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Implant-retained oral appliances: a novel treatment for edentulous patients with obstructive sleep apnea–hypopnea syndrome

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Abstract

Objectives: Mandibular repositioning appliances (MRAs) are a viable treatment alternative in patients with obstructive sleep apnea–hypopnea syndrome (OSAHS). Because these appliances require retention in the patient's dentition, edentelous patients generally do not qualify for this treatment. This study describes our experiences with an implant-retained MRA in the treatment of edentulous OSAHS patients.

Patients and methods: Six edentulous OSAHS patients were included in this study. Standard treatment consisted of the placement of four endosseous dental implants in the mandible and the construction of a new maxillary denture and a mandibular overdenture. Subsequently, an MRA was made. After a habituation and adjustment period, the effect of treatment was evaluated with polysomnography. Treatment was considered effective in cases where it yielded an apnea–hypopnea index <5.

Results: Of the six patients included, two did not tolerate the MRA because of pressure-induced discomfort on the labial mucosa in the maxilla. These two patients were offered an implant-retained overdenture and MRA in the maxilla. One of the two patients proceeded with this secondary treatment. Of the five patients completing the follow-up polysomnography, effective OSAHS treatment was attained in four.

Conclusions: The results from this study suggest that an implant-retained MRA in the mandible is a viable treatment modality in edentulous OSAHS patients. Because the therapeutic effectiveness of this treatment may be compromised by excessive pressure of the MRA on the labial mucosa in the maxilla, we suggest that an implant-retained MRA in the maxilla be offered as a secondary treatment in selected patients.

The obstructive sleep apnea–hypopnea syndrome (OSAHS) is a prevalent sleep-related breathing disorder, affecting approximately 4% of the male and 2% of the female adults in the North-American population (Young et al. 1993). The condition is characterized by disruptive snoring and repetitive obstructions of the upper airway during sleep. Airway obstructions in OSAHS patients are either partial (hypopnea) or complete (apnea) and often result in (severe) oxygen desaturations. Patients have recurrent arousals from sleep as an attempt to restore upper airway patency. This results in activation of the sympathetic nervous system and sleep fragmentation (Malhotra & White 2002). The neurobehavioral consequences of sleep fragmentation include excessive sleepiness, an increased risk of accidents, and impairment of the quality of life (Teran-Santos et al. 1999; Patel et al. 2003; Giles et al.

2006). Cardiovascular sequelae of OSAHS include hypertension and an increased risk for ischemic heart disease, congestive heart failure, and stroke (Wolk et al. 2003; Marin et al. 2005; Yaggi et al. 2005). Because obesity is a risk factor for OSAHS, it should be considered a serious and increasing public health problem (Newman et al. 2005). In order to diagnose OSAHS, a sleep registration (e.g., polysomnography) should demonstrate five or more apneas or hypopneas per hour sleep (i.e., apnea–hypopnea index $\geq$ 5) (AASM 1999).

Continuous positive airway pressure (CPAP) prevents upper airway collapse during sleep, and is currently regarded as the treatment of choice for OSAHS (Giles et al. 2006). However, poor compliance may compromise the effect of CPAP due to its obtrusive nature (Barbe et al. 2001; Barnes et al. 2002). Over the past decade, oral appliance therapy has emerged as an increasingly popular alternative for CPAP therapy (Cistulli et al. 2004). Oral appliances that reposition the mandible (mandibular repositioning appliances, MRAs) are currently considered a viable treatment modality, in particular for mild to moderate OSAHS (Hoekema et al. 2004). In up to 34% of cases, an MRA cannot be inserted because of dental limitations (Petit et al. 2002). Factors of consideration include (extensive) periodontal disease and dental decay, active temporomandibular joint disorders, and restrictions in mobility of the mandible. In the majority of cases, however, there are an insufficient number of teeth to support and retain the appliance (Petit et al. 2002; Hoekema et al. 2004). This is especially the case in edentulous patients.

Several types of oral appliances have been described for managing OSAHS in edentulous patients (Cartwright et al. 1988; Meyer & Knudson 1990; Robertson 1997; Kingshott et al. 2002; Eskafi et al. 2004; Nayar & Knox 2005). Full-night application of these appliances is generally compromised by discomfort or poor retention. In order to stabilize and retain an MRA in the edentulous mandible, osseointegrated implants may be used (Meyer & Knudson 1990). However, clinical studies of this technique have not been reported to date. This study describes our experiences with an implant-retained MRA in the treatment of edentulous OSAHS patients.

Patients and methods

Patient selection

All edentulous OSAHS patients treated with an MRA at the Medical Center Leeuwarden (the Netherlands) in the period January 2003 to January 2005 were included in this study (Table 1). Before treatment, all patients had been subjected to polysomnography and an upper airway examination. MRA therapy was indicated in mild OSAHS cases not qualifying for CPAP therapy (four male patients) or in patients declining CPAP therapy (two male patients). Written informed consent had been obtained from each patient before treatment was initiated.

Treatment procedure

Except for one patient, all subjects received four endosseous dental implants (Straumann AG, Waldenburg, Switzerland) in the interforaminal region of the mandible. Because one patient had previously (>10 years ago) received a transmandibular implant (M+R Haren b.v., Haren, Groningen, the Netherlands), placement of endosseous implants was not required in this subject. The implants were placed by one surgeon (K. H.) under local anesthesia (Sutter et al. 1988). After a 2-month osseointegration period, the MRA could be constructed.

Before the MRA was constructed, a new maxillary denture and a mandibular overdenture were made (Batenburg et al. 1993). A bar construction was screwed onto the implants (Fig. 1a). This construction provided support for a clip attachment that was incorporated into the mandibular overdenture. When the denture was finished, it was duplicated in transparent acrylic.

MRA therapy was performed with a modified version of the Thornton adjustable positioner (Airway Management Inc., Dallas, TX, USA) (Pancer et al. 1999). This MRA consists of an adjustable construction that allows patients to titrate the amount of mandibular advancement. The construction was incorporated into the duplicated denture. In the maxilla, the MRA was retained by the suction force of the duplicate of the upper denture. In the mandible, the MRA was retained by the bar construction and a clip attachment that was incorporated into the duplicate of the lower overdenture (Figs 1a and 2a). Patients were instructed to wear the MRA instead of their dentures whenever they slept. When initiating MRA therapy, the mandible was adjusted to approximately 50% of the patient's maximum advancement.

Table 1. **Patient characteristics**

Patient	Age (years)	Baseline AHI (No./h)	BMI (kg/m^2)	Implantological procedure
1	55	5.8	24.8	Four implants mandible Six implants maxilla (secondary treatment)
2	48	10.6	24.0	Four implants mandible
3	53	13.1	24.5	Four implants mandible
4	57	18.3	28.7	Four implants mandible
5	63	14.3	30.9	Transmandibular implant
6	58	18.3	28.4	Four implants mandible

AHI, apnea–hypopnea index; BMI, body mass index.

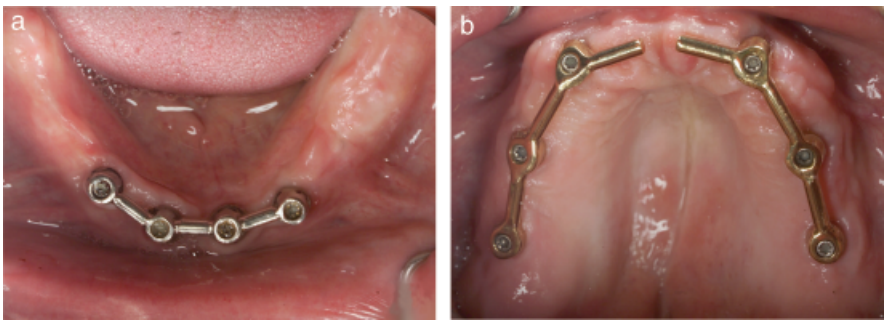

Fig. 1. Features of the bar constructions that provide retention for a mandibular repositioning appliance (patient 1); (a) bar construction screwed onto the implants in the mandible, (b) bar construction screwed onto the implants in the maxilla.

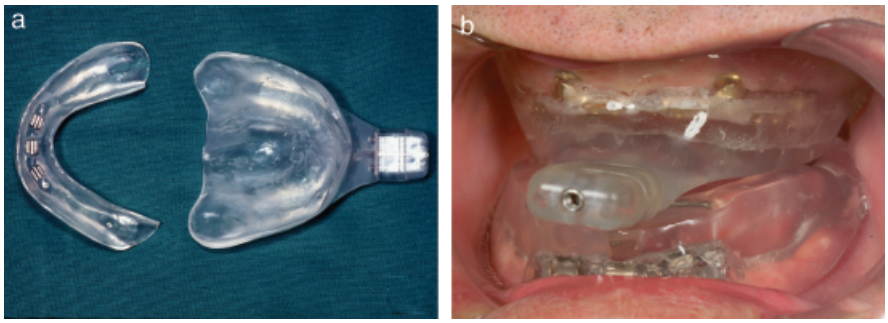

Fig. 2. Features of the mandibular repositioning appliance (MRA) (patient 1); (a) upper and lower part of the MRA before placement of implants in the maxilla; note the clip attachment in the mandibular part of the MRA, (b) intraoral view with MRA after placement of implants in the maxilla.

***Table 2.* Polysomnographic outcomes**

Patient	Follow-up* (months)	AHI (no/h)		$MinSaO_2$ (%)		desaturation index (No./h)	
		Baseline	MRA	Baseline	MRA	Baseline	MRA
1	24	5.8	0.0	90	92	13.5	1.1
2	8	10.6	4.0	85	83	5.7	2.3
3	7	13.1	4.7	90	91	10.6	2.4
4	6	18.3	3.4	84	79	22.4	12.2
5	10	14.3	12.4	86	88	14.1	4.5
6	–	18.3	–	84	–	5.3	–

*Follow-up period from treatment initiation until follow-up polysomnography of MRA therapy. AHI, apnea–hypopnea index; $MinSaO_2$, minimum oxyhemoglobin saturation during sleep; MRA, mandibular repositioning appliance.

Patients could accustom to this position during a 2-week period. Subsequently, patients were instructed to advance the mandible with 1–2 increments (i.e., 0.2–0.4 mm) each night. This titration was continued until symptoms of OSAHS (e.g., snoring, apneas and hypopneas, or excessive sleepiness) abated or until further advancement of the mandible resulted in discomfort. After the MRA was titrated, a second polysomnographic study was performed.

Polysomnography

Polysomnography at baseline and follow-up evaluations was conducted ambulatory in the patient's home situation (Embla® A10 digital recorder, Medcare, Reykjavik, Iceland). Standardized criteria were used to score apneas and hypopneas (AASM 1999). All polysomnographic studies were evaluated and scored by one neurophysiologist.

Outcome measures

The apnea–hyponea index (AHI) was used as the primary outcome measure. MRA therapy was considered effective in case it resulted in an AHI <5. Secondary outcomes were changes in the minimum oxyhemoglobin saturation during sleep ($MinSaO_2$) and the desaturation index (i.e., the mean number of oxyhemoglobin desaturations $>4\%$/h sleep).

Results

The time interval between placement of the implants and initiation of MRA therapy varied from 6 months (four patients) to 10 months (patient 1). In the sixth patient, who already had an implant-retained overdenture in the mandible (patient 5), MRA therapy could be initiated within a month. Besides the loss of one of the implants (patient 6), no complications were encountered after placement of the implants.

MRA therapy was well tolerated by four of the six patients. In the remaining two patients (patients 1 and 6), the MRA was not tolerated because of pressure-induced discomfort of the labial mucosa in the maxilla. However, advancement of the mandible was limited for the same reason in three patients who did tolerate the MRA (patients 2, 3, and 5). Attempts to relieve the labial mucosa by trimming the acrylic of the upper appliance or by applying a silicone lining were unsuccessful in the two patients who did not tolerate the MRA. In order to resolve the pressure problems, these two patients were offered an implant-retained overdenture and MRA in the maxilla. Because this would require additional surgery, one patient declined further treatment (patient 6). The other patient was treated under general anesthesia with a bone augmentation of the maxillary sinuses using autologous grafts from the right anterior iliac crest. After 3 months, six endosseous implants were inserted into the posterior region of the maxilla, and after another 3 months, two bar constructions were screwed onto the maxillary implants. These bar constructions provided retention for an overdenture and MRA in the maxilla (Figs 1b and 2b). The pressure on the labial mucosa was relieved and the further course of MRA therapy was uncomplicated in this patient.

All five patients who completed the follow-up review displayed an improvement in the AHI as a result of MRA therapy (Table 2). Effective OSAHS treatment (i.e., AHI <5) was attained in four patients. The $MinSaO_2$ showed a small improvement in three out of five patients. The desaturation index improved in all five patients. The deterioration in $MinSaO_2$ and modest improvement in the desaturation index in one patient (patient 4) could be explained by a chronic obstructive pulmonary disease.

Four out of the five patients who completed the follow-up review of MRA therapy reported a satisfactory improvement of their symptoms (e.g., snoring, excessive sleepiness). Despite an adequate improvement of the AHI, the remaining patient complained of persistence in socially disruptive snoring (patient 2). To resolve these complaints, additional advancement of the mandible was necessary. Because this again caused excessive pressure on the labial mucosa in the maxilla, an implant-retained MRA in the maxilla, as described earlier, was offered. This patient is currently contemplating this secondary treatment.

Discussion

Edentulous OSAHS patients are generally excluded from MRA therapy (Hoekema et al. 2004). In the general Dutch popula-

tion, up to 35% of subjects aged 20 years or older are edentulous (van den Berg 1982). Therefore, in theory, a considerable proportion of OSAHS patients do not qualify for MRA therapy. This study demonstrates that placement of endosseous implants, in order to stabilize and retain an MRA, is worth the consideration in edentulous OSAHS patients. After implant insertion, MRA treatment can generally be initiated within a 6-month period. By adopting the technique described in this study, a larger proportion of OSAHS patients qualify for MRA therapy. Moreover, edentulous OSAHS patients may be offered a greater variety of treatment options when CPAP therapy is not indicated or has failed.

Four out of the six patients tolerated the implant-retained MRA well. However, in five of the six patients, the therapeutic effectiveness was compromised by pressure of the MRA on the labial mucosa in the maxilla. In two patients, this phenomenon made it impossible to wear the MRA. We have successfully treated one of these patients with six implants in the maxilla retaining the upper part of an MRA. We suggest that this solution be offered to patients failing the primary treatment due to pressure discomfort of the upper appliance. When compared with the mandible, placement of implants in the posterior region of the maxilla is generally associated with more morbidity and more prolonged treatment periods (Raghoebar et al. 2001). To overcome these limitations, we currently offer patients requiring an implant-retained MRA in the maxilla two implants in the canine regions. These two implants can be provided with ball attachments that may subsequently be used for retention of an overdenture and MRA. By doing so, surgical intervention is minimized and secondary treatment may be initiated more quickly.

In four out of five patients, the MRA therapy resulted in an AHI < 5. In the fifth patient, therapy was not effective. This may be related to the limitation in mandibular advancement that resulted from pressure of the MRA on the labial mucosa in the maxilla. Despite the disappointing effect on the AHI, the desaturation index improved substantially in this patient. Because the patient experienced a satisfactory improvement in symptoms, he refused secondary treatment.

The results from this study suggest that an implant-retained MRA in the mandible is a viable treatment modality in edentulous OSAHS patients. However, the therapeutic effectiveness of this treatment may be compromised by excessive pressure of the MRA on the labial mucosa in the maxilla. To overcome this limitation, we suggest that an implant-retained MRA in the maxilla be offered as a secondary treatment in selected patients. Additional studies evaluating the feasibility of this secondary treatment and the feasibility of an implant-retained MRA in OSAHS patients with more severe disease are of interest. It is advised that treatment with an implant-retained MRA is performed by an oral and maxillofacial surgeon and dentist experienced in treating patients with sleep-related breathing disorders.

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要旨

目的：下顎位修正装置（MRA）は閉塞性睡眠時無呼吸－呼吸低下症候群（OSAHS）の患者にとって実行可能な治療法である。同装置を使用するには患者の歯列に維持を求める必要があるので、無歯顎患者は一般には同治療法の対象とはならない。本稿はインプラント維持型の MRA を無歯顎 OSAHS 患者の治療に用いた経験を報告する。

患者と方法：無歯顎 OSAHS 患者６名を本研究に組み入れた。標準治療として、下顎に骨内歯科インプラント４本を埋入し、新しい上顎義歯と下顎オーバーデンチャーを製作し、次に MRA を製作した。順応と調整期間後、睡眠ポリグラフ計によって治療効果を評価した。治療は無呼吸－呼吸低下指数が＜５となった場合に、治療有効とみなした。

結果：患者６名のうち２名は、MRA の圧力によって上顎の唇粘膜に不快感が生じたため、MRA を忍容しなかった。これら 2 名の患者にはインプラント維持型のオーバーデンチャーと、上顎の MRA を提供した。この２名のうち１名は同代替法によって治療を進めた。経過観察時の睡眠ポリグラフを記録した５名のうち、４名においてOSAHS 治療は有効であった。

結論：本研究の所見は、下顎におけるインプラント維持型の MRA は無歯顎 OSAHS 患者にとって有望な治療様式であることを示唆している。本治療法の効果は、MRA が上顎の唇粘膜を過剰に圧迫することによって損なわれる可能性があるので、当該患者には代替治療として、上顎にインプラント維持型の MRA を装着することを提案する。

References

AASM. (1999) Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research. The report of an American Academy of Sleep Medicine task force. *Sleep* **22**: 667–689.

Barbe, F., Mayoralas, L.R., Duran, J., Masa, J.F., Maimo, A., Montserrat, J.M., Monasterio, C., Bosch, M., Ladaria, A., Rubio, M., Rubio, R., Medinas, M., Hernandez, L., Vidal, S., Douglas, N.J. & Agusti, A.G. (2001) Treatment with continuous positive airway pressure is not effective in patients with sleep apnea but no daytime sleepiness. a randomized, controlled trial. *Annals of Internal Medicine* **134**: 1015–1023.

Barnes, M., Houston, D., Worsnop, C.J., Neill, A.M., Mykytyn, I.J., Kay, A., Trinder, J., Saunders, N.A., Douglas McEvoy, R. & Pierce, R.J. (2002) A randomized controlled trial of continuous positive airway pressure in mild obstructive sleep apnea. *American Journal of Respiratory and Critical Care Medicine* **165**: 773–780.

Batenburg, R.H., Reintsema, H. & van Oort, R.P. (1993) Use of the final denture base for the intermaxillary registration in an implant-sup-

ported overdenture: technical note. *International Journal of Oral & Maxillofacial Implants* **8**: 205–207.

van den Berg, J. (1982) *Dentures in the Dutch population. Monthly Report in Health Statistics Nr. 1*. the Netherlands: Central Bureau for Statistics .

Cartwright, R., Stefoski, D., Caldarelli, D., Kravitz, H., Knight, S., Lloyd, S. & Samelson, C. (1988) Toward a treatment logic for sleep apnea: the place of the tongue retaining device. *Behaviour Research and Therapy* **26**: 121–126.

Cistulli, P.A., Gotsopoulos, H., Marklund, M. & Lowe, A.A. (2004) Treatment of snoring and obstructive sleep apnea with mandibular repositioning appliances. *Sleep Medicine Reviews* **8**: 443–457.

Eskafi, M., Ekberg, E., Cline, C., Israelsson, B. & Nilner, M. (2004) Use of a mandibular advancement device in patients with congestive heart failure and sleep apnoea. *Gerodontology* **21**: 100–107.

Giles, T., Lasserson, T., Smith, B., White, J., Wright, J. & Cates, C. (2006) Continuous positive airways pressure for obstructive sleep apnoea in adults. *Cochrane Database of Systematic Reviews* **1**: CD001106.

Hoekema, A., Stegenga, B. & de Bont, L.G.M. (2004) Efficacy and co-morbidity of oral appliances in the treatment of obstructive sleep apnea-hypopnea: a systematic review. *Critical Reviews in Oral Biology and Medicine* **15**: 137–155.

Kingshott, R.N., Jones, D.R., Taylor, D.R. & Robertson, C.J. (2002) The efficacy of a novel tongue-stabilizing device on polysomnographic variables in sleep-disordered breathing: a pilot study. *Sleep and Breathing* **6**: 69–76.

Malhotra, A. & White, D.P. (2002) Obstructive sleep apnoea. *Lancet* **360**: 237–245.

Marin, J.M., Carrizo, S.J., Vicente, E. & Agusti, A.G. (2005) Long-term cardiovascular outcomes in men with obstructive sleep apnoea-hypopnoea with or without treatment with continuous positive airway pressure: an observational study. *Lancet* **365**: 1046–1053.

Meyer, J.B. & Knudson, R.C. (1990) Fabrication of a prosthesis to prevent sleep apnea in edentulous patients. *The Journal of Prosthetic Dentistry* **63**: 448–451.

Nayar, S. & Knox, J. (2005) Management of obstructive sleep apnea in an edentulous patient with a mandibular advancement splint: a clinical report. *The Journal of Prosthetic Dentistry* **94**: 108–111.

Newman, A.B., Foster, G., Givelber, R., Nieto, F.J., Redline, S. & Young, T. (2005) Progression and regression of sleep-disordered breathing with changes in weight: the Sleep Heart Health Study. *Archives of Internal Medicine* **165**: 2408–2413.

Pancer, J., Al-Faifi, S., Al-Faifi, M. & Hoffstein, V. (1999) Evaluation of variable mandibular advancement appliance for treatment of snoring and sleep apnea. *Chest* **116**: 1511–1518.

Patel, S.R., White, D.P., Malhotra, A., Stanchina, M.L. & Ayas, N.T. (2003) Continuous positive airway pressure therapy for treating sleepiness in a diverse population with obstructive sleep apnea: results of a meta-analysis. *Archives of Internal Medicine* **163**: 565–571.

Petit, F.X., Pepin, J.L., Bettega, G., Sadek, H., Raphael, B. & Levy, P. (2002) Mandibular advancement devices: rate of contraindications in 100 consecutive obstructive sleep apnea patients. *American Journal of Respiratory and Critical Care Medicine* **166**: 274–278.

Raghoebar, G.M., Timmenga, N.M., Reintsema, H., Stegenga, B. & Vissink, A. (2001) Maxillary bone grafting for insertion of endosseous implants: results after 12–124 months. *Clinical Oral Implants Research* **12**: 279–286.

Robertson, C.J. (1997) Obstructive sleep apnoea Part. II: treatment with a customised dental appliance. *The New Zealand Dental Journal* **93**: 4–9.

Sutter, F., Schroeder, A. & Buser, D. (1988) New ITI implant concept – technical aspects and methods (I). *Die Quintessenz* **39**: 1875–1890.

Teran-Santos, J., Jimenez-Gomez, A. & Cordero-Guevara, J. (1999) The association between sleep apnea and the risk of traffic accidents. Cooperative Group Burgos-Santander. *The New England Journal of Medicine* **340**: 847–851.

Wolk, R., Kara, T. & Somers, V.K. (2003) Sleep-disordered breathing and cardiovascular disease. *Circulation* **108**: 9–12.

Yaggi, H.K., Concato, J., Kernan, W.N., Lichtman, J.H., Brass, L.M. & Mohsenin, V. (2005) Obstructive sleep apnea as a risk factor for stroke and death. *The New England Journal of Medicine* **353**: 2034–2041.

Young, T., Palta, M., Dempsey, J., Skatrud, J., Weber, S. & Badr, S. (1993) The occurrence of sleep-disordered breathing among middle-aged adults. *The New England Journal of Medicine* **328**: 1230–1235.