Oral Appliances for Treatment of Snoring and Obstructive Sleep Apnea: A Review of Clinical Effectiveness

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Introduction

Obstructive sleep apnea (OSA) syndrome is a disorder characterized by repetitive or partial closure of the upper airway during sleep, resulting in sleep fragmentation and oxygen desaturation.[1] OSA is defined as more than five apneas and/or hypopneas per hour of sleep (i.e., the apnea-hypopnea index [AHI] being greater than five per hour).[2] The symptoms are snoring, excessive daytime sleepiness, and deficits in neuropsychological function.[1] Long-term untreated OSA is associated with cardiovascular morbidity, including hypertension, myocardial infarction, and stroke.[2]

Continuous positive airway pressure (CPAP) is the most effective treatment to control respiratory abnormalities during sleep.[3] CPAP is applied to the upper airway through a nose mask during sleep and requires sealed tubing and a device connected to a power source to operate. Many patients refuse or discontinue CPAP therapy because of its cumbersome nature.[3]

Oral appliances (OAs) are a simpler alternative to CPAP for the treatment of OSA.[4-6] Two types of OAs are mandibular advancement devices (MAD) and tongue-retaining devices (TRD).[4] MADs generally attach to the dental arches and mechanically protrude the mandible, while TRDs use suction pressure to maintain the tongue in a protruded position during sleep.[4] Hence, MADs require patients to have sufficient teeth, whereas TRDs can be used by edentulous patients.[4] MADs are the most common type of OA being tested in many studies.[4] This report reviews the clinical effectiveness, compliance, and side effects of OAs for the treatment of snoring and OSA.

Objective

The objective of the report is to answer the following research question:

What are the clinical effectiveness, compliance, and side effects of OAs for the treatment of snoring and OSA?

Methods

A limited literature search was conducted on key health technology assessment resources, including PubMed, The Cochrane Library (Issue 1, 2009), the University of York Centre for Reviews and Dissemination (CRD) databases, ECRI, EuroScan, international health technology agencies, and a focused Internet search. Results include articles published between 2004 and March 2009 and are limited to English language publications only. Filters were applied to limit the retrieval to health technology assessments, systematic reviews, meta-analyses, randomized controlled trials (RCT), controlled clinical trials, and observational studies. Internet links are provided, where available.

Results

Three systematic reviews/meta-analyses,[7-9] nine RCTs,[10-18] and 26 observational studies[19-44] were identified on the effects of OAs for OSA. No health technology assessments or controlled clinical trials were identified.

Systematic Reviews and Meta-analyses

One systematic review/meta-analysis[7] reviewed the effects of OAs in the treatment of obstructive sleep apnea-hypopnea in adults. The selection criteria were RCTs comparing OAs with control or other treatment. Seventeen trials were included for analysis. Six trials reported data

comparing MADs or active OAs with devices that did not protrude the mandible. Ten trials compared data on OAs with CPAP. One study reported data for OAs versus upper airway surgery. Shortcomings of the trials included small sample size, under reporting of methods and data, and lack of blinding.

Active OAs versus control OAs: Active OAs significantly reduced Epworth Sleepiness Scale (ESS) (ESS is a measurement of daytime sleepiness), AHI, and arousal index scores. Active OAs significantly improved minimum arterial oxygen saturation ($MinSaO_2$) in the crossover studies, but not in the parallel studies. There was no significant difference between active and control OAs for number of patients who stopped using the device. One trial reported blood pressure outcomes, where active OA therapy led to lower blood pressure compared with control, particularly blood pressure taken for 24 hours and during the day. Three crossover trials reported side effects and tolerability. Patients given the active OA suffered side effects more frequently than those given the control device. Most frequent side effects reported were jaw discomfort, tooth tenderness, excessive salivation, mouth dryness, and gum irritation. Compliance was 68% for OAs (wearing the device almost every night).

Active OAs versus CPAP: There was no statistically significant difference in term of ESS between treatments. OAs were significantly less effective in reducing AHI, $MinSaO_2$, and arousal index scores than CPAP as shown in both parallel and crossover trials. Patients treated with OAs were more likely to withdraw than those treated with CPAP. Noticeable adverse effects such as jaw and oral pain occurred more frequently with OAs. There were higher rates of excessive salivation and appliance removal during sleep with OAs, while there were higher rates of leak, dry upper airway, stuffy nose, and inconvenience with CPAP. No statistically significant differences on blood pressure were observed. There were conflicting results in terms of quality of life and preference. Some studies showed that there was no statistically significant difference between treatment groups, while others showed a significant effect in favour of CPAP versus OA.

Active OAs versus upper airway surgery: Symptoms of daytime sleepiness were initially lower with surgery, but the difference disappeared at 12 months. Mean AHI was not different between OA and surgery at six months, but was statistically different at 12 months and four years in favour of OAs. For quality of life, there were improvements in both groups compared with baseline, but no difference between treatments in terms of vitality and sleep. At 12 months, there was a significant difference detected in favor of surgery on the contentment component.

The authors[7] concluded that OAs improve subjective sleepiness and sleep disordered breathing. CPAP appears to be more effective in improving sleep disordered breathing than OA. OA therapy should be recommended to patients with mild OSA, and those patients who are unwilling or unable to tolerate CPAP therapy.

A systematic review published in 2004[8] reviewed the efficacy and comorbidity of OA therapy in obstructive sleep apnea-hypopnea syndrome. Sixteen controlled trials related to efficacy were included, which were, overall, rated as having adequate quality. Fourteen studies related to comorbidity were included, the majority of which were patient series.

Active OAs versus control devices: Control devices were designed to increase vertical opening minimally without advancing the mandible. Compared with the control devices, all four trials reported that active OA therapy was more effective in improving AHI, mean arousal index, $MinSaO_2$, and snoring frequency and intensity. Active OA therapy improved both subjective and objective daytime sleepiness. Although patients generally experienced more side effects with OA therapy, poorer patient satisfaction and compliance were reported with control devices.

Active OAs versus upper airway surgery: One trial compared the effect of OA treatment with surgery. At one year of treatment, OAs were

more effective in improving AHI compared with surgery. Other physiological parameters such as oxygen desaturation, registered snoring time, and daytime sleepiness did not differ between treatments. The surgery group showed a greater level of contentment than the OA-treated patients after one year of treatment.

Active OAs versus CPAP: Compared with OA treatment, CPAP resulted in a significant improvement in the AHI in five out of six trials and $MinSaO_2$ in three trials. There was no difference in arousal index and ESS between interventions. CPAP was more effective in reducing the frequency of snoring compared with OAs. The included studies showed conflicting results on quality of life between interventions.

The authors[8] concluded that OA therapy is a viable treatment for mild-to-moderate OSA, despite the higher effectiveness of CPAP and the adverse effects of OAs.

One systematic review[9] evaluated the efficacy of OAs or functional orthopedic appliances for OSA in children and concluded that there is insufficient evidence to state that OAs or functional orthopedic appliances are effective in the treatment of OSA in children.

Randomized Controlled Trials

Of the included RCTs, four used parallel design,[12-15] while the remaining five were crossover trials.[10,11,16-18] One trial[10] evaluated the efficacy of TRDs and the rest assessed the efficacy of MAD as OA therapy for the treatment of snoring and OSA.

TRD (active suction versus non-suction): The active suction device significantly reduced AHI and snoring index compared with the non-suction device. Compliance was 54% for the active suction device and 12% for the non-suction device. Thus, the RCT showed that the TRD (suction) had better outcomes than the non-suction device.

Custom-made MAD (MAD_{CM}) versus prefabricated MAD (MAD_{PF}): AHI was significantly reduced with MAD_{CM}; no difference in AHI was seen with MAD_{PF}. Treatment success was higher with MAD_{CM} compared with MAD_{PF}. Compliance failure was lower with MAD_{CM} compared with MAD_{PF} and 82% preferred MAD_{CM} while 9% had no preference. The authors concluded that custom-made MAD was more effective than a thermoplastic device in the treatment of sleep-disordered breathing.

MAD versus mandibular non-advancement device (MND): Overall, MAD was better than MND in the improvement of AHI, daytime sleepiness, snoring, and quality of life. One trial[18] showed a significant reduction in blood pressure in the MAD treatment group. Limited information on compliance and side effects were reported in those trials. All trials concluded that MAD offers a better treatment of OSA than MND.

Non-adjustable OAs versus CPAP: CPAP was significantly better than non-adjustable OAs in improving AHI, overall quality of life, and morning diastolic blood pressure. Side effects of OAs included excessive salivation, temporomandibular joint discomfort, dry throat, and tooth discomfort. The authors concluded that CPAP produced the best improvement on physiological, symptomatic, and health-related quality of life measures, while OAs were slightly less effective.

MAD versus CPAP: No significant changes were found in the sexual satisfaction or testosterone levels in patients who underwent MAD and CPAP therapy. It was found that CPAP and MAD both improved sleep outcomes (AHI), but CPAP had a greater effect. Both active treatments improved quality of life, symptoms, and subjective sleepiness in a similar fashion. Thus, the RCTs indicated that CPAP was more effective than MAD in treating obstructive breathing events; whereas, both therapies had no significant changes in sexual functioning.

Observational Studies

Twenty-six articles studied the effects of MAD therapy on various clinical aspects of snoring and OSA. Of the included studies, all reported effectiveness except six studies.[20,21,23,31,32,36] Fourteen studies[19,21,22,25,28,32-34,37,40-44] also reported compliance, and 17 studies[19-24,27,28,32,36,37,39-44] also reported side effects.

Effectiveness: Compared with baseline, MAD therapy significantly improved AHI, oxygen desaturation, snoring, daytime sleepiness, and blood pressure. Treatment effectiveness, including complete and partial responses in improving AHI and snoring, ranged from 52% to 97%. One study[33] showed that OAs altered upper airway morphometry toward a profile consistent with decreased propensity to collapse, which may have contributed to the improvement of OSA. Most studies showed that AHI was reduced more than 50% compared with baseline. One study correlated a modest decrease in blood pressure with the reduction in AHI.[34] Snoring was satisfactorily controlled in 75% of users in two studies,[39,40] and 86% of patients' partners had better quality of sleep as reported in one study.[39] In predicting the treatment success for an individually adjusted, one-piece MAD in patients with snoring and OSA, one study[42] found that women with sleep apnea (in both supine and lateral position) and men with supine-dependent sleep apneas, as well as snorers without sleep apnea, had a high likelihood of success.

Compliance: In the 14 studies reporting compliance, the compliance ranged from 51% to 88%.[19,21,22,25,28,32-34,37,40-44] A survey[21] of 180 OSA patients who had been using MAD for 10 years reported a 65% compliance, of which 47% wore the device every night and 18% wore the device up to six nights per week. A second survey[28] of 260 snoring and OSA patients who were treated with OAs for more than five years showed that, of the respondents, 51.9% were frequent users, 17.8% were infrequent users, 14% were discontinued, and 16% had modified treatment. Patients with mild cases of OSA were likely to continue treatment than those with more severe cases. A third survey[40] of 544 patients who used OAs for the treatment of snoring or OSA for more than five years concluded that patients who were compliant with OA therapy reported long periods of use and adequate control of snoring.

Side effects: No serious side effects of cases of pathology of aggravation occurred in the 17 studies that reported side effects.[19-24,27,28,32,36,37,39-44] Common side effects included jaw discomfort, tooth tenderness, excessive salivation, difficulty sleeping, difficulty breathing, dental damage, and dry mouth. These side effects often prevented the use of MAD.[37] Orthodontic side effects were occlusal changes, including significant reductions in overbite and overjet. Two studies[20,36] showed that after long-term use (more than five years), OAs appeared to cause changes in tooth positions that also might affect mandibular posture.

Limitations

Since OSA is associated with cardiovascular mortality, long-term data on cardiovascular health with OA use in OSA patients are lacking. Evidence on the effectiveness of OAs in children and on patients with more severe symptoms of OSA is inadequate. Evidence on the effectiveness of a TRD, another form of an OA, was also insufficient. The assessment on the effect of variations in OA design on clinical outcomes is currently lacking.

Conclusions

The literature showed that compared with inactive devices or compared with pretreatment, MAD therapy is effective in improving sleep disordered breathing and quality of life in snoring and OSA patients. The compliance for MAD therapy was high in the included studies, and patients who were compliant tended to be long-term users. There were no serious adverse events associated with MAD therapy in the literature, but occlusal changes were noted over a long period of use. Some common side effects, which occurred during the acclimatization period in the studies, were usually minor and self-limiting, but they could discourage some patients from continuing the therapy. The literature indicated that both MAD and CPAP

treatments improved sleep outcomes, but CPAP was found to be more effective. Compared with upper airway surgery, MAD therapy appeared to be more effective over a long period of use. Thus, MAD may be a simpler alternative to CPAP and surgery. Recent systematic reviews/meta-analyses recommended the prescription of MAD therapy to patients with mild-to-moderate OSA, and those patients who are unwilling or unable to tolerate CPAP therapy. There is evidence that patients with mild cases of OSA were likely to continue treatment than patients with more severe cases. One study recommended MAD for all women with sleep apnea, for men with supine dependent sleep apnea, and for non-OSA snorers.

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