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SLEEP BREATHING PHYSIOLOGY AND DISORDERS · ORIGINAL ARTICLE

Long-term efficacy of an oral appliance in early treated patients with obstructive sleep apnea

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Abstract

Purpose The purpose of the present study was to evaluate the long-term efficacy of oral appliances (OAs) in early treated patients with obstructive sleep apnea (OSA).

Method and patients Polysomnographic sleep recordings without and with an OA were performed at treatment start and in patients who had been continuously treated with OAs for at least 15 years.

Results Nine patients (eight men) with a median age of 68.1 years (interquartile range (IQR) 60.0 to 76.3 years) and a median treatment time of 16.5 years (IQR 16.3 to 18.0 years) were included. The apnea–hypopnea index decreased from a median of 17.3 (IQR 9.7 to 26.5) to 7.2 (IQR 4.0 to 9.6; $p=$ 0.03) at the short-term follow-up. After long-term use, the apnea–hypopnea index was 32.4 (IQR 22.2 to 58.8) without the device and 35.1 (IQR 13.6 to 46.2) with it ($p=0.08$). There were increases in the apnea–hypopnea index, both without the device ($p=0.02$) and with it ($p=0.008$). The degree of mandibular advancement did not differ between the two study occasions ($p=1.0$).

Conclusions Patients treated with oral appliances may experience deteriorations in disease severity and treatment efficacy during continuous long-term OA treatment. Regular follow-up schedules with renewed sleep apnea recordings should be considered for these patients in order to avoid suboptimal or a total loss of effects on sleep apneas.

Abbreviations

AHI	Apnea–hypopnea index
BMI	Body mass index (kg/m^2)
OA	Oral appliance
OSA	Obstructive sleep apnea

Introduction

Oral appliances (OAs) that move the mandible forward in order to treat snoring and obstructive sleep apnea (OSA) have been used for more than 30 years. The short-term efficacy of OAs has been studied in many randomized controlled trials, with encouraging results in all age groups [1–5]. The efficacy of OAs is lower compared with that of continuous positive airway pressure (CPAP), particularly in patients with more severe OSA [6, 7]. A higher tolerance of OA than of CPAP is suggested to level out this discrepancy and produce similar degrees of disease alleviation from both treatments [8]. In addition, the outcome in terms of daytime sleepiness and quality of life does not differ between OA and CPAP treatment in the shorter term [9].

The long-term efficacy of this intended lifelong treatment with OAs is more uncertain. Small samples of sleep apnea patients have been studied in the long term [10–18]. The efficacy of OAs on the apnea–hypopnea index (AHI) is described in seven studies up to 5 years [10–16] and the results in terms

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of the oxygen desaturation index (ODI) in another two studies up to 10 years [17, 18]. Sleep apneas or oxygenation dips were still low and unchanged with OAs in five of these studies. The other two studies report a deterioration, with increases in the apnea–hypopnea index. After 2 years, the mean (SD) apnea–hypopnea index increased from 4.2 (3.3) to 8.3 (3.5) [14] and after 4 years in terms of the mean (95 % CI) from 4.5 (2.6) to 7.2 (2.6) ($p<0.01$) [15]. The degree of mandibular advancement was unaltered in the majority of the 58 studied patients in these two studies, while 2 patients experienced improved efficacy from greater mandibular advancement. The aim of the present study was to evaluate the long-term efficacy of OAs in early treated patients with OSA.

Methods

Participants

Patients who had been treated continuously for a minimum of 15 years were considered for inclusion. They belonged to an early cohort of OA-treated patients starting in 1989 [19]. The patients had been treated according to existing clinical routines at the time. These routines included an objective assessment of the efficacy of the device and continuous follow-ups thereafter. These controls comprised an assessment of subjective treatment effects and the subjective need for renewed sleep apnea recordings or CPAP treatment before a new appliance was made. Subjective side effects and the control of bite changes were also estimated. The Epworth Sleepiness Scale score was measured at the final follow-up. Approval for the study was obtained from the Medical Ethics Committee at Umeå University.

Methodology

Polysomnography

Level 2 recordings were performed including polysomnography (Embla; Natus Neurology), with continuous recordings of EEG (C3-M2 and C4-M1), electrooculograms, submental EMG, nasal flow pressure sensor, piezo-electric belts (piezo respiratory effort sensor, Pro-Tech, Philips Respironics), pulse oximetry (Nonin XPOD+ 8000JSensor Adult Flex System, Nonin Medical), electrocardiograms (V5), and a body position sensor. All recordings were scored manually. An obstructive apnea was defined as the cessation of airflow in nasal pressure for at least 10 s with continuing abdominal and thoracic movements [20]. An obstructive hypopnea was defined as a 50 % reduction in nasal pressure for at least 10 s, accompanied by abdominal and thoracic movements in combination with an arousal or an oxygen desaturation of ≥3 %. Sleep was scored in 30-s epochs

according to Rechtschaffen and Kales [21]. The obstructive apnea–hypopnea index was defined as the mean number of obstructive apneas and hypopneas per hour of sleep. The long-term follow-ups without and with the device were performed in a randomized order. The patients had been without their devices for 1 week before the sleep recording without the device [22].

Devices

All devices were made by a dental technician from duplicate casts of the teeth and construction bites taken by the dentist. The initial appliances were fixed, but the degree of mandibular advancement was adjusted by a dental technician in patients with an initially insufficient treatment effect. Mandibular positioning was then controlled with every device renewal and continuously adjusted to keep the original effective mandibular advancement and compensate for bite changes and subjective effects, if needed. The degree of mandibular advancement was measured on the casts with the bite registration or the device between the upper and lower jaw on each occasion using a transparent millimeter sheet oriented along the occlusal plane. In addition, the most recent mandibular position was compared with the initial one. This was done by adapting the most recent bite registration or device on the initial casts, if possible.

Statistical analysis

The variables are described in median and interquartile ranges (IQRs). Wilcoxon's test for paired samples was used to compare the results at baseline and at follow-up. The Spearman correlation was used to analyze the relationship between Epworth Sleepiness Scale (ESS) and AHI with the device. The SPSS 22 Statistical Software Package (SPSS; Chicago, IL) was used in all calculations; $p<0.05$ was considered significant.

Results

Nine patients (eight men) who fulfilled the inclusion criteria were identified. They had a median (IQR) age of 68.1 years (60.0 to 76.3 years) and had been treated for 16.5 years (16.3 to 18.0 years). The baseline median BMI was 26.5 (kg/m^2) (24.7 to 31.1 kg/m^2) and was unchanged at the final follow-up. Patient characteristics are given in Table 1.

The short-term apnea–hypopnea index decreased from 17.3 (9.7 to 26.5) to 7.2 (4.0 to 9.6) ($p=0.03$) with OA. At the long-term follow-up, the apnea–hypopnea index was 32.4 (22.2 to 58.8) without the device and 35.1 (13.6 to 46.2) with it ($p=0.08$) (Table 2 and Fig. 1). There were increases in the apnea–hypopnea index, both without the device ($p=0.02$) and with it ($p=0.008$).

Table 1 Patient characteristics described in median and interquartile ranges

	Baseline (n=9)	Long-term follow-up (n=9)	p value
Age	51.7 (41.7–59.1)	68.1 (60.0–76.3)	<0.001
BMI (kg/m^2)	26.5 (24.7–31.1)	26.5 (24.4–30.2)	0.77
Treatment time (years)		16.5 (16.3–18.0)	
Mandibular advancement (mm)	6.0 (5.0–7.5)	6.0 (6.0–7.0)	1.00
Overjet change (mm)		−1.1 (−1.6 to −0.6)	0.02
Overbite change (mm)		−1.6 (−2.2 to −1.2)	0.02

Five of the patients had been included in a previous 5-year follow-up of treatment effects [13]. In these patients, the AHI decreased from 17.3 (9.7 to 45.6) to 7.2 (4.7 to 9.6) (p=0.04) at the initial recordings, from 17.1 (9.3 to 27.8) to 2.8 (0.7 to 24.4) (p=0.04) at the 5-year follow-up, and from 57.0 (32.4 to 66.7) to 35.5 (23.8 to 55.3) (p=0.08) after a median of 18 years (Fig. 1).

The ESS score was 6 (6–13) at the final follow-up. There was no correlation between the ESS score and AHI with the device at the final follow-up (p=0.82).

All nine patients had started treatment with fixed oral appliances in hard acrylic. The appliances had been continuously replaced with soft elastomeric fixed devices from the second time of renewal. Three patients were being treated with adjustable devices at the long-term follow-up.

Mandibular advancements did not differ between the short-term and 16-year follow-ups (p=1.0). There was a tendency toward an increase in mandibular advancement when the final appliance or bite registration was measured on the initial study casts, 1.0 mm (0.0 to 2.0 mm) (p=0.06). This measurement could not be performed in one patient, because of extensive dental reconstruction.

Both the overjet and the overbite decreased significantly during treatment with OA (Table 1). The overjet changed between 0.1 and −5.0 mm, with a median value of −1.1 mm, while the overbite changed between 0.1 and −3.9 mm, with a median value of −1.6 mm.

Discussion

Deteriorations in OSA severity and a loss of OA efficacy were found in the present small sample of patients treated continuously for more than 15 years with this method.

Previous long-term studies report an unchanged or only minor decrease in the efficacy of oral appliance therapy [10–18]. In one of these studies with some of the present patients included, the AHI was reduced from a mean (range) of 22 (6.5 to 60) to 4.9 (0.0 to 20) after 5 years of treatment [13]. This outcome did not differ from the short-term result in the 19 evaluated patients [13]. All five patients who were included in both studies had more severe sleep apnea in the long term. With the device, all patients had an AHI of ≤5 at 5 years, while only one patient had an index of below 30 at 18 years. These findings indicate that some patients may experience a large-scale deterioration in sleep apneas with their devices after decades of treatment. Older people have more frequent sleep apneas than younger ones. Peppard et al. report a 15 % higher frequency of OSA defined as an AHI of ≥5 among 50- to 70-year-old men compared with 30- to 49-year-old men [23]. In women, this difference is 20 % between the corresponding age groups. The anticipated increase in sleep apnea frequency is generally not foreseen when initiating treatment with an oral appliance for sleep apnea.

Increased weight with time is thought to be one explanation of the worsening of sleep-disordered breathing in the

Table 2 Effect of the oral appliance on respiratory variables (median and interquartile ranges)

	Short-term			Long-term follow-up (n=8)^a			Without (n=8)	With (c=9)
	Without	With	p value	Without	With	p value	p value	p value
Total sleep time (min)	415 (390–462)	413 (380–451)	0.753	425 (361–443)	340 (397–472)	0.401	0.866	0.917
Supine sleep (%)	46.0 (12.1–83.0)	35.4 (23.6–42.9)	0.249	23.0 (16.1–45.2)	41.7 (19.2–68.4)	0.093	0.463	0.116
AHI	17.3 (9.7–26.5)	7.2 (4.0–9.6)	0.028	32.4 (22.2–58.8)	35.1 (13.6–46.2)	0.080	0.017	0.008
AHI supine	23.7 (11.0–49.9)	17.4 (12.1–27.3)	0.600	42.2 (34.0–58.1)	33.3 (19.5–49.3)	0.123	0.116	0.028
AHI non-supine	8.2 (5.1–20.5)	1.2 (0.6–7.9)	0.345	24.6 (11.9–48.1)	19.5 (8.5–28.0)	0.208	0.500	0.046
ESS					6 (6–13)			

AHI apnea–hypopnea index, ESS Epworth Sleepiness Scale

^{a} One patient refused the sleep apnea recording without the device

Fig. 1 The apnea–hypopnea index without and with the OA in the short term (*n*=9), at 5 years (*n*=5) and at the final follow-ups (*n*=9). At the last follow-up, one patient refused the recording without the device
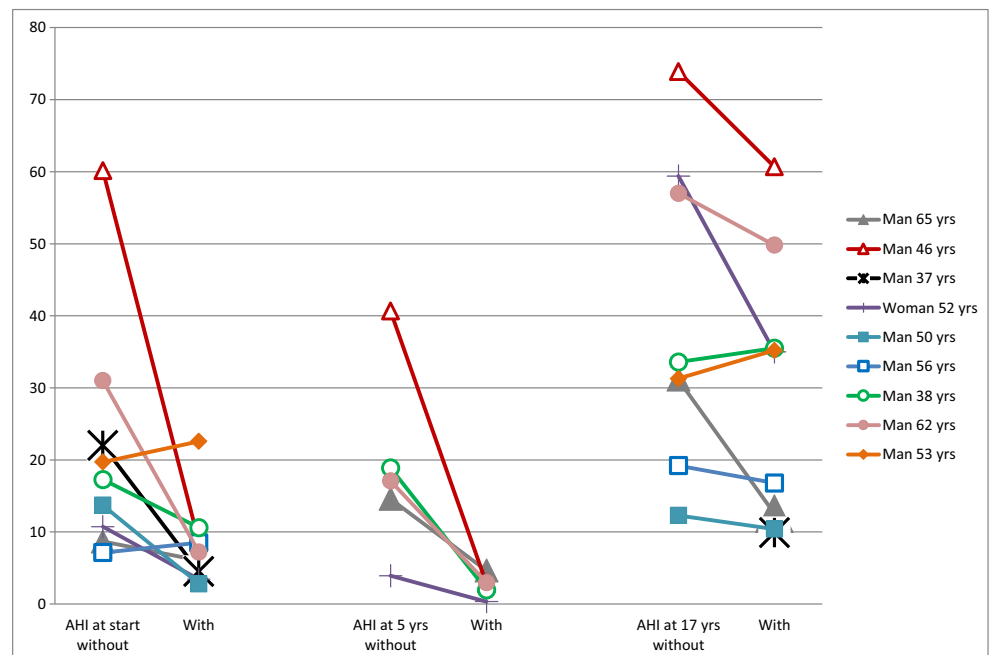
population [23]. This factor was not able to explain the increase in sleep apneas in the present sample, since the patients did not gain weight during the long-term treatment with oral appliances. More future phenotyping of obstructive sleep apnea patients might explain differences in success with oral appliance therapy in both the shorter and the longer term [24].

Bite changes are common during longer-term treatment with oral appliances [25]. Decreases in overjet and overbite and an overall mesial shift in the occlusion are to be expected. This also means that the degree of mandibular advancement might decrease, if there are no adjustments of the degree of mandibular positioning during treatment. The present patients decreased their overjet and overbite. With every device renewal, the degree of mandibular advancement was adapted to these changes, if needed and possible. This intended procedure was also apparent from the tendency toward an increase in mandibular advancement with time when compared with the initial plaster casts (*p*=0.06). Despite this, only three of nine patients had a treated index of below 15 with the device. Even so, there is probably a continuous need to titrate the lower jaw forward during longer-term treatment with oral appliances for sleep apnea patients. These procedures are easier to implement with adjustable devices compared with the predominantly fixed devices that were used in the present study.

With fixed CPAP machines, some patients also require adjustments of the pressure in order to experience optimal outcomes [26]. Greater use of automatic machines simplifies this problem. These alternatives are not available for oral appliance therapy.

The withdrawal of effective CPAP treatment includes the return of sleep apneas in most patients [27], and the patients may experience increased daytime symptoms [27–29]. Moreover, during long-term OA treatment, sleep apneas remain without the device in situ [12, 13]. This indicates that an improvement in disease severity is unlikely and further strengthens the need for continuous follow-ups.

Sleep in the supine position increases together with a decrease in sleep apneas, according to two short-term studies of oral appliance treatment [5, 19]. There was also a trend toward more supine sleep in the present sample, despite insignificant changes in positional indices with the device. A small reduction in supine sleep apneas or the introduction of a device in the mouth might perhaps stimulate supine sleep.

The main limitation of the present study was the small sample size. It was difficult to find patients who had received continuous long-term treatment with only an oral appliance. Only five patients had an intermediate 5-year follow-up. Although the outcome was successful, these patients also had a poorer outcome in terms of sleep apneas after a total of 18 years. The ESS score was not widely available when the patients started treatment. The 17-year follow-up showed a normal median ESS score. Patients' own experiences of the treatment appear to be unreliable when it comes to determining the outcome in terms of sleep apneas and more strict follow-ups are required.

In conclusion, patients treated with oral appliances may experience deteriorations in disease severity and treatment outcome during continuous long-term treatment. Regular follow-up schedules with renewed sleep apnea recordings should be performed in these patients in order to avoid suboptimal or a total loss of effects on sleep apneas.

Compliance with ethical standards

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Comment

These results provide unprecedented long-term follow-up data regarding the efficacy of oral appliances (OA) in moderate to severe OSA. They demonstrate the potential for OSA to progress and raise a question mark over the sustained effectiveness of OA. The sample is small and highly selected but these data support the case for lifelong follow-up of such patients. More work is needed to build larger, more inclusive long-term OSA cohorts.

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