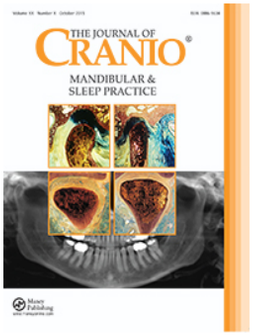

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Reasons for failure of mandibular advancement splint therapy in the treatment of obstructive sleep apnea

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ABSTRACT

Objective: To investigate the reasons for poor adaptation to mandibular advancement splint (MAS) treatment.

Methods: The study consisted of 44 patients with obstructive sleep apnea who had unsuccessful MAS treatment. Data were collected on age, body mass index, gender, general and mental diseases, continuous positive airway pressure (CPAP) tryout, usage of occlusal splint, dental overjet, temporomandibular disorders, shortened dental arch, sleep apnea severity, and Apnea-Hypopnea Index. Sixty patients who underwent successful MAS treatment were controls.

Results: Patients with missing molars failed significantly more often in MAS therapy than the controls ($p = 0.020$). Patients with CPAP tryout prior to MAS treatment had a tendency to fail MAS treatment. MAS treatment was more likely to be successful in patients with prior occlusal splint experience ($p = 0.050$).

Conclusion: The study could not identify a single reason for MAS failure.

KEYWORDS

Obstructive sleep apnea; sleeping disorder; mandibular advancement splint; missing molars; shortened dental arch

Introduction

Obstructive sleep apnea (OSA) is a sleep disorder characterized by repetitive upper airway collapse resulting in fragmented sleep and neurobehavioral and cardiovascular consequences, such as daytime sleepiness, high blood pressure, and increased risk of ischemic heart disease. Snoring, breathing disturbances during sleep, morning headaches, and daytime sleepiness remain typical symptoms. OSA is considered mild when the Apnea-Hypopnea Index (AHI; breathing disturbances per hour during sleep registration) is between 5 and 15, moderate with AHI 15 to <30/h, and severe with AHI ≥ 30/h [1].

Moderate to severe OSA and mild OSA with prominent daytime symptoms are treated primarily with continuous positive airway pressure (CPAP) therapy. However, in patients with mild OSA and those with moderate to severe OSA who are not able to tolerate CPAP therapy, a mandibular advancement splint (MAS) is a treatment option [2]. MAS is an oral appliance that increases the volume of oropharyngeal space by advancing the mandible [3]. MAS treatment has been shown to effectively reduce obstructive sleep events and snoring [4,5].

The success rate for OSA treatment using custom-made adjustable MAS has been shown to be approximately 80% [6]. The appliance has several potential side effects, e.g., jaw muscle, temporomandibular joint (TMJ) and tooth pain, irritation of the oral mucosa, dryness of the mouth, vomiting, occlusal changes, and increased salivation. Most MAS treatment side effects are temporary and disappear during the first few weeks [3,5].

In addition, a shortened dental arch or missing teeth can also cause problems in MAS treatment. Tooth loss is a highly prevalent oral health problem with a high impact on general health and quality of life [7]. A shortened dental arch causes reduced masticatory performance, and distal-extension removable partial dentures are commonly used to compensate for edentulism, although the effects of the dentures are not fully conclusive [8]. Patients with a distally reduced mandibular dental arch do not report greater perceived satisfaction, function, or quality of life by wearing removable partial dentures [9].

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Patients with a shortened dental arch who wear an MAS may be perceived negatively, as many removable denture wearers are, and this may reflect poor adaptation to MAS treatment. The definition of a shortened dental arch in this study is inspired by Eichner's index, which is simplified to only considering missing molars at least unilaterally in either the upper or lower dental arch [10].

The aim of this study was to investigate the possible association of certain background variables with poor adaption to MAS treatment.

Materials and methods

Patients

This retrospective primary cohort consisted of 397 patients diagnosed with OSA at the Department of Oral and Maxillofacial Diseases, Helsinki University Hospital (HUH), Finland during the years 2006–2013 and who had unsuccessful MAS treatment. In total, 44 patients were included in this study. All data regarding the sleep apnea treatment of these patients were reviewed. The treatment was considered unsuccessful if the patient no longer used the device in the first follow-up visit after starting treatment and the device could not be repaired, for example, with minor grinding, for the patient's use.

MAS therapy

Inter-occlusal wax bite registration was performed to obtain approximately 70% of the maximal protrusion of the mandible. Alginate impressions of the upper and lower dentition were obtained to create working models, which were surveyed to construct a customized MAS (Figure 1). The appliance has maxillary and mandibular acrylic splints with bilateral telescopic arms to prevent retrusion of the mandible [6]. The follow-up visits for the patient with the appliance were set up after 1 to 2 months and then on demand.

Exclusion criteria

Patients with insufficient data and those who resumed occasional CPAP therapy along with the mandibular advancement device were excluded from this study. In addition, patients who did not attend their first follow-up visit at 1 month were excluded. In total, 44 patients were included in this study.

Data collection

To investigate the possible causes of poor adaptation to oral splint treatment, data were collected on the variables listed in Table 1. Dentists' findings of pain upon palpation in the TMJs and limitations in mandibular movements and positive findings in the loading test of the TMJs were counted as TMD symptoms. A shortened dental arch was categorized into the following: 1) no missing molars, 2) only some or all upper molars

Figure 1. The mandibular advancement splint appliance (MAD) (Herbst-type). (photo by Ari Laine).

Table 1. Background variables used in this statistical model to find the possible association with poor MAS treatment adaption.

Variable	Scale	
Age	Interval	32–75 years
BMI (kg/m^2)	Interval	18.4–42.0
Gender	Nominal	1 = male, 2 = female
Diabetes or high blood pressure (general diseases)	Nominal	1 = yes, 2 = no
Psychiatric diseases	Nominal	1 = yes, 2 = no
CPAP tryout	Nominal	1 = yes, 2 = no
Occlusal splint usage prior to MAS treatment	Nominal	1 = yes, 2 = no
Temporomandibular disorders	Nominal	1 = yes, 2 = no
Dental overjet	Nominal	1 = normal, 2 = >4 mm
Shortened dental arch	Nominal	1 = no missing molars 2 = only some or all upper molars missing 3 = only some or all lower molars missing 4 = molars missing on both upper and lower arches
Sleep apnea severity	Ordinal	1 = mild 2 = moderate 3 = severe
Apnea-Hypopnea Index (AHI/h)	Interval	1–70.5

MAS: Mandibular advancement splint; BMI: Body mass index.

missing, 3) only some or all lower molars missing, and 4) molars missing on both upper and lower arches.

Controls

Sixty patients with successful MAS treatment during the same time period were randomly selected from a larger cohort of 811 patients with OSA. They were treated with MAS at the Department of Oral and Maxillofacial Diseases, HUH, Helsinki, Finland, between the years 2006 and 2013 and served as the control group [3]. The MAS treatment was defined as successful if the MAS therapy had continued after their first follow-up visit at 1 month.

Statistical analysis

The statistical significance between the differences between the case and control groups was compared using Student's *t*-test and chi-square test. As a multivariable method, logistic regression was used. The dependent variable was successful in MAS treatment, and the dependent variables in the initial model were all covariates (Table 1). Manual backward elimination was used, and the final model included only those covariates for which $p < 0.05$. All analyses were conducted using the SPSS Statistics software package (IBM SPSS® Statistics 19.0, Armonk, NY, USA).

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The Hospital District of Helsinki and Uusimaa (HUS/197/2016) approved the protocol of the retrospective study. Due to the retrospective nature of this study, informed consent was not obtained from the study subjects.

Results

CPAP tryout

Eighty percent of patients with failed MAS treatment and 65% of controls had a tryout with CPAP therapy prior to MAS therapy. None of these patients tried to use both devices simultaneously. A decreased probability ($p = 0.106$) in adapting to OSA treatment with prior experience with CPAP therapy was found. Prior experience with CPAP therapy slightly tended to decrease the probability of adapting to MAS treatment (Table 2).

Table 2. Mean values for age and BMI, number of patients (n) and percentages of gender and other variables according to the success of MAS treatment (*t*-test and chi-square test).

Variable		Failed MAS n = 44	Successful MAS n = 60	*p*-value
Age (years)		54.4	56.8	0.212
BMI (kg/m^2)		28.7	27.6	0.231
Gender (female), n (%)		18 (41 %)	31 (52 %)	0.278
General diseases, n (%)		25 (57 %)	26 (43 %)	0.174
Psychiatric diseases, n (%)		8 (18 %)	6 (10 %)	0.227
CPAP tryout, n (%)		35 (80 %)	39 (65 %)	0.106
Occlusal splint, n (%)		0 (0 %)	5 (8 %)	0.050*
Overjet > 4 mm, n (%)		12 (27 %)	16 (27 %)	0.929
TMD, n (%)		15 (33 %)	15 (25 %)	0.376
No Missing molars, n (%)		35 (80 %)	55 (92 %)	0.020*
Missing molars, n (%)		9 (20 %)	5 (8 %)	
Only upper, n		3	1	
Only lower, n		6	1	
Both upper and lower, n		0	3	
Sleep apnea severity, n (%)	1	17 (39 %)	28 (46 %)	0.559
	2	16 (36%)	22 (37 %)	
	3	11 (25 %)	10 (17 %)	

*Statistically significant; BMI: Body mass index; MAS: Mandibular advancement splint; CPAP: Continuous positive airway pressure; TMD: Temporomandibular disorder.

Occlusal splint prior to MAS treatment

None of the patients with unsuccessful MAS treatment used an occlusal splint. Eight percent of patients in the control group had used an occlusal splint for bruxism/TMD problems that had been replaced by MAS for treating OSA. The results suggest that MAS treatment is more likely to be successful in patients with prior experience with an occlusal splint ($p = 0.050$) (Table 2).

Missing molars

Of the patients in the successful treatment group (n = 60), five (8%) had missing molars, and in the failure group (n = 44), nine patients (20%) had missing molars. Bivariate associations showed that missing molars were associated with treatment failure ($p = 0.020$, Table 2). Those who had missing molars in only the lower dental arch were more likely to have unsuccessful treatment outcomes than those with no missing molars (Table 3).

Discussion

This was a retrospective controlled study of a single-center university hospital cohort of 44 patients who failed treatment for OSA with MAS. Patients with missing molars failed significantly more often in the MAS treatment compared to patients with no missing molars. In addition, the use of CPAP treatment prior to MAS showed a tendency to fail with MAS treatment. In contrast, MAS treatment is more likely to be successful in

patients with prior experience with occlusal splint use. According to the present results, the success of MAS treatment is not affected, at least significantly, by age, body mass index (BMI), sex, systemic or psychiatric diseases, dental overjet, TMD, or sleep apnea severity. Thus, there does not appear to be a clear reason for treatment failure. The current results are similar to the previous results of Mintz et al. [7], who also found no clear reason for treatment failure. Instead, they also found several different reasons for the failure of MAS treatment, e.g., TMJ or masticatory muscle pain, difficulties in tolerating MAS, bite changes, tooth loss, tooth pain, gagging, and lack of retention.

The use of an occlusal splint prior to MAS treatment seemed to be a predictive factor for MAS success. According to dentists' clinical experience, patients who are used to having some appliance in their mouth during sleep (orthodontic appliance/occlusal splint) are more willing to try a MAS appliance. Conversely, occlusal splints, which are used for TMD or masticatory muscle problems, might cause worsening of OSA by moving the mandible backward, narrowing the airway [11].

Sleep apnea severity, according to AHI values, was not found to correlate with failure of MAS treatment. A larger lower jaw forward movement in MAS will have a better effect on the AHI, although there is no linear relationship [12]. In a systematic review, Bartolucci et al. concluded that there is a small body of moderate-quality evidence to suggest that increasing the mandibular advancement does not produce significant improvements in the success rate since there is a high interindividual variability in response to the MAS therapy [13].

The motivation for this study was to identify the causes of failed MAS treatment. A large-scale study on oral appliances in sleep apnea treatment, its respiratory and clinical effects, and long-term adherence was carried out on all patients treated for a diagnosis of sleep apnea at the Department of Oral and Maxillofacial Diseases, HUH, Helsinki, Finland, between the years 2006 and 2013 (n = 1208) [3]. All patients were reviewed, and patients who discontinued OSA therapy after a 1-month follow-up visit were excluded from the study. The authors wanted to study the excluded group of patients (n = 397) to find possible correlations between certain factors and failed MAS treatment.

In this study, patients with deficient recorded data, patients who had resumed occasional CPAP therapy along with MAS, and patients who did not show up for the 1-month follow-up visit were excluded. A major limitation of the current study was the small amount of research material resulting in little statistical significance.

Table 3. Results of the final logistic regression model on treatment failure. Missing molars are categorized into the following: 1) only some or all upper molars missing, 2) only some or all lower molars missing, and 3) molars missing on both upper and lower arches.

	p	OR	95% CI
Missing molars (reference group: no missing molars)			
Only upper	0.187	4.7	0.5–47.1
Only lower	0.042	9.4	1.1–81.7
Both upper and lower	0.999	0.0	

OR: Odds ratio; CI: Confidence interval.

Special emphasis was placed on background variables relating to the length of the dental arch. The hypothesis was that a free-ending splint resembling a distal-extension removable partial denture could affect the comfort and frequency of use of the MAS oral appliance. The appliance presumably presses the alveoli and oral mucosa more easily and feels uncomfortable on a shortened dental arch, reflecting similar perceived dissatisfaction as that found with removable denture wearers [8]. Dissatisfaction has been shown to be higher for mandibular dentures than for maxillary dentures, which is in line with the findings of this study [14]. The study showed a statistically significant relationship between shortened lower dental arch and failed MAS treatment.

In the present study, a correlation between BMI and the failure of the MAS treatment was not found. However, the success of MAS treatment seems to be related to BMI. Suzuki et al. [15] found BMI to be significantly lower in responders versus non-responders (23.6 ± 2.8 vs. 27.9 ± 4.7 kg/m^2; $p < 0.05$) in patients treated with MAS [15]. Normal BMI at baseline seems to affect MAS success, although its strength as a predictor of MAS success is questionable in clinical practice. Weight increase during treatment has, however, been related to treatment failure [12]. Both the baseline BMI and its increase during MAS treatment seem to have some effect on the success/failure of MAS treatment. Thus, the BMI control in patients with OSA is an important part of MAS treatment.

In a previous study by Bachour et al. [3], MAS treatment (years 2006–2013) was successful in 67% of patients. Due to the continuous development of the MAS treatment, the current success rate is most likely higher. However, there still exists a group of patients who do not respond to MAS treatment. It seems that the reasons for MAS failure are individual, and no single reason can explain it.

Conclusion

In conclusion, MAS is an important part of OSA treatment options. The reasons for MAS failure are individual, and no single reason can be pointed out. Special attention should be paid to patients with CPAP tryout or missing molars in both dental arches and overweight patients to avoid treatment failure. Occlusal splint use prior to MAS treatment seems to improve the prognosis of MAS treatment.

Disclosure statement

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