

The use of mandibular advancement devices for the treatment of Obstructive Sleep Apnea

Stavros Kiriopoulos¹,
Dimosthenis Lykouras²,
Agathi Spiropoulou²,
Panagis Drakatos³,
Kiriakos Karkoulas²,
Kostas Spiropoulos²

¹Orthodontist, Department of Pneumology Medicine, University Hospital of Patras, Patras, Greece

²Department of Pneumology Medicine, University Hospital of Patras, Patras, Greece

³Guy's and St Thomas' Hospital, Sleep Disorders Centre, London, United Kingdom

Key words:

- Obstructive Sleep Apnea (OSA)
- Mandibular Advancement Device
- Continuous Positive Airway Pressure devices (CPAP)

Correspondence:

Kostas Spiropoulos, Professor of Pneumology Medicine, University of Patras, Patras 26500, Greece
Tel.: +30 2610 999523, Fax: +30 2610 999523,
E-mail: spircos@upatras.gr

ABSTRACT

Obstructive Sleep Apnea (OSA) is the most common type of sleep disordered breathing, having numerous systematic consequences. Continuous Positive Airway Pressure devices (CPAP) have been used effectively so far for the treatment of OSA, but there is an important number of patients, up to 50%, that show bad adherence to CPAP treatment and may finally quit. Other therapeutic interventions that have been effective are dental devices that force the mandible to a forward position. The placement of these so called mandibular advancement devices (Mandibular Advancement Devices/MADs) causes the mandible to be positioned forward and downwards to its normal position. These dental devices are an acceptable option for the treatment of OSA apart from CPAP. Although, their efficacy is lower than that of CPAP in severe OSA, they can be effectively used in mild to moderate OSA because of their ease of use, lower cost and because they can be well-tolerated.

Pneumon 2016, 29(2):147-151.

INTRODUCTION

The two main types of Sleep disordered breathing are Obstructive Sleep Apnea (OSA) and Central Sleep Apnea (CSA). These disorders can also be present at the same type in mixed apneas. Central sleep apnea is less common and is caused by reduced respiratory drive¹, causing intermittent oxygenation during sleep^{2,3}.

Obstructive Sleep Apnea is the most common type of sleep apneas. It is estimated that 14% of middle-aged men and 5% of middle-aged women suffer from OSA^{4,5}. The syndrome is characterized by partial or total obstruction of the upper airways during the sleep, that causes recurrent episodes of breathing stops and is linked with intermittent hypoxia during the night sleep, snoring and daytime symptoms, such as daytime sleepiness. According to American Academy of Sleep Medicine (AASM) OSA is diagnosed in patients with 5 or more episodes of apneas or hypopneas per hour of sleep, who also present with clinical symptoms of daytime sleepiness, elevated

blood pressure, tiredness, or in patients with 15 or more episodes of apneas or hypopneas per hour of sleep without symptoms^{6,7}.

Apnea is characterized by total upper airway obstruction for at least 10 seconds. Hypopnea is characterized by a reduction in airflow by 30% (less than in previous 2 minutes) and a reduction in oxygen saturation by $\geq 3\%$ or an arousal in electroencephalogram (EEG). It is also important that there is a respiratory muscle effort during an obstructive apnea or hypopnea. The total number of apneas and hypopneas pre sleep hour is called Apnea-Hypopnea Index (AHI) and is used for the classification of disease severity: mild OSA ($5 \leq \text{AHI} < 15$), moderate ($15 \leq \text{AHI} < 30$) and severe OSA ($\text{AHI} \geq 30$)⁸.

THERAPEUTIC OPTIONS

Initial interventions in patients with diagnosed OSA include body weight reduction, especially in obese patients, as there is a well-established connection between lowering of body weight and reduction of sleep apnea episodes. Sleeping in certain positions and avoidance of the supine position during the sleep may also be effective in some patients (positional-related sleep apnea). Moreover, it is suggested that patients should not use muscle relaxants and antidepressants. Using alcohol, especially at night, can also make apneas worse, because they make the muscles to relax and the patency of the upper airways is affected^{9,10}.

However, the most efficacious and widely used therapeutic option for OSA is the use of Continuous Positive Airway Pressure devices (CPAP). CPAP not only leads to the reduction of apneas, but also improves the quality of life of the patients^{11,12}. The main disadvantage of CPAP treatment is that it has innate defects that make some patients difficult to bear; as a result, it is estimated that almost 50% of patients abandon CPAP treatment. The main defects include the noise of the CPAP device, claustrophobia due to the mask, ulcers on the nose because of the pressure of the plastic parts of the mask, reduced confidence in younger patients and high cost.

Apart from the CPAP, there are dental devices that can be used for the successful treatment of OSA. Two main categories are now available: Mandibular Advancement Devices (MAD) and Tongue Retaining Devices (TRD). The latter is not widely used, because of its low efficacy resulting in partial airway obstruction by the tongue.

Mandibular advancement devices can be either one device (Monobloc) that is applicable both in maxillary and

mandible (Figure 1) or two separate devices that are linked together in order to push the mandible forward to avoid airway collapse during sleep (Figure 2). The customized production of the device by a qualified dental technician guarantees better results for the patient.

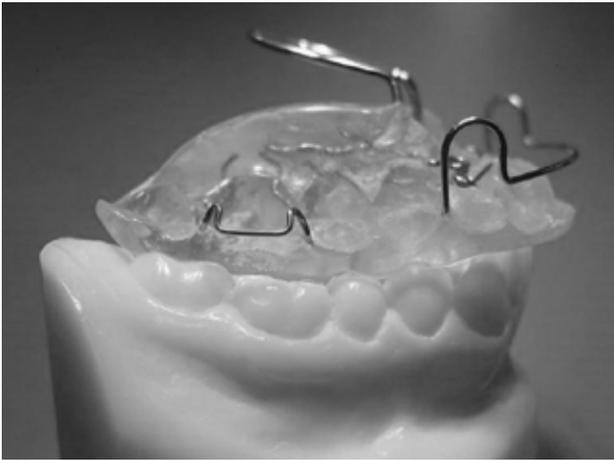
There are, also, dental devices that can be purchased even over the internet, which do not require special measurements on the patients. These appliances are made of a type of plastic that allows the patient to modify its shape to fit his own mouth after heating the plastic in warm water. These MADs are cheaper to buy, but in some cases may cause discomfort to the patients as they are not custom made; therefore, some patients may discontinue their utilization. Moreover, they can destroy the dental barrier or even cause damage to the temporomandibular joints. Finally, these devices, which are not customized for the patient are not suggested for the treatment of OSA and should be avoided¹³.

The effects of mandibular advancement on OSA has been studied in several studies. In a study of OSA patients, different mandibular advancement options were selected (2mm, 4mm and 6mm). The study showed that the improvement of hypoxemia was related to the mandibular advancement (25%, 48% and 65% respectively)¹⁴. The use of the MADs in patients with moderate OSA has been proved to be effective. A mandibular advancement of 75% reduces AHI by 52, whereas an advancement of 50% reduces AHI by 31%¹⁵. In any case, the mandibular advancement has to be careful, because an advancement of more than 50% may cause discomfort or even injuries¹⁶.

The placement of these so called mandibular advancement devices (MADs) causes the mandible to be positioned forward and downwards to its normal position. The interincisal opening of the mandible has been investigated and the existing results show that there are no differences between a interincisal opening of 4mm or 14mm (while having the same mandibular advancement); however, the patients preferred the 4mm¹⁶. Moreover, a greater interincisal opening results in the obstruction of the oropharynx by the tongue. Therefore, MADs should not cause overt changes to the mouth in order to lead to a more efficacious result.

MECHANISM OF ACTION

The mandibular advancement that is caused by the MADs, urges the tongue to open the airway at the level of the oropharynx. Moreover, the genioglossus muscle is activated, resulting in alterations to its shape and posi-



EIKONA 1.



EIKONA 2.

tion. The tongue is, then, moving a bit forward in the oral cavity. However, increasing the width of the oropharynx is not limited only to the level of the oropharynx, but also affects the soft palate. The mandibular advancement increases the transverse dimension of the oropharynx behind the soft palate as it stretches the walls of the pharynx and activates the glossopalatine muscle and the pharyngopalatine muscle. So, the soft palate is prevented from falling and the lateral diameter of the oropharynx is increased¹⁷. This is particularly important in patients with OSA with a narrower oropharynx. The use of MADs leads to a rearrangement of skeletal muscle tissue and the hyoid bone is moving as well. Therefore, the use of the MADs increases the width of the airways and thereby OSA severity is reduced.

THE USE OF MAD AND CPAP IN THE TREATMENT OF OSA

The efficacy of the MADs in the treatment of OSA has been studied in patients receiving treatment with these devices by the means of night polysomnography. In order to have a successful treatment of OSA, a reduction in AHI below 5 episodes/hour has to be achieved in patients with mild OSA and a reduction of 50% in AHI after treatment in patients with severe OSA¹⁸. There are four clinical studies investigating into the efficacy of MADs in OSA¹⁹⁻²². They have all agreed that the mandibular advancement plays an important role in the reduction of apneas. In another study in patients with moderate OSA the use of MADs leads to an effective treatment in 65% of the patients²³.

Moreover, it is also important to improve sleep quality, reduce snoring and arousals during night sleep. There is a study that has shown reduction of arousals (16/hour instead of 33.8/hour before treatment)²⁰. Furthermore, snoring was reduced and so was daytime sleepiness as recorded in FOSQ (Functional Outcomes of Sleep Questionnaire) και ESS (Epworth Sleepiness Scale). In another study, the use of MADs in OSA resulted in the decrease of systolic blood pressure, a finding that is more important in patients with an AHI>15 and excessive daytime sleepiness¹⁹.

However, the efficacy of MADs is inferior to that of CPAP. In a systematic review of 11 randomized clinical trials comparing MAD to CPAP treatment the results suggested that both treatments can be used for the treatment of patients with OSA, but CPAP treatment has better results in most patients. Nevertheless, MADs are easier for the patient to use²⁴. American Sleep Disorders Association suggests using MADs in mild to moderate OSA or in patients that cannot tolerate CPAP treatment²⁵.

CLINICAL OUTCOMES OF THE USE OF MAD AND ADVERSE EFFECTS

A successful treatment of OSA using MADs depends on multiple factors such as the skills of the dentist, the co-operation of the patient, morphological characteristics of the patient and anatomy of the airway. In a study of the characteristics that may lead to a successful treatment with MADs, it was shown that patients with lower BMI and AHI had better results²⁶. Moreover, the narrower pharynx, the position of the hyoid bone, the angle of the mandible and the, the smaller face of the patient and

the length of the soft palate are factors that affect the efficacy of the MADs.

But, the use of these devices may also have some adverse effects. Some of them are temporary, such as salivation and dry mouth. A dysfunction in the temporomandibular junction may also occur, especially with badly designed devices. In other patients, these devices can be harmful for the teeth, but this adverse effect is correlated to the time that they are used, the age, gender and BMI of the patient. And of course, the greater the AHI, the greater is the impact of these devices on the teeth as they are needed for longer times and the mandibular advancement is greater²⁷.

Therefore, these devices should be carefully used and adverse effects should always be taken into consideration. Patients with pre-existing disorders of the temporomandibular junction should not receive treatment with MADs and so do patients with teeth diseases. In order to reduce all major adverse effects, the mandibular advancement must not exceed 70% of the maximum advancement; and up to the limit of 5mm, whereas interincisal opening must not exceed 5mm.

The American Academy of Sleep Medicine (AASM) and the American Academy of Dental Sleep Medicine (ADSM) have come up with clinical information regarding the use of MADs. 1) The use of MADs is suggested in patients with excessive snoring even if the patients have not been diagnosed with OSA. 2) In case the somnologist prescribes a MAD, the customized devices, that are made by dentists with an expertise in the field, should be preferred, because the mandibular advancement can be controlled. 3) Patients diagnosed with OSA that do not prefer using CPAP may be given the option to use MADs instead. 4) The application of MADs must always be performed by specialized dentists and the patients should be periodically re-evaluated. 5) It is suggested that patients using MADs undergo full night sleep studies to monitor the efficacy of treatment. 6) All patients should be notified that their treatment involves periodical evaluations by the referring sleep center and their dentist to check treatment efficacy.

CONCLUSION

Dental devices are currently a reliable option for the treatment of OSA apart from the CPAP device. Although, their efficacy is lower than that of CPAP in severe OSA, they can be effectively used in mild and moderate OSA

because of their ease of use, lower cost and acceptance from the patients. The design and application of these dental devices should only be done by experienced and specially trained dentists and orthodontics in cooperation with the sleep specialists and pulmonologist, while having in mind that they have certain advantages and disadvantages.

REFERENCES

1. Sherring D, Vowles N, Antic R, Krishnan S, Goss A. Obstructive sleep apnoea: a review of the orofacial implications. *Aust Dent J* 2001; 46:154-65.
2. Ronchi P, Cinquini V, Ambrosoli A, Caprioglio A. Maxillomandibular advancement in obstructive sleep apnea syndrome patients: a retrospective study on the sagittal cephalometric variables. *J Oral Maxillofac Res* 2013; 1;4(2).
3. Lykouras D, Theodoropoulos K, Sampsonas F, et al. The impact of obstructive sleep apnea syndrome on renin and aldosterone. *Eur Rev Med Pharmacol Sci* 2015; 19:4164-70.
4. Peppard PE, Young T, Barnet JH, et al. Increased prevalence of sleep-disordered breathing in adults. *Am J Epidemiol* 2013;177:1006-14.
5. Strollo P, Rogers R. Obstructive sleep apnea. *N Eng J Med* 1996; 334:99-104.
6. American Academy of Sleep Medicine. International classification of sleep disorders 3rd ed. Darien, IL: s.n., 2014.
7. Ramar K, Dort L, Katz S, et al. Clinical Practice Guideline for the Treatment of Obstructive Sleep Apnea and Snoring with Oral Appliance Therapy: An Update for 2015. *J Clin Sleep Med* 2015; 11:773-827.
8. Berry R, Camaldo C, Harding S, Marcus C, Vaughn B. The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications, Version 2.0. Darien, Illinois: American Academy of Sleep Medicine, 2012.
9. Cartwright R. Effect of sleep position on sleep apnoea severity. *Sleep* 1984; 7:110-4.
10. Smith P, Gold A, Myer D. Weight loss in mild to moderately obese patients with obstructive sleep apnoea. *Ann Intern Med* 1985; 105:850-61.
11. Karkoulas K, Lykouras D, Sampsonas F, et al. The impact of obstructive sleep apnea syndrome severity on physical performance and mental health. The use of SF-36 questionnaire in sleep apnea. *Eur Rev Med Pharmacol Sci* 2013; 17:531-6.
12. Epstein L, Kristo D, Strollo P, et al. Clinical guideline for the evaluation, management and long-term care of obstructive sleep apnea in adults. *J Clin Sleep Med* 2009; 5:263-76.
13. Vanderveken O, Devolder A, Marklund M, et al. Comparison of a custom-made and a thermoplastic oral appliance for the treatment of mild sleep apnea. *Am J Respir Crit Care Med* 2008; 178:197-202.
14. Kato J, Isono S, Tanaka A, et al. Dose-dependent effects of mandibular advancement on pharyngeal mechanics and nocturnal oxygenation in patients with sleep-disordered

- breathing. *Chest* 2000; 117:1065-72.
15. Walker-Engstrom M, Ringqvist I, Vestling O, Wilhelmsson B, Tegelberg A. A prospective randomized study comparing two different degrees of mandibular advancement with a dental appliance in treatment of severe obstructive sleep apnea. *Sleep Breath* 2003; 7:119-30.
 16. Pitsis A, Darendeliler M, Gotsopoulos H, Petocz P, Cistulli P. Effect of vertical dimension on efficacy of oral appliance therapy in obstructive sleep apnea. *Am J Respir Crit Care Med* 2002; 166:860-4.
 17. Ryan C, Love L, Peat D, Fleetham J, Lowe A. Mandibular advancement oral appliance therapy for obstructive sleep apnoea: effect on awake calibre of the velopharynx. *Thorax* 1999; 54:972-7.
 18. Sutherland K, Vanderveken O, Tsuda H, et al. Oral appliance treatment for obstructive sleep apnea: an update. *J Clin Sleep Med* 2014; 10:215-27.
 19. Andren A, Hedberg P, Walker-Engstrom M, Wahlen P, Tegelberg A. Effects of treatment with oral appliance on 24-h blood pressure in patients with obstructive sleep apnea and hypertension: a randomized clinical trial. *Sleep Breath* 2013; 17:705-12.
 20. Blanco J, Zamarron C, Abeleira Pazos M, Lamela C, Suarez Quintanilla D. Prospective evaluation of an oral appliance in the treatment of obstructive sleepapnea syndrome. *Sleep Breath* 2005; 9:20-5.
 21. Hans M, Nelson S, Luks V, Lorkovich P, Baek S. Comparison of two dental devices for treatment of obstructive sleep apnea syndrome (OSAS). *Am J Orthod Dentofacial Orthop* 1997; 111:562-70.
 22. Petri N, Svanholt P, Solow B, Wildschiodtz G, Winkel P. Mandibular advancement appliance for obstructive sleep apnoea: results of a randomised placebocontrolled trial using parallel group design. *J Sleep Res* 2008; 17:221-9.
 23. Brette C, Ramanantsoa H, Renouardiere J, Renouardiere R, Roisman G, Escourrou P. A mandibular advancement device for the treatment of obstructive sleep apnea: long-term use and tolerance. *Int Orthod* 2012; 10:363-76.
 24. Phillips C, Grunstein R, Darendeliler M, et al. Health outcomes of continuous positive airway pressure versus oral appliance treatment for obstructive sleep apnea: a randomized controlled trial. *Am J Respir Crit Care Med* 2013; 187:879-87.
 25. American Sleep Disorders Association. Practice parameters for the treatment of snoring and obstructive sleep apnea with oral appliances. *Sleep* 1995; 18:511-513.
 26. Prescinotto R, Haddad FL, Fukuchi I, et al. Impact of upper airway abnormalities on the success and adherence to mandibular advancement device treatment in patients with Obstructive Sleep Apnea Syndrome. *Braz J Otorhinolaryngol* 2015; 81:663-70.
 27. Pliska B, Nam H, Chen H, Lowe A, Almeida F. Obstructive sleep apnea and mandibular advancement splints: occlusal effects and progression of changes associated with a decade of treatment. *J Clin Sleep Med* 2014; 10:1285-91.