European Journal of Orthodontics 32 (2010) 490–495
doi:10.1093/ejo/cjp135
Advance Access Publication 28 January 2010

© The Author 2010. Published by Oxford University Press on behalf of the European Orthodontic Society.
All rights reserved. For permissions, please email: journals.permissions@oxfordjournals.org

Functional treatment of snoring based on the tongue-repositioning manoeuvre

Wilfried Engelke*, Wolfgang Engelhardt*, Milagros Mendoza-Gärtner*, Oscar Deccó**, Jenifer Barrirero** and Michael Knösel***

Departments of *Maxillofacial Surgery and ***Orthodontics, University of Göttingen, Germany, **Laboratorio Bioimplantes, Universidad Nacional de Entre Ríos, Paraná, Argentina

Correspondence to: Professor Wilfried Engelke, Department of Maxillofacial Surgery, Georg August University Göttingen, Robert Koch Street 40, D-37075 Göttingen, Germany. E-mail: wengelke@med.uni-goettingen.de

SUMMARY Orofacial biofunction comprises muscular and physical effects, which may contribute to stabilization of the oropharyngeal airway. The tongue-repositioning manoeuvre (TRM) provides physical stabilization of the tongue and the soft palate together with, as a prerequisite, a nasal breathing mode. The aim of the present study was to evaluate the influence of a TRM treatment concept on primary snoring.

The TRM was used to achieve a closed biofunctional rest position of the orofacial system and to re-educate the nasal breathing pattern. Pressure indicating oral shields were used for home exercises as a biofeedback instrument and to support nocturnal mouth closure. Treatment was undertaken on 125 consecutive primary snorers [101 males, mean age 52.4 years, range 34–75, mean body mass index (BMI) 28.1, range 18.9–38.5, and 24 females, mean age 55.2 years, range 36–70, mean BMI 26.8, range 22.7–31.9]. Bed partner ranking was performed, and snoring was judged using a 10-cm visual analogue scale (VAS).

The VAS score was 8.4 (range 6–10) before treatment and decreased to 4.1 (range 0–10) after treatment [mean observation time 4.6 months (1–10)]. Analysis of variance showed a significant influence of treatment in subjects with a normal body weight (BMI 18.5–25).

The data provide evidence that dynamic stabilization of the orofacial system with the TRM in conjunction with nocturnal wear of an oral shield is beneficial for reducing the symptoms in primary snorers with a normal BMI.

Introduction

Snore is sound generated from the upper airway due to vibration of the soft palate and the pharyngeal walls. It occurs during inspiration, but rarely during expiration (Gabriely and Jensen, 1993). Snoring is associated with changes in the calibre of the upper airway, which reduces flow and increases airway resistance. These changes may not be influential enough to produce clinical symptoms or to cause disruption in sleep (Guilleminault *et al.*, 1991). Snoring under these circumstances is termed 'primary snoring' (Rappai *et al.*, 2003). Snoring may be a risk factor in the development of cardiovascular disease and is a cardinal symptom of obstructive sleep apnoea (OSA; Issa and Sullivan, 1984).

It is common knowledge that most snorers breathe through their mouths while snoring (Fajdiga, 2005). Generally, two different types of constriction may be formed during nasal breathing in the mesopharynx, i.e. between the posterior pharyngeal wall, the soft palate, and the tongue base, and during mouth breathing in the isthmus faucium between the tongue dorsum and the soft palate.

Snoring and mouth breathing

Since breathing through the nose appears to be the preferred route during sleep, nasal obstruction may lead to snoring via nocturnal mouth breathing. Hypothetically, snoring may be reduced by anterior displacement of the tongue with the intention to compensate inadequate activity of the pharyngeal opening muscles. Direct anterior displacement of the tongue leads to an amplification of the mesopharyngeal airway space, but is difficult to achieve with clinical manoeuvres at night. However, the use of tongue retaining devices has been reported to reduce the time of loud snoring during sleep (Cartwright *et al.*, 2000).

As an additional factor, the position of the mandible during mouth opening is considered to have an effect on the patency of the upper airway. Mouth opening has been documented during sleep in normal subjects and in patients with OSA (Hollowell and Suratt, 1991; Miyamoto *et al.*, 1998). Mouth opening is associated with a backward and downward displacement of the mandible and the tongue (Shikata *et al.*, 2004) and has been shown to increase the propensity to upper airway collapse (Meurice *et al.*, 1996).

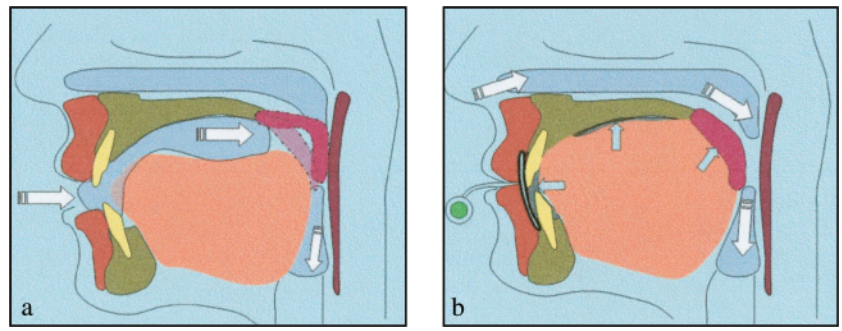

Figure 1 Effect of the tongue-repositioning manoeuvre (TRM) on the oronasopharyngeal rest position. (a) Open rest position with mixed oronasal breathing mode showing a tendency for soft palate vibration. (b) Control of closed rest position by negative intraoral pressure during the TRM.

Table 1 Gender and body mass index (BMI) of the sample used.

Gender	BMI			Total
	Normal (18.5–25)	Overweight (25–30)	Obese (30–35)	
Male	36	45	20	101
Female	8	10	6	24
Total	44	55	26	125

One explanation for this phenomenon is that jaw opening is associated with a posterior movement of the angle of the jaw, which compromises the oropharyngeal airway diameter (Kuna and Remmers, 1985).

It has been shown that upper airway resistance during sleep is significantly lower during nasal breathing than oral breathing (Fitzpatrick *et al.*, 2003). Thus, pure nasal breathing and complete mouth closure appears to be a physiological status for normal breathing at rest. During sleep, however, it was found that males breathe a greater percentage of total ventilation through the mouth than females (Gleeson *et al.*, 1986). The switch from nasal to oral breathing may occur in increased nasal resistance during sleep, and may further compromise the airway and increase the effort of breathing (Rappai *et al.*, 2003). However, the physiological explanation for the marked predominance of nasal ventilation over oral ventilation during sleep in normal subject is unknown. A possible explanation has been proposed by Engelke *et al.* (2006): a closed oral rest position with intraoral negative pressure may represent an additional physical stabilizing mechanism of the soft palate as well as the tongue and, in turn, may reduce the amount of neuromuscular activity needed for maintenance of airway patency. Thus, regarding the physical co-factor of stabilization, it appears obvious that healthy subjects should choose to breathe almost exclusively through the nasal route during sleep (Fitzpatrick *et al.* 2003), because mouth breathing does not permit an anterior and posterior oral seal as required for a closed oral rest position.

Tongue-repositioning manoeuvre

The tongue-repositioning manoeuvre (TRM; Engelke, 2003) is a clinical manoeuvre to place the tongue in a soft palate contact position by intraoral negative pressure formation (closed rest position) that requires exclusively a nasal breathing mode. Using a membrane funnel shield as a pressure indicating device, subjects can observe the formation of negative intraoral pressure during and after deglutition. This can be taken as indicator for the hermetic closure of the orofacial functional spaces, including the valve mechanisms of the lips, the tongue, and the velum. Radiographically, during the TRM, a tongue position at the hard palate can be observed together with the formation of a close palatolingual seal (Engelke *et al.*, 2006). The concept of the closed rest position is depicted in Figure 1. Thus, the TRM leads to an anterior and superior intraoral tongue position, and according to the vacuum experiment of Fränkel (1967), contributes to continuous jaw closure.

With regard to the biomechanical aspects considered above, exercises using the TRM are likely to have a beneficial influence on snoring and breathing. The aim of training is to achieve a nasal breathing mode and a closed oral rest position. Additionally, nocturnal support of mouth closure was assisted by wearing an oral shield. The aim of the present study was therefore to evaluate the effect of the TRM treatment concept on primary snoring.

Subjects and methods

A total of 125 consecutive patients from the Göttingen Rhonchopathy Clinic were assessed retrospectively. Approval was given by the local ethics committee. Distribution of gender and body mass index (BMI) is shown in Table 1. The patients were classified into three groups depending on their BMI: normal (18.5–25), overweight (25–30), and obese (30–35).

The mean age of the 101 male patients was 52.37 years (range 10 to 76 years) and of the 24 female patients, 55.21 years (range 36–72 years).

All patients suffered from snoring; diagnosis was based on a standardized questionnaire evaluation (Engelke, 2007). Snoring loudness was judged by bed partner ranking on a 10-cm visual analogue scale (VAS). To be included in the study, only primary snoring was accepted. Patients exhibiting a BMI of >35 were excluded. As the aim of treatment was exclusively restricted to the reduction of snoring, following the questionnaire evaluation, subjects with OSA were excluded.

Biofunctional exercises

All patients received a standardized training device (membrane funnel shield, MFS; Duderstädter Dental Labor, Duderstadt, Germany). The device was adapted individually by thermoplastic moulding. During the first appointment, the patients received instructions concerning the performance of the TRM.

The patients were asked to collect saliva with the MFS placed between the anterior teeth and the lips, observing the position of the membrane in the funnel with a mirror. During swallowing of saliva, negative pressure formation can be observed with the MFS by inversion of the membrane into the funnel (Figure 2). After swallowing, the patients were instructed to breathe quietly and to maintain the intraoral negative pressure indicated by the inward position of the membrane for as long as possible.

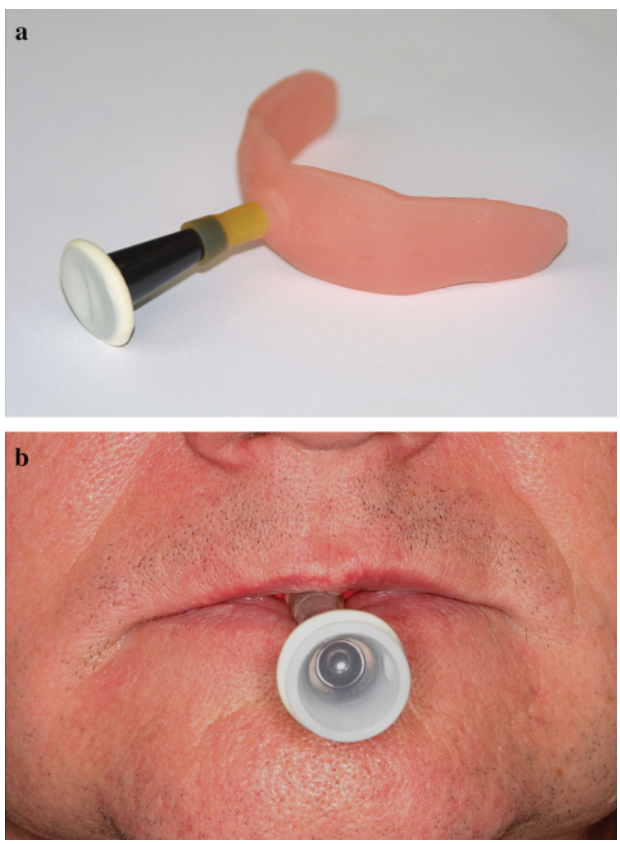

Figure 2 Use of the membrane funnel shield. (a) Training device. (b) Patient during generation of negative intraoral pressure (membrane is inverted).

The performance of the TRM was controlled after evaluation of the patients by pressure monitoring. The device used for recording intraoral pressure was a digital pressure meter (GMH 3150; GSG Greisinger, Würzburg, Germany) and display program (GSOFT 3050; GSG Greisinger; Figure 3). All measurements were performed in the vestibulum with a polyethylene tube connected to a dental suction tip.

The patients were informed that the aim of the treatment was to achieve a nasal breathing pattern and a tongue parking position at the palate in order to stabilize the tongue and the soft palate. They were instructed not to provoke excessive negative pressure during the exercise to avoid any side-effects by pressure on the gingiva. In the case of nasal obstruction, the patients were instructed to interrupt the training immediately and to see his/her otorhinolaryngologist for further examination.

Following instruction, the patients underwent 30- to 60-minute daily home training for at least 4 weeks. The recommendation was to practise the TRM in the evening before rest.

If no signs of nasal obstruction were present after 4 weeks of daytime training, the patients were allowed to use an oral shield overnight to continuously support mouth closure.

Evaluation

Snoring was assessed using bed partner ranking on a 10-cm VAS. The patient's bed partners were asked to describe snoring loudness on a 10-point scale. Evaluation was carried out before treatment and during the last follow-up. The mean observation time was 4.6 months (range 1–16 months).

All data were entered into a computer database and the Statistical Package for Social Sciences (version 15.0 for Windows, SPSS Inc., Chicago, Illinois, USA) was used for statistical analysis. Therapeutic effects were tested with the Spearman rank correlation in the male patient group. Due to the limited data, in the female patient group exact randomization test was chosen. Significance was established at the 5 per cent level.

Results

The bed partner ranking of 125 snorers showed a score of 8.4 (range 6–10) before treatment. After treatment (mean observation time 4.6 months), the score decreased to 4.1 (range 1–10).

Male patients

The distribution of pre- and post-therapeutic VAS scores is shown in Figure 4a. In the normal weight group, a significant improvement of VAS was observed; Spearman rank correlation

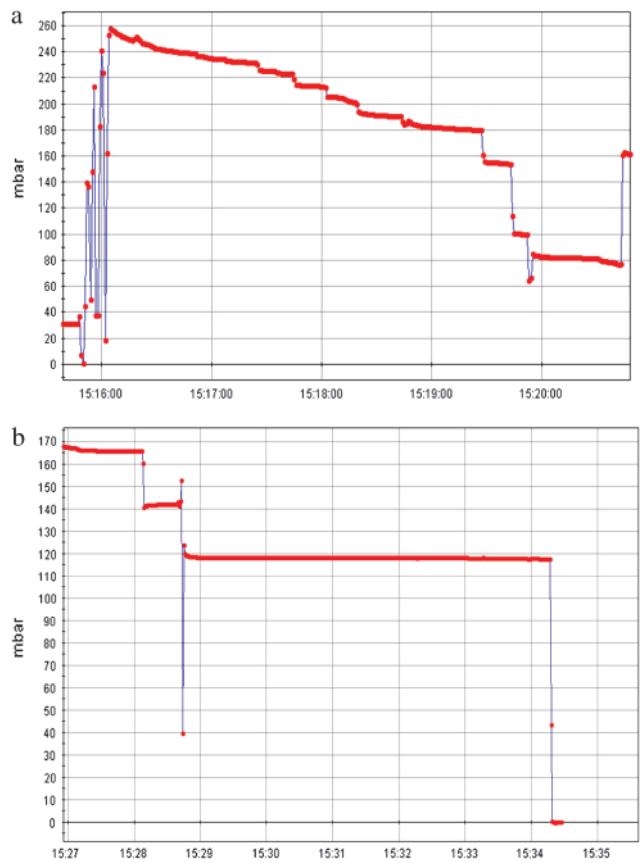

Figure 3 Tongue-repositioning manoeuvre (TRM) performance monitoring with intraoral pressure gauge. Pressure/time diagrams: (a) Initially repetitive negative pressure generation is shown followed by a phase of constant negative pressure; (b) Subject producing continuous negative pressure during TRM interrupted by swallowing activity.

was $\rho = 0.557$, explaining 31 per cent of the variance as being due to the influence of treatment. In the moderate overweight group, a significant improvement of VAS was also observed ($P < 0.05$), but Spearman's rank correlation was $\rho = 0.376$, explaining only 14 per cent of the variance. In the obese group, the correlation was $\rho = 0.015$, i.e. not significant.

Female patients

Descriptive parameters of pre- and post-therapeutic VAS ranking in the different BMI groups are shown in Figure 4b. For normal and overweight patients, the differences between pre- and post-therapeutic VAS was confirmed at the 0.05 level of significance indicating an improvement of symptoms. In the group of obese female patients, no significant improvement was observed.

Discussion

Treatment concept

Primary snoring without OSA affects between 19–37 per cent of the general population, and 41 per cent of middle-aged males (Norton and Dunn, 1985). Based on the importance of the problem of snoring as a widespread social risk factor, it was the aim of this study to provide a treatment concept that can be applied widely, at low cost and without major side-effects. The results of an ongoing study were recently presented using bed partner ranking as an instrument of evaluation (Engelke *et al.* 2007).

In a recent review of oral appliances for sleep-disordered breathing, Hoffstein (2007) divided the appliances into three general groups: soft palatal lifters, tongue retaining devices, and mandibular advancement appliances. Although the mechanism of mandibular advancement appliances, according to many researchers, can enlarge the airway and reduce pharyngeal collapsibility by advancing the mandible, there is only limited information in the literature about the biofunctional aspects of tongue and soft tissue posture during the use of tongue retaining devices (Hoffstein, 2007).

Biofunctional training in conjunction with oral shields is different from the use of passively acting devices and focuses on the use of the closed rest position as a therapeutic goal. Since, according to Mew (2004), weak muscles and open mouth postures are now endemic in our society and may lead to postural deformity, the present treatment is directed towards a well-known and wide-spread disorder with two therapeutic goals: (1) change of breathing mode and (2) change of postural habit.

Re-education of nasal breathing was the first therapeutic intention of the concept. The generation of subatmospheric intraoral pressure during performance of the TRM serves as an objective parameter to control and to establish nasal breathing via functional training. Pressure monitoring was used to control the patient's ability to perform and to maintain the subatmospheric pressure during the instruction phase.

The second aspect of the treatment concept was the change of the open mouth posture associated with snoring, i.e. to achieve complete mouth closure and a palatal contact position of the tongue with intraoral negative pressure formation using the TRM. The description of subatmospheric pressure and the use of oral shields *per se* are not new and have been reported previously. Strong negative pressure in conjunction with oral shields was observed by Fränkel (1967), and moderate negative pressures were measured by Witt and Kühr (1969) when using oral shields in volunteers. Negative pressure is present in newborns (Lindner, 1991; Lindner and Hellsing, 1991) and during dummy sucking. In awake subjects, negative pressure can be observed in the palatal vault at rest (Thüer *et al.*, 1999). However, the therapeutic consequences of the treatment of snoring using the oral vacuum mechanism do not appear to have been previously considered. As a result of the evacuation of the oral cavity during TRM, the orofacial system shows stable conditions comparable with a closed hydraulic chamber.

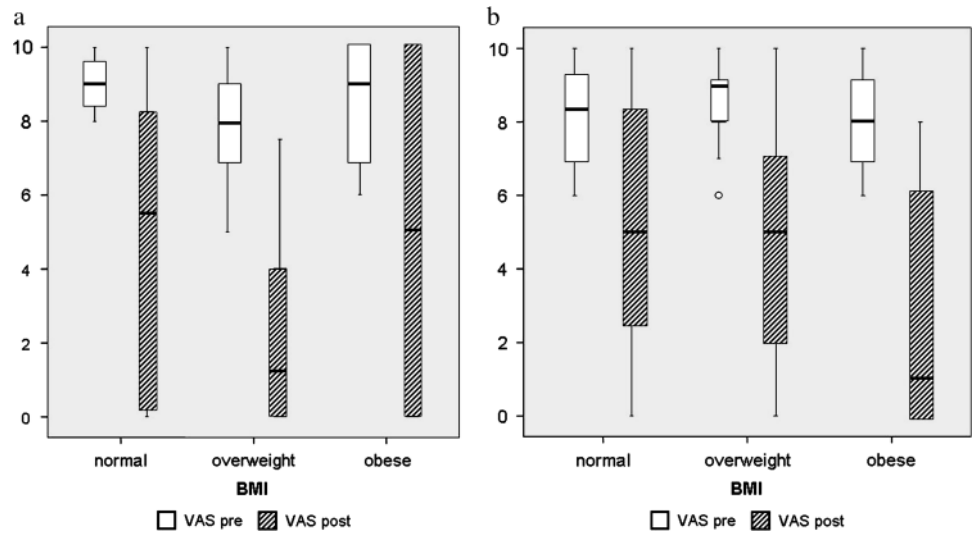

Figure 4 Visual analogue scale (VAS) versus body mass index (BMI) for (a) male (n = 101) and (b) female (n = 24) patients.

It should be stressed that nocturnal biofunction of the orofacial system in the present study has still not been objectively documented. Pressure monitoring was used only to control the patient's ability to perform and to maintain subatmospheric pressure during the instruction phase. Further research, including polysomnographic observation in a setting with intraoral pressure monitoring, is necessary to evaluate TRM training on the nocturnal phases of obstruction.

However, there is evidence that mouth breathing, which implies an open rest position of the tongue, but does not allow the tongue to be stabilized in a closed palate contact position, may play a role in snoring and also in OSA. This hypothesis is in line with the observations of Raskin *et al.* (2000) who found an increased apnoea-hypopnea index (AHI) in children with mouth breathing. Nasal breathing as an important preventive therapeutic goal (Rappai *et al.*, 2003) may be directly responsible for airway opening or indirectly by allowing the orofacial system to be physically stabilized in a closed rest position.

Successful TRM training at least implies that the patient is able to breathe during the training phase of 30–60 minutes exclusively through the nose. The successful exercise may be taken as a sign of the absence of anatomical obstructions and the basis for re-education of a nasal breathing mode in the case of habitual oronasal respiration. If patients show signs of dyspnoea during the exercises, nocturnal nasal obstruction is probable and TRM-based training contraindicated. These patients should be referred to an ear, nose, and throat specialist in order to determine the cause of the obstruction.

Daytime training generally influences orofacial functions and the symptoms of nightime snoring. Puhan *et al.* (2006) reported that daytime training of patients with OSA can be performed successfully using a wind instrument. Playing a didgeridoo resulted in a decrease in AHI, bed partner ranking of sleep disturbance, and the Epworth Sleepiness Scale significantly improved. A possible explanation might be that posterior mouth closure during didgeridoo playing serves as a means to establish nasal breathing and a closed rest position. Electromyostimulation of tongue muscles performed during the day has been shown to have a morphological effect on submental muscles (Wiltfang *et al.*, 1999; Ludwig, 2008). Although daytime tongue-muscle training by electromyostimulation cannot generally be recommended for the treatment of sleep apnoea, the method has proven to be effective in the treatment of snoring (Randerath *et al.*, 2004).

The use of oral shields in the treatment of snoring has also been reported previously (Campion, 1985; Veres, 1993). The findings generally support the formation of external mouth closure. However, oral shields alone do not provide an effective mechanism for the control of nasal breathing because an oral airstream may bypass the shield, if a close rest position is not achieved. This may be responsible for failures of an oral shield therapy of snoring in the study of Marklund and Franklin (1996).

In the present research, a significantly higher correlation of treatment success for patients was observed for normal weight subjects compared with obese patients who did not respond significantly to the exercises. This is in accordance with the pilot study of Ojay and Ernst (2000) who reported that overweight subjects seemed to respond less well during singing exercises to reduce snoring. Furthermore, Pai *et al.* (2008), who studied the prevalence and severity of snoring and daytime somnolence among semiprofessional choir singers and non-singers, found that as BMI approached 40, the difference in snoring scale score values between the groups decreased. They concluded that snorers with a normal BMI are more likely to benefit from singing practice. Thus,

it may be speculated that the functional treatment described is indicated for primary snorers of normal weight.

A shortcoming of the present research is that only subjective data have been provided so far. This was due to the fact that only primary snorers were included in the study, who were not motivated to undergo any extensive diagnostic procedures. For further studies, it is planned to integrate home monitoring of intraoral pressure in the treatment concept.

Conclusion

Daytime training using the TRM in conjunction with nocturnal wear of an oral shield is a valuable instrument to reduce snoring severity in primary snorers with a normal BMI.

References

Campion P C 1985 The management of snoring. Background and a series of cases. Medical Journal of Australia 143: 337–338

Cartwright R, Venkatesan T K, Caldarelli D, Diaz F 2000 Treatments for snoring: a comparison of somnoplasty and an oral appliance. Laryngoscope 110: 1680–1683

Engelke W 2003 Ein Manöver zur Positionierung der Zunge am Gaumen. Sprache Stimme Gehör 27: 71–175

Engelke W 2007 Systematische Rhonchopathiebehandlung in der zahnärztlichen Praxis. Cuvillier Verlag, Göttingen, pp. 34–36.

Engelke W, Repetto G, Mendoza-Gärtner M 2006 Preliminary radiographic observations on the tongue repositioning manoeuvre. European Journal of Orthodontics 28: 618–623

Engelke W, Repetto G, Mendoza-Gärtner M, Knösel M 2007 Functional treatment of snoring using oral shields in conjunction with the tongue repositioning manoeuvre. International Journal of Odontostomatology 1: 133–139

Fajdiga I 2005 Snoring imaging: could Bernoulli explain it all? Chest 128: 896–901

Fitzpatrick M F, McLean H, Urton A M, Tan A, O'Donnell D, Driver H S 2003 Effect of nasal or oral breathing route on upper airway resistance during sleep. European Respiratory Journal 22: 827–832

Fränkel R 1967 Die Dynamik des interokklusalen Unterdruckes. Deutsche Zahnärztliche Zeitschrift 22: 282

Gabriely N, Jensen O 1993 Theory and measurement of snores. Journal of Applied Physiology 74: 2828–2837

Gleeson K, Zwillich C W, Braier K, White D P 1986 Breathing route during sleep. American Review of Respiratory Diseases 134: 115–120

Guilleminault C, Stoohs R, Duncan S 1991 Snoring (I). Daytime sleepiness in regular heavy snorers. Chest 99: 40–48

Hoffstein V 2007 Review of oral appliances for treatment of sleep-disordered breathing. Sleep and Breath 11: 1–22

Hollowell D E, Suratt P M 1991 Mandible position and activation of submental and masseter muscles during sleep. Journal of Applied Physiology 57: 520–527

Issa F G, Sullivan C E 1984 Upper airway closing pressures in obstructive sleep apnea. Journal of Applied Physiology 57: 520–527

Kuna S T, Remmers J E 1985 Neural and anatomic factors related to upper airway occlusion during sleep. Medical Clinics of North America 69: 1221–1242

Lindner A 1991 Measurement of intraoral negative air pressure during dummy sucking in human newborn. European Journal of Orthodontics 13: 317–321

Lindner A, Hellsing E 1991 Cheek and lip pressure against maxillary dental arch during dummy sucking. European Journal of Orthodontics 13: 362–366

Ludwig A 2008 Results of electromyostimulation therapy in obstructive sleep apnoea. Artificial Organs 32: 655–658

Marklund M, Franklin K A 1996 Dental appliances in the treatment of snoring. A comparison between activator, soft palate lifter and a mouth shield. Swedish Dental Journal 20: 183–188

Meurice J C, Marc I, Carrier G, Series F 1996 Effect of mouth opening on upper airway collapsibility in normal sleeping subjects. American Journal of Respiratory and Critical Care Medicine 153: 255–259

Mew J R 2004 The postural basis of malocclusion: a philosophical review. American Journal of Orthodontics and Dentofacial Orthopedics 126: 729–738

Miyamoto K *et al.* 1998 Mandibular posture during sleep in healthy adults. Archives of Oral Biology 43: 269–275

Norton P G, Dunn E V 1985 Snoring as a risk factor for disease: an epidemiological survey. British Medical Journal 291: 630–632

Ojay A, Ernst E 2000 Can singing exercise reduce snoring? A pilot study. Complementary Therapies in Medicine 8: 151–156

Pai I, Lo S, Wolf D, Kajieker A 2008 The effect of singing on snoring and daytime somnolence. Sleep and Breathing 12: 265–268

Puhan M A, Suarez A, Lo Cascio C, Zahn A, Heitz M, Braendli O 2006 Didgeridoo playing as an alternative treatment for obstructive sleep apnoea syndrome: randomised controlled trial. British Medical Journal 332: 266–270

Randerath W J, Galetke W, Domenski U, Weikunat R, Ruehle K H 2004 Tongue muscle training by intraoral electrical stimulation in patients with obstructive sleep apnoea. Sleep 27: 254–259

Rappai M, Collop N, Kemp S, de Shazo R 2003 The nose and sleep disordered breathing: what we know and what we do not know. Chest 126: 316–317

Raskin S, Limme M, Poirrier R 2000 Could mouth breathing lead to obstructive sleep apnea syndromes. A preliminary study. L'Orthodontie Française 71: 27–35

Shikata N *et al.* 2004 Association between nasal respiratory obstruction and vertical mandibular position. Journal of Oral Rehabilitation 31: 957–962

Thüer U, Sieber R, Ingervall B 1999 Cheek and tongue pressures in the molar areas and the atmospheric pressure in the palatal vault in young adults. European Journal of Orthodontics 21: 299–309

Veres E 1993 Clinical trial of an oral vestibular shield for the control of snoring. Journal of the Dental Association of South Africa 48: 15–17

Wiltfang J *et al.* 1999 First results on daytime submandibular electrostimulation of suprahyoidal muscles to prevent night time hypopharyngeal collapse in obstructive sleep apnea syndrome. International Journal of Oral and Maxillofacial Surgery 28: 21–25

Witt E, Kühr H W 1969 Experimentelle Untersuchungen über die physiologischen Vorgänge beim Tragen der Vorhofplatte. Schweizer Monatsschrift für Zahnmedizin 79: 650–667