)	Decreased <sup>7,9,22,31,35,39,40</sup>
7	Sleep Apnea Quality of Life Index (SAQLI)	Alleviated symptoms (Domain D) <sup>16</sup> Decreased <sup>26,27,36</sup>
8	Subjective symptoms: Snoring, daytime sleepiness, and night sleep quality	Improved snoring, daytime sleepiness and night sleep quality <sup>39</sup> Improved snoring, daytime sleepiness <sup>19,22</sup> improved snoring <sup>15</sup>
9	BQ variables	Reduced snoring loudness, frequency, tiredness after sleeping, breathing pauses <sup>11,38</sup>
10	Pichot QD2A depression score	Improved symptoms of depression <sup>9,32</sup>
11	Hospital anxiety and depression (HAD) scale	Improved depression rate <sup>20</sup>
12	Functional outcomes of sleep quality (FOSQ score)	Improved neurobehavioral outcome <sup>17</sup> Improved daytime sleepiness <sup>18</sup> Increased except general productivity & social outcome <sup>5</sup> Overall improved (increased) <sup>12,14,15,22,26-29,31,37</sup>
13	FOSQ-SE	No improvement in sexual activity <sup>17</sup>
14	Short-form 36 (SF36) score	Increased <sup>12,15,26,30,33,37,41</sup>
15	SF12 score	Increased <sup>15,32</sup>
16	Quebec sleep Questionnaire (QSQ)	Increased <sup>7,8</sup>
17	Visual Analog Scale	Decreased snoring loudness and frequency <sup>5,8,32</sup>
18	Pichot fatigue score	Decreased <sup>7,8,15,32</sup>
19	Pittsburg Sleep Quality Index (PSQI)	Decreased <sup>22,30-32</sup>
20	DASS21score	State of depression improved <sup>31</sup>
21	MSLT	Improved sleep latency <sup>33</sup>
22	SPAS (superior posterior airway space); MAS (middle airway space); IAS (inferior airway space)	Increased <sup>23</sup>
23	TMJ disorder	No change in shape and magnitude of incision edge, percussion, masticatory, and condylar movement <sup>42</sup> MAD therapy is not a risk factor for TMD signs <sup>10</sup>
24	BP	No change <sup>8,24,37</sup>
25	Non-REM sleep	Stage N3 & N4 percent increased <sup>17</sup> Improved stage N1 & N3 (mild and moderate) <sup>18</sup> Improved stage R, stage N3 <sup>29</sup>
26	REM sleep	Increased REM sleep duration <sup>14,33</sup>
27	Arousal index	Reduced <sup>14,25,30</sup>
28	HBA1c Level (Objective outcome)	Decreased in the mild and moderate group <sup>11</sup>
29	Vitamin C, B6 Level	Increased <sup>25</sup>
30	Oxidative stress parameters	Reduced <sup>25</sup>
31	Inflammatory markers	Mild-to-moderate OSA: Improved CRP, IL-1 $\beta$ , TNF- $\alpha$ <sup>18</sup> Severe OSA: Improved TNF- $\alpha$ <sup>18</sup>
32	Cost-effectiveness	Costs per quality-adjusted life-years (QALY) <sup>15,24,25</sup>

side effects were comparatively more to custom-made MAD. For the patients with OSA who refused or did not tolerate the CPAP therapy, the thermoplastic heat-molded titratable MAD was demonstrated to be equivalent in the short term to the custom-made acrylic MAD.<sup>9</sup>

Alessandri-Bonetti et al.<sup>10</sup> analyzed the effects of MADs on TMD in patients with and without the presence of signs and symptoms, which indicated that the evidence available was of moderate to low quality, showing that MAD therapy was not a risk factor for TMD signs and symptoms. Therefore, the TMD should not be considered an absolute contraindication for the use of MADs in the treatment of OSA.

The study by Baslas et al.,<sup>11</sup> after intervention with MAD found a statistically significant difference between HbA1c level and apnea hypopnea index AHI score in all groups except HbA1c level in severe OSA patients. It was therefore concluded that MAD may be recommended for patients with OSA and T2DM. This study provided evidence to inform health workers about the possible use of MAD in OSA and T2DM. Considering the higher level of evidence, systematic review can provide excellent evidence in comparing the quality of life outcomes with other outcomes between CPAP and MAD. So the systematic reviews and meta-analysis showed that the treatment effect of CPAP was greater in the vitality dimension. The score estimates of the improvement in the vitality scale (not the other seven scales) were similar for CPAP and MADs when compared with control. There were no statistically significant differences in quality of life, cognitive function outcomes, or functional outcomes in patients using CPAP vs MAD. However, CPAP was more effective in reducing AHI compared to oral appliances. With quality of life (SF-36 score), the results showed that both CPAP and MAD had



similar improvements in mental health and physical functioning. In terms of performance results, the results showed that both CPAP and MAD improved FOSQ scores without significant statistical differences, consistent with previous review studies where MAD users showed significantly higher compliance ( $p = 0.004$ ) than CPAP users.<sup>12–14</sup>

Further, it was reviewed that maintenance costs for MAD were low and relatively high for CPAP therapy, which could influence cost-effectiveness when considering long-term therapy. De Vries et al.<sup>15</sup> compared clinical efficacy with the cost of MAD treatment with CPAP treatment in the moderate OSA, where CPAP was more effective clinically (in terms of AHI reduction) and less expensive than MAD.

Finally to conclude, although both CPAP and MAD improved the quality of life, sleep, and performance and cognitive outcomes in patients with OSA, this review presented limited quality of evidence to suggest a significant difference in favor of CPAP in reducing AHI. Although the two therapies worked differently with the efficacy and treatment usage profiles, these results were similar in the overall performance. As effectiveness is a combination of efficacy and treatment compliance, sleep medicine specialists should monitor the use of treatment and provide patients who do not comply with CPAP orally for treatment. Choosing CPAP as the first line of treatment for patients with OSA symptoms but MAD should be considered as an appropriate alternative to reducing symptoms and improving QOL, where apnea and hypopnea are successfully reduced based on the findings of this scoping review.

The limitation of this review was that all the studies available were comparative. The designs of orthodontic appliances and the degree of titration were different in different studies. In addition, different levels of evidence studies were taken for this review, which had different limitations such as small sample size; the subjects had dropped out in between the treatment in follow-up studies; nonrandomized trials were included; along with this, there was a lack of blinding of participants and outcome in the trials.

## CONCLUSION

This scoping review finally concluded that:

- There were no differences in quality of life, functional outcomes, or cognitive function outcomes in patients using CPAP and MAD.
- Patients using MAD showed better adherence and compliance as compared to CPAP; along with this, the daytime sleepiness, state on waking, morning headache, oxygen saturation, frequency and intensity of snoring, and sleep quality for both patients who snore and their bed partners showed a marked improvement with MAD.
- The effectiveness of titratable MAD thermoplastic was to reduce SDB and associated symptoms in patients with mild to severe OSA, and the efficacy was similar in both the thermoplastic and custom-made MAD machine in terms of severity, symptoms, quality of life, and reducing blood pressure.
- Side effects of oral appliances include aggravation of temporomandibular disorder (TMD) but the presence of TMD should not be considered a general objection to the use of MAD in OSA administration.
- Maintenance costs for MAD were low and relatively high for CPAP therapy, which could influence cost-effectiveness when

considering long-term therapy. However, the cost per QALY was better with MAD compared to that with CPAP.

Choosing CPAP as a first-line treatment for patients with OSA symptoms but MAD should be considered an appropriate alternative to reducing symptoms and improving QOL when apnea and hypopnea are successfully reduced.

## RECOMMENDATIONS

We recommend that future research projects should include appropriate randomized studies, blinding treatment groups, concealing outcome tests, robust fitness method, critical and reproductive diagnostic approach, and quality-tested studies included to reduce bias.

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